Compaq Visual Fortran

Programmer's Guide

Date:	August, 2001
Software Version:	Visual Fortran Version 6.6
Operating Systems:	Microsoft Windows 98, Windows Me, Windows 95, Windows 2000, or Windows NT Version 4

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Copyright Information

New Features for Compaq Visual Fortran Version 6.6

New features added to Compaq Visual Fortran (Visual Fortran) Version 6.6 (since Visual Fortran Version 6.5 and 6.5A) include the following:

- Support has been added for 8-byte integer and 8-byte logical intrinsic data types.
- The Windows API interface header files DFWINTY.F90 and DFWIN.F90 (and its component files) have been extensively revised to work in both a 32-bit and a 64-bit environment.
- A new version of the Compaq Extended Math Library (CXML) is included with Visual Fortran Version 6.6. CXML Version 5.0 includes improved performance for many CXML routines, a new set of routines for solving sparse matrix problems using direct methods, sample files that show how to invoke the direct sparse solver routines from Fortran and C, changes to certain sparse iterative solver functions, changes in how messages can be printed with the iterative solver functions (including changes to the argument iounit), and other changes. The skyline solver routines are no longer supported. The auxiliary LAPACK routine XLAENV is no longer supplied by CXML; instead, the LAPACK routines DLAMCH and SLAMCH have been modified to return compile-time constants instead of computing values on each call.
- The types of Visual Fortran run-time libraries displayed in the visual development environment Fortran tab (Project menu, Settings dialog box) more closely match the run-time libraries available in Visual C++ (C/C++ tab). Also, the types of run-time libraries linked against while linking against debug versionsof DLL libraries have changed, as described in Visual Fortran/Visual C++ Mixed-Language Programs and Specifying Consistent Library Types.
- The following new graphics functions let you draw Bezier curves (based on fitting a cubic curve to four points):
  - POLYBEZIER and POLYBEZIER_W
  - POLYBEZIERTO and POLYBEZIERTO_W
- The following compiler options have changed or have been added:
  - /annotations now provides information about optimizations in a listing file.
  - /architecture and /tune options now support the pn4 keyword for Pentium 4 systems. In addition, the pn1, pn2, and pn3 keywords have been added (pn is an abbreviation for Pentium) as the preferred

keywords in place of p5, p6, and p6p.

- The /ccdefault:default option now allows other options, such as /vms, to set the default carriage control.
- The keyword /fpscomp:ldio_spacing, for list-directed output, controls whether a blank is inserted at run-time after a numeric value before a character value. This option is set by /fpscomp:general.
- /integer_size now supports a value of 64 to allow INTEGER and LOGICAL declarations to be treated as 8 bytes long (KIND=8).
- Specifying the /stand option (without keywords) now sets /stand:f95 (Fortran 95 standards checking) instead of /stand:f90 (Fortran 90 standards checking).
- If you specify /fast with /stand, /align:dcommons and /align:sequence (usually set by /fast) are not set.

- A derived-type variable that is data initialized via default initialization of any of its components will no longer be saved by default. A RECORD variable that is data initialized via default initialization specified in its STRUCTURE declaration will no longer be saved by default.
- The Fortran preprocessor fpp supports the macros __DATE__ and __FILE__. When you request that fpp expand macros using "-fpp:-m", these expand into character literals that give the name of the source file being processed and the current date/time respectively.
- For additional new features and details, see the online release notes (`relnotes.txt` or `relnotes.htm`).
- New or significantly revised sections in the Programmer's Guide include Copying Projects and Viewing Fortran Data Types in the Debugger.

Beginning with Version 6.6, Visual Fortran no longer supports Windows NT Alpha systems.

Changes to Compaq Array Visualizer are described separately in the Array Visualizer HTML Help documentation.

New Features for Compaq Visual Fortran Version 6.5 and 6.5A

New features added to Compaq Visual Fortran (Visual Fortran) Version 6.5A (since Visual Fortran Version 6.5) include the following:

- The Fortran COM Server now allows you to select an out-of-process (.EXE) COM server. Users now have a choice of the type of server, either a DLL (in-process) COM server and an EXE (out-of-process) COM server. Other Fortran COM Server enhancements allow array arguments to be assumed shape and you can now add the ISupportErrorInfo interface to your server.
- The following new compiler options have been added:
  - /assume:[no]protect_constants specifies whether constant actual arguments can be changed.
  - /check:arg_temp_created requests that a run-time informational message appear if actual arguments are copied into temporary storage before routine calls.
  - /warn:ignore_loc requests that the compiler issues warnings when %LOC is stripped from an argument
- The following new ATTRIBUTES directives have been added: ALLOW_NULL, DECORATE, IGNORE_LOC, and NOMIXED_STR_LEN_ARG
- The optional KIND argument has been added to **INDEX**, **LEN_TRIM**, **MAXLOC**, **MINLOC**, **SCAN**, and **VERIFY** intrinsic procedures.
- For additional new features and details, see the online release notes (`relnotes.txt` or `relnotes.htm`).
- New or significantly revised sections in the Programmer's Guide based on customer feedback include Coding Requirements for Fortran Windows Applications, Using Menus and Dialogs in SDI and MDI Fortran Windows Applications, Using the Resource Editor to Design a Dialog, and Compatibility with Compaq Fortran on Other Platforms.
- The section Pointer Arguments in the Language Reference has been significantly revised based on customer feedback.

New features added to Compaq Visual Fortran Version 6.5 (since Visual Fortran Version 6.1) include the following:

- The Fortran COM Server project type and the Fortran COM Server Wizard, described in Creating a COM Server. The Fortran COM Server Wizard helps you create a COM server or dual interface server. In addition, new information about using COM and Automation is provided in Getting a Pointer to an Object's Interface.
- New COM routines are provided:
  - COMStringFromGUID passes a GUID and returns the corresponding string representation.
  - COMIsEqualGUID determines if two GUIDs are the same.
- Visual Fortran now generates optimized code for the Intel™ Pentium™ III, AMD™ K6, and AMD Athlon™ architectures, by providing new keywords for the /arch and /tune compiler options.
- New intrinsic procedures added:
  - INT_PTR_KIND returns the INTEGER KIND that will hold an address.
  - KIND= is now an optional argument to the intrinsic procedures LEN, SHAPE, SIZE, LBOUND, and UBOUND.
  - For *x*86 systems, POPCNT, POPPAR, LEADZ, and TRAILZ perform bit-related operations on integer data.
- New exception handling routines are provided:
  - CLEARSTATUSFPQQ exception flags in the floating-point processor status word (*x*86 processors).
  - GETEXCEPTIONPTRSQQ returns a pointer to C run-time exception information pointers appropriate for use in signal handlers established with **SIGNALQQ** or direct calls to the C rtl signal() routine (*x*86 processors). For additional information about **GETEXCEPTIONPTRSQQ**, see Obtaining Traceback Information with TRACEBACKQQ and TRACEBACKQQ.
- The new QuickWin graphics routine SETTEXTCURSOR has been added to set the height and width of the text cursor (the caret) for the window in focus.
- The interface to the AUTOAddArg subroutine has changed. The *output_arg* argument (LOGICAL) is now the *intent_arg* argument (INTEGER). New code should use the new documented interface. The old interface is supported for compatibility purposes.
- New information about advanced exception handling and setting up various

types of handlers for *x*86 systems is provided in Advanced Exception and Termination Handling Considerations.

- For non-native unformatted files, you can now use the FORT_CONVERT.ext or FORT_CONVERT_ext environment variable method to specify that files with certain file extensions (such as .DAT) are in a specified non-native format (see Methods of Specifying the Data Format). (Visual Fortran's native numeric formats are little endian, including IEEE floating-point formats.)
- Previous versions of Visual Fortran allowed only procedures and **COMMON** blocks to have the **DLLEXPORT** or **DLLIMPORT** ATTRIBUTE. You can now export/import module variables and arrays.
- A Visual Fortran compiled module now contains all of the information from modules used (**USE** statement) by the module. This may greatly increase the size of compiled modules, especially if the modules contain a `USE DFWIN` or `USE DFWINTY` statement. There are ways to minimize the information contained in compiled modules when calling Win32 routines, as described in Calling Win32 Routines and the Visual Fortran Windows Module.
- In order to conform with clarified wording in the Fortran 95 standard, the compiler has been changed so that when a READ statement encounters an end-of-file condition, and there is no END specifier but there is an ERR specifier, the ERR= branch is *not* taken. Similarly, if an end-of-record condition occurs but there is no EOR specifier, an ERR branch is not taken. If you do not specify a routine to handle such errors with the IOSTAT specifier, omitting the END or EOR specifier results in a severe run-time error (such as numbers 24 or 268 respectively).
- The run-time system has been changed to perform more thorough edit checking on list-directed input. In accordance with the Fortran 95 Standard, the run-time system no longer accepts as numeric input "+", "-", ".", "D", "E", or "Q" without expressing at least 1 digit. For example, the run-time system used to allow a single "+" to convert to a 0, but now it will return a FOR$IOS_LISIO_SYN (number 59) error. In addition, ambiguous expressions such as "+-" and "--" will be rejected
- Support has been added for reading nondelimited character strings as input for character NAMELIST items.
- The %VAL and %REF used on actual arguments now override any argument-passing mechanism specified in an explicit interface.
- New Visual Fortran Samples (described in Roadmap to the Visual Fortran Samples) are provided, including:
  - COM sample: Adder

- DIALOG sample: Celsicon
- ExceptionHandling samples: ClearFP, Cslexp2, Cslexp4, GetEptrs, Vbvf1, and Winexcp1
- Isovar sample (ISO varying strings)
- Mixed-language samples, new samples for MASM and Delphi
- QuickWin samples: Conapp, Dirkeys4, PostMini, and Resize
- Isovar, an ISO varying string sample

- Compiling modules is now faster.
- Concurrent-use licensing is now available.
- For additional new features and details, see the online release notes (`relnotes.txt` or `relnotes.htm`), located in the root directory of the Visual Fortran CD-ROM or installed in `Program Files\Microsoft Visual Studio\Df98`.
- New or significantly revised sections in the Programmer's Guide based on customer feedback include Specifying Consistent Library Types and Using the Console.

Changes to Compaq Array Visualizer are described separately in the Array Visualizer HTML Help documentation.

New Features for Compaq Visual Fortran Version 6.1

New features added to Compaq Visual Fortran (Visual Fortran) Version 6.1 (since Version 6.0.A) include the following:

- The Compaq Extended Math Library (CXML) is now provided with the Visual Fortran kit (all editions). CXML is a highly efficient set of math library routines that covers Basic Linear Algebra (BLAS), Linear Algebra Routines (LAPACK), sparse linear system solvers, sorting routines, random number generation, and signal processing functions.

  In addition to being provided with Visual Fortran, CXML is also available on other Compaq Fortran platforms. CXML is:

  - Provided with Compaq Fortran Version 5.3 (or later) for Tru64 UNIX Alpha systems and Compaq Fortran Version 1.0 (or later) for Linux Alpha Systems
  - Provided with Compaq Visual Fortran Version 6.1 (or later)
  - Provided with Compaq Fortran Version 7.3 (or later) for OpenVMS Alpha systems
  - Available as a separate download for most platforms (see the CXML home page at http://www.compaq.com/math)

  For more information on CXML, see Using the Compaq Extended Math Library (CXML) in the Programmer's Guide or the online PDF file Cxmlref.pdf. For information on online PDF files, see The IMSL Routines and CXML Routines Online PDF Documentation.

- IMSL® Version 4 libraries are now provided with the Professional Edition (prior to Visual Fortran 6.1, Visual Fortran provided IMSL Version 3 libraries). The IMSL routines reference documentation is available in PDF format (not HLP format).

  For information on using the IMSL libraries, see Using the IMSL Mathematical and Statistical Libraries in the Programmer's Guide. For information on online PDF files, see The IMSL Routines and CXML Routines Online PDF Documentation. For more information about IMSL and Visual Numerics®, Inc., see http://www.vni.com.

- New functionality has been added to the Dialog Procedures:

  - You can use ActiveX Controls in your dialog boxes. See Using ActiveX Controls in the Using Dialogs section in the Programmer's Guide.
  - Edit Box control enhancements:

You can now use multi-line edit controls and the maximum size restriction of 256 characters has been removed. The Edit Box control supports 2 additional integer indexes (see Using Edit Boxes):

- DLG_TEXTLENGTH - Sets or Gets the current length of the text in the edit box.
- DLG_POSITION - Sets or Gets the current text cursor position in the edit box.

- The dialog box supports a new callback index, DLG_SIZECHANGE (see Control Indexes). This callback is invoked when the size of the dialog box changes.
- New dialog routines are provided:
  - DlgSetTitle - Sets the title of the dialog box.
  - DlgFlush - Updates the display of the dialog box. Useful when changing the dialog box outside of a dialog callback.
  - DlgModalWithParent - Allows you to specify the parent window of a modal dialog box. Useful in an SDI or MDI Windows application that uses modal dialog boxes.
  - DlgIsDlgMessageWithDlg - Allows you to specify which dialog box to check. Useful when the dialog box was created in a DLL.

- New SPORT_xxx (Serial Port) routines have been added.

  The SPORT_xxx collection of routines helps Fortran programmers do basic input and output to serial communication ports. The programming model is much the same as a normal file except the user does a connect/release instead of an open/close. Two types of read and write operations are provided:

  - Read and write arbitrary data from/to the port
  - Read and write line terminated data

  Calls are provided to set basic port parameters such as baud rate, stop bits, timeouts, and so on. Additionally, a call is provided to return the WIN32 handle to the port so that raw WIN32 APIs may be used to implement additional needs of the programmer.

  The documentation overview can be found in Using the Serial I/O Port Routines in the Programmers Guide.

  For a detailed description of the routines, see the Language Reference, A to Z Reference under S (SPORT_xxx), such as SPORT_CONNECT.

- The new subroutine TRACEBACKQQ allows you to initiate a stack trace in your program whenever you like. The input arguments allow you to specify your own message text to head the output and other options as well. See the following for more information:
  - Obtaining Traceback Information with TRACEBACKQQ in the Programmer's Guide
  - TRACEBACKQQ in the Language Reference, A to Z Reference.
- In Developer Studio, you can now print a Fortran source file in color (requires a color printer). After you open the source file in the text editor, in the File menu select Print Colorized Fortran. This has been tested with the Internet Explorer and Netscape browsers. Because Print Colorized Fortran does not know when printing has completed, it creates and leaves the HTML file in your TEMP directory. Delete previously printed HTML files from your TEMP directory to free up disk space. Print Colorized Fortran uses the FSC utility to create an HTML file with the coloring information and then instructs the application on your system that handles HTML files to print the file. If you encounter a problem using the Print Colorized Fortran item, please use the FSC utility directly.

  The FSC.EXE utility takes an .F90 or .FOR source file and produces an HTML version that is colorized per the current Developer Studio Color settings in the registry. It has default colors that are used if the current registry settings are not available. The resultant HTML file may be printed or viewed with your favorite browser. This utility may be invoked from a command prompt (use FSC -? or FSC /h for help) or from within Developer Studio.
- VFRUN provides a self-extracting executable file that installs redistributable Visual Fortran run-time components on the target system. These run-time components include DLLs and other files, as described in "Redistributing Visual Fortran Files" in *Compaq Visual Fortran Installing and Getting Started*.

  VFRUN files are provided for different Visual Fortran releases and for *x*86 and Alpha systems. For example, for Visual Fortran v6.1, VFRUN61i.exe is provided for *x*86 systems and VFRUN61a.exe is provided for Alpha systems. You can download VFRUN from the Visual Fortran Web site, http://www.compaq.com/fortran (click on Downloads and Updates, then Run-Time Redistributables Kit). Please download the VFRUN kit for the version of Visual Fortran used to create the executable application.
- Visual Fortran (VF) Reporter is a new tool that helps you report problems by e-mail to the Visual Fortran team. This tool gathers and displays system information and guides you to send relevant information in an e-mail message. This tool can be optionally installed during Visual Fortran

installation. For information on technical support and using VF Reporter, see *Compaq Visual Fortran Installing and Getting Started*.

- Greater Access to Windows APIs

  Additional interface definitions have been provided to simplify calling Win32 routines from Visual Fortran:

  - DFWINTY.F90 has 980 new derived types and 4070 new Fortran parameter constants added. These new items represent the difference between Microsoft Visual C++ 4 header files and Visual C++ 6 header files.
  - USER32.F90 has 72 new interfaces to routines in USER32.LIB. These new routine interfaces again represent the difference between Microsoft Visual C++ 4 header files and Visual C++ 6 header files.
  - KERNEL32.f90 has 50 new interfaces to routines in KERNEL32.LIB.
  - GDI32.F90 has 25 new interfaces to routines in GDI32.LIB.
  - ADVAPI32.F90 has 50 new interfaces to routines in ADVAPI32.LIB.

  In all these files, the new material is under conditional compilation so that defining "__DO_NOT_INCLUDE_VC6_ITEMS" will remove the new items. Search for the string above to locate the new items which will be found towards the ends of the files.

  The files are shipped without the string being defined, and the mod files will contain the new items.

- New or changed compiler options include:

  - The /align option now includes the /align:sequence keyword to allow alignment of derived type data with the **SEQUENCE** statement. This option appears in the Fortran Data category in the Project Settings dialog box (see Categories of Compiler Options).
  - The /ccdefault:*keyword* option controls carriage control use when writing to a terminal screen. This new option appears in the Run-Time category in the Project Settings dialog box.
  - The /cxml option requests that the Compaq Extended Math Library (CXML) library be linked against (provided for documentation purposes only). This new option appears in the Library category in the Project Settings dialog box.
  - The /fast option now sets the /arch:host /tune:host /align:sequence options.

- The /imsl option ensures that the IMSL libraries will be passed to the linker (your program needs to specify the appropriate **USE** statements and set the IMSL environment variables). This new option appears in the Library category in the Project Settings dialog box.

- Visual Fortran puts literals into read-only memory so storing into a dummy argument that has a constant as its associated actual argument will result in an access violation and program termination:

```
call f(0)
...
subroutine f(i)
i=1                ! this will die
```

- Two new Fortran source directives for controlling optimizations are now available:

  - cDEC$ IVDEP
  - cDEC$ UNROLL

  For an overview of these directives, see Compiler Directives Related to Performance in the Programmer's Guide.

  For more detail, see IVDEP Directive and UNROLL Directive in the Language Reference.

- Version 6.1 for *x*86 (Intel) systems contains all of the applicable updated files from the Microsoft Visual Studio 6.0 Service Pack 3. Therefore, Version 6.1 *x*86 users do not need to install Visual Studio 6.0 Service Pack unless you have other Visual Studio products. Version 6.1 for Alpha systems contains all of the applicable updated files from the Microsoft Visual Studio 6.0 Service Pack 2.

- You can now maintain previously saved Fortran Environment Project Settings (see Saving and Using the Project Setting Environment for Different Projects. Use the Manage Saved Fortran Environment icon in the Fortran toolbar. Also, application wizards that assist in creating a new Fortran Windows project have been enhanced.

- HTML Help now supports the ability to define (View menu, Define Subset... item) and use subsets of the current collection of HTML Help titles (see *Compaq Visual Fortran Installing and Getting Started*). This is especially useful when using the full-text search capabilities of HTML Help.

- HTML help no longer includes embedded Adobe Acrobat PDF files. Instead, the PDF files ship on the Visual Fortran CD-ROM (and are installed if requested). For details, see The IMSL Routines and CXML Routines Online PDF Documentation. This reduces the size of the Visual Fortran HTML help (CHM) file and minimizes the possibility of software problems displaying embedded PDF files reported on certain systems.

- For additional details, see the online release notes, installed in `Program Files\Microsoft Visual Studio\Df98`.

Changes to Compaq Array Visualizer are described separately in the Array Visualizer HTML Help documentation.

Introduction to the Programmer's Guide

In this document, links are denoted by a or when you pass your pointer over a blue-colored term. In either case, click on the link to see further information.

The *Programmer's Guide* contains the following information:

- How to build and debug efficient applications:
  - Building Programs and Libraries
  - Using the Compiler and Linker from the Command Line
  - Compiler and Linker Options
  - Debugging Fortran Programs
  - Performance: Making Programs Run Faster
- Special coding and related considerations for certain Visual Fortran project types:
  - Using QuickWin
  - Creating Fortran DLLs
  - Creating Windows Applications
- Topics about programming with Visual Fortran on Windows® 2000, Windows NT® 4.0, Windows Me, Windows 98, and Windows 95 systems:
  - Portability and Design Considerations
  - Using Dialogs
  - Drawing Graphics Elements
  - Using Fonts from the Graphics Library
  - Using National Language Support Routines
  - Portability Library
  - Files, Devices, and I/O Hardware
  - Using COM and Automation Objects
  - Creating a COM Server
  - Programming with Mixed Languages
  - Creating Multithread Applications
- Topics related to data types and handling run-time errors:
  - Data Representation
  - Handling Run-Time Errors

  - The Floating-Point Environment
  - Advanced Exception and Termination Handling Considerations
  - Converting Unformatted Numeric Data
  - Hexadecimal-Binary-Octal-Decimal Conversions

- Topics discussing how to use IMSL® and CXML library routines:

  - Using the IMSL Mathematical and Statistical Libraries
  - Using the Compaq Extended Math Library (CXML)

- Topics discussing compatibility and tools:

  - Compatibility Information
  - Using Visual Fortran Tools

Note: Visual Fortran contains many extensions to the full ANSI/ISO standard language. In this book, the Visual Fortran extensions to the Fortran 95 standard appear in this color.

Programmer's Guide Conventions

This section discusses the following:

- General Conventions
- Syntax Conventions
- Platform labels

General Conventions

The *Programmer's Guide* uses the following general conventions. (Note that in most cases, blanks are not significant in Fortran 90 or 95.)

When You See This	Here Is What It Means
Extensions to Fortran 95	Dark teal type indicates extensions to the Fortran 95 Standard. These extensions may or may not be implemented by other compilers that conform to the language standard.
DF, LINK, FL32	Uppercase (capital) letters indicate filenames and MS®-DOS®-level commands used in the command console.
expression	Words in italics indicate placeholders for information that you must supply. A file-name is an example of this kind of information. Italics are also used to introduce new terms.
[optional item]	Items inside single square brackets are optional. In some examples, square brackets are used to show arrays.
{*choice1* | *choice2*}	Braces and a vertical bar indicate a choice among two or more items. You must choose one of the items unless all of the items are also enclosed in square brackets.

`s[, s]...`	A horizontal ellipsis (three dots) following an item indicates that the item preceding the ellipsis can be repeated. In code examples, a horizontal ellipsis means that not all of the statements are shown.
compiler option	This term refers to Windows options, OpenVMS qualifiers, and Tru64 UNIX and Linux options that can be used on the compiler command line.

`!  Comment line`
`WRITE (*,*) 'Hello &`
`&World'`
	This kind of type is used for program examples, program output, and error messages within the text. An exclamation point marks the beginning of a comment in sample programs. Continuation lines are indicated by an ampersand (&) after the code at the end of a line to be continued and before the code on the following line.

AUTOMATIC, **INTRINSIC, WRITE**	Bold capital letters indicate Compaq® Fortran statements, functions, subroutines, and keywords. Keywords are a required part of statement syntax, unless enclosed in brackets as explained above. In the sentence, "The following steps occur when a **DO WHILE** statement is executed," the phrase **DO WHILE** is a Compaq Fortran keyword. Bold lowercase letters are used for keywords of other languages. In the sentence, "A Fortran subroutine is the equivalent of a function of type **void** in C," the word **void** is a keyword of C.
Fortran	This term refers to language information that is common to ANSI FORTRAN 77, ANSI/ISO Fortran 95 and 90, and Compaq Fortran (formerly DIGITAL Fortran).

Fortran 95/90	This term refers to language information that is common to ANSI/ISO Fortran 95 and ANSI/ISO Fortran 90.
Fortran 95	This term refers to language information that is common to ANSI/ISO Fortran 95.
Fortran 90	This term refers to language information that is common to ANSI/ISO Fortran 90.
Compaq Fortran, DIGITAL Fortran	These terms refer to the same language.
OpenVMS, VMS	These terms refer to the same operating system.
Tru64 UNIX, DIGITAL UNIX	These terms refer to the same operating system.
Windows systems	This term refers to all supported Microsoft® Windows® operating systems. (See labels WNT and W9* in Platform Labels below.)
integer	This term refers to the INTEGER(KIND=1), INTEGER(KIND=2), INTEGER (INTEGER (KIND=4)), and INTEGER(KIND=8) data types as a group.
real	This term refers to the REAL (REAL (KIND=4)) and DOUBLE PRECISION (REAL (KIND=8)) data types as a group.
complex	This term refers to the COMPLEX (COMPLEX(KIND=4)), DOUBLE COMPLEX (COMPLEX(KIND=8)), and COMPLEX (KIND=16) data types as a group.
logical	This term refers to the LOGICAL(KIND=1), LOGICAL(KIND=2), LOGICAL (LOGICAL (KIND=4)), and LOGICAL(KIND=8) data types as a group.

Syntax Conventions

The *Programmer's Guide* uses certain conventions for language syntax. For example, consider the following syntax for the PARAMETER statement:

> **PARAMETER** [(] *c* = *expr* [, *c* = *expr*]...[)]

This syntax shows that to use this statement, you must specify the following:

- The keyword **PARAMETER**
- An optional left parenthesis
- One or more *c*=*expr* items, where *c* is a named constant and *expr* is a value; note that a comma must appear between c=expr items.
  The three dots following the syntax means you can enter as many *c*=*expr* items as you like.
- An optional terminating right parenthesis

The dark teal brackets ([ ]) indicate that the optional parentheses are an extension to standard Fortran.

Platform Labels

A platform is a combination of operating system and central processing unit (CPU) that provides a distinct environment in which to use a product (in this case, a language). For example, Microsoft® Windows® 98 on *x*86 is a platform.

Information applies to all supported platforms unless it is otherwise labeled for a specific platform (or platforms), as follows:

VMS	Applies to OpenVMS™ on Alpha processors.
U*X	Applies to Tru64 UNIX® and Linux® on Alpha processors.
TU*X	Applies to Tru64 UNIX® on Alpha processors.

WNT	Applies to Microsoft 2000 and Windows NT® 4.0 operating systems on AMD and Intel® *x*86 processors, and 64-bit Windows operating systems on Intel IA-64 processors.
W9*	Applies to Microsoft Windows 98, Windows Millennium Edition (Me), and Windows 95 operating systems on AMD and Intel *x*86 processors.
Alpha	Applies to operating systems on Alpha processors.
ia32	Applies to 32-bit Windows operating systems on AMD and Intel *x*86 processors (see "System Requirements and Optional Software" in *Compaq Visual Fortran Installing and Getting Started*).
ia64	Applies to 64-bit Windows operating systems on IA-64 processors.

Building Programs and Libraries

Visual Fortran includes the Microsoft visual development environment (also used by the same version of Visual C++®) and associated Visual Studio software development tools. This industry-leading environment makes it easy for you to create, debug, and execute your programs. It includes a full-feature text editor, debugger, and interactive help. You can build your source code into several types of programs and libraries, either using the visual development environment or working from the command line. For an introduction to this environment, see *Compaq Visual Fortran Installing and Getting Started*.

This section describes how to use the visual development environment to define a project, open and close a project workspace, and build a project:

- Overview of Building Projects
- Types of Projects you can build
- Defining Your Project and selecting project features with the visual development environment
- Errors During the Build Process
- Compiler Limits
- Running Fortran Applications
- Copying Projects
- Visual Fortran Samples

For more information on:

- Building programs and libraries at the command line, see: Using the Compiler and Linker from the Command Line and Using Visual Fortran Tools.
- Using the Debugger, see Debugging Fortran Programs.
- Details about using the development environment, see the *Visual C++ User's Guide*.

Overview of Building Projects

The Microsoft Visual C++™ Development Environment (also called Developer Studio) organizes development into *projects*. A project consists of the source files required for your application, along with the specifications for building the project. The build process involves defining your project, setting options for it, and building the program or library.

Each project can specify one or more *configurations* to build from its source files. A *configuration* specifies such things as the type of application to build, the platform on which it is to run, and the tool settings to use when building. Having multiple configurations lets you extend the scope of a project but still maintain a consistent source code base from which to work.

When you create a new project, the Microsoft visual development environment automatically creates Debug and Release configurations for you. The default configuration is the Debug configuration. To specify the current configuration, select Set Active Configuration from the Build menu.

Projects are contained in a *workspace*. When you create a new project, you indicate whether the project is created in a new workspace or an existing workspace. To open an existing project, you open its workspace. A workspace can contain multiple projects.

Once you open a workspace, the development environment displays a *FileView* pane, which displays the files contained in the project, and lets you examine visually the relationships among the files in your project. Modules, include files, or special libraries your program uses are automatically listed as *dependencies*. The output window displays information produced by the compiler, linker, Find in Files utility, and the profiler.

You can specify build options in the Project menu Settings dialog box, for one of the following:

- The entire project
- For certain configurations
- For certain files

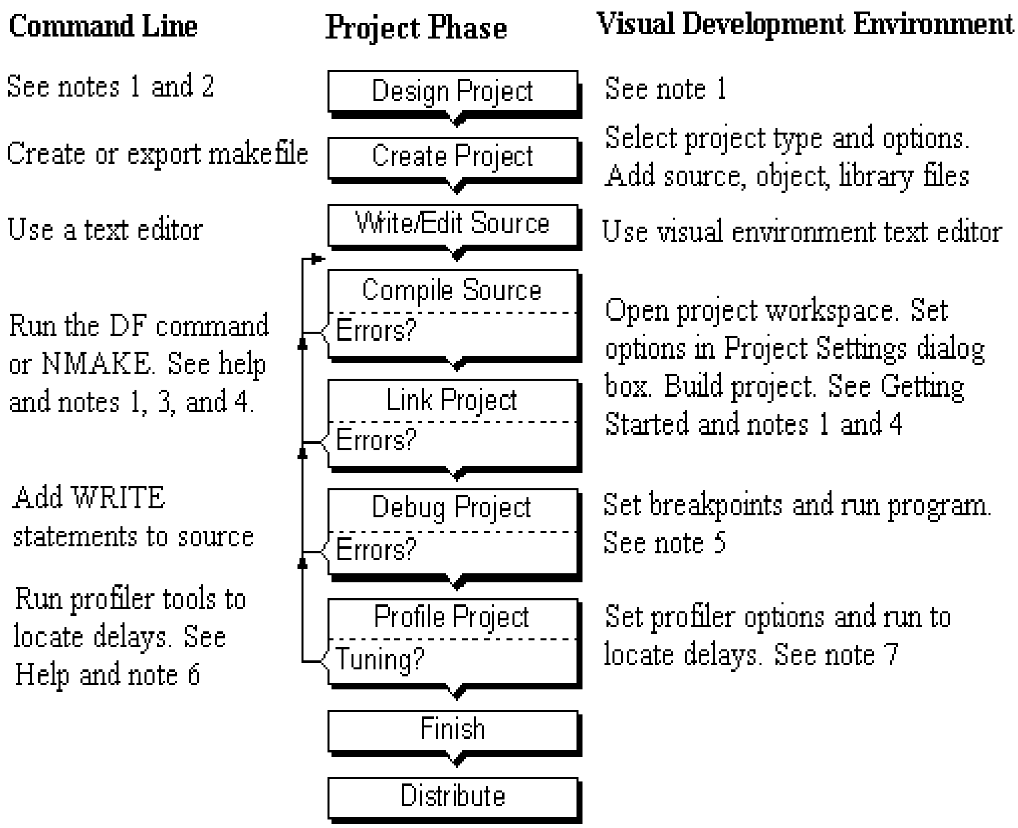
For example, you can specify certain kinds of compiler optimizations for your project in general, but turn them off for certain configurations or certain files.

Once you have specified the files in your project, the configurations that your project is to build, and the tool settings for those configurations, you can build the project with the commands on the Build menu.

In addition to using the visual development environment, you can also use the command line (DF command). You can also develop the application from the visual development environment and export a makefile for use in command-line processing (NMAKE command). Your choice of development environment determines what you can do at each stage.

The following diagram illustrates the development process for using the visual development environment or command line:

Example of Development Process



Notes in the diagram point to places where you can read more about a particular part of the development process:

1. Building Programs and Libraries (the current chapter)
2. Using the Compiler and Linker from the Command Line
3. Using Visual Fortran Tools
4. The Floating-Point Environment and Handling Run-Time Errors
5. Debugging Fortran Programs
6. Profiling Code from the Command Line
7. Analyze Program Performance

For more overview information about building projects with the visual development environment, see:

- How Information Is Displayed
- Menu Options
- Using the Shortcut Menu

How Information Is Displayed

The Microsoft visual development environment displays information in windows, panes, and folders. One window can contain several panes, and each pane can display one or more folders. A *pane* is a separate and distinct area of a window;

a *folder* is a visual representation of files in a project. Folders show the order in which Visual Fortran compiles the files, and the relationship of source files to their dependent files, such as modules.

When you initially create a project, the Project Workspace window contains some default panes, accessible through tabs at the bottom of the window, to display information about the content of the project. You can also open an output window, which has panes that display build output, debug output, Find in Files output, and profiler output. In addition to the default panes, you can create customized panes to organize and display project information in ways most useful to you.

You can access information about components of the project from the panes in the project window. Double-clicking any item in a pane displays that item in an appropriate way: source files in a text editor, dialog boxes in the dialog editor, help topics in the information window, and so on.

Be sure to select the appropriate pane when using the menu commands, in particular the Save and Save As commands. Commands on the File menu affect only the window that currently has the focus.

Menu Options

Menu options that are available to you may look different, depending on which window or pane has current focus. The Debug menu, for example, is only visible when you are debugging.

The visual development environment has the following menu bars and toolbars:

- Standard menu bar
- Standard toolbar
- Build toolbar
- Build minibar
- Resource toolbar
- Edit toolbar
- Debug toolbar
- Browse toolbar
- Fortran toolbar
- Controls toolbar

To select or deselect the menu bars and toolbars:

- In the Tools menu, click Customize item
- Click the Toolbar tab
- Select (click) the toolbar name

Using the Shortcut Menu

The project window has a shortcut menu that lists commands appropriate for the current selection in the window. This is a quick method to display commands that are also available from the main menu bar.

To display the shortcut menu:

- Move the mouse pointer into the project window and click the right mouse button.

You can now select project commands that are appropriate for your current selection in the project window.

Types of Projects

When you create the project, you must choose a *project type*. You need to create a project for each binary executable file to be created. For example, the main Fortran program and a Fortran dynamic-link library (DLL) would each reside in the same workspace as separate projects.

The project type specifies what to generate and determines some of the options that the visual development environment sets by default for the project. It determines, for instance, the options that the compiler uses to compile the source files, the static libraries that the linker uses to build the project, the default locations for output files, defined constants, and so on.

You can build seven kinds of projects with Visual Fortran. You specify the project type when you create a new project. They are summarized in the following table:

Project Type	**Key Features**
Fortran Console Application (.EXE)	Single window main projects without graphics (resembles character-cell applications). Requires no special programming expertise. For a Visual Fortran Sample of a Console Application, see ...`\COMMON\MSdev98\MYPROJECTS\CELSIUS`, as described in "Opening an Existing Project" in *Compaq Visual Fortran Installing and Getting Started*.

Fortran Standard Graphics Application (.EXE)	Single window main projects with graphics. The programming complexity is simple to moderate, depending on the graphics and user interaction used. Samples of Standard Graphics Applications (QuickWin single window) resemble those for QuickWin Applications (see below).
Fortran QuickWin Application (.EXE)	Multiple window main projects with graphics. The programming complexity is simple to moderate, depending on the graphics and user interaction used. Samples of QuickWin Applications (QuickWin multiple window) are in `...\DF98\SAMPLES\QUICKWIN`, such as QWPIANO and QWPAINT.
Fortran Windows Application (.EXE)	Multiple window main projects with full graphical interface and access to all Win32 API routines. Requires advanced programming expertise and knowledge of the Win32 routines. Samples of Win32 Applications are in `...\DF98\SAMPLES\ADVANCED\Win32`, such as PLATFORM or POLYDRAW.
Fortran COM Server (.DLL)	Uses the Component Object Model (COM) to implement a COM server. COM supports client-server interaction between a user of an object, the client, and the implementor of the object, the server. Clients may be written in Visual Fortran using the Fortran Module Wizard or in other languages, such as Visual C++ and Visual Basic. Requires advanced knowledge of COM. Samples of Fortran COM Server (and COM client) applications are in `...\DF98\SAMPLES\ADVANCED\COM`, such as Adder.
Fortran Static library (.LIB)	Library routines to link into .EXE files.
Fortran Dynamic-Link Library (.DLL)	Library routines to associate during execution.

The first four projects listed in the preceding table are main project types, requiring main programs. The last two are library projects, without main programs. The project types are discussed in detail in:

- Fortran Console Application
- Fortran Standard Graphics Application
- Fortran QuickWin Application
- Fortran Windows Application
- Fortran COM Server
- Fortran Static library

- Fortran Dynamic-Link Library

When migrating legacy applications, choosing a project type that will minimize porting effort depends on what the application does. A character-cell application that does not use any graphics (such as a program ported from a UNIX system) can usually be converted into a Fortran Console Application. When a legacy Windows 3.1 (or older) application uses graphics calls, you can try a Fortran Standard Graphics Application or a Fortran QuickWin Application project type. However, be aware that with such legacy graphics applications:

- The routine names of certain legacy graphic QuickWin routines might need to be changed to the current routine names (and their current argument lists). For example, the following table lists some of known obsolete routines and their supported replacement routines:

Obsolete QuickWin Routine	Replacement Routine
SETGTEXTVECTOR	SETGTEXTROTATION
GETGTEXTVECTOR	GETGTEXTROTATION
GETHANDLEQQ	GETHWNDQQ
WGGETACTIVE	GETACTIVEQQ
WGSETACTIVE	SETACTIVEQQ
INITIALMENU	INITIALSETTINGS
SETTEXTROWS	SETWINDOWCONFIG

- The character-oriented method of user interaction can be modernized with menus, mouse clicks, and dialog boxes. If the routine uses the **PEEKCHARQQ** routine, see the PEEKAPP or PEEKAPP3 Visual Fortran Samples in the QuickWin folder.

After you select your project type, you need to define your project (see Defining Your Project).

If you need to use the command line to build your project, you can:

- Initially use the visual development environment and later create a makefile (see The Project Makefile)
- Use the DF command compiler options to specify the project type (see Specifying Project Types with DF Command Options)
- Create the application from the DF command line (see Using the Compiler and Linker from the Command Line)

Fortran Console Application Projects

A Fortran Console application (.EXE) is a character-based Visual Fortran program that does not require screen graphics output. It looks similar to a program running on a UNIX® workstation or a terminal connected to a mainframe computer.

Fortran Console projects operate in a single window, and let you interact with your program through normal read and write commands. Console applications are better suited to problems that require pure numerical processing rather than graphical output or a graphical user interface. This type of application is also more transportable to other platforms than the other types of application.

Fortran Console applications can be faster than Fortran Standard Graphics or Fortran QuickWin graphics applications, because of the resources required to display graphical output (see Using the Console).

Any graphics routine that your program calls will produce no output, but will return error codes. A program will not automatically exit if such an error occurs, so your code should be written to handle this condition.

With a Fortran Console project, you can use static libraries, DLLs, and dialog boxes, but you cannot use the QuickWin functions. You can select the multithreaded libraries with this and all of the other Fortran project types.

As with all Windows command consoles, you can toggle between viewing the console in a window or in full-screen mode by using the ALT+ENTER key combination.

A sample Fortran Console project is Celsius (see `\MYPROJECTS\CELSIUS`), as described in "Opening an Existing Project" in *Compaq Visual Fortran Installing and Getting Started* or Defining Your Project.

Fortran Standard Graphics Application Projects

A Fortran standard graphics application (.EXE) is a Visual Fortran QuickWin program with graphics that runs in a single QuickWin window. A standard graphics (QuickWin single document) application looks similar to an MS-DOS program when manipulating the graphics hardware directly, without Windows.

A Fortran standard graphics application allows graphics output (such as drawing lines and basic shapes) and other screen functions, such as clearing the screen. Standard Graphics is a subset of Quickwin, sometimes called *Quickwin single window*. You can use all of the QuickWin graphics functions in these projects. You can use dialog boxes with these and all other project types (see Using Dialogs).

You can select displayed text either as a bitmap or as text. Windows provides

APIs for loading and unloading bitmap files. Standard graphics applications should be written as multithreaded applications. (For information about multithreaded programs, see Creating Multithread Applications.)

Fortran standard graphics (QuickWin single document) applications are normally presented in full-screen mode. The single window can be either full-screen or have window borders and controls available. You can change between these two modes by using ALT+ENTER.

If the resolution selected matches the screen size, the application covers the entire screen; otherwise, it is a resizable window with scroll bars. You cannot open additional windows in a standard graphics application. Standard graphics applications have neither a menu bar at the top of the window, nor a status bar at the bottom.

Fortran standard graphics applications are appropriate for problems that:

- Require numerical processing and some graphics
- Do not require a sophisticated user interface

When you select the Fortran standard graphics project type, the visual development environment includes the QuickWin library automatically, which lets you use the graphics functions. When building from the command line, you must specify the /libs:qwins option. You cannot use the run-time functions meant for multiple-window projects if you are building a standard graphics project. You cannot make a Standard Graphics application a DLL.

For more information about Standard Graphics (QuickWin single window) applications, see Using Quickwin.

Fortran QuickWin Application Projects

Fortran QuickWin graphics applications (.EXE) are more versatile than standard graphics (QuickWin single document) applications because you can open multiple windows (usually called multiple-document interface or MDI) while your project is executing. For example, you might want to generate several graphic plots and be able to switch between them while also having a window for controlling the execution of your program. These windows can be full screen or reduced in size and placed in various parts of the screen.

QuickWin library routines lets you build applications with a simplified version of the Windows interface with Visual Fortran. The QuickWin library provides a rich set of Windows features, but it does not include the complete Windows Applications Programming Interface (API). If you need additional capabilities, you must set up a Windows application to call the Win32 API directly rather than using QuickWin to build your program. For more information on QuickWin programming, see Using QuickWin.

Fortran QuickWin graphics applications (.EXE) have a multiple-document interface. Applications that use a multiple-document interface (MDI) have a menu bar at the top of the window and a status bar at the bottom. The QuickWin library provides a default set of menus and menu items that you can customize with the QuickWin APIs. An application that uses MDI creates many "child" windows within an outer application window. The user area in an MDI application is a child window that appears in the space between the menu bar and status bar of the application window. Your application can have more than one child window open at a time.

Fortran QuickWin applications can also use the DFLOGM.F90 module to access functions to control dialog boxes. These functions allow you to display, initialize, and communicate with special dialog boxes in your application. They are a subset of Win32 API functions, which Windows applications can call directly. For more information on using dialog boxes, see Using Dialogs.

When you select the Fortran QuickWin project type, the visual development environment includes the QuickWin library automatically, which lets you use the graphics functions. QuickWin applications should be written as multithreaded applications. (For information about multithreaded programs, see Creating Multithread Applications.)

When building from the command line, you must specify the /libs:qwin compiler option to indicate a QuickWin application (or /libs:qwins option to indicate a Fortran Standard Graphics application). A Fortran QuickWin application that uses the compiler option is similar to a Fortran Standard Graphics application in that it has no menu bar or status bar. (A Fortran Standard Graphics application is a QuickWin application with a set of preset options that is offered in the program types list for your convenience.)

As with a Fortran Standard Graphics application, the application covers the entire screen if the resolution selected matches the screen size; otherwise, it is a resizable window with scroll bars.

You cannot make a Fortran QuickWin application a DLL.

For information on how to use QuickWin functions, including how to open and control multiple windows, see Using Quickwin.

Fortran Windows Application Projects

Fortran Windows applications (.EXE) are main programs selected by choosing the Fortran Windows Application project type. This type of project lets you calls the Windows APIs directly from Visual Fortran. This provides full access to the Win32 APIs, giving you a larger (and different) set of functions to work with than QuickWin.

Although you can call some of the Win32® APIs from the other project types, Fortran Windows applications allow you to use the full set of Win32 routines and use certain system features not available for the other project types.

The DFWIN.F90 module contains interfaces to the most common Win32 APIs. If you include the **USE DFWIN** statement in your program, nearly all of the Win32 routines are available to you. The DFWIN.F90 module gives you access to a full range of routines including window management, graphic device interface, system services, multimedia, and remote procedure calls.

Window management gives your application the means to create and manage a user interface. You can create windows to display output or prompt for input. Graphics Device Interface (GDI) functions provide ways for you to generate graphical output for displays, printers, and other devices. Win32 system functions allow you to manage and monitor resources such as memory, access to files, directories, and I/O devices. System service functions provide features that your application can use to handle special conditions such as errors, event logging, and exception handling.

Using multimedia functions, your application can create documents and presentations that incorporate music, sound effects, and video clips as well as text and graphics. Multimedia functions provide services for audio, video, file I/O, media control, joystick, and timers.

Remote Procedure Calls (RPC) gives you the means to carry out distributed computing, letting applications tap the resources of computers on a network. A distributed application runs as a process in one address space and makes procedure calls that execute in an address space on another computer. You can create distributed applications using RPC, each consisting of a client that presents information to the user and a server that stores, retrieves, and manipulates data as well as handling computing tasks. Shared databases and remote file servers are examples of distributed applications.

Writing Fortran Windows applications is much more complex than other kinds of Visual Fortran projects. For more information on how to create Fortran Windows applications, see Creating Windows Applications.

You can access the Windows API online documentation help file, Platform SDK, included with Visual Fortran. You can also obtain information through the Microsoft Developer Network. Microsoft offers Developer Network membership, which includes a development library and a quarterly CD containing technical information for Windows programming.

For information on calling Win32 routines, see Calling Win32 Routines.

Fortran Static Library Projects

Fortran static libraries (.LIB) are blocks of code compiled and kept separate from the main part of your program. The Fortran static library is one of the Fortran project types.

Static libraries offer important advantages in organizing large programs and in sharing routines between several programs. These libraries contain only subprograms, not main programs. A static library file has a .LIB extension and contains object code.

When you associate a static library with a program, any necessary routines are linked from the library into your executable program when it is built. Static libraries are usually kept in their own directories.

If you use a static library, only those routines actually needed by the program are incorporated into the executable image (.EXE). This means that your executable image will be smaller than if you included all the routines in the library in your executable image. Also, you do not have to worry about exactly which routines you need to include — the Linker takes care of that for you.

Because applications built with a static library all contain the same version of the routines in the library, you can use static libraries to help keep applications current. When you revise the routines in a static library, you can easily update all the applications that use it by relinking the applications.

A static library is a collection of source and object code defined in the FileView pane. The source code is compiled when you build the project. The object code is assembled into a .LIB file without going through a linking process. The name of the project is used as the name of the library file by default.

If you have a library of substantial size, you should maintain it in a dedicated directory. Projects using the library access it during linking.

When you link a project that uses the library, selected object code from the library is linked into that project's executable code to satisfy calls to external procedures. Unnecessary object files are not included.

When compiling a static library from the command line, include the /c compiler option to suppress linking. Without this option, the compiler generates an error because the library does not contain a main program.

To debug a static library, you must use a main program that calls the library routines. Both the main program and the static library should have been compiled using the debug option. After compiling and linking is completed, open the Debug menu and choose Go to reach breakpoints, use Step to Cursor to reach the cursor position, or use the step controls on the Debug toolbar.

Using Static Libraries

You add static libraries to a main project in the visual development environment with the Add to Project, Insert Files option in the Project menu. You can enter the path and library name in the Insert Files into Project dialog box with a .LIB extension on the name. If you are using a foreign makefile, you must add the library by editing the makefile for the main project. If you are building your project from the command line, add the library name with a .LIB extension and include the path specification if necessary.

For an example of a static library project, see the Visual Fortran Samples folder `...\DF98\Samples\Scigraph\Scigraph`, which creates a static library.

To create a static library from the command line, use the /c compiler option to suppress linking and use the LIB command (see Managing Libraries with LIB).

To create a static library from the visual development environment, specify the Fortran Static Library project type.

Fortran Dynamic-Link Library Projects

A dynamic-link library (.DLL) is a source-code library that is compiled and linked to a unit independently of the applications that use it. A DLL shares its code and data address space with a calling application. A DLL contains only subprograms, not main programs.

A DLL offers the organizational advantages of a static library, but with the advantage of a smaller executable file at the expense of a slightly more complex interface. Object code from a DLL is not included in your program's executable file, but is associated as needed in a dynamic manner while the program is executing. More than one program can access a DLL at a time.

When routines in a DLL are called, the routines are loaded into memory at run-time, as they are needed. This is most useful when several applications use a common group of routines. By storing these common routines in a DLL, you reduce the size of each application that calls the DLL. In addition, you can update the routines in the DLL without having to rebuild any of the applications that call the DLL.

With Visual Fortran, you can use DLLs in two ways:

1. You can build a DLL with your own routines. In the visual development environment, select Fortran Dynamic-Link Library as your project type. From the command line, use the /DLL option with the DF command.

2. You can build applications with the run-time library stored in a separate

DLL instead of in the main application file. In the visual development environment, after you open a workspace:

- From the Project menu, click Settings to display the project settings dialog box
- Click the Fortran tab
- Select the Library category
- In the Use Fortran Run-Time Libraries box, select DLL

From the command line, use the /libs:dll compiler option to build applications with the run-time library stored in a separate DLL.

For more information about DLLs, see:

- Creating Fortran DLLs

Defining Your Project

To define your project, you need to:

1. Create the project
2. Populate the project with files
3. Choose a configuration
4. Define build options, including project settings
5. Build (compile and link) the project

To create a new project:

1. Click the File menu and select New. A dialog box opens that has the following tabs:
   - Files
   - Projects
   - Workspaces
   - Other Documents

2. The Projects tab displays various project types. Click the type of Fortran project to be created. If you have other Visual tools installed, make sure you select a Fortran project type. You can set the Create New Workspace check box to create a new Workspace.

3. Specify the project name and location.

4. Click OK to create the new project. Depending on the type of project being created, one or more dialog boxes may appear allowing you to only create the project without source files or create a template-like source file.

   If a saved Fortran environment exists for the Fortran project type being created, you can also import a Fortran environment to provide default project settings for the new project (see Saving and Using the Project Setting Environment for Different Projects).

This action creates a project workspace and one project. It also leaves the project workspace open.

To discontinue using this project workspace, click Close Workspace from the File menu.

To open the project workspace later, in the File menu, click either Open Workspace or Recent Workspaces.

To add files to an existing project:

- To add an existing file to the project:
  1. If not already open, open the project workspace (use the File menu).
  2. In the Project menu, select Add to Project and click Select Files... from the submenu.
  3. The Insert Files into Project dialog box appears. Use this dialog box to select the Fortran files to be added to the Project. To add more than one file to the project, hold down the Ctrl key as you select each file name.

- To add a new file to the project:
  1. If not already open, open the project workspace (use the File menu).
  2. In the Project menu, select Add to Project and click New... from the submenu.
  3. The New dialog box appears. Specify the file name and its location.
  4. Click (select) the type of file (Fortran Fixed Format Source or Fortran Free Format Source).
  5. Click OK. The editor appears, letting you type in source code. The file name appears in the FileView pane.

To define a project from a set of existing or new source files:

1. On the File menu, click New...
2. Click the Projects tab.
3. Select the type of project.
4. Name the project.
5. Click OK. Depending on the type of project being created, one or more dialog boxes may appear allowing you to only create the project without source files or create template-like source files.

   If a saved Fortran environment exists for the project type being created, you can also import a Fortran environment to provide default project settings for the new Fortran project (see Saving and Using the Project

Setting Environment for Different Projects).

6. Add existing files and/or new files to the project.

   To add an existing file to the project:

   1. In the Project menu, select Add to Project and click Files... from the submenu.
   2. The Insert Files into Project dialog box appears. Use this dialog box to select the Fortran files to be added to the Project. To add more than one file to the project, hold down the Ctrl key as you select each file name.

   To add each new file to the project:

   1. In the Project menu, select Add to Project and click Select New... from the submenu.
   2. The New dialog box appears. Specify the file name and its location.
   3. Click the type of file (Fortran Fixed Format Source or Fortran Free Format Source).
   4. Click OK. The editor appears allowing you to type in source code. The file name appears in the FileView pane.
7. You can now select "Build *filename*" from the Build Menu to build your application.

You need to add these kinds of files to your project:

- Program files with .F90, .FOR, or .F extension
- A resource file with an .RC extension
- If your project references routines or data in a Fortran dynamic-link library (DLL), you need to add the import library (.LIB file created while building the DLL) as a file to your project (see Building and Using Dynamic-Link Libraries)

For information on:

- How to use icon files, see Using QuickWin.
- Using binary files, see Files, Devices, and I/O Hardware.
- Using the Dialog Editor, Graphics Editor, or other Resource Editors, see the *Visual C++ User's Guide*.

For more information on defining and building projects, see:

- Files in a Project
- Selecting a Configuration
- Setting Build Options
- Specifying Consistent Library Types

- Creating the Executable Program

Files in a Project

When you create a project, the Microsoft visual development environment always creates the following files:

File	Extension	Description
Project workspace file	.DSW	Stores project workspace information.
Project file	.DSP	Used to build a single project or subproject.
Workspace options file	.OPT	Contains environment settings for Visual Fortran, such as window sizes and positions, insertion point locations, state of project breakpoints, contents of the Watch window, and so on.

Directly modifying the .DSW and .DSP files with a text editor is not supported.

For information on creating (exporting) a makefile, see The Project Makefile.

When you create a project, you also identify a project subdirectory. If the subdirectory does not exist, the visual development environment creates it. Project files that the visual development environment creates are put into this directory.

When you create a project, the visual development environment also specifies subdirectories for intermediate and final output files for the various configurations that you specify. These subdirectories allow you to build configurations without overwriting intermediate and final output files with the same names. The General tab in the Project Settings dialog box lets you modify the subdirectories, if you choose.

If you have existing source code, you should organize it into directories before building a project, although it is easy to move files and edit your project definitions if you should later decide to reorganize your files.

If your program uses modules, you do not need to explicitly add them to your project, they appear as dependencies (.mod files).

For a newly created project (before you request a Update Dependencies), the visual development environment scans the file list for modules and compiles them before program units that use them. The visual development environment automatically scans the added project files recursively for modules specified in **USE** statements, as well as any **INCLUDE** statements. It scans both source files (.FOR, .F, .F90) and the resource file (.RC), and adds all the files it finds to a Dependencies folder. You cannot directly add or delete the files listed in this folder.

Module files are a precompiled, binary version of a source file, stored as a .mod file. When you change the source definition of a module, you can update the .mod file before you rebuild your project by compiling that source file separately by clicking (selecting) the file in the FileView pane and select Compile from the Build menu.

To control the placement of module files in directories, use the /[no]module compiler option.

To control the search for module files in directories, use the /[no]include and the /assume:source_include compiler options.

The Project Makefile

The visual development environment speeds and simplifies the task of building programs and libraries outside of the visual development environment by allowing you to export a makefile, which is a set of build instructions for each project. Makefiles contain the names of the source, object, and library files needed to build a program or library, plus the compiler and linker options selected in the Project Settings dialog boxes.

The visual development environment updates the build instructions in internal makefiles when you add or remove project files in the project window, and when you make changes to the compiler or linker options in the Project Settings dialog boxes. To get an updated version of a makefile, update project dependencies (use the Build menu) and from the Project menu, select Export Makefile. The makefile is used by the external program maintenance utility, NMAKE.EXE.

You can edit the makefile generated by the visual development environment if you need to perform unusual or exceptional builds. Remember, however, that once you have edited a makefile, exporting the makefile again from the visual development environment will overwrite your changes.

If you use a foreign makefile for a project, the visual development environment calls NMAKE to perform the build. You can run NMAKE from the console command line to perform builds either with makefiles exported by the visual development environment or with foreign makefiles that you have edited. For more about the external program maintenance utility, see Building Projects with NMAKE.

Note: When you use a foreign makefile, the project is considered to be foreign. You cannot use the Project Settings dialog box to make changes to the build options, or use the Add to Project dialog box to add files.

Selecting a Configuration

A configuration defines the final binary output file that you create within a project. When you create a new project, the visual development environment creates the following configurations:

Debug configuration	By default, the debug configuration sets project options to include the debugging information in the debug configuration. It also turns off optimizations. Before you can debug an application, you must build a debug configuration for the project.
Release configuration	The release configuration does *not* include the debugging information, and it uses any optimizations that you have chosen.

Select the configuration in the Build menu, Set Active Configuration item. Only one configuration can be active at one time.

When you build your project, the currently selected configuration is built:

- If you selected the debug configuration, a subfolder called Debug contains the output files created by the build for the debug version of your project.
- If you selected the release configuration, a subfolder called Release contains the output files created by the build for the release version of your project.

A configuration has the following characteristics:

- Project type: specifies the type of Fortran application to build, such as a Fortran Static Library, Fortran Console application, Fortran QuickWin application, Fortran Windows application, and so on.
- Build options: specifies the build options, which include the compiler and linker options (project settings).

Although debug and release configurations usually use the same set of source files, the information about project settings usually differs. For example, the default debug configuration supplies full debug information and no optimizations, whereas the default release configuration supplies minimal debug information and full optimizations.

You can also define new configurations within your project. These configurations can use the existing source files in your project, the existing project settings, or other characteristics of existing configurations. A new configuration does not have to share any of the characteristics or content of existing configurations, however.

You could, for instance, create an initial project with debug and release configurations specifying an application for the Win32 environment, and add source files to the project. Later, within the project, you could create debug and release configurations specifying a DLL for the Win32 environment, add an entirely disjoint set of files to this configuration, and make these configurations dependencies of the application configurations.

Platform Types

The platform type specifies the operating environment for a project. The platform type sets options required specifically for a given platform, such as options that the compiler uses for the source files, the static libraries that the linker uses for the platform, the default locations for output files, defined constants, and so on. Visual Fortran supports the Win32 platform type.

For more information:

- On viewing and changing the project build options for the current configuration, use the Project settings dialog box (see Setting Build Options).
- On errors during the build process, see Errors During the Build Process.

Setting Build Options

When you create a new configuration, you specify options for file creation and build settings by selecting the Settings item in the Project menu.

For the currently selected configuration of a project, the Project Settings dialog box (see Categories of Compiler Options) allows you to specify the compile and link options, optimization, or browse information.

Configurations have a hierarchical structure of options. The options set at the configuration level apply to all files within the configuration. Setting options at the configuration level is sufficient for most configurations. For instance, if you set default optimizations for the configuration, all files contained within the configuration use default optimizations.

However, you can set different options for files within a configuration, such as specific optimization options — or no optimization at all — for any individual files in the configuration. The options that you set at the file level in the configuration override options set at the configuration level.

The FileView pane shows the files associated with the project configuration and allows you to select certain files.

You can set some types of options, such as linking or requesting browse information, only at the configuration level.

You can set options at the following levels within a configuration:

Configuration level	Any options set for the current configuration apply to every file in the configuration unless overridden at the file level. Options set for the configuration apply to all actions, such as compilation, linking, and requesting browser information.
File level	Any options set for a file apply only to that file and override any options set at the configuration level. Options set for selected files apply to file-level actions, such as compiling.

You can insert both source files (.FOR, .F90, .F, .FI, .FD) and object files (.OBJ) by using the Project menu Add to Project, Files item.

You should always insert all source files used by your application into the project. For example, when you update a source file, the next time you build your application, the visual development environment will create a new object file and link it into your project.

You should also insert the names of any necessary static libraries and DLLs with .LIB extensions to be linked with your project. Use only the library names, not the names of any files within the libraries.

If you have installed the same version of Microsoft Visual C++ and Visual Fortran (in the same directory tree), you can include C/C++ source code files. If the same version of Microsoft Visual C++ is *not* installed, include C/C++ object code instead.

You can set and save project settings as described in the following sections:

- Compile and Link Options for a Configuration or Certain Files
- Saving and Using the Project Setting Environment for Different Projects
- Source Browser Information for a Configuration

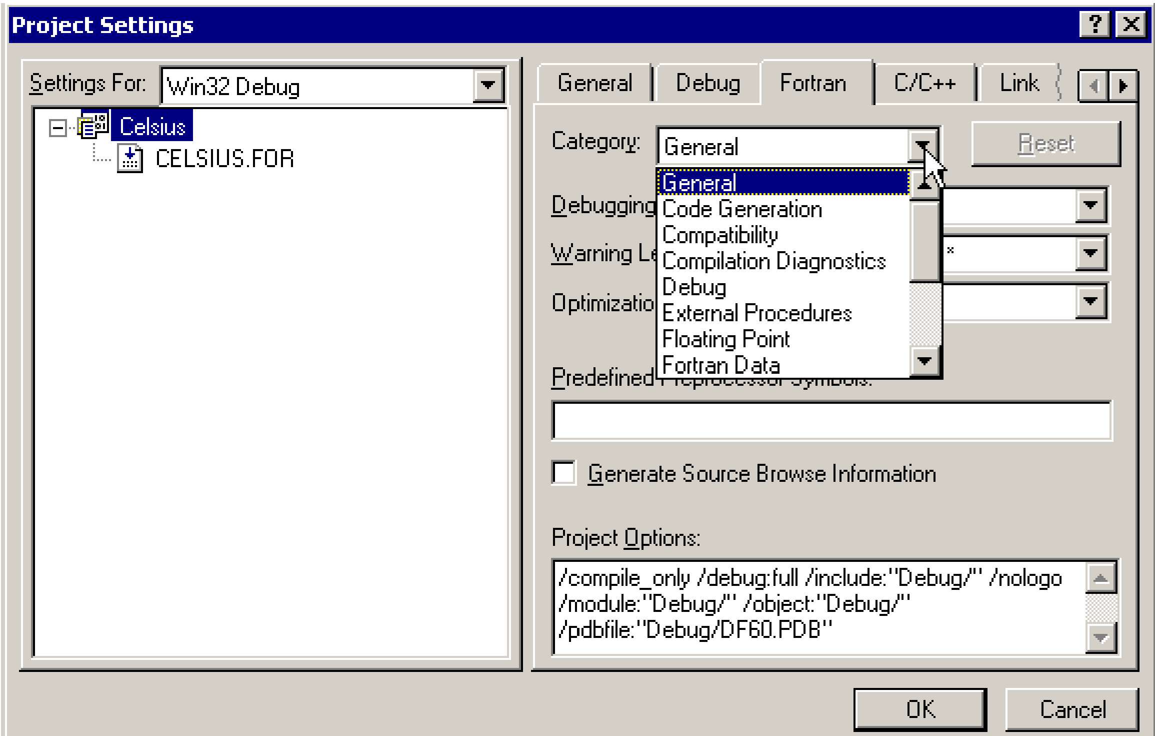
Compile and Link Options for a Configuration or Certain Files

You can set compiler or linker options by using the Project Settings dialog box.

To display the Project Settings dialog box:

1. Open your project workspace.
2. In the Project menu, click Settings.

The Fortran tab of this dialog box presents options grouped under different categories. Select the category from the Category drop-down list:



You can choose compiler and linker options through the various categories in the Fortran and Link tabs. For details about the compiler options, see Categories of Compiler Options.

If a compiler option is not available in the Project Settings dialog box you can enter the option in the lower part of the window under Project Options: just as you would using the command line.

The FileView pane shows the files associated with the project configuration and lets you select certain files. The options that you set at the file level in the configuration override options set at the configuration level. Linking options only be applied at the configuration level (not the file level).

The linker builds an executable program (.EXE), static library (.LIB), or dynamic-link library (.DLL) file from Common Object File Format (COFF) object files and other libraries identified in the linker options. You direct the linker by setting linker options either in the visual development environment, in a build instructions file, or on the console command line. For example, you can use a linker option to specify what kind of debug information to include in the program or library.

For more information on compiler and linker options, see Compiler and Linker Options.

Saving and Using the Project Setting Environment for Different Projects

You can set any of the compiler or linker options described in Compiler and Linker Options in the Project menu, Settings dialog box. The Fortran tab of this dialog box presents several categories of options to set.

Visual Fortran provides a facility to save and re-use the Project settings for multiple projects of the same project type. For example, you can save your Project settings environment for a Fortran QuickWin project and use those saved settings as defaults when you create a new Fortran QuickWin project type.

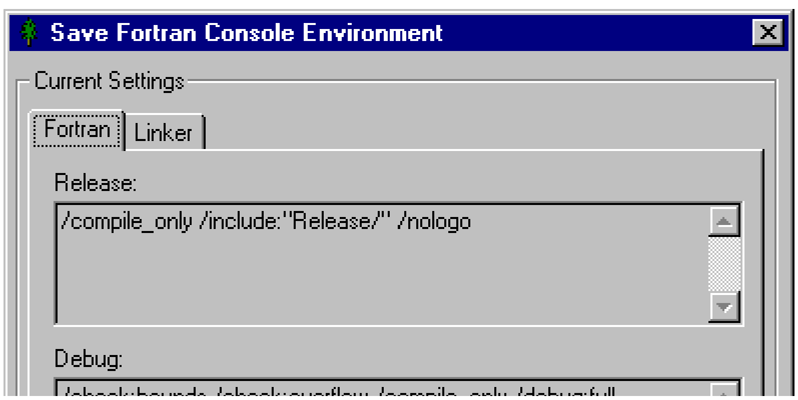
The saved Fortran environment project settings are those associated with the Fortran tab and the displayed tool tab(s) in the Project Settings dialog box. You can:

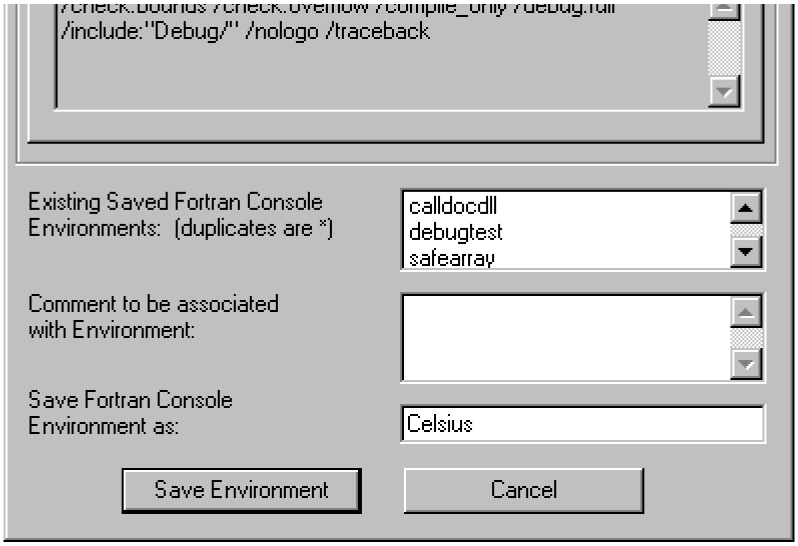
- Save a Fortran project settings environment for an existing project
- Use a previously saved project settings environment for a new project
- Manage the current set of saved Fortran environment settings

To save a project settings Fortran environment:

1. Open the appropriate workspace.
2. Modify the Project Settings dialog box as needed. If you specify actual file names for output files, consider changing them to use the default file naming conventions.
3. In the File menu, click Save Fortran Environment or click the green tree on the Fortran toolbar. A window resembling the following dialog box appears:

Saving a Project Settings Environment



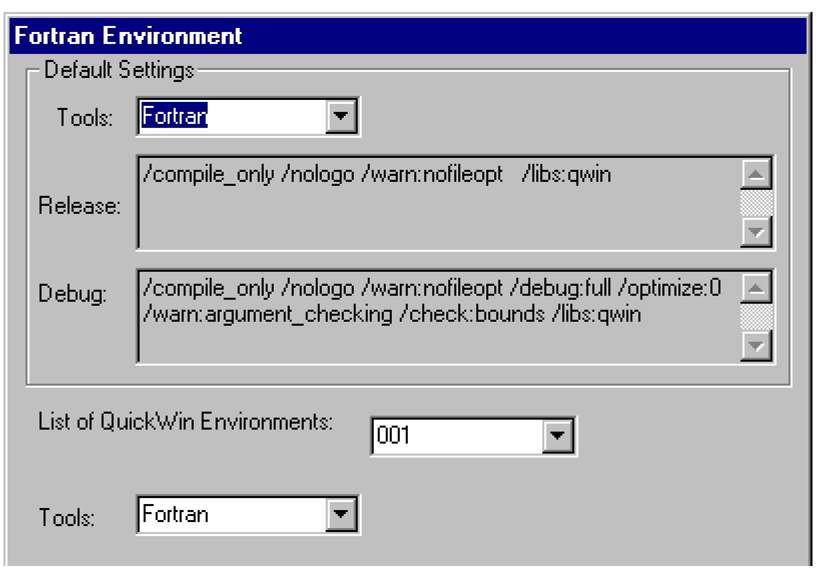


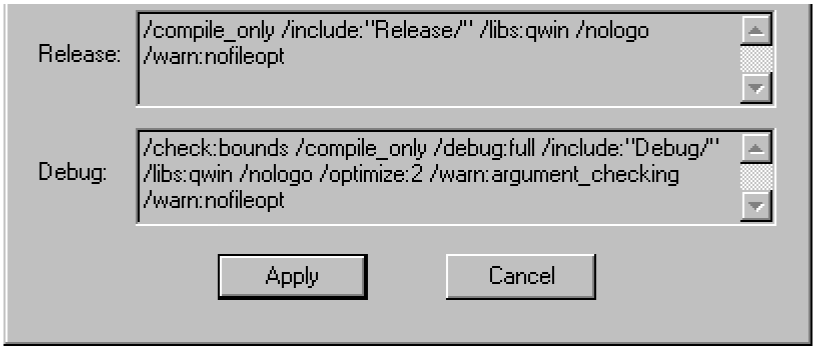
4. The Tool Combo box allows you to view the project settings for either the Fortran or the displayed tools (such as Linker). The Release and Debug configuration values are displayed for the selected tab. Verify that the displayed values are acceptable.
5. The edit box titled Saved Fortran Console Environment allows you to specify the name of the environment to be saved.
6. Click the Save Settings button to save the settings as a project settings environment.

To use an existing Fortran environment when creating a new project:

1. If a Fortran environment exists for the specified new Fortran project type, you will be asked whether you want to apply project settings options from a saved Fortran environment. If you click Yes, a window resembling the following dialog box appears:

Using an Existing Fortran Project Settings Environment



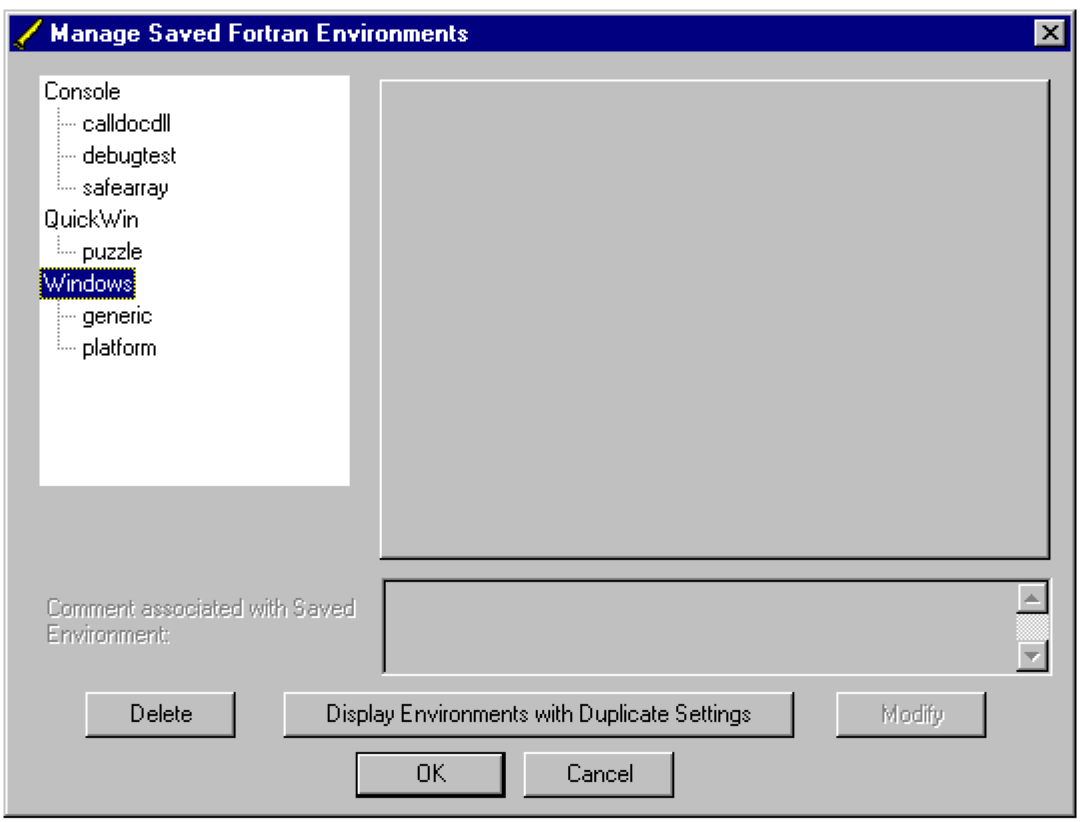


2. For the selected Fortran project type, a list of saved Fortran environments appears. Select a Fortran environment. Verify that the selected environment is correct by viewing the Project Settings options.
3. After selecting the appropriate Fortran environment for the Fortran project being created, click the Apply button to use the saved settings for the new project.
4. Complete other tasks associated with creating a new project, such as adding source files, and so on.

To manage saved Fortran environments:

1. In the Tools menu, click Managed Saved Fortran Environment or click the saw on the Fortran toolbar. A dialog box resembling the following appears:

Managing Saved Fortran Project Settings Environments



2. Initially, this dialog box displays the project types for which there are saved Fortran environments. Double-click on the project type name to view the saved Fortran environments for that project type.

   This dialog box allows you to display the Fortran environments associated with each project type. Double-click the name of a project type to display the Fortran environments associated with that project type.

3. To display the project settings for a Fortran environment:
   - Click the name of a Fortran environment.
   - View the project settings for the Fortran tab.
   - Click the other tool tab (such as Linker) and view that tool's project settings.
   - If needed, click (select) a different Fortran environment.
4. To determine whether a duplicates exist for a Fortran environment:
   - Click (select) the name of an environment or a project type.
   - Click the Display Environments with Duplicate Settings button.
   - If the Fortran environments have *different* project settings, No Duplicates Found is displayed.
   - If the Fortran environments have *identical* project settings, the duplicate environments are displayed.
5. To delete a Fortran environment:
   - Click (select) the name of an environment or the project type.
   - Click the Delete button.
   - Click OK to the delete confirmation box.

Source Browser Information for a Configuration

The Source Browser generates a listing of all symbols in your program; information that can be useful when you need to debug it, or simply to maintain large volumes of unwieldy code. It keeps track of locations in your source code where your program declares, defines, and uses names. You can find references to variables or procedures in your main program and all subprograms it calls by selecting one of the files in your project, then using the Go to Definition or Go to Reference button on the Browse toolbar. Source Browser information is available only after you achieve a successful build.

Browser information is off by default for projects, but you can turn it on if you wish. To set the browse option for the current configuration:

- In the visual development environment:

  1. In the Project menu, click Settings.
  2. In the General category of the Fortran tab, set the Generate Source Browse Information check box.
  3. Click the BrowseInfo tab and set the Build Browse info check box.

4. Click OK.
5. Build your application.
6. In the Tools menu, click Source Browser.
7. Near the bottom on the Browse window, locate the Case sensitive check box. Since Fortran is a case-insensitive language, make sure the Case sensitive check box is clicked off.
8. When you are done using the Browse window, click OK. The Browse window allows you to view graphs of calling relationships between functions and view the symbols contained within the file, and perform other functions.

- On the command line:

1. Specify the /browser option.
2. Use the Browse Information File Maintenance Utility (BSCMAKE) utility to generate a browse information file (.BSC) that can be examined in browse windows in the visual development environment.

When the browse option is on, the compiler creates intermediate .SBR files when it creates the .OBJ files; at link time, all .SBR files in a project are combined into one .BSC file. These files are binary, not readable, but they are used when you access them through the Browser menu.

Specifying Consistent Library Types

There are a number of Visual C++ run-time libraries that offer the same entry points but have different characteristics. The default Visual C++ library is libc.lib, which is single threaded, non-debug, and static. The Visual C++ and Visual Fortran libraries must be the same types. The incompatible types are:

- Mixing single-threaded with multi-threaded versions of the libraries
- Mixing static and dynamic-link versions of the libraries
- Mixing debug with non-debug versions of the libraries

The default Fortran libraries depend on the project type:

Fortran Project Type	**Default Libraries Used**
Fortran Console	Static, single-threaded libraries dfor.lib and libc.lib
Fortran Standard Graphics	Static, multithreaded libraries dformt.lib and libcmt.lib
Fortran QuickWin	Static, multithreaded libraries dformt.lib and libcmt.lib

Fortran Windows	Static, multithreaded libraries dformt.lib and libcmt.lib
Fortran DLL	Dynamic-link libraries dfordll and msvcrt (and their import libraries)
Fortran Static Library	Static, single-threaded libraries dfor.lib and libc.lib

Pure Fortran applications can have mismatched types of libraries. One common scenario is a Fortran QuickWin application that links with a Fortran Static library. Fortran QuickWin (and Fortran Standard Graphics) applications must use the static, multithreaded libraries, and by default, Fortran Static libraries are built using static, single-threaded libraries. This causes a conflict, so the Fortran Static library and the QuickWin application must both be built using static, multithreaded libraries.

Similarly, different C/C++ applications link against different C libraries. If you mix the different types of applications without modifying the defaults, you can get conflicts. The debug version of a library has a letter "d" appended to its base file name:

- Static, single-threaded: libc.lib and libcd.lib
- Static, multithreaded: libcmt.lib and libcmtd.lib
- Dynamic-link libraries: msvcrt and msvcrtd (.lib import library and .dll)

When using a Debug configuration, Visual C++ selects the debug libraries. Visual Fortran does not select debug libraries for any configuration, but provides a Project Settings option to request their use. To specify different types of Fortran libraries in the visual development environment, open the Project Settings dialog box, click the Fortran tab, and select the Libraries category:

- To specify static libraries, select the appropriate type of static (non-DLL) library under Use Run-Time Libraries (see /libs:static).
- To specify dynamic-link libraries, select the appropriate type of DLL library under Use Run-Time Libraries (see /libs:dll).
- To specify multithreaded libraries, select the appropriate type of Multi-thread library under Use Fortran Run-Time Libraries (see /threads).
- To specify the debug libraries, select the appropriate type of Debug library under Use Run-Time Libraries (see /[no]dbglibs). If you specify debug libraries (/dbglibs) and also request DLL libraries (/libs:dll) (Use Run-Time Libraries that include both Debug and DLL), be aware that this combination selects the debug versions of the Fortran DLLs. These Fortran DLL files have been linked against the C debug DLLs.
- When you specify QuickWin or Standard Graphics libraries under Use Run-Time Libraries, this selection implicitly requests Multi-threaded libraries.

For details about the Visual C++ libraries used and compiler options available, see Visual Fortran/Visual C++ Mixed-Language Programs.

Creating the Executable Program

When you are ready to create an executable image of your application, select the Build menu. You can:

- Compile a file without linking
- Build a project
- Rebuild all parts of a project
- Batch build several configurations of a project
- Clean extra files created by project builds
- Execute the program, either in debug mode or not
- Update program dependencies
- Select the active project and configuration
- Edit the project configuration
- Define and perform profiling

When you have completed your project definition, you can build the executable program.

When you select Build *projectname* from the Build menu (or one of the Build toolbars), the visual development environment automatically updates dependencies, compiles and links all files in your project. When you build a project, the visual development environment processes only the files in the project that have changed since the last build.

The Rebuild All mode forces a new compilation of all source files listed for the project.

You either can choose to build a single project, the current project, or you can choose multiple projects (requires batch build) to build in one operation.

You can execute your program from the visual development environment using Ctrl+F5 or Execute from the Build menu (or Build toolbar), or from the command line prompt.

Compiling Files In a Project

You can select and compile individual files in any project in your project workspace. To do this, select the file in the project workspace window (FileView tab). Then, do one of the following:

- Press Ctrl+F7.

  – or –

- Choose Compile from the Build menu (or Build toolbar).

  – or –

- Click the right mouse button to display the pop-up menu and select Compile.

You can also use the Ctrl+F7 or Compile from the Build menu (or Build toolbar) options when the source window is active (input focus).

Errors During the Build Process

Compiler and linker errors are displayed in the Build pane of the output window. If the Output window is not displayed, in the View menu, click Output.

To quickly locate the source line causing the error, follow these steps:

1. Double-click the error message text in the Build pane of the output window.

   - or -

2. Press F4. The editor window appears with a marker in the left margin that identifies the line causing the error. You can continue to press F4 to scroll through additional errors.

If you need to set different compiler options for some of your source files, you can highlight the source file name and select the Project menu, Settings item. Options set in this manner are valid only for the file you selected.

After you have corrected any compiler errors reported during the previous build, choose Build from the Build menu. The build engine recompiles only those files that have changed, or which refer to changed include or module files. If all files in your project compile without errors, the build engine links the object files and libraries to create your program or library.

You can force the build engine to recompile all source files in the project by selecting Rebuild All from the Build menu. This is useful to verify that all of your source code is clean, especially if you are using a foreign makefile, or if you use a new set of compiler options for all of the files in your project.

If your build results in Linker errors, be aware that the project type selected and the project settings in the Libraries category (see Categories of Compiler Options) determine the libraries linked against. Also, you can specify additional user-created libraries.

To view the include file and library directory paths in the visual development environment:

1. In the Tools menu, click Options.
2. Click the Directories tab.
3. In the drop-down list for Show Directories For, select Include files and view the include file paths.
4. In the drop-down list for Show Directories For, select Library files and view the library paths.
5. Click OK if you have changed any information.

To view the libraries being passed to the linker in the visual development environment:

1. If not already open, open your Project Workspace (File menu, Open Workspace).
2. In the Project menu, click Settings.
3. Click the Link tab
4. In Link tab's Project Options box, type the following option:

   ```
   /verbose:lib
   ```

5. Click OK. The next time you build the project, the list of libraries will be displayed with other build-related messages in the output pane (bottom of screen).

If you have trouble linking CXML libraries, see also Using CXML from Visual Fortran.

With the Professional and Enterprise Editions, if you have trouble linking IMSL libraries, specify the /imsl option and see Using the IMSL Libraries from Visual Fortran.

If you encounter linker errors, see Linker Diagnostic Messages and Error Conditions.

To view a description of build and run-time messages, see Error Messages or, in the visual development environment, highlight the error identifier (such as LNK2001) in the output pane and press F1.

Compiler Limits

The following table lists the limits to the size and complexity of a single Visual Fortran program unit and to individual statements contained in it.

The amount of data storage, the size of arrays, and the total size of executable programs are limited only by the amount of process virtual address space available, as determined by system parameters:

Language Element	Limit
Actual number of arguments per CALL or function reference	No limit
Arguments in a function reference in a specification expression	No limit
Array dimensions	7
Array elements per dimension	9,223,372,036,854,775,807 or process limit
Constants; character and Hollerith	2000 characters
Constants; characters read in list-directed I/O	2048 characters
Continuation lines	511
DO and block IF statement nesting (combined)	128
DO loop index variable	9,223,372,036,854,775,807 or process limit
Format group nesting	8
Fortran source line length	132 characters
INCLUDE file nesting	20 levels
Labels in computed or assigned GOTO list	500
Lexical tokens per statement	3000
Named common blocks	250
Parentheses nesting in expressions	40
Structure nesting	20
Symbolic name length	63 characters

Running Fortran Applications

You can execute programs built with this version of Visual Fortran only on a computer running the Microsoft Windows 2000, Windows NT, Windows Me, or Windows 9*x* operating system. You can run the programs from the command console, Start ... Program ... group, Windows Explorer, and the Microsoft visual development environment.

Each program is treated as a protected user application with a private address space and environment variables. Because of this, your program cannot accidentally damage the address space of any other program running on the computer at the same time.

Environment variables defined for the current user are part of the environment that Windows sets up when you open the command console. You can change these variables and set others within the console session, but they are only valid during the current session.

If you run a program from the console, the operating system searches directories listed in the PATH user environment variable to find the executable file you have requested. You can also run your program by specifying the complete path of the .EXE file. If you are also using DLLs, they must be in the same directory as the .EXE file or in one specified in the path.

You can easily recover from most problems that may arise while executing your program.

If your program is multithreaded, Windows NT and Windows 2000 starts each thread on whichever processor is available at the time. On a computer with one processor, the threads all run in parallel, but not simultaneously; the single processor switches among them. On a computer with more than one processor, the threads can run simultaneously.

If you specified the /fpscomp:filesfromcmd option (Compatibility category in Project Settings, Fortran tab), the command line that executes the program can also include additional filenames to satisfy **OPEN** statements in your program in which the filename field (FILE specifier) has been left blank. The first filename on the command line is used for the first such **OPEN** statement executed, the second filename for the second **OPEN** statement, and so on. In the visual development environment, you can provide these filenames in the Project menu Settings item, Debug tab, in the Program Arguments text box.

Each filename on the command line (or in a visual development environment dialog box) must be separated from the names around it by one or more spaces or tab characters. You can enclose each name in double quotation marks ("*filename*"), but this is not required unless the argument contains spaces or tabs. A null argument consists of an empty set of double quotation marks with no filename enclosed ("").

The following example runs the program MYPROG.EXE from the console:

```
MYPROG "" OUTPUT.DAT
```

Because the first filename argument is null, the first **OPEN** statement with a blank filename field produces the following message:

```
File name missing or blank - please enter file name<R>
UNIT number  ?
```

The *number* is the unit number specified in the **OPEN** statement. The filename OUTPUT.DAT is used for the second such **OPEN** statement executed. If additional **OPEN** statements with blank filename fields are executed, you will be prompted for more filenames. Programs built with the QuickWin library prompt for a file to open by presenting a dialog box in which you can browse for the file or type in the name of a new file to be created.

Instead of using the /fpscomp:filesfromcmd option, you can:

- Call the GETARG library routine to return the specified command-line argument. To execute the program in the visual development environment, provide the command-line arguments to be passed to the program in the Project menu Settings item, Debug tab, in the Program Arguments text box.
- Call the GetOpenFileName Win32 routine to request the file name using a dialog box. For an example of how to call the GetOpenFileName routine, see the Visual Fortran Sample GetOpenFileName in `...Df98\Samples\Advanced\Win32\GetOpenFileName`.

If you use the visual development environment debugger and need to specify a working directory that differs from the directory where the executable program resides, specify the directory in the Project menu Settings item, Debug tab, in the Working Directory text box.

Run-time error messages are displayed in the console or in a message box depending upon the project type of the application you build (see Run-Time Message Display and Format). If you need to capture these messages, you can redirect *stderr* to a file. For example, to redirect run-time error messages from a program called BUGGY.EXE to a file called BUGLIST.TXT, you would use the following syntax:

```
BUGGY.EXE > BUGLIST.TXT
```

The redirection portion of the syntax must appear last on the command line.

You can append the output to an existing file by using two greater-than signs (>>) instead of one. If the file does not exist, one is created. For more information about command-line redirection, see Redirecting Command-Line Output to Files.

To run (deploy) your application on another Windows system, use the VFRUN tool to install the necessary run-time DLLs and related files. The VFRUN tool provides the run-time redistributable files for Visual Fortran applications, in the form of a self-installing kit. You can download the run-time redistributable files VFRUN kit from the Visual Fortran Web page (click Downloads area). VFRUN and the deployment of Visual Fortran applications is further described in the *Compaq Visual Fortran Installing and Getting Started* guide.

For more information:

- On using the debugger with Fortran programs, see Debugging Fortran Programs.
- Locating errors in the debugger, see Locating Run-Time Errors in the Debugger.
- On locating the source of exceptions, see Locating Run-Time Errors and Using Traceback Information.
- On handling run-time errors with source changes, see Methods of Handling Errors
- On environment variables recognized during run-time, see Run-Time Environment Variables
- On each Visual Fortran run-time message, see Run-Time Errors

Copying Projects

You need to follow certain procedures to move a project's location, whether you copy a project to:

- Another disk or directory location on the same PC system
- Another PC system where Visual Fortran is also installed

To copy an existing Visual Fortran project to another disk or system:

1. Copy all project files to the new location. You do not need to copy the subdirectories created for each configuration.

   Keep the folder/directory hierarchy intact by copying the entire project tree to the new computer. For example, if a project resides in the folder `\MyProjects\Projapp` on one computer, you can copy the contents of that directory, and all subdirectories, to the `\MyProjects\Projapp` directory on another computer.
2. After copying all of the files, delete the following files from the main

directory at the new location. These files are disk- and computer-specific and should not be retained:
  - *.opt files
  - *.ncb files (if present)
3. After copying the files, if you copied the subdirectories associated with each configuration, you need to delete these contents of subdirectories at the new location, such as the Debug and Release subdirectories. The files contained in these subdirectories are disk- and computer-specific files and should not be retained. For example, Visual Fortran module (.MOD) files contained in these subdirectories should be recreated by the Visual Fortran compiler, especially if a newer version of Visual Fortran has been installed. The internal structure of module files can change for Visual Fortran releases.

   If you copied the project files to the same system or a system running the same platform or major Visual Fortran version, do the following steps to remove most or all of the files in the configuration subdirectory:
   - Open the appropriate project workspace. In the File menu, either select Open Workspace or select Recent Workspaces. If you use Open Workspace, select the appropriate .DSW file.
   - For each configuration, select the appropriate configuration by selecting Set Active Configuration in the Build menu.
   - For the current configuration, select Clean in the Build menu.
   - Repeat the previous two steps for other configurations whose subdirectories have been copied.
4. If you copied the project from a PC running a Visual Fortran 5, you should open the project at its new location using Visual Fortran 5, *before* you convert the project to Visual Fortran Version 6 format.

   If you open a project created with Visual Fortran 5 with Visual Fortran Version 6, Visual Fortran 6 will convert the project to Visual Fortran Version 6 format. Converting the project back to Version 5 format is not easily performed (must be done manually).

   If possible, open the project under Visual Fortran Version 5 after you move it, before you convert the project to Version 6 format. This ensures that the project has been moved successfully and minimizes the chance of conversion problems. An alternative is to make an archive copy of the Visual Fortran 5 project files before you open and convert the project to Visual Fortran Version 6 format.
5. View the existing configurations. To view the existing configurations associated with the project:
   - Open the project workspace. In the File menu, either select Open Workspace or select Recent Workspaces. If you use Open Workspace, specify the appropriate .DSW file (navigate to the appropriate project directory and double-click the .DSW file).
   - Select Configurations from the Build menu.

- View the available configurations. You can also remove or add configurations.

6. If you copied the project to a PC running a different platform, specify new configurations.

   If you copied the project to the same system or to a system where the same major version of Visual Fortran is installed that uses the same platform, you may not need to create any new configurations.

   If you copy the files to a different platform, opening the project reveals that the target platform is still set to the original platform. Although this is not obvious, you can tell this is so because the Build, Compile, and Execute options are grayed out in the Build menu. Before you can build the application on the new platform, you must first specify one or more new configurations for the project on the new platform.

   To create Debug and Release targets for this project, you create a new configuration while running Visual Fortran on the new platform. The platform for a new configuration is assumed to be the current platform. This same behavior applies when moving projects between any two platforms.

   To create a new project configuration:

   a. In the Configurations dialog box, click the Add button. The Add Project Configuration dialog box appears.
   b. In the Configuration box, type a new configuration name. The names do not matter, as long as they differ from existing configuration names.
   c. Select the configuration from which to copy the settings for this configuration and click OK. Usually, you will want to copy the settings from a similar configuration. For example, if this new configuration is a release configuration, you will usually copy settings from an existing release configuration.
   d. The Projects dialog box appears with the new project configuration. Repeat the process as necessary to create as many configurations as you need.

7. Check and reset project options.

   Because not all settings are transportable across different disks, systems, or platforms, you should verify your project settings on the new platform. To verify your project settings:

   a. From the Project menu, choose Settings. The Project Settings dialog box appears.
   b. Review the tabs and categories to ensure that the project settings you want are selected. Pay special attention to the following items:

- General Tab – Review the directories for intermediate and output files. If you moved the project to a different system, be aware that any absolute directory paths (such as `C:\TEMP` or `\Myproj\TEMP`) will most likely need to be changed. Instead, use relative path directory names (without a leading back slash), such as `Debug`.
- Custom Build Tab – Review for any custom commands that might change between platforms.
- Fortran and Linker tabs – Nonstandard options in the original configurations must be replicated (as applicable) in the new configurations.

  For example, if you moved a project from a Windows NT Alpha system running Visual Fortran 6.5A or earlier, a few Alpha-only compiler options are either not needed (such as /synchronous_exceptions and /granularity) or are not available on ia32 systems (such as /rounding_mode, /pipeline, and /math_library:accurate). You also might find new compiler options that might benefit your application (see Compiler Options).
- Pre-link and Post-build Step tabs – Review for any custom commands that might change between platforms.

8. If you are copying your project between systems, check your source code for directory paths referenced in **INCLUDE** or similar statements. Developer Studio provides a multi-file search capability called Find in Files, available from the Edit menu.

Visual Fortran Samples

On the Visual Fortran media CD-ROM, Samples are located in folders under `Info\Df\Samples`. After a Custom installation, the Samples are installed by default in folders under ...`\Microsoft Visual Studio\Df98\Samples`.

You can view and copy the source code samples for use with your own projects. Use a text editor to view the sample programs (Samples); they are not listed as topics in HTML Help Viewer.

If you do not install Samples, you can copy appropriate Samples folders or files from the Visual Fortran CD-ROM to your hard disk (remove the Read-Only attribute file property for the files copied).

For a description (roadmap) of the Samples, see Roadmap to the Visual Fortran Samples (Samples.htm) or in a Web browser open the file Samples.htm (use File menu, Open). The following table shows where to locate Samples.htm and the Samples on the Visual Fortran CD-ROM (at any time) or on your hard disk (after installation):

To Locate:	Look:
Roadmap to the Samples	On the Visual Fortran CD-ROM, open the file: `Info\Df\Samples\Samples.htm` On your hard disk (after installation), open the file: `...\Microsoft Visual Studio\Df98\Samples\Samples.htm`
Samples folders	On the Visual Fortran CD-ROM, locate folders under: `Info\Df\Samples` On your hard disk (after installation), locate folders under: `...\Microsoft Visual Studio\Df98\Samples`

For example, after a Custom installation, the `...\Df98\Samples\Tutorial` folder contains short example programs, called Tutorial samples. The Tutorial samples describe (as source comments) how they can be built. Unlike other samples, all Tutorial samples are contained in a single directory.

Longer sample programs are also provided in their own subdirectories and include a makefile (for command-line use) as well as the source files. Many samples include a project workspace file, allowing you to open the project workspace in the visual development environment, view the source files in the FileView pane, build the sample, and run it.

Samples for the Compaq Array Visualizer (Professional and Enterprise Editions) are located in folders under `...\ArrayVisualizer\Samples`.

For a description of the Samples, see the Roadmap to the Visual Fortran Samples.

Roadmap to the Visual Fortran Samples

The Visual Fortran kit provides a number of source code sample programs (samples) that cover a variety of topics. These samples are provided for illustration purposes only, although they can be freely used as a basis for other programs. You can copy the samples as needed. Use a text editor to view the samples; they are not listed as topics in HTML Help viewer.

On the Visual Fortran media CD-ROM, samples are located in folders under `Info\Df\Samples`. If you request that samples be installed using a Custom installation, the samples are by default installed in subdirectories under `...\Microsoft Visual Studio\Df98\Samples`.

Visual Fortran samples include the following:

- Advanced Samples:
  - Samples Using Component Object Model
  - Samples Showing Direct Fortran 90 Descriptor Manipulation
  - Samples Using OpenGL®
  - Samples Using Win32 API Calls
- Dialog Box Samples
- DLL Samples
- Exception Handling
- ISO Varying Strings
- Mixed-Language Programming Samples
- QuickWin Programming Samples
  - Includes the Postmini graphical postprocessing software, which can be used to examine the output of a number of process, device and circuit simulation (TCAD) programs, as well as import data from ASCII files.
- Scientific Graphing (SciGraph) Utility Samples
- Tutorial Samples (illustrate Fortran language constructs)
- Miscellaneous Samples:
  - Includes a sample that converts data files created by Lahey Fortran to unformatted files which can be read by CVF

Advanced

Within the Advanced category, there are several other categories of samples. Each category is described below, and the specific samples within each are described in its section. Each category is contained within its own subdirectory of `...\Df98\Samples\Advanced`:

- Samples using Component Object Model (advanced\com)
- Samples Showing Direct Fortran 90 Descriptor Manipulation (advanced\descript)
- Samples Using OpenGL (advanced\opengl)
- Samples Using Win32 API Calls (advanced\win32)

Component Object Model (`Advanced\Com`)

The COM samples demonstrate use of the Component Object Model from within Visual Fortran:

- **adder**: The Adder sample demonstrates a Fortran COM server and its use by Visual Fortran, Visual C++, and Visual Basic clients. The COM server implements a very simple "adding machine" object. Each client displays a dialog box that uses the server. Adder is used as an example in Creating a COM Server.
- **autodice**: The autodice sample demonstrates interactions between Fortran

and Excel 97. This program takes 12 numbers and uses Automation to tell Excel 97 to draw a histogram of the numbers. The EXCEL97A module generated by the Fortran Module Wizard is used as the interface to EXCEL. You must have Microsoft Excel 97 installed on your computer in order to successfully run this sample.

- **dlines**: The dlines sample demonstrates interactions between Fortran and the Developer Studio. This program converts Debug lines to IFDEF directives (metacommands). It uses COM to drive Microsoft Developer Studio to edit the source file.
  The COM interfaces defined in DSAPP.F90 are taken from:
  `...\Microsoft Visual Studio\Common\Msdev98\Bin\devshl.dll`
  The COM interfaces defined in DSTEXT.F90 are taken from:
  `...\Microsoft Visual Studio\Common\Msdev98\Bin\devedit.pkg`

  The dlines sample program is invoked with the following command line:
  `dlines` ***`inputsource outputsource debugchar ifdefname`***

  Where: *Inputsource* is the filename of the input source file. Note: The source file must be fixed form.

  outputsource is the filename of the output source file.

  debugchar is the the debug character in the source file to replace with IFDEF directives (metacommands)

  ifdefname is the name to use with the IFDEF directives

  This program is useful as a tool to edit PowerStation Fortran files that used something other than "C" or "D" as the comment character.

- **dsbuild**: The dsbuild sample demonstrates using Automation to drive Developers Studio to rebuild a project configuration.
  The Automation interfaces defined in DSAPPA.F90 are taken from:
  `...\Microsoft Visual Studio\Common\Msdev98\Bin\devshl.dll`
  The Automation interfaces defined in DSBLDA.F90 are taken from:
  `...\Microsoft Visual Studio\Common\Msdev98\Bin\devbld.pkg`
  The dsbuild program is invoked with the following command line:
  `dsbuild` ***`project`***`.dsw` ***`configuration`***

  Where: *project*.dsw is the file specification of the project file.

  configuration is the name of the configuration to rebuild.

- **ErrorInfo**: The ErrorInfo sample demonstrates a Fortran COM Server that supports COM ErrorInfo objects. For information about COM ErrorInfo objects, see Adding Support for COM ErrorInfo Objects and the Platform SDK online documentation.
- **iweb**: The iweb sample uses the COM interfaces in SHDOCVW.DLL to start a Web Browser and direct the browser to navigate to a specified URL. The iweb program is invoked with the following command line:
  `iweb` ***`url`***

Where: *url* is the URL to display

Any arguments not provided on the command line will be prompted for.

- **safearray**: The safearray sample demonstrates converting a Fortran two-dimensional array to a COM SafeArray and reading the data back from the SafeArray.
- **variant**: The variant sample demonstrates using the VARIANT manipulation routines in Visual Fortran. VARIANTs are used in COM interfaces.

Direct Fortran 90 Descriptor Manipulation (`Advanced\Descript`)

In other languages, such as C or Pascal, pointers are simple memory addresses with no notion of how the information is organized at the address pointed to. Fortran 90 pointers differ dramatically, by not just containing a memory address, but also keeping track of the bounds and strides of each dimension of an array. To accomplish this, the Fortran 90 compiler uses something called an Array Descriptor, which stores the details of how the array is organized. Array Descriptors may also be called Dope Vectors in other implementations.

By manipulating the contents of a descriptor directly, you can perform operations that would otherwise not be possible in strict Fortran 90. You can associate a Fortran 90 pointer with any piece of memory, organized in any way desired (so long as it is rectangular in terms of array bounds). You can also pass Fortran 90 pointers to other languages, such as C, and have the other language correctly interpolate the descriptor to obtain the information it needs. Important for mixed-language programming, you can create a Fortran 90 pointer associated with an array which is accessed in C's row order, rather than Fortran's traditional column order, allowing the same array to be used with the same subscripts from both C and Fortran.

The descript workspace has three subprojects. Each creates its own executable, and there are no dependencies between them:

- **cassign**: A Fortran 90 pointer is associated with a C array, in row order. This pointer is then passed back to Fortran, which reads the values written by C in exactly the same way that C wrote them. This project uses descript.h, which provides the C prototypes, routines, and structure definitions to the Fortran 90 pointers.
- **fassign**: A Fortran 90 pointer is associated with a Fortran 90 array, in row order, and then passed to a C routine which can read the array in natural C notation.
- **cube**: Through use of the Bitmap module a Fortran 90 pointer is created that points to an internal .BMP file, with its special structure (rows reversed). Once this pointer is setup, the .BMP can be written to directly and then quickly displayed on a QuickWin child window. This method is

used to show a flicker-free spinning cube.

OpenGL (`Advanced\Opengl`)

OpenGL is a protocol for performing advanced 3-dimensional graphics. Visual Fortran includes Fortran 90 modules and link libraries for using OpenGL from Fortran. The sample programs included in this section illustrate programs that take advantage of these facilities.

All OpenGL samples will run under Windows NT, Windows 2000, Windows Me, and Windows 98, but require the OSR2 release of Windows 95 to run there. Refer to our Frequently Asked Questions at http://www.compaq.com/fortran/visual/faq.html for more information.

- **3dcube**: The 3dcube sample displays a three-dimensional box on a black background. It uses QuickWin to create the window and draw the shapes using primitive 3D graphics.
- **olympic**: The olympic sample displays 5 rings on a window that rotate and move towards each other, ultimately creating the Olympic symbol. It illustrates calls to the OpenGL libraries, techniques for supporting code on 32- and 64-bit systems, techniques for reading arguments from the command line, and interface blocks, among other Fortran 90 concepts. This sample must be compiled with /fpscomp:logicals due to a difference in the way that Visual Fortran and Microsoft PowerStation Fortran interpret logical values. It must also be linked against the QuickWin libraries.
- **puzzle**: The puzzle sample displays a Rubik's Cube, and allows you to try and solve it. There is currently a problem with the colors in this sample. It uses Win32 calls to manage the windowing interface. Again, it illustrates techniques for supporting code on 32- and 64-bit systems.
- **simple**: The simple sample displays some points, lines, and simple shapes in a window. It uses QuickWin to manage the windowing interface. It is, as it sounds, a very simple example, using primitive 2-D graphics. One interesting aspect of it is the use of color and how to set some of the standard colors.
- **wave**: The wave sample displays a window with a surface waving. It uses QuickWin to manage the windowing interface. Beyond the usage of OpenGL, here are many interesting demonstrations in this sample, including the animation and the trapping of characters typed while the window has focus. The keys that are trapped are:
    - C, which changes the contour of the wave
    - [space], which pauses the animation. To resume, hit space again
    - S, which changes the shading of the wave
    - A, which causes the wave to spin. To stop spinning, hit A again
    - L, which changes the color of the wave.

Win32 API Calls (`Advanced\Win32`)

Visual Fortran includes Fortran 90 modules and libraries for doing Windows programming at the Win32 API level. For information on calling Win32 routines from a Fortran application, see Calling Win32 Routines. These samples presented here show Win32 API examples of how this is done:

- **angle**: The angle sample uses the Windows interface to manage the GUI. It illustrates a basic Windows program, including the event dispatcher, and the use of pens and dialog boxes. The angle sample displays a shape consisting of a straight line plus an arc, and allows the user to input X,Y coordinates, angle of the arc, and radius of the arc, and then redraws.
- **bounce**: The bounce sample uses Win32 calls but creates a console application, rather than a Windows based one. It is a multi-threaded application that creates a new thread whenever the letter "A" is typed, up to a maximum of 32. Each thread bounces a happy face of a different color across the screen. All threads are terminated when the letter "Q" is typed. This particular application requires that several compatibility switches be set: /fpscomp:logicals, /fpscomp:ioformat, /fpscomp:general. These are found under the Compatibility entry on the Fortran tab of the Project Settings dialog box.
- **check_sd**: The check_sd sample illustrates the use of security descriptors. The purpose of the sample is to assist people who want to manipulate security descriptors with sample code that they can start from. This sample, as is, examines the security descriptor on files, and could be easily modified to check the security descriptor on other objects. To use this sample, `check_sd` with no arguments checks the security descriptors on the A: device. `check_sd d:\a.fil` will check the d:\a.fil file. In this case, D: must be formatted with the NTFS file system because only NTFS files have security descriptors.
- **cliptext**: The cliptext sample demonstrates copying text to and from the clipboard. It uses the Windows interface to manage the GUI, and as such, also demonstrates the use of WinMain and MainWndProc that contains the event dispatcher. It has an "about" box, located under the File menu item, as there is no Help.
- **cmndlg**: The cmndlg sample demonstrates the use of common dialog boxes, including "About", File access dialogs, and error message dialogs. Each dialog box is demonstrated being used in three different ways: standard, using a modified template, and using a hook function. Cmndlg displays "Hello World" in a window, and allows the user to change the text and colors, etc.
- **consolec**: The consolec sample demonstrates the use of the SetConsoleTxtAttribute and GetConsoleScreenBufferInfo APIs to set or get the console text color attributes. This is a console application that is linked against dfwin.lib. If no arguments are passed to consolec, it prints out a color sample in a command window. The arguments are FOREGROUND color and BACKGROUND color, and the valid options are BLACK, BLUE, GREEN, CYAN, RED, MAGENTA, YELLOW or WHITE. The color argument

passed must be in uppercase, or an error will be output.

- **crypto**: The crypto sample demonstrates using the Cryptography API to encrypt and decrypt files.
- **cursor**: The cursor sample demonstrates how to manipulate a cursor and select a region. It uses the Windows interface to manage the GUI. The program will either let the user draw boxes (regions) or will calculate 1027 prime numbers when RETURN is entered. During that calculation, the cursor is turned into an hourglass.
- **drives**: The drives sample determines all drives on the system, both local and remote, and determines their file system type. This is a console application that links against dfwin.lib.
- **event**: The event sample demonstrates the basic concepts involved when using asynchronous I/O. It reads one file asynchronously and writes another synchronously. This is a console application that links against dfwin.lib and requires two arguments, the input file and output file. This executable transfers one file to another. Refer to the readme.txt for information on how to set it up in the Developer Studio.
- **exitwin**: The exitwin sample demonstrates how to shut down applications. When run, it will ask whether you want to continue, as it will log you off. Optionally, you can compile it to reboot the system. This is a Windows application that uses Windows to manage the GUI.
- **floppy**: The floppy sample demonstrates how to access a physical floppy disk using the Win32 API set. It has two major functions:
  1. It can be used to display the geometry of a disk, floppy -g a:
  2. It can be used to produce a disk image or to write a disk image to a floppy, floppy -c a: bootdisk (produces a disk image of a:) or floppy -c bootdisk a: (make a: identical to bootdisk image).

  This is a Fortran Console program that is linked against dfwin.lib.

- **generic**: The generic sample demonstrates the basic concepts required in building a Windows application and could be used as a basis for building a first Windows program. The specific features that generic implements are:
  1. Custom icon
  2. Standard Menu Bar
  3. Standard Help Menu
  4. Full WinHelp Support
  5. Keyboard Accelerator Usage
  6. Version Control Information
- **getdev**: The getdev sample demonstrates the GetDeviceCaps() API. Also, in this sample, the main window is a dialog box, and all the interesting code is in the window procedure for that dialog box. This is different than many of the other Windows-based samples, which use MainWndProc to handle the events.
- **getopenfilename**: The getopenfilename sample demonstrates the use of the API GetOpenFileName(). When run, it brings up a dialog box listing either text files or Fortran files in the project directory. It also gives you the

option of opening the file read-only.

- **getsys**: The getsys sample demonstrates the APIs GetSysColor(), GetSystemDirectory(), GetSystemInfo(), GetSystemMetrics(), GetSystemPaletteEntries(), and GetSystemTime(). Also, in this sample, the main window is a dialog box, and all the interesting code is in the window procedure for that dialog box. This is different than many of the other Windows-based samples, which use MainWndProc to handle the events.
- **inherit**: The inherit sample demonstrates inheritance of file handles from one process to a child process. It also demonstrates the use of anonymous pipes as stdout and stderr replacements. It contains two projects, *child* and *inherit*. The inherit project creates inherit.exe, which can be run without the other project. To run inherit, specify two parameters:
  1. Trace file to write stdout and stderr
  2. Command to execute

  The inherit program is run within QuickWin so that it can be a "console-less" parent. Otherwise, there are configuration problems when trying to pipe.
  To use this sample, first set the current project to *child* and build it, then set the current project to *inherit* and build it. Before you run it, read the readme.txt file in the project; this will tell you what changes you need to make to your project configuration in order to run this sample.

- **input**: The input sample is a basic Windows application that does very general processing on mouse button events and keyboard events. It demonstrates how input messages are received, and what additional information comes with the message. When run, it displays the current pointer location, whether the right or left mousebutton was clicked, and outputs a message based on a 5 second timer.
- **maskblt**: The maskblt sample is intended to demonstrate masked bit block transfers. It is unclear that it is working correctly, either in its current form, or as received from Microsoft. However, it does demonstrate basic calls to functions that support bitmaps and keyboard accelerators used by clipboard functions.
- **MDI**: The MDI sample demonstrates the multiple document interface. It creates a simple window that can create child windows within itself. It also can set the titles on these child windows.
- **menu**: The menu sample demonstrates the use of popup menus, user defined menus and menu functions. It is a very simple program that allows you to select items off a menu, invoke a pop-up menu, and basically do little else, but is a good example of how to start with menus.
- **mltithrd**: The mltitrhd sample demonstrates the use of multiple threads. The main routine, mltithrd.f90, has a brief guide to writing multi-threaded applications at the top of the file. It uses the multi-document interface to create child windows, and bounces colored traces through each one.
- **output**: The output sample demonstrates using TextOut() and DrawText() to write to a window. It is a very simple sample, outputting text and a few

simple shapes, such as a rectangle, ellipse, and pie-wedge.

- **owncombo**: The owncombo sample demonstrates the use of functions and messages for combo boxes and owner-draw control styles. It brings up a window and lets you play with the different combo box styles.
- **paths**: The paths sample demonstrates the use of paths and clipping regions. A *path* is one or more figures or shapes that are filled, outlined, or both filled and outlined. Paths are used in various drawing and painting applications. This sample demonstrates how 6 different types of paths can be set up. With this release, when the application first runs, the window is too small for the titles on the paths, and must be manually resized.
- **platform**: The platform sample demonstrates some very simple menu choices, and the popup dialog boxes that you can create from them. This sample displays "menus" that give you information about which platform you are running on.
- **plgdraw**: The plgdraw sample demonstrates the PlgBlt() API. The PlgBlt function performs a bit-block transfer of the bits of color data from the specified rectangle in the source device context to the specified parallelogram in the destination device context. The sample displays a rendered version of the contents of the middle grid in the leftmost grid.
- **polydraw**: The polydraw sample demonstrates capturing mouse clicks and movement, and combining that with some keyboard input (the Ctrl or Shift keys). It is a very simple program that allows the user to draw lines, curves, and move some points around on the screen.
- **process**: The process sample demonstrates creating and terminating processes from within another program. The user interface is very simple, a dialog box with two buttons "Create" and "Terminate", and window with the list of created processes.
- **registry**: The registry sample demonstrates the Registry API. This sample displays information from the system registry, allowing the user to traverse the various trees. It is a fairly simple sample, but could be used as an example.
- **select**: The select sample demonstrates how to manipulate a cursor and select a region. This sample has two projects under it:
    1. Select, which provides a dynamic link library (dll) of routines for selecting a region
    2. Demo, which contains an executable program that uses the select library above.

  To use this sample, first set *select* as the current project and build select.dll, then set *demo* as the current project to build the executable.
- **setinfo**: The setinfo sample demonstrates how to set the attributes of a file. It has a simple interface, allowing the user to enter a filename in an edit field. The GetInfo button will retrieve information about the file and display it. To set file information, modify the values in the Time and Date edit fields, and click the SetInfo button. To set file attributes, set the appropriate check boxes and click on the SetAttr button.
  This sample also demonstrates the use of the GetFileTime() and

SetFileTime() API calls.

- **sharemem**: The sharemem sample demonstrates the use of named shared memory between two independent processes. There are two projects in this sample, *sharemem* and *othrproc*. These can be built in either order; neither depends on the other. To use this sample, first start Sharemem, then start Othrproc. (Note, this is best done outside of Developer Studio.) The visual effect is better if the focus remains with Othrproc, while the mouse moves with Sharemem. A "shadow" mouse is displayed on Othrproc with the same coordinates as the mouse on Sharemem.
- **startp**: The startp sample demonstrates various CreateProcess() parameters, including starting processes in a given priority class. This is very similar to the "start" command but with added functionality. It is best run from outside Developer Studio, but when run from within Developer Studio, will give usage information in a console window.
- **streblt**: The streblt sample demonstrates the use of the StretchBlt function. This Block Transfer function goes beyond a simple BitBlt, giving the option of stretching or compressing a bitmap to fit a different area in the destination device context.
- **subclass**: The subclass sample demonstrates subclassing of standard windows controls, such as button, edit field, and list box. It allows the user to create an arbitrary number of child controls on the main window. These controls are subclassed, and the subclass procedure provides the user a way to move and size the controls. A menu item switches in and out of "Test Mode". When this is on, the subclass procedure passes all message through to the standard procedure, and the controls act just like normal.
- **takeown**: The takeown sample demonstrates how to give an Administrator access to a file that has been denied to all. It must be run from an Administrator account. There is a sample file provided named takeown.txt which may be used by the sample.
- **termproc**: The termproc sample demonstrates how to terminate a process, given its process id. Although this can be built within the Developer Studio, it is best run from the command line.
- **threads**: The threads sample demonstrates suspending, resuming, and setting the priorities of threads. The display shows two threads, red and green, which draw paths across the window. There are menu items to suspend, resume, and set the priority of the two threads. Caution, if the priority of one or the other of the threads is set too high little else will run on the system.
- **timers**: The timer sample demonstrates the use of the SetTimer() and KillTimer() APIs. It creates 4 rectangles on its window, each with a different and inverts the color whenever the timer goes off. This sample demonstrates two timer mechanisms.
- **tls**: The tls sample demonstrates multiple threads calling into a single DLL. It also demonstrates the use of DLLEXPORT to export entry points from a DLL, rather than using .DEF files. The tls sample has two projects, *tlsdll* and *tls*. The workspace is configured such that the tls project is dependent

on the tlsdll project. If you build tls, it will automatically build tlsdll. When running, each thread is blocked waiting for the user to click OK in a message box. The thread may be running in a minimized window.
- **virtmem**: The virtmem sample demonstrates the use of various virtual memory APIs. The sample has a main window with menu items that will modify a set page to have different attributes. In order to write to memory, the page must be committed and set to read/write access. Attempting to write to a read only page will cause an access error, "memory cannot be read".
- **world**: The world sample demonstrates scaling and translating an image from a metafile with world coordinate transforms. It uses the calls SetWorldTransform() and PlayEnhMetaFile() to do the linear transformation between world space and page space, and to play the enhanced metafile. The sample provides a single sample metafile, sample.emf, although others could be used.
- **wxform**: The wxform sample demonstrates world transforms. It has three dialog boxes that display help, track mouse movements, or allow the user to enter transform information. The different quadrants of the screen have different properties, as described in the help box. This sample also demonstrates using messages to communicate between different window procedures.

Dialog Boxes (Dialog)

The Dialog samples demonstrate several of the newer dialog controls available through Visual Fortran. There is also a sample that demonstrates how to use modeless dialog boxes. The dialog samples can be found in the directory `...\Df98\Samples\Dialog`:

- **CelsiCon**: The CelsiCon sample is a Fortran Console application that uses a dialog box. It uses an undocumented hook into the dialog initialization event WM_INITDIALOG. It also sets special customizations on that dialog box by using Win32 calls. With a simple modification to the source program, it can also be built as a QuickWin application.
- **dllprgrs**: The dllprgrs sample demonstrates using the Visual Fortran Dialog Procedures in a DLL. The public routines in the DLL can be called to:
  - DisplayProgressBox – Display a dialog box containing a progress bar
  - SetProgress – Set the current progress bar value
  - DestroyProgressBox – Destroy the dialog box
- **fxplorer**: The fxplorer sample demonstrates an SDI Fortran Windows application using the Visual Fortran Dialog Procedures. It uses an Internet Explorer ActiveX control in the main window of the application. The Internet Explorer control is installed with Internet Explorer. If Internet Explorer is not installed, this sample will not run.
- **mmplayer**: The mmplayer sample demonstrates a dialog-based Fortran Windows application using the Visual Fortran Dialog Procedures. It uses an ActiveMovie control in the main window of the application. The ActiveMovie

control is installed with Internet Explorer. If Internet Explorer is not installed, this sample will not run.
- **progress**: The progress sample program demonstrates a "dialog-based" Fortran application using the Visual Fortran Dialog Routines, including the progress bar. The main window of the application is a dialog box. It contains Start, Stop, and Exit buttons plus a progress bar. The Start button begins a lengthy operation that is broken into 100 steps. In this simple example, each step is sleeping for .25 seconds.
- **showfont**: The showfont sample demonstrates a "dialog-based" Fortran application using the Visual Fortran Dialog Routines. The main window of the application is a dialog box. This program demonstrates the use of a Tab control. The Tab control is used to select the properties of a font. The font is used to display a sample text string.
- **therm**: The therm program demonstrates a "dialog-based" Fortran application using various Visual Fortran Dialog Routines, including several that are new to CVF V6.0. The main window of the application is a dialog box. This program uses a Spin control, a Slider control, a Progress bar control, and Picture controls. It also demonstrates using multiple modeless dialog boxes.
- **whizzy**: The whizzy sample demonstrates many of the controls available with the dialog manager module provided by Visual Fortran. Note that it is built with the "Logical Values" compatibility switch set. This is required for correct interaction with the dialog manager routines.

DLL Examples (DLL)

Within Visual Fortran you can create and use dynamically linked libraries (DLLs). A DLL is loaded at run time by its calling modules (.EXE or .DLL). When a DLL is loaded, it is mapped into the address space of the calling process. There are generally two ways to bring in a DLL, either at image activation time or at run-time. If an image is linked against the import library for a DLL the code is mapped into the image's address space at image activation time. If the import library is not available, the DLL needs to be mapped in with Windows API calls. The following DLL examples can be found in subdirectories under `...\Df98\Samples\DLL`:

- **DLLEXP1**: The DLLEXP1 sample demonstrates a workspace that contains two projects: one that creates a DLL and a second that uses that DLL, linking against the import library created by the first project. Note that for the Fortran Console application to run, the DLL created by the first project must be found somewhere along the PATH.
- **DLLEXP2**: The DLLEXP2 sample demonstrates how COMMON variables defined in a DLL can be shared between multiple programs. Two programs are built against the same DLL. The first program is run, and then PAUSEs. The second program is run and changes the COMMON variables, and exits. When the first program resumes, it displays the changed values.

- **LoadExp1**: The LoadExp1 sample demonstrates how to dynamically map a DLL without using an import library. It is a workspace with two projects, one the DLL and the other the executable that uses it.

Exception Handling (ExceptionHandling)

Visual Fortran Version 6.5 introduces some routines to make it easier for the user to control floating-point exception handling:

- **ClearFP**: The ClearFP sample demonstrates CLEARSTATUSFPQQ, a subroutine to clear the ia32 floating-point status word exception flags.
- **Cslexcp2**: The Cslexcp2 sample demonstrates exception and termination handling in a Fortran Console application.
- **Cslexcp4**: The Cslexcp4 sample demonstrates how to wrap a Fortran entry point inside a C try/except block to allow testing for exceptions that might occur in the protected Fortran code.
- **GetEptrs**: The GetEptrs sample demonstrates how to establish a signal handler with SIGNALQQ (or the C signal() function) and use the TRACEBACKQQ and GETEXCEPTIONPTRSQQ Fortran library routines to generate a traceback display from the handler.
- **Winexcp1**: The Winexcp1 sample demonstrates exception handling in a Fortran Windows application. It was based on the GENERIC sample, with structured exception handling (SEH) incorporated.
- **VBVF1**: The VBVF1 sample demonstrates exception handling in a Visual Basic application that calls a Visual Fortran DLL. This is an ia32-only sample.

ISO Varying Strings (Isovar)

The Isovar samples demonstrate one possible implementation for the interface to dynamic-length character strings in Fortran 95. The publicly accessible interface defined by this module is conformant with the auxiliary standard, ISO/IEC 1539-2: 1999. The Isovar samples are in separate directories under `...\Df98\Samples\Isovar` and include:

- **unittest**: The unittest sample contains 80 small functions that test each of the features of the ISO varying string module. Some of the features tested are concatenation, assignment, and searching for a substring.
- **vocab**: The vocab sample uses the ISO varying string module to read a text file and keep a list of each word found in the file and its frequency. When the file is completely read, it prints out the word list and the frequency of each word.
- **wrdcnt**: The wrdcnt sample uses the ISO varying string module to read a text file and keep count of how many words are seen. When the file is completely read, it prints out the total number of words found in the file.

Miscellaneous (Misc)

There are a number of miscellaneous samples that demonstrate some specific aspects of Visual Fortran or its utilities. The following miscellaneous examples can be found in separate subdirectories under `...\Df98\Samples\Misc`:

- **calcaver**: The calcaver sample demonstrates Fortran 90 features, including an interface block, assumed shape array, and the use of modules. It does have a Developer Studio workspace associated with it, or can be built using nmake and the makefile.
- **char2**: The char2 sample demonstrates the use of the utility fsplit90. This utility creates separate files for each program unit within a file. Once it has been split, it is identical to charexmp. Build this sample using nmake.
- **charexmp**: The charexmp sample does some simple character handling, generating arrays of the alphabet and outputting them to the screen. It has a Developer Studio workspace associated with it, or it can be built using nmake.
- **console**: The console sample demonstrates some of the basic console-manipulating routines. Console sets the size of the console, clears the console, and positions the cursor to write a line at the top of the console, and again at a line further below. A DOS command prompt is an example of a console.
- **cvt_lf_unf**: The cvt_lf_unf sample converts data files created with Lahey Fortran to an unformatted binary file. There are two projects within this sample:
  - *cvt_lf_unf* which builds the conversion utility
  - *test* which uses cvt_lf_unf to convert a data file created by Lahey Fortran and then read it from CVF.
- **fctrl**: The fctrl sample is a very simple one, demonstrating recursion. It is a console application, and computes and displays the factorials of the integers 1 to 12. 13! is too big for a 32-bit integer. This sample can be built either from within Developer Studio, or by using the makefile.
- **fivt**: The fivt sample is a basic Installation Verification program for Visual Fortran. It compiles and links a program, and then reads the listing file to make sure the expected version of the compiler was used. It can be compiled and run from either the command line or the Developer Studio. To run fivt from the command line, either set FORT5=FIVT.INP, or invoke it as FIVT < FIVT.INP. To run from Developer Studio, refer to the README.TXT file in that directory.
- **forprint**: The forprint sample is a console application that uses the OpenFile and Print dialog boxes to select and print text files, including files with Fortran carriage control. Forprint preprocesses the file, generating a text file that can be printed by any printer. This sample can be built either from within Developer Studio or by using the makefile.
- **fppdemo**: The fppdemo sample demonstrates the use of the Fortran Preprocessor, FPP. FPP is a C-like preprocessor, as opposed to the

preprocessing directives that are part of the Fortran 90 standard. It is easiest to build using the makefile, but there is a Developer Studio workspace for it. This workspace has 5 projects, one per variation of fpp defines. It illustrates how to pass fpp flags to the compiler from the Developer Studio; it must be done by hand from within the Settings dialog box.

- **mandel**: The mandel sample demonstrates a simple Win32 application with a C main program calling a Fortran subroutine.
- **uopen**: The uopen sample demonstrates the use of the USEROPEN keyword from the **OPEN** statement. In this particular example, the Fortran file calls a C program to do the specialized **OPEN**.
- **lcinfo**: The lcinfo sample demonstrates the use of NLS routines to support some natural language extensions. It also demonstrates how the string order is affected by choice of natural language. The lcinfo sample is a console application that prints out information about what the different language and currency settings are on the computer.

Mixed-Language (Mixlang)

Visual Fortran can be called by a number of other languages, including Visual C/C++, Visual Basic, and MASM (Assembler). Also, it can call other languages, such as C/C++. The following samples in subdirectories under `...\Df98\Samples\Mixlang` demonstrate some of the calling standards or argument definitions that must be used to effectively interwork with other languages:

- **c_call_f**: The C_Call_F sample demonstrates a mixed-language application in which a C (or C++) main program calls a Fortran subroutine. It is presented in two different styles; one where the Fortran and C code are built together in the same project and one where the Fortran code is built separately into a DLL which is then called from C. This sample also demonstrates how to pass character/string arguments to Fortran.
- **delphi**: This ia32-only sample demonstrates various interactions between Visual Fortran and Borland™ Delphi. Delphi must be installed to build and run this sample:
    - **CallDVF**: The CallDVF sample demonstrates calling Fortran from Delphi. There are examples of an integer function, a REAL function, and a character function.
- **spline**: The spline sample demonstrates mixed language programming with Visual C/C++. Spline is easiest built from within Developer Studio. The project contains four projects, *Console, QuickWin, VC,* and *spldll*. The last project, *spldll*, creates the dll file used by the other projects.
  The spline sample implements a "best fit curve" algorithm to a set of coordinates. The coordinates are input by clicking on a window or through a data file. Each of the first three projects within this workspace create a different program, using different paradigms:
    - Console creates an application that runs in a console window and

  takes input from a data file, fsplit.dat
  - QuickWin creates an application using the QuickWin interface that takes input from mouse clicks.
  - VC creates an application using Visual C/C++ and the Microsoft Foundation Classes that takes input from mouse clicks.

  This workspace and its projects also demonstrate one method of dealing with interproject dependencies. It copies the dependent .DLL file to the local directory before linking and running the project.
- **vb**: This set of samples demonstrates various interactions between Visual Fortran and Visual Basic (VB). In all cases, there is an executable that is the VB program which you can run. There is also the VB Project, as well as the Visual Fortran project available so you can modify them as you wish:
  - **arrays**: The arrays sample demonstrates how to pass arrays of strings from VB to CVF
  - **callback**: The callback sample demonstrates how to invoke VB callback routines passed to a CVF subroutine
  - **returnstring**: The returnstring sample demonstrates how to call a Fortran character string function from Visual Basic.
  - **simple**: The simple sample shows very basic interactions between Visual Fortran and VB, passing numbers from one to the other
  - **typearrays**: The typearrays sample demonstrates how to pass an array of user-defined types from VB to Visual Fortran, including how to write into some fields of that type from within the Fortran routine.
- **MASM**: This set of ia32-only samples demonstrates various interactions between Visual Fortran and MASM, Microsoft's Assembly Language. MASM must be installed to build these samples:
  - **simple**: The simple sample demonstrates the most simple call from Fortran to MASM.
  - **vecprod**: The vecprod sample demonstrates how to calculate the inner product of two vectors in a MASM program. These two vectors were passed from Fortran to MASM, and the result was passed back to the Fortran main program.
  - **allocabl**: The allocabl sample is a rewrite of vecprod using allocatable arrays rather than static ones.

QuickWin (Quickwin)

Visual Fortran provides a library of routines called QuickWin. QuickWin is a library that lets you build applications with a simplified version of the Windows interface with Visual Fortran. The QuickWin library provides a rich set of Windows features, but it does not include the complete Windows Applications Programming Interface (API). If you need additional capabilities, you must set up a Windows application to call the Win32 API directly rather than using QuickWin to build your program. The following samples demonstrate how to use QuickWin, and how to program around some of the strange paradigms of the package.

The following QuickWin examples can be found in subdirectories under `...\Df98\Samples\QuickWin`:

- **calendar**: The calendar sample is a simple QuickWin application. It displays a graphical monthly calendar for the current month.
- **chaos**: The chaos sample is a QuickWin application that demonstrates the use of menus, dialog boxes for input and output, message boxes for the signaling of error states, various ways of recovering from error conditions and still keep the program running, QuickWin graphics routines, multi-threading, and Fortran 90. There is a document in the CHAOS subdirectory, README.TXT, that describes this program and its algorithms in more detail.
- **cleanwin**: This sample illustrates how to use native Windows APIs to radically change the appearance of a standard QuickWin window.
- **conapp**: This sample demonstrates a method for creating a console window from within a QuickWin application. The sample has two parts: a DLL which creates the console window and performs I/O to or from it, and a QuickWin program that calls that DLL. To allow the DLL to access the console using units *, 5, and 6, this sample uses a technique not recommended for any other use. The DLL is linked against the Fortran dynamic-link libraries, but the QuickWin application is linked against the Fortran static libraries. Generally this is discouraged, because using the two different libraries means that the main program and the DLL cannot share I/O units. In this case, that is the intended outcome.
- **dirkeys**: This sample demonstrates a mechanism for passing directional keys from QuickWin to the user's program.
- **dirkeys2**: This sample illustrates the use of a callback procedure (hook) using SetWindowsHookEx for keyboard events. It demonstrates how to get around the limitations of the PASSDIRKEYS routine, specifically how to trap for Insert, Delete, and Ctrl-C keys.
- **dirkeys4**: This sample demonstrates the PASSDIRKEYSQQ routine. The PASSDIRKEYSQQ routine allows easy access to the Insert, Delete, and Ctrl-C keys.
- **menudriv**: This sample illustrates three programming idioms for use in QuickWin applications. These are: using the menu to drive various functions; getting control on EXIT; using the status bar to indicate program progress.
- **peekapp**: This multi-threaded sample simulates a compute loop with Peekchar and Getchar to handle input as it comes in character by character. It is intended to be used within a QuickWin program.
- **peekapp3**: This multi-threaded sample is similar to peekapp, but contains a procedure to perform an orderly shutdown on the character-reading thread.
- **poker**: The poker sample demonstrates the use of QuickWin and some simple controls on the window. This sample uses QuickWin to manage the windowing interface, but uses some of the Win32 API calls, and must be linked against dfwin.lib. It should be mentioned that the file CARDS.F90 takes a longer time to compile than any of the o ther files that make up the

poker sample. Also, before building, you should make sure you update all dependencies, as there are many.

- **postmini**: The Postmini graphical postprocessing software can be used to examine the output of a number of process, device and circuit simulation (TCAD) programs, as well as import data from ASCII files. This version of PostMini uses QuickWin for the graphical interface. Other versions are available for Compaq Tru64 UNIX and OpenVMS Alpha that use other graphical interfaces. Refer to the README file in the PostMini directory for details on this sample.
- **qwpaint**: The qwpaint sample demonstrates using mouse callbacks and graphics routines in a QuickWin application. It has two windows, a "control grid" window and a "canvas" window. QuickWin's built-in File.Save option can be used to save the contents of either window as a bitmap (.BMP) file.
- **qwpiano**: The qwpiano sample demonstrates using mouse callbacks and menu callbacks in a QuickWin application. It draws a graphical piano keyboard on the screen that can be played using the mouse. It should be noted that two compatibility options, "Logical Values" and "Filenames from Command Line" are set for this sample. The former affects interacting with the QuickWin routines, and the latter causes a File dialog box to come up in response to an **OPEN** request.
- **Resize**: The resize sample demonstrates how to use Win32 API calls from within a QuickWin application to correctly size the information to be displayed to a QuickWin window.
- **testscrl**: The testscrl sample demonstrates how to scroll to the last line of a window that has scroll bars. It also shows how to make a window without scroll bars.

Scientific Graphing Utility (SciGraph)

SCIGRAPH is a package of Fortran routines for drawing scientific graphs. Graph types available include line, bar, XY, and pie graphs. All graphs are fully customizable, including control over axis, log scales, data points, colors and shades, error bars, and many other aspects of a scientific graph. All graphs are drawn using Visual Fortran's QuickWin graphics routines, so they can be easily added to an already existing QuickWin application.
The SciGraph package can be found in `...\Df98\Samples\SciGraph`:

- **scigraph**: The SciGraph sample offers a starting scientific graphing package to support some basic forms of graphs. There are two projects in this sample:
  - Scigraph, which creates a library and some .MOD files
  - Sgdemo, which creates a program to demonstrate some of the basic forms of graphs

  Build the Scigraph project first, followed by Sgdemo. Note that the output area for the SCIGRAPH.LIB project is included as a path to find .MOD files. There is a .WRI file in the SCIGRAPH directory that contains basic reference information on the various SciGraph calls, including a list of error returns and possible causes.

A known limitation of SciGraph is directly related to the known QuickWin limitation of 256 colors on the graphics device. This limitation shows itself when trying to print or save as a bitmap file; only a black screen is printed or saved.

Tutorial

All Tutorial samples are simple programs, and most of them are standalone. Each contains compilation information at the top of the file, both for command line and from within Developer Studio. If there are multiple files, this is noted at the top of the program. All tutorial samples can be found in the directory `...\Df98\Samples\Tutorial`:

- **assocn**: The assocn sample illustrates the non-associativity of floating-point addition.
- **cycle**: The cycle sample illustrates the Fortran 90 statements **CYCLE** and **EXIT**.
- **derived**: The derived sample demonstrates a derived type structure, type variables, and assign values.
- **dtypearg**: The dtypearg sample demonstrates the use of SEQUENCE to allow passing a derived-type argument.
- **dtypecom**: The dtypecom sample demonstrates placing derived-type objects in **COMMON** blocks.
- **dtypemod**: The dtypemod sample demonstrates the use of a module to allow passing a derived-type argument. It also shows WRITE of a derived-type.
- **epsilon**: The epsilon sample illustrates several calculations of machine epsilon.
- **internal**: The internal sample illustrates the use of an internal subroutine and the **CONTAINS** statement.
- **interval**: The interval sample demonstrates the use of rounding control. This sample must be compiled without optimizations.
- **keynames**: The keynames sample demonstrates the Fortran concept of using a type structure and a subroutine defined within a module. This sample also requires NAME_SSN.F90 to build.
- **matherr**: The matherr sample demonstrates handling run-time math exceptions. This sample is not a standalone application, but can be included in other programs.
- **mathtest**: The mathtest sample uses matherr above to demonstrate the response to error conditions on intrinsic math calls. It uses the MATHERRQQ subroutine in MATHERR.F90.
- **mbcomp**: The mbcomp sample demonstrates the use of the National Language Support (NLS) routines.
- **namelist**: The namelist sample demonstrates the NAMELIST Statement.
- **percent**: The percent sample demonstrates a user-defined operator, in

this case a unary operator .c. that converts a floating point number to a "percentage".

- **pointer**: The pointer sample demonstrates allocating and deallocating pointers and targets.
- **pointer2**: The pointer2 sample demonstrates pointing at a pointer and target, and the use of the **ASSOCIATED** intrinsic.
- **realg**: The realg sample demonstrates using coordinate graphics. This sample uses the QuickWin package to display to the screen.
- **recurs**: The recurs sample is a very simple demonstration of a recursive subroutine.
- **showfont**: The showfont sample uses QuickWin to display a variety of fonts. This sample demonstrates various calls to QuickWin.
- **sigtest**: The sigtest sample demonstrates user-defined exception handlers. It shows how to establish the name of the exception handler as the function to be invoked if an exception happens.
- **sine**: The sine sample demonstrates the use of QuickWin to output sine waves and some simple shapes.
- **testget**: The testget sample illustrates the use of internal READ to convert from REAL to CHARACTER. This is best run from outside of Developer Studio, and can be built simply by df testget.f90.
- **threads**: The threads sample demonstrates multiple threads with QuickWin. It is a much simpler program than advanced\win32\bounce, but is not as efficient at run time.
- **unclear**: The unclear sample demonstrates the use of generic module procedures. A generic procedure called "dup" has three instances; one with real arguments, one with integer arguments, and one with character arguments.
- **where**: The where sample demonstrates the Fortran 90 constructs **WHERE** and **ELSEWHERE**.

Using the Compiler and Linker from the Command Line

The DF command is used to compile and link your programs. In most cases, you will use a single DF command to invoke the compiler and linker. The DF command invokes a *driver program* that is the actual user interface to the compiler and linker. It accepts a list of command options and file names and directs processing for each file.

If you will be using the DF command from the command line, you can use:

- The supplied Fortran Command Prompt window in the Compaq Visual Fortran program folder, in which the appropriate environment variables in `DFVARS.BAT` are preset.
- Your own terminal window, in which you have set the appropriate environment variables by executing the `DFVARS.BAT` file. This file sets the environment variables (such as PATH, INCLUDE, and LIB) and allows use of IMSL and CXML libraries. By default, `DFVARS.BAT` is installed in `\Program Files\Microsoft Visual Studio\Df98\BIN`.

The driver program does the following:

- Calls the Visual Fortran compiler to process Fortran files.
- Passes the linker options to the linker.
- Passes object files created by the compiler to the linker.
- Passes libraries to the linker.
- Calls the linker or librarian to create the .EXE or library file.

The DF command automatically references the appropriate Visual Fortran Run-Time Libraries when it invokes the linker. Therefore, to link one or more object files created by the Visual Fortran compiler, you should use the DF command instead of the LINK command.

Because the DF driver calls other software components, error messages may be returned by these other components. For instance, the linker may return a message if it cannot resolve a global reference. Using the /watch:cmd option on the DF command line can help clarify which component is generating the error.

This section contains the following information:

The Format of the DF Command

This section describes the format of the DF command. It also provides an alphabetical list of DF command options.

The DF command accepts both compiler options and linker options. The command driver requires that the following rules be observed when specifying the DF command:

- Except for the linker options, options can be specified in any order.
- Linker options must be preceded by the keyword /link and must be specified at the end of the command line, following all other options.

The DF command has the following form:

```
DF options [/link options]
```

options

A list of compiler options (or linker options preceded by the /link option). These lists of options take the following form:

```
[/option:[arg]] [filename.ext]...
```

Where:

/option[:arg]

Indicates either special actions to be performed by the compiler or linker, or special properties of input or output files.

The following rules apply to options and their names:

- Options begin with a slash (/). You can use a dash (-) instead of a slash.
- Visual Fortran options are *not* case-sensitive. Certain options provided for compatibility with Microsoft Fortran PowerStation options *are* case-sensitive, such as /FA and /Fa*file*.
- You can abbreviate option names. You need only enter as many characters as are needed to uniquely identify the option.

Certain options accept one or more keyword arguments following the option name. For example, the /warn option accepts several keywords, including argument_checking and declarations.

To specify only a single keyword, specify the keyword after the colon (:). For example, the following specifies the /warn option declarations keyword:

```
DF /warn:declarations test.f90
```

To specify multiple keywords, specify the option name once, and place each keyword in a comma-separated list enclosed within parentheses with no spaces between keywords, as follows:

```
DF /warn:(argument_checking,declarations)  test.f90
```

Instead of the colon, you can use an equal sign (=):

```
DF /warn=(argument_checking,declarations)  test.f90
```

filename.ext

Specifies the files to be processed. You can use wildcard characters (such as *.f90) to indicate multiple files or you can specify each file name.

The file extension identifies the type of the file. With Fortran source files, certain file extensions indicate whether that source file contains source code in free (such as .f90) or fixed (such as .for) source form. You can also specify compiler options to indicate fixed or free source form (see /[no]free).

The file extension determines whether that file gets passed to the compiler or to the linker. For example, files myfile.for and projfile.f are passed to the compiler and file myobj.obj is passed to the linker.

Compiler Options, Alphabetic List

The following table lists the DF command compiler options alphabetically:

/[no]alignment	/[no]altparam
/architecture	/[no]asmattributes
/[no]asmfile	/assume
/[no]automatic	/bintext
/[no]browser	/ccdefault
/[no]check	/[no]comments

/[no]compile_only	/convert
/cxml	/[no]d_lines
/[no]dbglibs	/[no]debug
/define	/dll
/[no]error_limit	/[no]exe
/[no]extend_source	/extfor
/extfpp	/extlnk
/[no]f66	/[no]f77rtl
/fast	/[no]fixed
/[no]fltconsistency (ia32 only)	/[no]fpconstant
/fpe	/fpp
/[no]fpscomp	/[no]free
/help or /?	/iface
/imsl	/[no]include
/[no]inline	/[no]intconstant
/integer_size	/[no]keep
/[no]libdir	/libs
/[no]link	/[no]list
/[no]logo	/[no]machine_code
/[no]map	/math_library
/[no]module	/names
/[no]object	/[no]optimize
/[no]pad_source	/[no]pdbfile
/[no]pipeline (ia64 only)	/preprocess_only
/real_size	/[no]recursive

/[no]reentrancy	/[no]show
/source	/[no]static
/[no]stand	/[no]syntax_only
/[no]threads	/[no]traceback
/[no]transform_loops	/tune
/undefine	/unroll
/[no]vms	/[no]warn
/[no]watch	/what
/winapp	

For more information:

- On DF command examples, see Examples of the DF Command Format
- On compiler option categories, see Categories of Compiler Options
- On using the FL32 command, see Microsoft Fortran PowerStation Command-Line Compatibility
- About Fortran PowerStation options (such as /MD) and their DF command equivalents, see Equivalent Visual Fortran Compiler Options

Examples of the DF Command Format

The following examples demonstrate valid and invalid DF commands:

Valid DF Commands

In the following example, the file to be compiled is test.f90 and the file proj.obj is passed to the linker:

```
DF test.f90 proj.obj
```

In this example, the .f90 file extension indicates test.f90 is a Fortran free-form source file to be compiled. The file extension of obj indicates proj.obj is an object file to be passed to the linker. You can optionally add the /link option before the file proj.obj to indicate it should be passed directly to the linker.

In the following example, the /check:bounds option requests that the Fortran compiler generate additional code to perform run-time checking for out-of-bounds array and substring references for the files myfile.for and test.for (fixed-form source):

```
DF /check:bounds myfile.for test.for
```

In the following example, the /link option indicates that files and options after the /link option are passed directly to the linker:

```
DF myfile.for /link myobject.obj /out:myprog.exe
```

Invalid DF commands

The following DF command is invalid because the /link option indicates that items after the /link option are passed directly to the linker, but the file test.for should be passed to the compiler:

```
DF myfile.for /link test.for /out:myprog.exe
```

The following DF command is invalid because the /link option is missing and the /out linker option is not recognized as a compiler option:

```
DF myfile.for test.for /out:myprog.exe
```

A correct form of this command is:

```
DF myfile.for test.for /link /out:myprog.exe
```

In this case, you can alternatively use one of the DF options (/exe) that specifies information to the linker:

```
DF myfile.for test.for /exe:myprog.exe
```

For more information:

- Environment Variables Used with the DF Command
- Specifying Project Types with DF Command Options
- Using the DF Command to Compile and Link
- DF Indirect Command File Use
- Compiler and Linker Messages

Input and Output Files

You can use the DF command to process multiple files. These files can be source files, object files, or object libraries.

When a file is not in your path or working directory, specify the directory path before the file name.

The file extension determines whether a file gets passed to the compiler or to the linker. The following types of files are used with the DF command:

- Files passed to the compiler: .f90, .for, .f, .fpp, .i, .i90, .inc, .fi, .fd, .f77

  Typical Fortran (DF command) source files have a file extension of .f90, .for, and .f. When editing your source files, you need to choose the source form, either free-source form or fixed-source form (or a variant of fixed form called tab form). You can either use a compiler option to specify the source form used by the source files (see /fixed or /free), or you can use the following file extensions when creating or renaming your files:

  - The compiler assumes that files with an extension of .f90, .F90, or .i90 are free-form source files.
  - The compiler assumes that files with an extension of .f, .for, .FOR, or .i are fixed-form (or tab-form) files.

- Files passed to the linker: .lib, .obj, .o, .exe, .res, .rbj, .def, .dll

  For example, object files usually have a file extension of .obj. Files with extensions of .lib are usually library files.

The output produced by the DF command includes:

- An object file (.OBJ) if you specify the /compile_only, /keep, or /object option on the command line.
- An executable file (.EXE) if you do not specify the /compile_only option
- A dynamic-link library file (.DLL) if you specify the /dll option and do not specify the /compile_only option
- A module file (.MOD) if a source file being compiled defines a Fortran 90 module (**MODULE** statement)
- A program database file (.PDB) if you specify the /pdbfile or /debug:full (or equivalent) options
- A listing file (.LST) if you specify the /list option
- A browser file (.SBR) if you specify the /browser option

You control the production of these files by specifying the appropriate options on the DF command line. Unless you specify the **/compile_only** option or /keep option, the compiler generates a single temporary object file from one or more source files. The linker is then invoked to link the object file into one executable image file.

If fatal errors are encountered during compilation, or if you specify certain options such as /compile_only, linking does not occur.

When a path or file name includes an embedded space or a special character, enclose the entire file location name in double quotation marks ("). For example:

```
DF "Project xyz\fortmain.f90"
```

For more information about naming input and output files, see:

- Naming Output Files
- Temporary Files

Naming Output Files

To specify a file name for the executable image file, you can use one of several DF options:

- The /exe:*file* or the /out:*file* linker option to name an executable program file.
- The /dll:*file* alone or the /dll option with the /out:*file* linker option to name an executable dynamic-link library.

You can also use the /object:*file* option to specify the object file name. If you specify the /compile_only option and omit the /object:*file* option, each source file is compiled into a separate object file. For more information about the output file(s) created by compiling and linking multiple files, see Compiling and Linking Multiple Fortran Source Files.

Many compiler options allow you to specify the name of the *file* being created. If you specify only a filename without an extension, a default extension is added for the file being created, as summarized below:

Default File Extensions for Compiler Options

Option	Default File Extension
/asmfile:*file*	.ASM
/browser:*file*	.SBR
/dll:*file*	.DLL
/exe:*file*	.EXE
/list:*file*	.LST
/map:*file*	.MAP
/pdbfile:*file*	.PDB (default filename is df60.pdb)

Temporary Files

Temporary files created by the compiler or linker reside in the directory used by the operating system to store temporary files. To store temporary files, the operating system first checks for the TMP environment variable.

If the TMP environment variable is defined, the directory that it points to is used for temporary files. If the TMP environment variable is not defined, the operating system checks for the TEMP environment variable. If the TEMP environment variable is not defined, the current working directory is used for temporary files. Temporary files are usually deleted, unless the /keep option was specified. For performance reasons, use a local drive (rather than using a network drive) to contain the temporary files.

To view the file name and directory where each temporary file is created, use the /watch:cmd option. To create object files in your current working directory, use the /compile_only or /keep option. Any object files (.obj files) that you specify on the DF command line are retained.

Environment Variables Used with the DF Command

The following table shows the environment variables that affect the DF command.

Environment Variables Affecting the DF Command

Environment Variable	**Description**
PATH	The PATH environment variable sets the search path.
LIB	The linker uses the LIB environment variable to determine the location of .LIB files. If the LIB environment variable is not set, the linker looks for .LIB files in the current directory.
LINK_F90	The LINK_F90 environment variable contains a list of libraries used for linking IMSL libraries (Professional and Enterprise Editions), as listed in Library Naming Conventions.
INCLUDE	The make facility (NMAKE) uses the INCLUDE environment variable to locate INCLUDE files and module files. The Visual Fortran compiler uses the INCLUDE environment variable to locate files included by an INCLUDE statement or module files referenced by a USE statement. Similarly, the resource compiler uses the INCLUDE environment variable to locate #include and RCINCLUDE files.

DF	The DF environment variable can be used to specify frequently used DF options and files. The options and files specified by the DF environment variable are added to the DF command; they are processed before any options specified on the command line. You can override an option specified in the DF environment variable by specifying an option on the command line. For information about using the DF environment variable to specify frequently-used options, see Using the DF Environment Variable to Specify Options.

You can set these environment variables by using the DFVARS.BAT file or the Fortran Command Prompt command-line window (see "Using the Command-Line Interface" in *Compaq Visual Fortran Installing and Getting Started*).

For a list of environment variables recognized at run-time, see Run-Time Environment Variables.

Specifying Project Types with DF Command Options

This section provides the DF command options that correspond to the visual development environment project types.

When creating an application, you should choose a *project type*. The first four projects are main project types, requiring main programs:

- To create a Fortran Console Application with the DF command, you do not need to specify any options (if you link separately, specify the link option /subsystem:console). This is the default project type created.
- To create a Fortran Standard Graphics Application with the DF command, specify the /libs=qwins option (which also sets certain linker options).
- To create a Fortran QuickWin Application with the DF command, specify the /libs:qwin option (which also sets certain linker options).
- To create a Fortran Windows Application with the DF command, specify the /winapp option (which also sets certain linker options).

To create a Fortran COM Server, you must use Developer Studio (see Creating COM Servers); you cannot create a Fortran COM Server project type with the DF command.

The following types are library projects, without main programs:

- To create a Fortran Dynamic-Link Library with the DF command, specify the /dll option (sets the /libs:dll option).

- To create a Fortran Static library with the DF command:
  - If your application will not call any QuickWin or Standard Graphics routines, specify /libs:static and /compile_only options to create the object files. Use the LIB command to create the library (see Managing Libraries with LIB).
  - If your application will call QuickWin routines, specify /libs:qwin and /compile_only options to create the object files. Use the LIB command to create the library (see Managing Libraries with LIB).
  - If your application will call Standard Graphics routines, specify /libs:qwins and /compile_only options to create the object files. Use the LIB command to create the library (see Managing Libraries with LIB).

For an introduction to Visual Fortran project types, see Types of Projects.

Redirecting Command-Line Output to Files

When using the command line, you can redirect standard output and standard error into separate files or into a single file. How you redirect command-line output depends on which operating system you are using:

- On Windows NT 4 and Windows 2000 systems, to place standard output into file `one.out` and standard error into file `two.out`, type the df command (with its *filenames* and *options*) as follows:

  ```
  df filenames /options 1>one.out 2>two.out
  ```

  You can also use a short-cut form (omit the 1):

  ```
  df filenames /options >one.out 2>two.out
  ```

  To place standard output and standard error into a single file `both.out` on a Windows NT 4 or Windows 2000 system, type the df command as follows:

  ```
  df filenames /options 1>both.out 2>&1
  ```

  You can also use a short-cut form (omit the 1):

  ```
  df filenames /options >both.out 2>&1
  ```

- On Windows 98, Windows Me, and Windows 95 systems, use the EC command-line tool to place standard output and standard error into separate files or into a single file. The EC tool is located on the Visual Fortran CD-ROM in the `x86\Usupport\Misc\Win95` folder. Copy ec.exe into a folder in your command-line path (PATH environment variable) on your hard disk.

Precede the DF command line with the EC command and place the entire DF command in quotes. For example, to place standard output into the file `one.out` and standard error into file `two.out`, type the EC and DF command (with its *filenames* and *options*) as follows:

```
ec "df filenames /options 1>one.out 2>two.out"
```

To place standard output and standard error into a single file `both.out` on a Windows 98, Windows Me, or Windows 95 system, type the EC and DF commands as follows:

```
ec "df filenames /options 1>both.out 2>&1"
```

Using the DF Command to Compile and Link

By default, when you use the DF command, your source files are compiled and then linked. To suppress linking, use the /compile_only option. The following topics show how to use the DF command:

- Compiling and Linking a Single Source File
- Using the DF Environment Variable to Specify Options
- Compiling, but not Linking, a Fortran Source File
- Compiling and Linking Multiple Fortran Source Files
- Generating a Listing File
- Linking Against Additional Libraries
- Linking Object Files
- Compiling and Linking for Debugging
- Compiling and Linking for Optimization
- Compiling and Linking Mixed-Language Programs

Compiling and Linking a Single Source File

The following command compiles x.for, links, and creates an executable file named x.exe. This command generates a temporary object file, which is deleted after linking:

```
DF x.for
```

To name the executable file, specify the /exe option:

```
DF x.for /exe:myprog.exe
```

Alternatively, you can name the executable file by using the linker /out option:

```
DF x.for /link /out:myprog.exe
```

Using the DF Environment Variable to Specify Options

The following command-line sequences show the use of the DF environment variable. In the first command sequence, the SET command sets the DF environment variable. When the DF command is invoked, it uses the options specified by the DF environment variable, in this case, /debug:minimal and /list:

```
set DF=/debug:minimal /list
DF myprog.for
```

You can also specify additional options on the DF command line. In the following command sequence, the SET command sets the DF environment variable. The DF options specified are /debug:minimal and /list.

```
set DF=/debug:minimal /list
DF myprog.for /show:map
```

If the options specified on the command line conflict with the options specified by the DF environment variable, the option specified on the command line takes precedence. In the following command sequence, the /debug:minimal option specified by the DF environment variable is overridden by the /debug:none option specified on the command line:

```
set DF=/debug:minimal /list
DF myprog.for /debug:none
```

Compiling, but not Linking, a Fortran Source File

The following command compiles x.for and generates the object file x.obj. The /compile_only option prevents linking (it does not link the object file into an executable file):

```
DF x.for /compile_only
```

Compiling and Linking Multiple Fortran Source Files

The following command compiles a.for, b.for, and c.for. It creates a single temporary object file, then links the object file into an executable file named a.exe:

```
DF a.for b.for c.for
```

If the files a.for, b.for, and c.for were the only .for files in the current directory, you could use a wildcard character to similarly compile the three source files:

```
DF  *.for
```

If you use the /compile_only option to prevent linking, also use the /object:*file* option so that multiple sources files are compiled into a single object file, allowing more optimizations to occur:

```
DF /compile_only /object:a.obj  a.for b.for c.for
```

When you use modules and compile multiple files, compile the source files that define modules *before* the files that reference the modules (in **USE** statements).

When you use a single DF command, the order in which files are placed on the command line is significant. For example, if the free-form source file moddef.f90 defines the modules referenced by the file projmain.f90, use the following DF command line:

```
DF moddef.f90 projmain.f90
```

Generating a Listing File

To request a listing file, specify the /list option with the DF command. When you request a listing file, a separate listing file is generated for each object file created.

The content of the listing file is affected by the /show option. For more information about this option, see Compiler and Linker Options.

The following command compiles and links a.for, b.for, and c.for. It generates one listing file for the three source files:

```
DF a.for b.for c.for /list
```

The following command compiles a.for, b.for, and c.for. It generates three listing files (and three object files) for the three source files:

```
DF a.for b.for c.for /list /compile_only
```

The following command sequence compiles and links a.for, b.for, and c.for. It generates one named object file (a.obj) and one listing file (a.lst). The second command links the object files into an executable file (a.exe):

```
DF a.for b.for c.for /list /compile_only /object:a.obj
DF a.obj
```

The following command sequence compiles and links a.for, b.for, and c.for. It generates three object files (a.obj, b.obj, and c.obj) and three listing files (a.lst, b.lst, and c.lst). The second command links the object files into an executable file (a.exe):

```
DF a.for b.for c.for /list /compile_only
```

```
DF a.obj b.obj c.obj
```

Linking Against Additional Libraries

By default, the DF command automatically adds the libraries needed to build a Fortran Console application to the link command that it generates.

The /libs:dll option indicates that you want to link against single-threaded DLLs; other /libs options allow you to link against other types of libraries.
The /libs:static option (the default) indicates that you want to link against single-threaded static libraries.

You can link against additional libraries by listing those libraries on the command line.

For example, the following command links against static libraries. In addition to linking against the default libraries, it links against the library `mylib.lib`:

```
DF x.f90 mylib.lib
```

The following command links against single-threaded DLLs:

```
DF x.f90 /libs:dll
```

The following command links against single-threaded DLLs. It links against the default libraries and `mylib.lib`:

```
DF x.f90 /libs:dll mylib.lib
```

To request the creation of a dynamic-link library, see /dll.

For more information on the types of libraries available to link against, see the following options:

- /dbglibs
- /libs
- /threads
- /winapp
- /fpscomp:libs

For more information about compiling and linking Visual Fortran and Visual C++ programs (and the libraries used), see Specifying Consistent Library Types.

Linking Object Files

The following command links x.obj into an executable file. This command automatically links with the default Visual Fortran libraries:

```
DF x.obj
```

Compiling and Linking for Debugging

If you use a single DF command to compile and link, specify the /debug option (/debug sets the default optimization level to /optimize:0), as follows:

```
DF x.for /debug
```

By default, the debugger symbol table information is created in a PDB file, which is needed for the debugger integrated within the visual development environment.

If you use separate DF commands to compile and link, you will want to specify the same debugging information level for the compiler and the linker. For example, if you specify /debug:minimal to the compiler, you will also specify /link /debug:minimal. The following command sequence compiles and then links `x.for` for debugging with the integrated visual development environment debugger:

```
DF x.for /debug:full /optimize:0 /compile_only
DF x.obj /debug:full
```

For more information about preparing your command-line program for debugging, see Preparing Your Program for Debugging.

Compiling and Linking for Optimization

If you omit both the /compile_only and the /keep options, the specified Fortran source files are compiled together into a single object module and then linked. (The object file is deleted after linking.) Because all the Fortran source files are compiled together into a single object module, full interprocedural optimizations can occur. With the DF command, the default optimization level is /optimize:4 (unless you specify /debug with no keyword).

If you specify the /compile_only or /keep option and you want to allow full interprocedural optimizations to occur, you should also specify the /object option. The combination of the /compile_only and /object:*file* options creates a single object file from multiple Fortran source files, allowing full interprocedural optimizations. The object file can be linked later.

The following command uses both the /compile_only and /object options to allow interprocedural optimization (explicitly requested by the /optimize:4 option):

```
DF /compile_only /object:out.obj /optimize:4 ax.for bx.for cx.for
```

If you specify the /compile_only or /keep option without specifying the /object option, each source file is compiled into an object file. This is acceptable if you specified no optimization (/optimize:0) or local optimization (/optimize:1). An information message appears when you specify multiple input files and specify an option that creates multiple object files (such as /compile_only without /object) and specify or imply global optimization (/optimize:2 or higher optimization level).

If you specify the /compile_only option, you must link the object file (or files) later by using a separate DF command. You might do this using a makefile processed by the NMAKE command for incremental compilation of a large application.

However, keep in mind that either omitting the /compile_only or /keep option or using the /compile_only option with the /object:*file* option provides the benefit of full interprocedural optimizations for compiling multiple Fortran source files.

Other optimization options are summarized in Software Environment and Efficient Compilation.

Compiling and Linking Mixed-Language Programs

Your application can contain both C and Fortran source files. If your main program is a Fortran source file (myprog.for) that calls a routine written in C (cfunc.c), you could use the following sequence of commands to build your application:

```
cl -c cfunc.c
DF myprog.for cfunc.obj /link /out:myprog.exe
```

The cl command (invokes the C compiler) compiles but does not link cfunc.c. The -c option specifies that the linker is not called. This command creates cfunc.obj. The DF command compiles myprog.for and links cfunc.obj with the object file created from myprog.for to create myprog.exe.

For more information about compiling and linking Visual Fortran and Visual C++ programs, and the libraries used, see:

- Specifying Consistent Library Types
- Visual Fortran/Visual C++ Mixed-Language Programs.

DF Indirect Command File Use

The DF command allows the use of indirect command files. For example, assume the file `text.txt` contains the following:

```
/pdbfile:testout.pdb /exe:testout.exe /debug:full /optimize:0 test.f90 rest.f90
```

The following DF command executes the contents of file text.txt as an indirect command file to create a debugging version of the executable program and its associated PDB file:

```
DF @test.txt
```

Indirect command files do not use continuation characters; all lines are appended together as one command.

Compiler and Linker Messages

The following sections describe compiler limits and messages:

- Compiler Diagnostic Messages and Error Conditions
- Linker Diagnostic Messages and Error Conditions

For information on compiler limits, see Compiler Limits.

Compiler Diagnostic Messages and Error Conditions

The Visual Fortran compiler identifies syntax errors and violations of language rules in the source program. If the compiler finds any errors, it writes messages to the standard error output file and any listing file. If you enter the DF command interactively, the messages are displayed.

Compiler messages have the following format:

```
filename(n) : severity: message-text
        [text-in-error]
--------^
```

The pointer (---^) indicates the exact place on the source program line where the error was found. The following error message shows the format and message text in a listing file when an **END DO** statement was omitted:

```
echar.for(7): Severe: Unclosed DO loop or IF block
        DO I=1,5
--------^
```

Diagnostic messages usually provide enough information for you to determine the cause of an error and correct it.

When using the command line, make sure that the appropriate environment variables have been set by executing the DFVARS.BAT file. These environment variables are preset if you use the Fortran Command Prompt window in the

Compaq Visual Fortran program folder (see "Using the Command-Line Interface" in *Compaq Visual Fortran Installing and Getting Started*). For example, this BAT file sets the environment variables for the include directory paths.

For errors related to **INCLUDE** and module (**USE** statement) file use, see /[no] include.

For a list of environment variables used by the DF command during compilation, see Environment Variables Used with the DF Command.

To control compiler diagnostic messages (such as warning messages), see /[no] warn.

To view the passes as they execute on the DF command line, specify /watch:cmd or /watch:all.

Linker Diagnostic Messages and Error Conditions

If the linker detects any errors while linking object modules, it displays messages about their cause and severity. If any errors occur, the linker does not produce an executable file.

Linker messages are descriptive, and you do not normally need additional information to determine the specific error. For a description of each Linker message, see Linker Messages (LNK*xxxx*).

To view the libraries being passed to the linker on the DF command line, specify /watch:cmd or /watch:all.

On the command line, make sure the DFVARS.BAT file was executed to set the appropriate environment variables (see "Using the Command-Line Interface" in *Compaq Visual Fortran Installing and Getting Started*). For example, this BAT file sets the environment variables for the library directory paths. For a list of environment variables used by the DF command during compilation, see Environment Variables Used with the DF Command.

You specify the libraries to be linked against using compiler options in the Libraries category (see Categories of Compiler Options, Libraries category). Also, you can specify libraries (include the path, if needed) on the command line.

With the Professional and Enterprise Editions, if you have trouble linking IMSL libraries, specify the /imsl option and see also Using the IMSL Libraries from Visual Fortran.

For information on handling build errors in the visual development environment, see Errors During the Build Process.

Compiler and Linker Options

Most of the compiler and linker options can be specified within the Microsoft visual development environment or on the command line. This section contains a description of the options available to you in building programs.

You can set *compiler options* from:

- Within the visual development environment, by using the Fortran tab in the Project menu, Settings dialog box.
- The DF command line. Compiler options must precede the /LINK option.

Unless you specify certain options, the DF command line will both compile and link the files you specify. To compile without linking, specify the /compile_only (or equivalent) option.

After the /LINK option on the DF command line, you can specify *linker options*. Linker options and any libraries specified get passed directly to the linker, such as /NODEFAULTLIB. If you choose to use separate compile and link commands, you can also specify linker options on a separate LINK command.

This section contains the following information:

Compiler Options

This section describes the compiler options and how they are used. It includes the following topics:

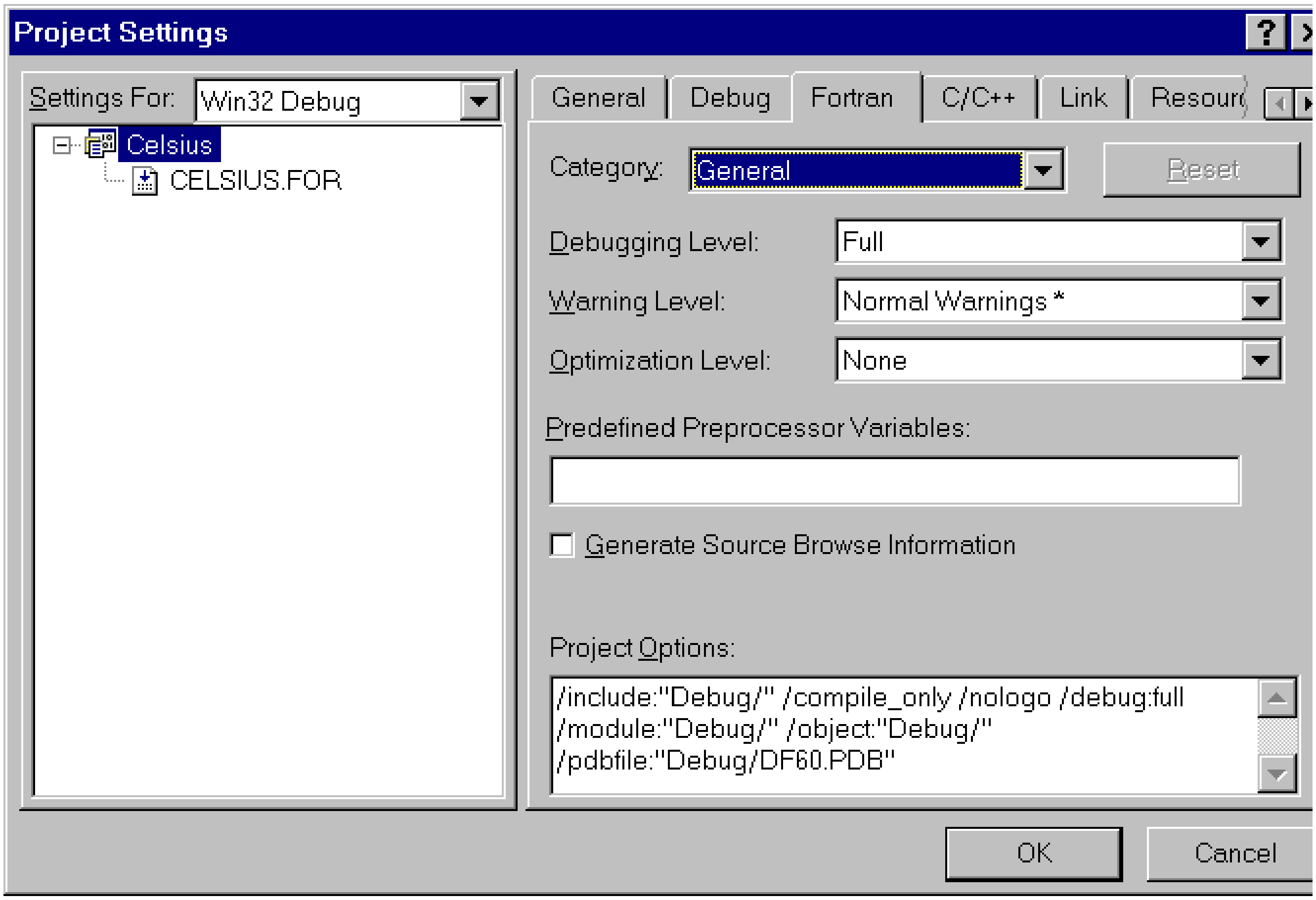
- Categories of compiler options, according to functional grouping.
- Descriptions of each compiler option, listed alphabetically.

Categories of Compiler Options

If you will be using the compiler and linker from the command line, specify the options needed on the DF command line (as described in Using the Compiler and Linker from the Command Line). You can use the functional categories of options below to locate the options needed for your application.

If you will be using the compiler and linker from the Microsoft visual development environment, select the options needed by using the various tabs in the Project menu Settings item (see Project Settings). The following graphic shows a sample Fortran tab:

Project Settings, Fortran Tab



The options are grouped under functional categories (the initial Category is General, as shown) to help you locate the options needed for your application. From the Fortran tab, you can select one of the following categories from the Category drop-down list (exception: those options listed in the Miscellaneous category below):

General	Code Generation
Compatibility	Compilation Diagnostics
Debug	External Procedures
Floating Point	Fortran Data
Fortran Language	Libraries
Listing Files	Miscellaneous
Optimizations	Preprocessor

Run-Time

If a compiler option is not available in the dialog boxes, you can enter the option in the lower part of the Project Settings dialog box just as you would at the command line (under Project Options:).

The following tables list the Visual Fortran compiler options by category in the Fortran tab:

General-Purpose Options

Debugging Level	/[no]debug
Warning Level	/warn
Optimization Level	/[no]optimize
Predefined Preprocessor Symbols	/define
Generate Source Browse Information	/[no]browser[:*file*]

Code Generation Options

Generate Most-Optimized Code	/[no]fast (changes multiple options)
Enable Recursive Routines	/[no]recursive
Object text *string* inserted into object file	/bintext:*string*
Math Library: Checking or Fast Performance	/math_library
Generate Code for *xxx* Chip	/architecture

Compatibility Options (See also Fortran Data)

Unformatted File Conversion (Nonnative Data)	/convert (also see /assume:[no]byterecl)
Enable VMS Compatibility	/[no]vms
Enable F77 Run-Time Compatibility	/[no]f77rtl
Use F77 Integer Constants	/[no]intconstant

Microsoft Fortran PowerStation V4 Compatibility Options	/[no]fpscomp (various keywords listed below)
Microsoft Fortran PowerStation: Filenames from Command Line	/fpscomp:[no]filesfromcmd
Microsoft Fortran PowerStation: I/O Format	/fpscomp:[no]ioformat
Microsoft Fortran PowerStation: Libraries	/fpscomp:[no]libs
Microsoft Fortran PowerStation: List Directed I/O Spacing	/fpscomp:[no]ldio_spacing
Microsoft Fortran PowerStation: Logical Values	/fpscomp:[no]logicals
Microsoft Fortran PowerStation: Other Run-time Behavior	/fpscomp:[no]general
Microsoft Fortran PowerStation: Predefined Preprocessor Symbols	/fpscomp:[no]symbols

Compilation Diagnostic Options

Compilation Error Limit	/[no]error_limit
Warning Levels (Ignore, Normal, Treat Warnings as Errors)	/warn:nogeneral, default settings, or /warn:errors
Fortran Standards Checking (None, Fortran 90, or Fortran 95)	/stand:*keyword*
Treat Fortran Standard Warnings as Errors	/warn:[no]stderrors
Argument Mismatch	/warn:[no]argument_checking
Data Alignment	/warn:[no]alignments
Inform when Compiling Files Separately (effect on interprocedure optimization)	/warn:[no]fileopt
Truncated Source	/warn:[no]truncated_source
Uncalled Routines	/warn:[no]uncalled
Undeclared Variables/Symbols	/warn:[no]declarations
Uninitialized Variables	/warn:[no]uninitialized

Unused Variables	/warn:[no]unused
Usage (Fortran language)	/warn:[no]usage

Debug Options

Debugging Level (None, Minimal, Partial, Full)	/[no]debug
Compile Lines With D in Column 1	/[no]d_lines
Use Program Database for Debug Information and File Name	/[no]pdbfile [:*file*]

External Procedures (and Argument Passing) Options

Argument Passing Conventions	/[no]iface:*keyword*
External Names Case Interpretation	/names:*keyword*
String Length Argument Passing	/[no]iface:mixed_str_len_arg
Append Underscore to External Names	/assume:[no]underscore

Fortran Data Options (See also Compatibility)

Default REAL and COMPLEX Kind	/real_size:*num*
Default INTEGER and LOGICAL Kind	/integer_size:*num*
Append Underscore to External Names (under Data Options)	/assume:[no]underscore
Enable Dummy Arguments Sharing Memory Locations	/assume:[no] dummy_aliases
Extend Precision of Single-Precision Constants	/[no]fpconstant
Use Bytes as RECL= Unit for Unformatted Files	/assume:[no]byterecl
Variables Default to Automatic or Static Storage	/[no]automatic or /[no] static
Common Element Alignment	/[no]alignment:[no] common

Structure Element Alignment (Derived Type and Record Data)	/alignment:[no]records
Allow SEQUENCE Types to be Padded for Alignment	/alignment:[no]sequence

Floating-Point Options (See also Optimizations)

Floating-Point Exception Handling	/fpe
Enable Floating-Point Consistency	/[no]fltconsistency (ia32 only)
Extend Precision of Single-Precision Constants	/[no]fpconstant
Enable IEEE Minus Zero Support	/assume:[no]minus0

Fortran Language Options

Enable FORTRAN 66 Semantics	/[no]f66
Enable Alternate PARAMETER Syntax	/[no]altparam
Name Case Interpretation	/names:*keyword*
Source Form (File Extension, Fixed Form, or Free Form)	/[no]free or /[no] fixed
Fixed-Form Line Length	/[no]extend_source
Pad Fixed-Form Source Records	/[no]pad_source

Library Options (See also External Procedures)

Enable Reentrancy Support	/[no]reentrancy
Use Run-Time Libraries, DLL version	/libs:dll
Use Run-Time Libraries, Static library version	/libs:static
Use Run-Time Libraries, QuickWin version	/libs:qwin
Use Run-Time Libraries, Standard Graphics version	/libs:qwins
Use Run-Time Libraries, Debug version	/[no]dbglibs

Use Run-Time Libraries, Multi-Threaded version	/[no]threads
Disable Default Library Search Rules	/libdir:noauto
Disable OBJCOMMENT Library Names in Object	/libdir:nouser
Use Common Windows Libraries	/winapp
Use Compaq Extended Math Library (CXML)	/cxml
Use IMSL Math Libraries	/imsl

Listing and Assembly File Options

Source Listing	/[no]list
Contents of Source Listing File	/show:*keyword*... or /[no]machine_code
Annotations	/annotations:*keyword*
Assembly Listing	/[no]asmfile [:*file*] and /[no]asmattributes

Miscellaneous Linker Tab and Command-Line Options (Not Listed in Fortran Tab)

Specify Linker Options (after /link)	/link (use Linker tab)
Generate Link Map	/[no]map (use Linker tab)
Compile, Do Not Link	/compile_only or /c (use Compile in Build menu)
Create Dynamic Link Library (DLL project type)	/dll and Specifying Project Types with DF Command Options
Software Instruction Scheduling	/[no]pipeline (ia64 only; command line only)
Display Help Text File	/help or /? (command line only)
Specify Custom File Extension for Compiler	/source (command line only)
Specify Custom File Extension for Compiler	/extfor (command line only)

Specify Custom File Extension for Linker	/extlnk (command line only)
Create one object file for each input source file	/[no]keep (command line only)
Name of Executable Program or DLL File	/[no]exe[:*file*] (command line only)
Name of Object File	/[no]object[:*file*] (command line only)
Perform Syntax Check Only (No Object File)	/[no]syntax_only (command line only)
Display Copyright and Compiler Version	/nologo and /what (command line only)
Display Compilation Details	/[no]watch (command line only)
Write C-Style Comments for FPP	/comments (command line only; for FPP)
Specify Custom File Extension for FPP	/extfpp (command line only)
Only Preprocess FPP Files	/preprocess_only (command line only)
Undefine Preprocessor Symbols	/undefine (command line only)

Optimization Options (See also Code Generation)

Optimization Level	/[no]optimize
Variables Default to Automatic Storage	/[no]automatic
Enable Dummy Arguments Sharing Memory Locations	/assume:[no]dummy_aliases
Transform Loops	/[no]transform_loops
Enable I/O Buffering	/assume:[no]buffered_io
Loop Unrolling	/unroll
Math Library: Checking or Fast Performance	/math_library
Inlining Procedures	/[no]inline

Code Tuning for *xxx* chip	/tune
Allow Reordering of Floating-Point Operations	/assume:[no]accuracy_sensitive
Software Instruction Scheduling	/[no]pipeline (ia64 only; command line only)

Preprocessor Options

Define Preprocessor Symbols	/define
Default INCLUDE and USE Path	/assume:[no]source_include
Module path (to place module files)	/module[:*file*]
INCLUDE and USE Path	/[no]include
Use FPP and specify options	/fpp[:"options"]
Predefined Preprocessor Symbols to FPP Only	/nodefine

Run-Time Options

Generate Traceback Information	/[no]traceback
Default Output Carriage Control	/ccdefault:*keyword*
Array and String Bounds	/check:[no]bounds
Integer Overflow	/check:[no]overflow
Floating-Point Underflow	/check:[no]underflow
Power Operations	/check:[no]power
Edit Descriptor Data Type	/check:[no]format
Flawed Pentium® Chip	/check:[no]flawed_pentium (ia32 only)
Edit Descriptor Data Size	/check:[no]output_conversion

For a table of DF command options listed alphabetically, see Compiler Options, Alphabetic List.

/[no]alignment

Syntax:

> **/alignment**[:*keyword...*], **/noalignment**, or **/Zp***n*

The /alignment option specifies the alignment of data items in common blocks, record structures, and derived-type structures. The /Zp*n* option specifies the alignment of data items in derived-type or record structures.

The /alignment options are:

- /align:[no]commons

  The /align:commons option aligns the data items of all **COMMON** data blocks on natural boundaries up to four bytes. The default is /align:nocommons (unless /fast is specified), which does not align data blocks on natural boundaries. In the visual development environment, specify the Common Element Alignment as 4 in the Fortran Data Compiler Option Category.

- /align:dcommons

  The /align:dcommons option aligns the data items of all **COMMON** data blocks on natural boundaries up to eight bytes. The default is /align:nocommons (unless /fast is specified), which does not align data blocks on natural boundaries. Specifying /fast sets /align:dcommons. In the visual development environment, specify the Common Element Alignment as 8 in the Fortran Data Compiler Option Category.

- /align:[no]records

  The /align:records option (the default) requests that components of derived types and fields of records be aligned on natural boundaries up to 8 bytes (for derived types with the **SEQUENCE** statement, see /align:[no]sequence below). The /align:norecords option requests that components and fields be aligned on arbitrary byte boundaries, instead of on natural boundaries up to 8 bytes. In the visual development environment, specify the Structure Element Alignment in the Fortran Data Compiler Option Category.

- /align:[no]sequence

  The /align:sequence option requests that components of derived types with the **SEQUENCE** statement will obey whatever alignment rules are currently in use (default alignment rules will align unsequenced components on natural boundaries). The default value (unless /fast is specified) is /align:nosequence, which means that components of derived types with the **SEQUENCE** property will be packed, regardless of whatever alignment rules are currently in use. Specifying /fast sets /align:sequence.

In the visual development environment, specify Allow SEQUENCE Types to be Padded for Alignment in the Fortran Data Compiler Option Category.

- /align:rec*N*byte or /Zp*n*

  The /align:rec*N*byte or /Zp*n* options request that fields of records and components of derived types be aligned on the smaller of:

  - The size byte boundary (*N*) specified.
  - The boundary that will naturally align them.

  Specifying /align:rec*N*byte, /Zp*n*, or /align:[no]records does not affect whether common block fields are naturally aligned or packed. In the visual development environment, specify the Structure Element Alignment in the Fortran Data Compiler Option Category.

Specifying	**Is the Same as Specifying**
/Zp	/alignment:records or /align:rec8byte
/Zp1	/alignment:norecords or /align:rec1byte
/Zp2	/align:rec2byte
/Zp4	/align:rec4byte
/alignment	/Zp8 with /align:dcommons, /alignment:all, or /alignment:(dcommons,records)
/noalignment	/Zp1, /alignment:none, or /alignment:(nocommons,nodcommons,norecords)
/align:rec1byte	/align:norecords
/align:rec8byte	/align:records

When you omit the /alignment option, records and components of derived types are naturally aligned, but fields in common blocks are packed. This default is equivalent to:

```
/alignment=(nocommons,nodcommons,records,nosequence)
```

You can also control the alignment of components in records and derived types and data items in common blocks by Using the cDEC$ OPTIONS Directive.

/[no]altparam

Syntax:

/altparam, **/noaltparam**, **/4Yaltparam**, or **/4Naltparam**

The /altparam option determines how the compiler will treat the alternate syntax for PARAMETER statements, which is:

```
PARAMETER par1=exp1 [, par2=exp2] ...
```

This form does not have parentheses around the assignment of the constant to the parameter name. With this form, the type of the parameter is determined by the type of the expression being assigned to it and not by any implicit typing.

In the visual development environment, specify the Enable Alternate PARAMETER Syntax in the Fortran Language Compiler Option Category.

When the /[no]altparam or equivalent options are not specified, the compiler default will be to allow the alternate syntax for **PARAMETER** statements (/altparam).

To disallow use of this form, specify /noaltparam or /4Naltparam. To allow use of this form, allow the default or specify /altparam or /4Yaltparam.

/[no]annotations

Syntax:

/annotations:*keyword* or **/noannotations**

The /annotations option specifies that additional information will be added to the source listing file. This information indicates which of a set of optimizations the compiler applied to particular parts of the source file. Note that some of the values of *keyword* may exist for optimizations that are not supported on your platform. If so, the source listing file contains no corresponding annotations (such as feedback). In the visual development environment, specify the various annotations keywords under the Annotations list box in the Listing Compiler Option Category.

You can view the resulting annotations in the source listing file to see what optimizations the compiler performed or else why the compiler was not able to optimize a particular code sequence. The default is /noannotations, which places no annotations in the source listing file.

The /annotations option *keywords* are as follows:

- /annotations:none

  Same as /noannotations, the default value.
- /annotations:all

  Specifying /annotations all selects all of the following annotations.
- /annotations:code

  Specifying /annotations:code annotates the machine code listing with descriptions of special instructions used for prefetching, alignment, and so on.
- /annotations:detail

  Specifying /annotations:detail provides, where available, an additional level of annotation detail.
- /annotations:feedback

  Specifying /annotations:feedback provides information about any feedback optimizations (not available for Windows systems).
- /annotations:inlining

  Specifying /annotations:inlining indicates where code for a called procedure was expanded inline.
- /annotations:loop_transforms

  Specifying /annotations:loop_transforms indicates where advanced loop nest optimizations have been applied to improve cache performance (unroll and jam, loop fusion, loop interchange, and so on).
- /annotations:loop_unrolling

  Specifying /annotations:loop_unrolling indicates where a loop was unrolled (contents expanded multiple times).
- /annotations:prefetching

  Specifying /annotations:prefetching indicates where special instructions were used to reduce memory latency.
- /annotations:shrinkwrapping

  Specifying /annotations:shrinkwrapping indicates removal of code establishing routine context when it is not needed.
- /annotations:software_pipelining

  Specifying /annotations:software_pipelining indicates where instructions have been rearranged to make optimal use of the processor's functional units (not available for ia32 systems).
- /annotations:tail_calls

Specifying /annotations:tail_calls indicates an optimization where a call from one routine to another can be replaced with a jump.

- /annotations:tail_recursion

  Specifying /annotations:tail_recursion indicates an optimization that eliminates unnecessary routine context for a recursive call.

The /annotations option is ignored unless you also specify the /list[:*file*] option or select the equivalent Source Listing option in the Listing File category in the visual development environment.

/architecture

Syntax:

/architecture:*keyword*

The /architecture (/arch) option controls the types of processor-specific instructions generated for this program unit. The /arch:*keyword* option uses the same keywords as the /tune:*keyword* option.

All processors of a certain architecture type (ia32) implement a core set of instructions. Certain (more recent) processor versions include additional instruction extensions.

Whereas the /tune:*keyword* option is primarily used by certain higher-level optimizations for instruction scheduling purposes, the /arch:*keyword* option determines the type of machine-code instructions generated for the program unit being compiled.

In the visual development environment, specify the Generate Code For in the Code Generation Compiler Option Category.

For ia32 (Intel and AMD) 32-bit processor systems, the supported /arch keywords are:

- /arch:generic

  Generates code (sometimes called blended code) that is appropriate for processor generations for the architecture type in use. This is the default. Programs compiled on an ia32 system with the generic keyword will run on all ia32 systems.

- /arch:host

  Generates code for the processor generation in use on the system being used for compilation. Depending on the host system used on ia32 systems, the program may or may not run on other ia32 systems. Using /arch:host on a:

- Intel Pentium processor system selects the pn1 keyword
- Intel Pentium Pro, Intel Pentium II, or AMD K6 processor system selects the pn2 keyword
- Intel Pentium III processor system selects the pn3 keyword
- AMD K6_2 or AMD K6_III processor system selects the k6_2 keyword
- AMD Athlon processor system selects the k7 keyword
- Intel Pentium 4 processor system selects the pn4 keyword

- /arch:pn1

  Generates code for the Pentium processor systems. Programs compiled with the pn1 keyword will run correctly on Pentium, Pentium Pro, Pentium II, Pentium III, AMD K6, and higher processors, but should *not* be run on 486 processors. The pn1 keyword replaces the p5 keyword (specifying /arch:pn1 and /arch:p5 are equivalent).

- /arch:pn2

  Generates code for the Pentium Pro, Pentium II, and AMD K6 processor systems only. Programs compiled with the pn2 or k6 keyword will run correctly on Pentium Pro, Pentium II, AMD K6, Pentium III, and higher processors, but should *not* be run on 486 or Pentium processors. The pn2 keyword replaces the p6 keyword (specifying /arch:pn2 and /arch:p6 are equivalent).

- /arch:k6

  Generates code for the AMD K6 (same as Pentium II systems) processor systems only. Programs compiled with the k6 or pn2 keyword will run correctly on Pentium Pro, Pentium II, AMD K6, Pentium III, and higher processors, but should *not* be run on 486 or Pentium processors.

- /arch:pn3

  Generates code for the Pentium III, AMD K6_2, and AMD K6_III processor systems only. Programs compiled with the pn3 keyword will run correctly on Pentium III, AMD K6_2, AMD K6_III, Pentium 4, and higher processors, but should *not* be run on 486, Pentium, Pentium Pro, Pentium II, or AMD K6 processors. The pn3 keyword replaces the p6p keyword (specifying /arch:pn3 and /arch:p6p are equivalent).

- /arch:k6_2

  Generates code for the AMD K6_2 and AMD K6_III processor systems.

Programs compiled with the k6_2 keyword will run correctly on AMD K6_2, AMD K6_III, and AMD Athlon™ processors, but should *not* be run on 486, Pentium, Pentium Pro, Pentium II (same as AMD K6), Pentium III, or Pentium 4 processors.

- /arch:k7

  Generates code for the AMD Athlon processor systems only. Programs compiled with the k7 keyword will run correctly on AMD Athlon processors, but should *not* be run on 486, Pentium, Pentium Pro, Pentium II (same as AMD K6), Pentium III, Pentium 4, AMD K6_2, or AMD K6_III processors.

- /arch:pn4

  Generates code for the Pentium 4 processor systems only. Programs compiled with the pn4 keyword will run correctly on Pentium 4 processors, but should *not* be run on 486, Pentium, Pentium Pro, or Pentium II (same as AMD K6), Pentium III, AMD K6_2, AMD K6_III, or AMD Athlon processors.

Other processors (not listed) that have instruction-level compatibility with the processors listed above will have results similar to those processors.

For ia64 (64-bit) systems, specify either /arch:generic or /arch:host.

The following table shows the ia32 /arch:*keywords* and the systems that programs using these keywords can be used on:

keyword	**AMD K6**	**AMD K6_2**	**AMD K6_III**	**AMD Athlon**	**Intel 486**	**Intel Pentium**	**Intel Pentium Pro and Pentium II**	**Intel Pentium III**	**Intel Pentium 4**
generic	*	*	*	*	X	*	*	*	*
pn1	*	*	*	*		X	*	*	*
pn2	*	*	*	*			X	*	*
pn3		*	*	*				X	*

pn4								X
k6	X	*	*	*		*	*	*
k6_2		X	X	*				
k7				X				

Legend: * indicates supported combinations of keyword and processor type

X indicates the best code generation combination of keyword and processor type

Specifying /fast sets /arch:host.

For more information:

- About timing program execution, see Analyze Program Performance.
- About the types of instructions used by the various keywords, see Requesting Code Generation for a Specific Processor Generation

/[no]asmattributes

Syntax:

> **/asmattributes**:*keyword*, **/noasmattributes**, **/FA**, **/FAs**, **/FAc**, or **/FAcs**

The /asmattributes option indicates what information, in addition to the assembly code, should be generated in the assembly listing file.

In the visual development environment, specify Assembly Options in the Listing File Compiler Option Category. The /asmattributes options are:

- /asmattributes:source or /FAs

  Intersperses the source code as comments in the assembly listing file.

- /asmattributes:machine or /FAc

  Lists the hex machine instructions at the beginning of each line of assembly code.

- /asmattributes:all or /FAcs

Intersperses both the source code as comments and lists the hex machine instructions at the beginning of each line of assembly code. This is equivalent to /asmattributes.

- /asmattributes:none or /FA

  Provides neither interspersed source code comments nor a listing of hex machine instructions. This is equivalent to /noasmattributes.

If you omit the /asmattributes option, /asmattributes:none is used (default).

The /asmattributes option is ignored if the /[no]asmfile[:file] option is *not* specified. The /FA, /FAs, /FAc, or /FAcs options can be used without the /[no] asmfile[:file] option.

/[no]asmfile

Syntax:

/asmfile[:*file*], **/noasmfile**, **/Fa**[*file*], **/Fc**[*file*], **/Fl**[*file*], or **/Fs**[*file*]

The /asmfile option or equivalent /F*x* option indicates that an assembly listing file should be generated. If the *file* is not specified, the default filename used will be the name of the source file with an extension of .asm.

In the visual development environment, specify Assembly Listing in the Listing File Compiler Option Category.

When the /asmfile option or equivalent /F*x*[*file*] option is specified and there are multiple source files being compiled, each source file will be compiled separately. Compiling source files separately turns off interprocedural optimization from being performed.

When you specify /noasmfile or the /asmfile option is not specified, the compiler does not generate any assembly files.

To specify the content of the assembly listing file, also specify /[no] asmattributes:*keyword* or specify the /F*x*[*file*] options:

- /FA[*file*] provides neither interspersed source code comments nor a listing of hex machine instructions.
- /FAs[*file*] provides interspersed source code as comments in the assembly listing file.
- /FAc[*file*] provides a list of hex machine instructions at the beginning of each line of assembly code.
- /FAcs[*file*] provides interspersed source code as comments and lists hex

machine instructions at the beginning of each line of assembly code.

/assume

Syntax:

/assume:*keyword*

The /assume option specifies assumptions made by the Fortran syntax analyzer, optimizer, and code generator. These option keywords are:

/assume:[no]accuracy_sensitive	/assume:[no]buffered_io
/assume:[no]byterecl	/assume:[no]dummy_aliases
/assume:[no]minus0	/assume:[no]protect_constants
/assume:[no]source_include	/assume:[no]underscore

The /assume options are:

- /assume:[no]accuracy_sensitive

  Specifying /assume:noaccuracy_sensitive allows the compiler to reorder code based on algebraic identities (inverses, associativity, and distribution) to improve performance. In the visual development environment, specify Allow Reordering of Floating-Point Operations in the Optimizations Compiler Option Category.

  The numeric results can be slightly different from the default (/assume:accuracy_sensitive) because of the way intermediate results are rounded.

  Numeric results with /assume:noaccuracy_sensitive are not categorically less accurate. They can produce more accurate results for certain floating-point calculations, such as dot product summations. For example, the following expressions are mathematically equivalent but may not compute the same value using finite precision arithmetic:

  ```
  X = (A + B) - C
  X = A + (B - C)
  ```

  If you omit /assume:noaccuracy_sensitive and omit /fast, the compiler uses a limited number of rules for calculations, which might prevent some optimizations.

  If you specify /assume:noaccuracy_sensitive, or if you specify /fast and omit /assume:accuracy_sensitive, the compiler can reorder code based on algebraic identities to improve performance.

For more information on /assume:noaccuracy_sensitive, see Arithmetic Reordering Optimizations.

- /assume:[no]buffered_io

  The /assume:buffered_io option controls whether records are written (flushed) to disk as each record is written (default) or accumulated in the buffer.

  For disk devices, /assume:buffered_io (or the equivalent **OPEN** statement BUFFERED='YES' specifier or the FORT_BUFFERED run-time environment variable) requests that the internal buffer will be filled, possibly by many record output statements (**WRITE**), before it is written to disk by the Fortran run-time system. If a file is opened for direct access, I/O buffering will be ignored.

  Using buffered writes usually makes disk I/O more efficient by writing larger blocks of data to the disk less often. However, if you request buffered writes, records not yet written to disk may be lost in the event of a system failure.

  Unless you set the FORT_BUFFERED environment variable to TRUE, the default is BUFFERED='NO' and /assume:nobuffered_io for all I/O, in which case, the Fortran run-time system empties its internal buffer for each **WRITE** (or similar record output statement).

  The **OPEN** statement BUFFERED specifier applies to a specific logical unit. In contrast, the /assume:[no]buffered_io option and the FORT_BUFFERED environment variable apply to all Fortran units.

  In the visual development environment, to enable /assume:buffered_io, specify the Enable I/O Buffering in the Optimizations Compiler Option Category.

  For more information on /assume:buffered_io, see Efficient Use of Record Buffers and Disk I/O.

- /assume:[no]byterecl

  The /assume:byterecl option applies only to unformatted files. In the visual development environment, specify the Use Bytes as Unit for Unformatted Files in the Fortran Data Compiler Option Category. Specifying the /assume:byterecl option:

  - Indicates that the units for an explicit **OPEN** statement RECL specifier value are in bytes.
  - Forces the record length value returned by an **INQUIRE** by output list to be in byte units.

  Specifying /assume:nobyterecl indicates that the units for RECL values with unformatted files are in four-byte (longword) units. This is the default.

- /assume:[no]dummy_aliases

  Specifying the /assume:dummy_aliases option *requires* that the compiler assume that dummy (formal) arguments to procedures share memory locations with other dummy arguments or with variables shared through use association, host association, or common block use. The default is /assume:nodummy_aliases.

  In the visual development environment, specify Enable Dummy Argument Aliasing in the Fortran Data (or Optimizations) Compiler Option Category.

  These program semantics do not strictly obey the Fortran Standard and they slow performance. If you omit /assume:dummy_aliases, the compiler does not need to make these assumptions, which results in better run-time performance. However, omitting /assume:dummy_aliases can cause some programs that depend on such aliases to fail or produce wrong answers.

  You only need to compile the called subprogram with /assume:dummy_aliases.

  If you compile a program that uses dummy aliasing with /assume:nodummy_aliases in effect, the run-time behavior of the program will be unpredictable. In such programs, the results will depend on the exact optimizations that are performed. In some cases, normal results will occur; however, in other cases, results will differ because the values used in computations involving the offending aliases will differ.

  For more information, see Dummy Aliasing Assumption.

- /assume:[no]minus0

  This option controls whether the compiler uses Fortran 95 standard semantics for the IEEE floating-point value of -0.0 (minus zero) in the **SIGN** intrinsic, if the processor is capable of distinguishing the difference between -0.0 and +0.0. The default is /assume:nominus0, where the value -0.0 or +0.0 in the **SIGN** function is treated as 0.0.

  To request Fortran 95 semantics to allow use of the IEEE value -0.0 in the

SIGN intrinsic, specify /assume:minus0.

In the visual development environment, specify Enable IEEE Minus Zero Support in the Floating Point Compiler Option Category.

- /assume:[no]protect_constants

  This option specifies whether constant actual arguments can be changed. By default, actual arguments that are constants are read-only (/assume:protect_constants). To allow changes to actual arguments that are constants, specify /assume:noprotect_constants.

  In the visual development environment, specify Constant Actual Arguments are Read-Only in the Fortran Data Compiler Option Category.

- /assume:[no]source_include

  This option controls the directory searched for module files specified by a **USE** statement or source files specified by an **INCLUDE** statement:

  - Specifying /assume:source_include requests a search for module or include files in the directory where the source file being compiled resides. This is the default.
  - Specifying /assume:nosource_include requests a search for module or include files in the current (default) directory.

  In the visual development environment, specify the Default INCLUDE and USE Paths in the Preprocessor Compiler Option Category.

- /assume:[no]underscore

  Specifying /assume:underscore option controls the appending of an underscore character to external user-defined names: the main program name, named **COMMON**, **BLOCK DATA**, and names implicitly or explicitly declared **EXTERNAL**. The name of blank **COMMON** remains _BLNK__, and Fortran intrinsic names are not affected.

  In the visual development environment, specify Append Underscore to External Names in the External Procedures (or Fortran Data) Compiler Option Category.

  Specifying /assume:nounderscore option does not append an underscore character to external user-defined names. This is the default.

For example, the following command requests the noaccuracy_sensitive and nosource_include keywords and accepts the defaults for the other /assume keywords:

```
df /assume:(noaccuracy_sensitive,nosource_include)  testfile.f90
```

/[no]automatic

Syntax:

/automatic, **/noautomatic**, **/4Ya**, or **/4Na**

The /automatic or /4Ya option requests that local variables be put on the run-time stack. In the visual development environment, specify Variables Default to Automatic in the Fortran Data (or Optimizations) Compiler Option Category.

The /noautomatic or /4Na option is the same as the /static option. The default is /noautomatic or /4Na, which causes all local variables to be statically allocated.

If you specify /recursive, the /automatic (/4Ya) option is set.

/bintext

Syntax:

/bintext:*string* or **/V***string*

Specifying /bintext (or /V) places the text *string* specified into the object file (.OBJ) being generated by the compiler. This *string* also gets propagated into the executable file. For example, the string might contain version number or copyright information.

In the visual development environment, specify Object Text in the Code Generation Compiler Option Category.

If the string contains a space or tab, the string must be enclosed by double quotation marks ("). A backslash (\) must precede any double quotation marks contained within the string.

If the command line contains multiple /bintext or /V options, the last (right-most) one is used. You can specify /nobintext to override previous /bintext or /V options on the same command line.

/[no]browser

Syntax:

/browser[:*filename*], **/nobrowser**, or **/FR**

The /browser or /FR option controls the generation of source browser information. When the /browser option is not specified, the compiler will not generate browser files (same as /nobrowser).

In the visual development environment, specify Generate Source Browse Information in the General Compiler Option Category. Also, in the BrowseInfo tab, set Build Browse info check box.

Browser information includes:

- Information about all the symbols in the source file
- The source code line in which a symbol is defined
- Each source code line where there is a reference to a symbol
- The relationships between calling functions and called functions

The default extension for source browser files is .SBR.

The browser output is intended to be used as input to the Browse Information File Maintenance Utility (BSCMAKE), which generates a browse information file (.BSC) that can be examined in browse windows in the Microsoft visual development environment.

Instead of using BCSMAKE, you can use the Project Settings dialog box in the visual development environment:

- Click the BrowseInfo tab.
- Set the Build browse info file check box.

When the /browser or /FR option is specified and there are multiple source files being compiled, each source file will be compiled separately. Compiling source files separately turns off interprocedure optimizations.

/ccdefault

Syntax:

/ccdefault:*keyword...*

The /ccdefault option specifies the default carriage control when a file is displayed on a terminal screen.

In the visual development environment, specify the Default Output Carriage Control in the Run-Time Compiler Option Category. The /ccdefault keywords are as follows:

- /ccdefault:default

Allows other options, such as Compatibility option /vms, to affect this default setting:

- If /vms is specified with /ccdefault:default, carriage control defaults to FORTRAN (/ccdefault:fortran) if the file is formatted, and the unit is connected to a terminal.
- If /novms (default) is specified with /ccdefault:default, carriage control defaults to LIST (/ccdefault:list).

- /ccdefault:fortran

  Uses normal Fortran interpretation of the first character, such as the character "0" resulting in a blank line before output.

- /ccdefault:list

  Adds one line-feed between records.

- /ccdefault:none

  Uses no carriage control processing.

/[no]check

Syntax:

/check:*keyword*, **/nocheck**, **/4Yb**, **/4Nb**

The /check, /4Yb, or /4Nb options control whether extra code is generated for certain run-time checking. Run-time checks can result in issuing run-time messages for certain conditions.

In the visual development environment, specify the Runtime Error Checking items in the Run time Compiler Option Category. The /check options are as follows:

/check:arg_temp_created (Actual Arguments use Temporary Storage)	/check:bounds (Array and String bounds)
/check:flawed_pentium (ia32 systems) (Flawed Pentium)	/check:format (Edit Descriptor Data Type)
/check:output_conversion (Edit Descriptor Data Size)	/check:overflow (Integer Overflow)

/check:power (Power Operations)	/check:underflow (Floating Point Underflow)
/4Yb	/check:none, /nocheck, or /4Nb
/check or /check:all	

If you omit these options, the default is:
/check:
(noarg_temp_created,nobounds,flawed_pentium,noformat,nopower,nooutput_con

When using the visual development environment debug configuration, the default for bounds checking changes from /check:nobounds to /check:bounds.

The /check keywords and /4Yb, and /4Nb options are:

- /check:arg_temp_created

  Requests that a run-time informational message appear if actual arguments are copied into temporary storage before routine calls. Specifying /check:noarg_temp_created (the default) does not generate the extra code needed to display a message run-time when this condition occurs.

- /check:bounds

  Requests a run-time error message if a reference to an array subscript or character substring is outside of the declared bounds. The default for the command line and the release configuration (visual development environment) is /check:nobounds, which does not issue a run-time message for this condition. The default for the debug configuration is /check:bounds, which issues a run-time message for an out-of-bounds array subscript or character substring.

- /check:flawed_pentium (ia32 systems)

  On ia32 systems, requests a run-time error message if a flawed Pentium (586) processor is detected. The default is /check:flawed_pentium, which *does* issue a run-time error message for this condition and stops program execution. To allow program execution to continue when this condition occurs, set the environment variable FOR_RUN_FLAWED_PENTIUM to true and rerun the program (see Run-Time Environment Variables).

  For more information on the Pentium flaw, see Intel Pentium Floating-Point Flaw. You can also use the FOR_CHECK_FLAWED_PENTIUM routine.

- /check:format

  Requests a run-time error message when the data type for an item being formatted for output does not match the FORMAT descriptor. Specifying /check:noformat suppresses the run-time error message for this condition.

- /check:output_conversion

  Requests a run-time message (number 63) when format truncation occurs (when a number is too large to fit in the specified format field length without loss of significant digits). Specifying /check:nooutput_conversion does not display the message when format truncation occurs.

- /check:overflow

  Requests a continuable run-time message when integer overflow occurs. Specifying /check:nooverflow suppresses the run-time message.

- /check:power

  Requests a run-time error message for arithmetic expressions 0.0 ** 0.0 and *negative-value* ** *integer-value-of-type-real*. The default is /check:nopower (suppress the run-time error message), allowing the calculations to occur, where 0.0 ** 0.0 equals 1.0 and (-3.0) ** 3.0 equals -27.0.

  You can specify /check:power to allow a run-time error message to be issued for this type of expression.

- /check:underflow

  Requests an informational run-time message when floating-point underflow occurs when /fpe:0 is specified (/check:underflow is not supported with /fpe:3). Specifying /check:nounderflow suppresses a run-time message when floating-point underflow occurs.

- /4Yb

  Sets /check:(overflow,bounds,underflow).

- /check:none, /nocheck, or /4Nb

  Equivalent to:
  /check:
  (noarg_temp_created,nobounds,noformat,nopower,nooutput_conversion,noo

- /check or /check:all

  Equivalent to:
  /check:
  (arg_temp_created,bounds,flawed_pentium,format,power,output_conversion

/[no]comments

Syntax:

/comments or **/nocomments**

The /comments option writes C-style comments to the output file.
The /nocomments option does not write C-style comments to the output file.
This option applies only to the FPP preprocessor.

For more information, type FPP /? to view FPP options.

/[no]compile_only

Syntax:

/compile_only, **/nocompile_only**, or **/c**

The /compile_only or /c option suppresses linking. The default is /nocompile_only (perform linking).

If you specify the /compile_only option at higher levels of optimization and also specify /object:*filename*, the /object:*filename* option causes multiple Fortran input files (if specified) to be compiled into a single object *file*. This allows interprocedural optimizations to occur.

However, if you use multiple source files and the /compile_only option without the /object:*file* option, multiple object files are created and interprocedural optimizations do not occur.

In the visual development environment, to compile (not link) a source file:

1. In the FileView pane, select (highlight) the file to be compiled
2. From the Build menu, select Compile *filename.xxx*

/convert

Syntax:

/convert:*keyword*

The /convert option specifies the format of unformatted files containing numeric data. On ia32 and ia64 systems, the format used in memory is always IEEE little endian format. If you want to read and write unformatted data in IEEE little endian format, you do not need to convert your unformatted data and can omit this option (or specify /convert:native).

This method affects all unit numbers that use unformatted data specified by the program. Other methods are available to specify the format for all or certain unformatted files (see Converting Unformatted Numeric Data).

In the visual development environment, specify the Unformatted File Conversion in the Compatibility Compiler Option Category. The /convert options are:

/convert:big_endian	/convert:cray
/convert:ibm	/convert:little_endian
/convert:native	/convert:vaxd
/convert:vaxg	

- /convert:big_endian

  Specifies that unformatted files containing numeric data are in IEEE big endian (nonnative) format. The resulting program will read and write unformatted files containing numeric data assuming the following:

  - Big endian integer format (INTEGER declarations of the appropriate size).
  - Big endian IEEE floating-point formats (REAL and COMPLEX declarations of the appropriate size).

- /convert:cray

  Specifies that unformatted files containing numeric data are in CRAY (nonnative) big endian format. The resulting program will read and write unformatted files containing numeric data assuming the following:

  - Big endian integer format (INTEGER declarations of the appropriate size).
  - Big endian CRAY proprietary floating-point formats (REAL and COMPLEX declarations of the appropriate size).

- /convert:ibm

Specifies that unformatted files containing numeric data are in IBM (nonnative) big endian format. The resulting program will read and write unformatted files containing numeric data assuming the following:

- Big endian integer format (INTEGER declarations of the appropriate size).
- Big endian IBM proprietary floating-point formats (REAL and COMPLEX declarations of the appropriate size).

- /convert:little_endian

  Specifies that numeric data in unformatted files is in native little endian integer format and IEEE little endian floating-point format (same as used in memory), as follows:

  - Integer data is in native little endian format.
  - REAL(KIND=4) and COMPLEX(KIND=4) (SINGLE PRECISION) data is in IEEE little endian S_floating format.
  - REAL(KIND=8) and COMPLEX (KIND=8) (DOUBLE PRECISION) data is in IEEE little endian T_floating format.

- /convert:native

  Specifies that numeric data in unformatted files is not converted. This is the default.

- /convert:vaxd

  Specifies that numeric data in unformatted files is in VAXD little endian format, as follows:

  - Integer data is in native little endian format.
  - REAL(KIND=4) and COMPLEX(KIND=4) (SINGLE PRECISION) data is in VAX F_floating format.
  - REAL(KIND=8) and COMPLEX (KIND=8) (DOUBLE PRECISION) data is in VAX D_floating format.

- /convert:vaxg

  Specifies that numeric data in unformatted files is in VAXG little endian format, as follows:

  - Integer data is in native little endian format.
  - REAL(KIND=4) and COMPLEX(KIND=4) (SINGLE PRECISION) data is in VAX F_floating format.
  - REAL(KIND=8) and COMPLEX(KIND=8) (DOUBLE PRECISION) data is

in VAX G_floating format.

For more information on unformatted file conversion, see Converting Unformatted Numeric Data.

/cxml

Syntax:

/cxml

The /cxml option requests that the Compaq Extended Math Library (CXML) library be passed to the linker. Your program still needs to specify the `INCLUDE 'CXML_INCLUDE.F90'` statement. The /cxml option is provided for documentation purposes only.

For more information, see Using the Compaq Extended Math Library (CXML).

In the visual development environment, specify the Use Compaq Extended Math Library (CXML) in the Library Compiler Option Category.

/[no]d_lines

Syntax:

/d_lines, **/nod_lines**, **/4ccD**, or **/4ccd**

The /d_lines, /4ccD, or /4ccd options indicate that lines in fixed-format files that contain a D in column 1 should be treated as source code. Specifying /nod_lines (the default) indicates that these lines are to be treated as comment lines.

In the visual development environment, specify Compile DEBUG (D) Lines in the Debug Compiler Option Category.

The compiler does not support the use of characters other than a D or d with the /4cc*string* (see the dlines Sample program in ...`\Samples\Advanced\com\`).

/[no]dbglibs

Syntax:

/dbglibs or **/nodbglibs**

The /dbglibs option controls whether the debug version or the non-debug version of the C run-time library is linked against. The default is /nodbglibs, which will link against the non-debug version of the C library, even when /debug:full is specified.

If you specify /debug:full for an application that calls C library routines and you need to debug calls into the C library, you should also specify /dbglibs to request that the debug version of the library be linked against.

In the visual development environment, specify one of the Debug library options in the Use Fortran Run-Time Libraries in the Libraries Compiler Option Category.

When you specify /dbglibs, the C debug library linked against depends on the specified /libs:*keyword* and /[no]threads options, and is one of: `libcd.lib`, `libcmtd.lib`, or `msvcrtd.lib`.

For More Information:

- Visual Fortran/Visual C++ Mixed-Language Programs
- Specifying Consistent Library Types

/[no]debug

Syntax:

> **/debug**:*keyword*, **/nodebug**, **/Z7**, **/Zd**, or **/Zi**

The /debug, /Z7, /Zd, or /Zi options control the level of debugging information associated with the program being compiled.

In the visual development environment, specify the Debugging Level in the General or Debug Compiler Option Category. The options are:

/debug:none or /nodebug	/debug:minimal or /Zd
/debug:partial	/debug:full, /debug, /Zi, or /Z7

The /debug options:

- /debug:none or /nodebug

  If you specify /debug:none or /nodebug, the compiler produces no symbol table information, which is needed for debugging or profiling. Only symbol information needed for linking (global symbols) is produced. The size of the resulting object module is the minimum size. If this option is specified, /debug:none is passed to the linker.

- /debug:minimal or /Zd

If you specify /debug:minimal or /Zd, the compiler produces minimal debug information, which allows global symbol table information needed for linking, but not local symbol table information needed for debugging. If /debug:minimal is specified, /debug:minimal and /debugtype:cv is passed to the linker.

If you omit the /[no]debug:*keyword*, /Z7, /Zd, and /Zi options, /debug:minimal is the default on the command line and for a release configuration in the visual development environment.

The /Zd option implies /nopdbfile and passes /debug:minimal /pdb:none /debugtype:cv to the linker.

The object module size is somewhat larger than if you specified /debug:none, but is smaller than if you specified /debug:full.

- /debug:partial

  If you specify /debug:partial, the compiler produces debugging information to allow global symbol table information needed for linking, but not local symbol table information needed for debugging. If /debug:partial is specified, /debug:partial /debugtype:cv /pdb:none is passed to the linker.

  The object module size is somewhat larger than if you specified /debug:none, but is smaller than if you specified /debug:full.

- /debug:full, /debug, /Zi, or /Z7

  If you specify /debug:full, /debug, /Zi, or /Z7, the compiler produces symbol table information needed for full symbolic debugging of unoptimized code and global symbol information needed for linking. This is the default for a debug configuration in the visual development environment.

  If you specify /debug:full for an application that make calls to C library routines and you need to debug calls into the C library, you should also specify /dbglibs to request that the appropriate C debug library be linked against (see Specifying Consistent Library Types).

  The /Z7 option implies /nopdbfile and passes /debug:full /debugtype:cv /pdb:none to the linker.

  The /debug:full, /debug, and /Zi options imply /pdbfile and pass /debug:full and /debugtype:cv to the linker.

  If you specify /debug (with no keyword), the default optimization level changes to /optimize:0 (instead of /optimize:4) for the DF command.

To request program counter run-time correlation to source file line numbers (full traceback) for severe run-time errors, specify the /traceback option.

/define

Syntax:

/define:*symbol*[=*value*]

The /define option defines the *symbol* specified for use with conditional compilation directives or the Fortran preprocessor, FPP. A *value* specified for /define can be a character or integer value. If a value is not specified, 1 is assigned to *symbol*.

When only using the Fortran preprocessor FPP, to request that symbol values defined by /define apply only to FPP and are not seen by compiler directives, also specify /nodefine on the DF command line.

In the visual development environment, specify the Predefined Preprocessor Symbols in the General or Preprocessor Compiler Option Category.

You can use the directives to detect symbol definitions, such as the IF Directive Construct. Like certain other compiler options, an equivalent directive exists (DEFINE directive).

The following preprocessor symbols are predefined by the compiler system and are available to compiler directives and FPP (except _DF_VERSION_ and _VF_VERSION_):

Predefined Preprocessor Symbols

Predefined Symbol Name and Value	Conditions When this Symbol is Defined
_DF_VERSION_=660 (660 for Version 6.6)	Compiler only
_DLL=1	Only if /libs:dll, /MDs, /MD, /dll, or /LD is specified, but *not* when /libs:static is specified
_INTEGRAL_MAX_BITS=32	Only for ia32 (32-bit) systems
_INTEGRAL_MAX_BITS=64	Only for ia64 (64-bit) systems

_ITANIUM_A3_=1	Only for ia64 (64-bit) systems
MSFORTRAN=401	Only if /fpscomp:symbols is specified or you use the FL32 command
_MT=1	Only if /threads or /MT is specified
_M_IX86=500	Only for ia32 (32-bit) systems
_M_IA64=64100	Only for ia64 (64-bit) systems
_VF_VERSION_=660 (660 for Version 6.6)	Compiler only
_WIN32=1	Always defined (both ia32 and ia64 systems)
_WIN64=1	Only for ia64 (64-bit) systems
_WIN95=1	Only for ia32 (32-bit) systems running the Windows 95 operating system
_WIN98=1	Only for ia32 (32-bit) systems running the Windows 98 operating system
_WINME=1	Only for ia32 (32-bit) systems running the Windows Me operating system
_X86_=1	Only for ia32 (32-bit) systems

When using the non-native ia64 compiler, platform-specific symbols are set for the target platform of the executable, not for the system in use.

/dll

Syntax:

/dll[:*file*], **/nodll**, or **/LD**

The /dll or /LD option indicates that the program should be linked as a DLL file. The /dll or /LD option overrides any specification of the run-time routines to be used and activates the /libs:dll option. A warning is generated when the /libs=qwin or /libs=qwins option and /dll option are used together.

In the visual development environment, specify the project type as Fortran Dynamic Link Library (DLL).

If you omit *file*, the /dll or /LD option interacts with the /exe and the /Fe options, as follows:

- If neither /exe nor /Fe is specified, the first file name used on the command line is used with an extension of .DLL.
- If either /exe:*file* or /Fe*file* is specified with a *file* name, that name is used for the DLL file. If the specified file name does not end with a "." or have an extension, an extension of .DLL is added to it.

To request linking with multithreaded libraries, specify the /threads option.

For information about building DLL files from the visual development environment, see Fortran Dynamic-Link Library Projects and Creating Fortran DLLs.

For a list of Fortran PowerStation style options (such as /LD and /MDs) and their DF command equivalents, see Equivalent Visual Fortran Compiler Options.

/[no]error_limit

Syntax:

> **/error_limit**[:*count*] or **/noerror_limit**

The /error_limit option specifies the maximum number of error-level or fatal-level compiler errors allowed for a given file before compilation aborts. If you specify /noerror_limit (command line), there is no limit on the number of errors that are allowed.

In the visual development environment, specify the Compilation Error Limit in the Compilation Diagnostics Compiler Option Category.

The default is /error_limit:30 or a maximum of 30 error-level and fatal-level messages. If the maximum number of errors is reached, a warning message is issued and the next file (if any) on the command line is compiled.

/[no]exe

Syntax:

> **/exe**[:*file*], **/noexe**, or **/Fe***file*

The /exe or /Fe option specifies the name of the executable program (EXE) or dynamic-link library (DLL) *file* being created. To request that a DLL be created instead of an executable program, specify the /dll option.

/[no]extend_source

Syntax:

/extend_source[:*size*], **/noextend_source**, or **/4L***size*

The /extend_source or /4L*size* option controls the column used to end the statement field in fixed-format source files. When a size is specified, that will be the last column parsed as part of the statement field. Any columns after that will be treated as comments.

Specifying /extend_source (or /4L132 or /4L80) sets the /fixed option.

In the visual development environment, specify the Fixed-Form Line Length in the Fortran Language Compiler Option Category. The following options are equivalent:

- /noextend_source, /extend_source:72, or /4L72 specify the last column as 72.
- /extend_source:80 or /4L80 specify the last column as 80.
- /extend_source, /extend_source:132, or /4L132 specify the last column as 132.

/extfor

Syntax:

/extfor:*ext*

The /extfor option specifies file extensions (*ext*) to be processed by the Compaq Fortran compiler. One or more file extensions can be specified. A leading period before each extension is optional (for and .for are equivalent).

/extfpp

Syntax:

/extfpp:*ext*

The /extfpp option specifies file extensions (*ext*) to be processed by the FPP preprocessor. One or more file extensions can be specified. A leading period before each extension is optional (fpp and .fpp are equivalent).

/extlnk

Syntax:

/extlnk:*ext*

The /extlnk option specifies file extensions (*ext*) to be processed by the linker. One or more file extensions can be specified. A leading period before each extension is optional (obj and .obj are equivalent).

/[no]f66

Syntax:

/f66 or **/nof66**

The /f66 option requests that the compiler select FORTRAN-66 interpretations in cases of incompatibility (default is /nof66). Differences include the following:

- **DO** loops are always executed at least once (see Execution of DO Constructs)
- FORTRAN-66 **EXTERNAL** statement syntax and semantics are allowed (see FORTRAN-66 Interpretation of the External Statement)
- If the OPEN statement STATUS specifier is omitted, the default changes to STATUS='NEW' instead of STATUS='UNKNOWN'
- If the **OPEN** statement BLANK specifier is omitted, the default changes to BLANK='ZERO' instead of BLANK='NULL'

In the visual development environment, specify Enable FORTRAN-66 Semantics in the Fortran Language Compiler Option Category.

/[no]f77rtl

Syntax:

/f77rtl or **/nof77rtl**

The /f77rtl option controls the run-time support that is used when a program is executed. Specifying /f77rtl uses the Compaq Fortran 77 run-time behavior. In the visual development environment, specify Enable F77 Run-Time Compatibility in the Compatibility Compiler Option Category.

Specifying /nof77rtl uses the Visual Fortran (Compaq Fortran) run-time behavior. Unless you specify /f77rtl, /nof77rtl is used.

/fast

Syntax:

/fast

The /fast option sets several options that generate optimized code for fast run-time performance. Specifying this option is equivalent to specifying:

- /alignment:(dcommons, records, sequence)
- /architecture:host
- /assume:noaccuracy_sensitive
- /math_library:fast
- /tune:host

If any of the /stand options are also specified, /align:dcommons and /align:sequence are not set.

In the visual development environment, specify the Generate Most Optimized Code in the Code Generation Compiler Option Category.

If you omit /fast, these performance-related options will not be set.

/[no]fixed

Syntax:

/fixed, **/nofixed**, **/4Nf**, or **/4Yf**

The /fixed or /4Nf option specifies that the source file should be interpreted as being in fixed-source format. Equivalent options are as follows:

- The /fixed, /nofree, and /4Nf options are equivalent and request fixed-source form.
- The /nofixed, /free, and /4Yf options are equivalent and request free-source form.

In the visual development environment, specify the Source Form in the Fortran Language Compiler Option Category.

If you omit /[no]free, /[no]fixed, /4Nf, and /4Yf, the compiler assumes:

- Files with an extension of .f90, .F90, or .i90 are free-format source files.
- Files with an extension of .f, .for, .FOR, or .i are fixed-format files.

/[no]fltconsistency (ia32 only)

Syntax:

/fltconsistency, **/nofltconsistency**, or **/Op**

The /fltconsistency or /Op option enables improved floating-point consistency on ia32 systems. Floating-point operations are not reordered and the result of each floating-point operation is stored into the target variable rather than being kept in the floating-point processor for use in a subsequent calculation. This option is ignored on ia64 systems.

In the visual development environment, specify Enable Floating-Point Consistency in the Floating Point Compiler Option Category.

The default is /nofltconsistency, which provides better accuracy and run-time performance at the expense of less consistent floating-point results.

/[no]fpconstant

Syntax:

/fpconstant or **/nofpconstant**

The /fpconstant option requests that a single-precision constant assigned to a double-precision variable be evaluated in double precision. If you omit /fpconstant (or specify the default /nofpconstant), a single-precision constant assigned to a double-precision variable is evaluated in single precision. The Fortran 90 standard requires that the constant be evaluated in single precision.

In the visual development environment, specify Extended Precision of Single-Precision Constants in the Floating Point (or Fortran Data) Compiler Option Category.

Certain programs created for FORTRAN-77 compilers (including Compaq Fortran 77) may show different floating-point results, because they rely on single-precision constants assigned to a double-precision variable to be evaluated in double precision.

In the following example, if you specify /fpconstant, identical values are assigned to D1 and D2. If you omit the /fpconstant option, the compiler will obey the standard and assign a less precise value to D1:

```
REAL (KIND=8) D1, D2
DATA D1 /2.71828182846182/    ! REAL (KIND=4) value expanded to double
DATA D2 /2.71828182846182D0/  ! Double value assigned to double
```

/fpe

Syntax:

/fpe:*level*

The /fpe:*level* option controls floating-point exception handling at run time for the main program. This includes whether exceptional floating-point values are allowed and how precisely run-time exceptions are reported. The /fpe:*level* option specifies how the compiler should handle the following floating-point exceptions:

- When floating-point calculations result in a divide by zero, overflow, or invalid operation.
- When floating-point calculations result in an underflow.
- When a denormalized number or other exceptional number (positive infinity, negative infinity, or a NaN) is present in an arithmetic expression

For performance reasons:

- On ia32 systems, the default is /fpe:3. Using /fpe:0 will slow run-time performance on ia32 systems.
- On ia64 systems, the default is /fpe:0 (many programs do not need to handle denormalized numbers or other exceptional values). Using /fpe:3 will slow run-time performance on ia64 systems.

In the visual development environment, specify the Floating-Point Exception Handling in the Floating Point Compiler Option Category. The /fpe:*level* (*level* is 0 or 3) options are as follows:

/fpe:*level* Option	**Handling of Underflow**	**Handling of Divide by Zero, Overflow, and Invalid Operation**
/fpe:0 (default on ia64 systems)	Sets any calculated denormalized value (result) to zero and lets the program continue. Any use of a denormalized number in an arithmetic expression uses a value of 0.0 and execution continues. A message is displayed only if /check:underflow is also specified.	Exceptional values are *not* allowed. The program terminates after displaying a message.

/fpe:3 (default on ia32 systems)	Leaves any calculated denormalized value as is. The program continues, allowing gradual underflow. Use of a denormalized (or exceptional) number in an arithmetic expression results in program continuation, but with slower performance.	The program continues. No message is displayed. A NaN or Infinity (+ or -) will be generated.

When compiling different routines in a program separately, you should use the same /fpe:*level* value.

On ia32 systems, the /fpe option, /check:underflow option, and MATHERRQQ routine interact as follows:

Specified /fpe:*n* Option	**Was /check:underflow Specified?**	**Is a User-Written MATHERRQQ Routine Present?**	**Underflow Handling by the Visual Fortran Run-Time System on ia32 Systems**
/fpe:0	No	No	The underflowed result is set to zero (0). The program continues.
/fpe:0	No	Yes	The underflowed result is set to zero (0). The program continues.
/fpe:0	Yes	No	The underflowed result is set to zero (0). The program continues. The number of underflowed results are counted and messages are displayed for the first two occurrences.
/fpe:0	Yes	Yes	The underflowed result is set to zero (0). The program continues. The number of underflowed results are counted and messages are displayed for the first two occurrences.

/fpe:3	No	No	Denormalized results are allowed and the program continues. Traps are masked and no handlers are invoked.
/fpe:3	No	Yes	Denormalized results are allowed and the program continues. Traps are masked and no handlers are invoked.
/fpe:3	Yes	No	For Version 6, a fatal error results and the program terminates.
/fpe:3	Yes	Yes	Depends on the source causing the underflow: • If the underflow occurs in an intrinsic procedure, the undefined result is left as is. The program continues with the assumption that the user-specified MATHERRQQ handler will perform any result fix up needed. • If the underflow does not occur in an intrinsic procedure, for Version 6.0, a fatal error results and the program terminates.

For more information:

- About the /fpe option on ia32 systems, see How the Floating-Point Exception Handling (/fpe) Compiler Option Works.
- About the floating-point environment and the MATHERRQQ routine (ia32 systems), see The Floating-Point Environment.

- About creating exception and termination handlers, see Advanced Exception and Termination Handling Considerations.
- About routines that can obtain or set the floating-point exception settings used by Visual Fortran at run-time, see FOR_SET_FPE and FOR_GET_FPE.
- About IEEE floating-point exception handling, see the *IEEE Standard for Binary Floating-Point Arithmetic* (ANSI/IEEE Standard 754-1985).

/fpp

Syntax:

/fpp[:"*options*"]

The /fpp option activates the FPP preprocessor and optionally passes *options* to FPP as is. The FPP preprocessor can process both free- and fixed-form Fortran source files. Alternatively, you can use compiler directives, such as the IF Directive Construct, to detect symbol definitions and perform conditional compilation.

You can run FPP:

- On the DF command line, by adding the /fpp option. By default, the specified files are compiled and linked. To retain the intermediate (`.i` or `.i90`) file, specify the /keep option.
- In the visual development environment, by specifying the Use FPP option in the Preprocessor Compiler Option Category. By default, the file is compiled and linked. To retain the intermediate (`.i` or `.i90`) file, specify the /keep option on the command line or (in the visual development environment, Project Settings dialog box) the Project Options: box.
- On the command line, by using the FPP command. In this case, the compiler is not invoked. When using the FPP command line, you need to specify the input file and the output intermediate (`.i` or `.i90`) file.

FPP is a modified version of the ANSI C preprocessor and supports a similar set of directives (including syntax and semantics). It supports the following directives: `#define`, `#elif`, `#else`, `#endif`, `#if`, `#ifdef`, `#ifndef`, `#include`, and `#undef`.

For example, the following DF command invokes FPP, specifies the /noC option to FPP, uses the /define option to define the symbol testcase, and preprocesses file `cond.for` before it is compiled and linked:

```
DF /fpp:"/noC" /define:testcase=2 cond.for
```

For a list of predefined preprocessor symbols (such as _X86_), see /define.

For information on FPP options, type FPP /HELP on the command line.

/[no]fpscomp

Syntax:

/fpscomp[:*keyword...*] or **/nofpscomp**

The /fpscomp option controls whether certain aspects of the run-time system and semantic language features within the compiler are compatible with Visual Fortran or Microsoft Fortran PowerStation.

If you experience problems when porting applications from Fortran PowerStation, specify /fpscomp:*keyword* (or /fpscomp:all). When porting applications from Compaq Fortran, use /fpscomp:none or /fpscomp:libs (the default).

In the visual development environment, specify the PowerStation 4.0 Compatibility Options in the Compatibility Compiler Option Category.
The /fpscomp options and their visual development environment names are:

/fpscomp:[no]filesfromcmd (Filenames from Command Line)	/fpscomp:[no]general (Other Run-time Behavior)
/fpscomp:[no]ioformat (I/O Format)	/fpscomp:[no]ldio_spacing (List Directed I/O Spacing)
/fpscomp:[no]libs (Libraries)	/fpscomp:[no]logicals (Logical Values)
/fpscomp:[no]symbols (Predefined Preprocessor Symbols)	/fpscomp:all and /fpscomp
/nofpscomp or /fpscomp:none	

/fpscomp:[no]filesfromcmd

Specifying /fpscomp:filesfromcmd for a file where the **OPEN** statement FILE specifier is blank (FILE=' '), requests that the following actions be taken at run-time:

- The program reads a filename from the list of arguments (if any) in the command line that invoked the program. If any of the command-line arguments contain a null string (''), the program asks the user for the corresponding filename. Each additional **OPEN** statement with a nameless FILE specifier reads the next command-line argument.
- If there are more nameless **OPEN** statements than command-line arguments, the program prompts for additional file names.

- In a QuickWin application, a File Select dialog box appears to request file names.

Specifying /fpscomp:nofilesfromcmd disables the run-time system from using the filename specified on the command line when the **OPEN** statement FILE specifier is omitted, allowing the application of default directory, file name, and extensions like Compaq Fortran, such as the FORT*n* environment variable and the FORT.*n* file name (where *n* is the unit number).

Specifying /fpscomp:filesfromcmd affects the following Fortran features:

- The **OPEN** statement FILE specifier

  For example, assume a program OPENTEST contains the following statements:

```
OPEN(UNIT = 2, FILE = ' ')
OPEN(UNIT = 3, FILE = ' ')
OPEN(UNIT = 4, FILE = ' ')
```

  The following command line assigns the file TEST.DAT to Unit 2, prompts the user for a filename to associate with Unit 3, then prompts again for a filename to associate with Unit 4:

```
opentest test.dat '' ''
```

- Implicit file open statements such as the **WRITE**, **READ**, and **ENDFILE** statements

  Unopened files referred to in **READ** or **WRITE** statements are opened implicitly as if there had been an **OPEN** statement with a name specified as all blanks. The name is read from the command line.

```
WRITE(UNIT = 8, FMT='(2I5)') int1, int2 ! Where "8" has not been
                                        ! explicitly associated with a file.
```

For more information about running Visual Fortran programs with the /fpscomp:filesfromcmd option or the use of alternative routines, see Running Fortran Applications.

/fpscomp:[no]general

Specifying /fpscomp:[no]general controls which run-time behavior is used when a difference exists between Visual Fortran and Microsoft Fortran PowerStation and either semantic must remain available for compatibility reasons:

- Specify /fpscomp:general to request Microsoft Fortran PowerStation semantics.
- Specify /fpscomp:nogeneral to request Visual Fortran semantics.

This affects the following Fortran features:

- The **BACKSPACE** statement:
  - Allows files opened with ACCESS='APPEND' to be used with the **BACKSPACE** statement.
  - Allows files opened with ACCESS='DIRECT' to be used with the **BACKSPACE** statement.

  Note: Allowing files that are not opened with sequential access (such as ACCESS='DIRECT') to be used with the **BACKSPACE** statement violates the Fortran 90 standard and may be removed in the future. Section 9.5 states the following: "A file that is not connected for sequential access must not be referred to by a **BACKSPACE**, an **ENDFILE**, or a **REWIND** statement..."

- The **READ** statement:
  - Formatted: `READ(eunit, format [, advance][, iostat]...)`
    Reading from a formatted file opened for direct access will read records that have the same record type format as Fortran PowerStation when /fpscomp:general is set. This consists of accounting for the trailing Carriage Return/Line Feed pair (<CR><LF>) that is part of the record.
    Allows sequential reads from a formatted file opened for direct access.

    Note: Allowing files that are not opened with sequential access (such as ACCESS='DIRECT') to be used with the sequential **READ** statement violates the Fortran 90 standard and may be removed in the future. Section 9.2.1.2.2 states the following: "Reading and writing records is accomplished only by direct access input/output statements."

  - Allows the last record in a file opened with FORM='FORMATTED' and a record type of STREAM_LF or STREAM_CR that does not end with a proper record terminator (<line feed> or <carriage return>) to be read without producing an error.
  - Unformatted: `READ(eunit [, iostat]...)`
    Allows sequential reads from an unformatted file opened for direct access.

    Note: Allowing files that are not opened with sequential access (such as ACCESS='DIRECT') to be read with the sequential **READ** statement violates the Fortran 90 standard and may be removed in the future. Section 9.2.1.2.2 states the following: "Reading and writing records is accomplished only by direct access input/output statements."

- The **INQUIRE** statement:
  - The CARRIAGECONTROL specifier returns the value "UNDEFINED" instead of "UNKNOWN" when the carriage control is not known and when /fpscomp:general is set.
  - The NAME specifier returns the file name "UNKNOWN" instead of space filling the file name when the file name is not known and when /fpscomp:general is set.
  - The SEQUENTIAL specifier returns the value "YES" instead of "NO" for a direct access formatted file when /fpscomp:general is set.
  - The UNFORMATTED specifier returns the value "NO" instead of "UNKNOWN" when it is not known whether unformatted I/O can be performed to the file and when /fpscomp:general is set.

    Note: Returning the value "NO" instead of "UNKNOWN" for this specifier violates the Fortran 90 standard and may be removed in the future. See Section 9.6.1.12.

- The **OPEN** statement:
  - If a file is opened with an unspecified STATUS keyword value, and is not named (no FILE specifier), the file is opened as a scratch file when /fpscomp:general is set. For example:

    ```
    OPEN (UNIT = 4)
    ```

    In contrast, when /fpscomp:nogeneral is in effect with an unspecified STATUS value with no FILE specifier, the FORT*n* environment variable and the FORT.*n* file name are used (where *n* is the unit number).
  - If the STATUS value was not specified and if the name of the file is "USER", the file is marked for deletion when it is closed when /fpscomp:general is set.
  - Allows a file to be opened with the APPEND and READONLY characteristics when /fpscomp:general is set.
  - If the CARRIAGECONTROL specifier is defaulted, gives "LIST" carriage control to direct access formatted files instead of "NONE" when /fpscomp:general is set.
  - Gives an opened file the additional default of write sharing when /fpscomp:general is set.
  - Gives the file a default block size of 1024 when /fpscomp:general is set as compared to 8192 (see Efficient Use of Record Buffers and Disk I/O).
  - If the MODE and ACTION specifier is defaulted and there was an error opening the file, then try opening the file read only, then write only.
  - If the CARRIAGECONTROL specifier is defaulted and if the device type

is a terminal file, the file is given the default carriage control value of "FORTRAN" as compared to "LIST" when /fpscomp:general is set.
- If a file that is being re-opened has a different file type than the current existing file, an error is returned when /fpscomp:general is set.
- Gives direct access formatted files the same record type as Fortran PowerStation when /fpscomp:general is set. This means accounting for the trailing Carriage Return/Line Feed pair (<CR><LF>) which is part of the record.

- The **STOP** statement:
  - Writes the Fortran PowerStation output string and/or returns the same exit condition values when /fpscomp:general is set.

- The **WRITE** statement:
  - Formatted: `WRITE(eunit, format [, advance][, iostat]...)`
    - Writing to formatted direct files

      When writing to a formatted file opened for direct access, records are written in the same record type format as Fortran PowerStation when /fpscomp:general is set. This consists of adding the trailing Carriage Return/Line Feed pair (<CR><LF>) that is part of the record.

      Ignores the CARRIAGECONTROL specifier setting when writing to a formatted direct access file.

    - Interpreting Fortran carriage control characters

      When interpreting Fortran carriage control characters during formatted I/O, carriage control sequences are written which are the same as Fortran PowerStation when /fpscomp:general is set. This is true for the "Space, 0, 1 and + " characters.

    - Performing non-advancing I/O to the terminal.

      When performing non-advancing I/O to the terminal, output is written in the same format as Fortran PowerStation when /fpscomp:general is set.

    - Interpreting the backslash (\) and dollar ($) edit descriptors
      When interpreting backslash and dollar edit descriptors during formatted I/O, sequences are written the same as Fortran PowerStation when /fpscomp:general is set.

  - Unformatted: `WRITE(eunit [, iostat]...)`

Allows sequential writes from an unformatted file opened for direct access.

Note: Allowing files that are not opened with sequential access (such as ACCESS='DIRECT') to be read with the sequential **WRITE** statement violates the Fortran 90 standard and may be removed in the future. Section 9.2.1.2.2 states the following: "Reading and writing records is accomplished only by direct access input/output statements."

- Specifying /fpscomp:general sets /fpscomp:ldio_spacing.

/fpscomp:[no]ioformat

Controls which run-time behavior is used for the semantic format for list-directed formatted I/O and unformatted I/O. Specify /fpscomp:ioformat to request Microsoft Fortran PowerStation semantic conventions and record formats (see Microsoft Fortran PowerStation Compatible Files).
Specify /fpscomp:noioformat to request Compaq Fortran semantic conventions. This affects the following Fortran features:

- The **WRITE** statement:
  - Formatted List-Directed: `WRITE(eunit, * [, iostat]...)`
  - Formatted Internal List-Directed: `WRITE(iunit, * [, iostat]...)`
  - Formatted Namelist: `WRITE(eunit, nml-group [, iostat]...)`

    If /fpscomp:ioformat is set, the output line, field width values, and the list-directed data type semantics are dictated according to the following sample for real constants (*N* below):

    - For 1 <= *N* < 10**7, use F15.6 for single precision or F24.15 for double.
    - For *N* < 1 or *N* >= 10**7, use E15.6E2 for single precision or E24.15E3 for double.

    See the Fortran PowerStation documentation for more detailed information about the other data types affected.

  - Unformatted: `WRITE(eunit [, iostat]...)`

    If /fpscomp:ioformat is set, the unformatted file semantics are dictated according to the Fortran PowerStation documentation. Be aware that the file format differs from that used by Compaq Fortran. See the Fortran PowerStation documentation for more detailed information.

The following table summarizes the default output formats for list-directed output with the intrinsic data types:

Default Formats for List-Directed Output

Data Type	Output Format with /fpscomp:noioformat	Output Format with /fpscomp:ioformat
BYTE	I5	I12
LOGICAL (all)	L2	L2
INTEGER(1)	I5	I12
INTEGER(2)	I7	I12
INTEGER(4)	I12	I12
INTEGER(8)	I22	I22
REAL(4)	1PG15.7E2	1PG16.6E2
REAL(8)	1PG24.15E3	1PG25.15E3
COMPLEX(4)	'(',1PG14.7E2, ', ',1PG14.7E2, ') '	'(',1PG16.6E2, ', ',1PG16.6E2, ') '
COMPLEX(8)	'(',1PG23.15E3, ', ',1PG23.15E3, ') '	'(',1PG25.15E3, ', ',1PG25.15E3, ') '
CHARACTER	A*w*	A*w*

- The **READ** statement:
  - Formatted List-Directed: `READ(eunit, * [, iostat]...)`
  - Formatted Internal List-Directed: `READ(iunit, * [, iostat]...)`
  - Formatted Namelist: `READ(eunit, nml-group [, iostat]...)`

  If /fpscomp:ioformat is set, the field width values and the list-directed semantics are dictated according to the following sample for real constants (*N* below):

  - For 1 <= *N* < 10**7, use F15.6 for single precision or F24.15 for double.
  - For *N* < 1 or *N* >= 10**7, use E15.6E2 for single precision or E24.15E3 for double.

See the Fortran PowerStation documentation for more detailed information about the other data types affected.

- Unformatted: `READ(eunit [, iostat]...)`

  If /fpscomp:ioformat is set, the unformatted file semantics are dictated according to the Fortran PowerStation documentation. Be aware that the file format to read differs from that used by Compaq Fortran. See the Fortran PowerStation documentation for more detailed information.

/fpscomp:[no]ldio_spacing

For list-directed output, controls whether a blank is inserted at run-time after a numeric value before a character value (undelimited character string). The default is /fpscomp:noldio_spacing, which conforms to the Fortran 95 standard by inserting a blank after a numeric value before a character value. To request non-standard behavior for compatibility with Microsoft Fortran PowerStation and Visual Fortran releases before Version 6.6, either specify /fpscomp:ldio_spacing or specify /fpscomp:general, which sets /fpscomp:ldio_spacing.

/fpscomp:[no]libs

Controls whether the library dfport.lib (Portability library) is passed to the compiler and linker. The default is /fpscomp:libs, which passes this library. Specifying /fpscomp:nolibs does not pass this library.

/fpscomp:[no]logicals

Controls the value used for logical true. Microsoft Fortran PowerStation and Compaq Fortran with the /fpscomp:logical option set uses any non-zero value (default is 1) for true. Compaq Fortran with the /fpscomp:nological option set only looks at the low bit of the value, using a -1 for true. Differences can occur when a logical is stored into an integer. Both use 0 (zero) for false.

This affects the results of all logical expressions and affects the return value for the following Fortran features:

- The **INQUIRE** statement specifiers OPENED, IOFOCUS, EXISTS, and NAMED.
- The **EOF** intrinsic function.
- The **BTEST** intrinsic function.
- The lexical intrinsic functions **LLT**, **LLE**, **LGT**, and **LGE**.

/fpscomp:[no]symbols

Adds one or more symbols related to Microsoft Fortran PowerStation to preprocessor and compiler invocations. The symbol currently set by specifying /fpscomp:symbols is _MSFORTRAN_=401.

/fpscomp:all and **/fpscomp**

Enable full Microsoft Fortran PowerStation compatibility or /fpscomp:(filesfromcmd,general,ioformat,ldio_spacing,libs,logicals,symbols).

/nofpscomp or **/fpscomp:none**

Enables full Compaq Fortran compatibility or /fpscomp:(nofilesfromcmd,nogeneral,noioformat,noldio_spacing,nolibs,nologicals,nosymbols

If you omit /fpscomp, the default is /fpscomp:libs.

The /fpscomp and /vms options are not allowed in the same command.

/[no]free

Syntax:

> **/free**, **/nofree**, **/4Yf**, or **/4Nf**

The /free or /4Yf option specifies that the source file should be interpreted as being in free source format. Equivalent options are as follows:

- The /nofixed, /free, and /4Yf options are equivalent and request free-source form.
- The /fixed, /nofree, and /4Nf options are equivalent and request fixed-source form.

In the visual development environment, specify the Source Form in the Fortran Language Compiler Option Category.

If you omit /[no]free, /[no]fixed, /4Nf, and /4Yf, the compiler assumes:

- Files with an extension of .f90, .F90, or .i90 are free-format source files.
- Files with an extension of .f, .for, .FOR, or .i are fixed-format files.

/help

Syntax:

> **/help** or **/?**

The /help and /? option display information about the DF command. The option can be placed anywhere on the command line.

For a table of DF command options listed alphabetically, see Options List, Alphabetic Order.

/iface

Syntax:

/iface[:*keyword...*]

The /iface option determines the type of argument-passing conventions used by your program for general arguments and for hidden-length character arguments.

In the visual development environment, specify the Default Calling Conventions and the String Length Argument Passing in the External Procedures Compiler Option Category. The /iface keywords are as follows:

- The general argument-passing convention keywords are one of: cref, stdref, and default (stdref and default are equivalent). The functions performed by each are described in the following table:

	/iface:cref	**/iface:default**	**/iface:stdref**
Arguments are passed	By reference	By reference	By reference
Append @n to names on ia32 systems?	No	Yes	Yes
Who cleans up stack	Caller	Callee	Callee
Var args support?	Yes	No	No

- To specify the convention for passing the hidden-length character arguments, specify /iface:[no]mixed_str_len_arg:
  - /iface:mixed_str_len_arg

    Requests that the hidden lengths be placed *immediately after* their corresponding character argument in the argument list, which is the method used by Microsoft Fortran PowerStation.

  - /iface:nomixed_str_len_arg

Requests that the hidden lengths be placed in sequential order at the *end* of the argument list, which is the method used by Compaq Fortran for Tru64 UNIX systems by default. When porting mixed-language programs that pass character arguments, either this option must be specified correctly or the order of hidden length arguments changed in the source code.

If you omit the /iface option, the following is used:

```
/iface=(default,mixed_str_len_arg)
```

For more information on argument passing, see Programming with Mixed Languages.

/imsl

Syntax:

/imsl

The /imsl option ensures that the IMSL libraries will be passed to the linker. Your program still needs to specify the appropriate USE statement(s) and set IMSL environment variables (see Using the Libraries from Visual Fortran).

In the visual development environment, specify Use IMSL Math Library in the Library Compiler Option Category.

/[no]include

Syntax:

/include[:*path*...], **/noinclude**, or **/I***path*

The /include or /I option specifies one or more additional directories (*path*) to be searched for module files (USE statement) and include files (INCLUDE statement).

In the visual development environment, specify Custom INCLUDE and USE Path in the Preprocessor Compiler Option Category.

For all **USE** statements and for those **INCLUDE** statements whose file name does not begin with a device or directory name, the directories searched are as follows:

1. The directory containing the first source file or the current directory (depends on whether /assume:source_include was specified).

2. The current default directory where the compilation is taking place
3. If specified, the directory or directories listed in the /include:*path* or /I*path* option. The order of searching multiple directories occurs within the specified list from left to right
4. The directories indicated in the environment variable INCLUDE

To request that the compiler search first in the directory where the source file resides instead of the current directory, specify /assume:source_include.

Specifying /noinclude (or /include or /I without a *path*) prevents searching in the standard directory specified by the INCLUDE environment variable.

/[no]inline

Syntax:

> **/inline**[:*keyword*], **/noinline**, or **/Ob2**

The /inline or /Ob2 option allows users to have some control over inlining. Inlining procedures can greatly improve the run-time performance for certain applications.

When requesting procedure inlining (or interprocedural optimizations), compile all source files together into a single object file whenever possible. With very large applications, compile as many related source files together as possible.

If you compile sources without linking (see the /compile_only option), be sure to also specify the /object[:filename] option to create a single object file.

In the visual development environment, specify the Inlining type in the Optimizations Compiler Option Category. The /inline options are:

/inline:none or /noinline	/inline:manual
/inline:size	/inline:speed or /Ob2
inline:all	

The /inline options:

- /inline:none or /noinline

  Prevents the inlining of procedures, except for statement functions. This type of inlining occurs if you specify /optimize:0 or /optimize:1 and omit /inline options.

- /inline:manual

  Prevents the inlining of procedures, except for statement functions. This type of inlining occurs if you specify /optimize:2 or /optimize:3 and omit /inline options.

- /inline:size

  Inlines procedures that will improve run-time performance without significantly increasing program size. It includes the types of procedures inlined when you specify /inline:manual.

- /inline:speed or /Ob2

  Inlines procedures that will improve run-time performance with a significant increase in program size. This type of inlining is available with /optimize:1 or higher. This type of inlining occurs if you specify /optimize:4 or /optimize:5 and omit /inline options.

- inline:all

  Inlines absolutely every call that it is possible to inline while still getting correct code. However, recursive routines will not cause an infinite loop at compile time. This type of inlining is available with /optimize:1 or higher. It includes the types of procedures inlined when you specify other /inline options.

  Using /inline:all can significantly increase program size and slow compilation speed.

For more detailed information on this option, see Controlling the Inlining of Procedures.

/[no]intconstant

Syntax:

/intconstant or **/nointconstant**

The /intconstant option requests that Fortran 77 semantics (type determined by the value) be used to determine the kind of integer constants instead of Fortran 90 default INTEGER type. If you do not specify /intconstant, the type is determined by the default INTEGER type.

In the visual development environment, specify Use F77 Integer Constants in the Compatibility Compiler Option Category.

/integer_size

Syntax:

/integer_size:*size* or **/4I2**

The /integer_size or /4I2 option specifies the size (in bits) of integer and logical declarations, constants, functions, and intrinsics. In the visual development environment, specify the Default Integer Kind in the Fortran Data Compiler Option Category. These options are:

- /integer_size:16 or /4I2

  Makes the default integer and logical variables 2 bytes long. INTEGER and LOGICAL declarations are treated as (KIND=2).

- /integer_size:32

  Makes the default integer and logical variables 4 bytes long (default). INTEGER and LOGICAL declarations are treated as (KIND=4).

- /integer_size:64

  Makes the default integer and logical variables 8 bytes long. INTEGER and LOGICAL declarations are treated as (KIND=8).

/[no]keep

Syntax:

/keep or **/nokeep**

The /keep option creates one object file for each input source file specified, which may not be desirable when compiling multiple source files. The /keep option does not remove temporary files, which might be created by the FPP preprocessor or the Visual Fortran compiler.

If the /keep option is specified, the FPP output files and object files are created in the current directory and retained. The /keep option also affects the number of files that are created and the file names used for these files.

/[no]libdir

Syntax:

/libdir[:*keyword*], **/nolibdir**, or **/Zl** or **/Zla**

The /libdir, /Zl, or /Zla option controls whether library search paths are placed into object files generated by the compiler. Specify one or more of the following options:

/libdir:all or /libdir	/libdir:none, /nolibdir, or /Zl
/libdir:automatic	/libdir:user

The /libdir options:

- /libdir:all or /libdir

  Requests the insertion of linker search path directives for libraries automatically determined by the DF command driver and for those specified by the *c*DEC$ OBJCOMMENT LIB source directives. Specifying /libdir:all is equivalent to /libdir:(automatic, user). This is the default.

- /libdir:none, /nolibdir, or /Zla

  Prevents *all* linker search path directives from being inserted into the object file (neither automatic nor user specified).

- /libdir:automatic

  Requests the insertion of linker search path directives for libraries automatically determined by the DF command driver (default libraries). To prevent the insertion of linker directives for default libraries, specify /libdir:noautomatic or /Zl. In the visual development environment, specify Disable Default Library Search Rules (for /libdir:noautomatic) in the Libraries Compiler Option Category.

- /libdir:user

  Allows insertion of linker search path directives for any libraries specified by the *c*DEC$ OBJCOMMENT LIB source directives. To prevent the insertion of linker directives for any libraries specified by the OBJCOMMENT directives, specify /libdir:nouser. In the visual development environment, specify Disable OBJCOMMENT Directives (for /libdir:nouser) in the Libraries Compiler Option Category.

/libs

Syntax:

> **/libs**
> [:*keyword*], **/MD**, **/MDd**, **/MDs**, **/ML**, **/MLd**, **/MT**, **/MTd**, **/MTs**, **/MW**, or **/MWs**

The /libs option controls the type of libraries your application is linked with. The default is /libs:static (same as /libs). In the visual development environment, specify the appropriate options in Use Fortran Run-Time Libraries list (for example, an option with DLL in its name sets /libs:dll) in the Libraries Compiler Option Category. These options are:

/libs:dll or /MDs	/libs:static or /ML
/libs:qwin or /MW	/libs:qwins or /MWs

This section also contains jumps to related information about libraries.

The /libs options:

- /libs:dll or /MDs

  The /libs:dll or /MDs option causes the linker to search for unresolved references in single threaded, dynamic link reference libraries (DLLs). If the unresolved reference is found in the DLL, it gets resolved when the program is executed (during program loading), reducing executable program size.
  Specifying /libs:dll with /threads is equivalent to /MD.
  Specifying /libs:dll with /threads and /dbglibs is equivalent to /MDd.

- /libs:static or /ML

  The /libs:static or /ML option requests that the linker searches only in single threaded, static libraries for unresolved references. This is the default. Specifying /libs:static does **not** request that dynamic link libraries (DLLs), QuickWin, or Standard Graphics libraries be searched. If you use QuickWin or Standard Graphics routines, use /libs:qwin or /libs:qwins.
  Specifying /libs (with no keyword) is the same as specifying /libs:static.

  Specifying /libs:static with /nothreads is equivalent to /ML.
  Specifying /libs:static with /nothreads and /dbglibs is equivalent to /MLd.
  Specifying /libs:static with /threads is equivalent to /MT.
  Specifying /libs:static with /threads and /dbglibs is equivalent to /MTd.

- /libs:qwin or /MW

Specifying /libs:qwin or /MW requests linking with libraries required of a Fortran QuickWin multi-doc (QuickWin) application.

- /libs:qwins or /MWs

  Specifying /libs:qwins or /MWs requests linking with libraries required of a Fortran Standard Graphics (QuickWin single-doc) application.

The following related options request additional libraries to link against:

- /dbglibs
- /threads
- /winapp
- /fpscomp:libs

To request the creation of a dynamic-link library, see /dll.

For information about compiling and linking Visual Fortran and Visual C++ programs (and the libraries used), see Specifying Consistent Library Types and Visual Fortran/Visual C++ Mixed-Language Programs.

For command-line examples of using the /libs option, see Linking Against Additional Libraries.

/[no]link

Syntax:

/link:*options* or **/nolink**

The /link option (without specifying *options*) precedes options to be passed to the linker as is (see Linker Options and Related Information). You can also specify the *options* to be passed to the linker as is using the form: /link:*options*.

To specify additional libraries to be linked on the command line, specify the library name on the DF command line either before or after the /link option, but the Linker option /nodefaultlib must follow the /link option:

```
DF /compiler-options filename.f90  mylib.lib /link /nodefaultlib
```

In the visual development environment, you can specify linker options using the Linker tab in the Project menu Settings dialog box. For example, to specify additional libraries to be linked in the visual development environment:

1. In the Project menu, click Settings to display the Project settings dialog box
2. Click the Linker tab

3. Select the General category
4. Type the additional library name to be linked with under Object/Library modules, such as mylib.lib
5. Click OK when done

The /nolink option suppresses linking and forces an object file to be produced even if only one program is compiled. Any options specified after the /nolink option are ignored.

If you encounter linker errors, see Linker Diagnostic Messages and Error Conditions.

/[no]list

Syntax:

/list[:*file*], **/nolist**, or **/Fs***file*

The /list or /Fs option creates a listing of the source file with compile-time information appended. To name the source listing file, specify *file*. If you omit the /list or /Fs options (or specify /nolist), no listing file is created.

In the visual development environment, specify Source Listing in the Listing File Compiler Option Category.

When a diagnostic message is displayed, the listing file contains a column pointer (such as .....1) that points to the specific part of the source line that caused the error.

To specify the content of the listing file, see /show.

To request a listing with Assembly instructions, see /asmfile.

To request a listing with information about optimizations, see /annotations.

The name of the listing file is the same as the source file (unless specified by *file*), with the extension .LST (unless the extension is specified by *file*).

If multiple object files are created, multiple listing files are usually created. For example, if you specify multiple source files with the /compile_only and /list options without a named object file (/object:*file*), multiple files are created. If you specify multiple source files with the /list, /compile_only, and /object:*file*, a single listing file is created. For command-line examples, see Generating a Listing File.

/[no]logo

Syntax:

/nologo or **/logo**

The /nologo option suppresses the copyright notice displayed by the compiler and linker. This option can be placed anywhere on the command line.

/[no]machine_code

Syntax:

/machine_code or **/nomachine_code**

The /machine_code option requests that a machine language representation be included in the listing file. The /machine_code option is a synonym for /show:code. In the visual development environment, specify Source Listing Options, Machine Code in the Listing File Compiler Option Category.

This option is ignored unless you specify /list[:*file*].

/[no]map

Syntax:

/map[:*file*], **/nomap**, or **/Fm***file*

The /map or /Fm option controls whether or not a link map is created. To name the map file, specify *file*.

In the visual development environment, in the Project menu Settings dialog box:

1. Click the Linker tab
2. Select the General category
3. Click the Generate mapfile option check box

If you omit /map or /Fm, a map file is not created.

The link map is a text file (see the Linker option /MAP).

/math_library

Syntax:

/math_library:*keyword*

The /math_library option specifies whether argument checking of math routines is done on ia32 systems. This option is ignored on ia64 systems.

In the visual development environment, specify the Math Library in the Optimizations (or Code Generation) Compiler Option Category.
The /math_library options are: /math_library:fast and /math_library:check:

- /math_library:fast

  On ia32 systems, /math_library:fast improves performance by not checking the arguments to the math routines. Using /math_library:fast makes tracing the cause of unexpected exceptional values results difficult. Specifying /math_library:fast does not change the accuracy of calculated floating-point numbers.

- /math_library:check

  On ia32 systems, /math_library:check validates the arguments to and results from calls to the Fortran math routines. This provides slower run-time performance than /math_library:fast, but with earlier detection of exceptional values. This is the default on ia32 systems.

/[no]module

Syntax:

/module[:*path*] or **/nomodule**

The /module option controls where the module files (extension .MOD) are placed. If you omit this option (or specify /nomodule), the .MOD files are placed in the directory where the source file being compiled resides.

When /module:*path* is specified, the *path* specifies the directory location where the module files will be placed.

In the visual development environment, specify the Module Path in the Preprocessor Compiler Option Category.

When /module is entered without specifying a path, it is interpreted as a request to place the MOD files in the same location that the object is being created. Should a *path* be specified on the /object option, that location would also be used for the MOD files.

You need to ensure that the module files are created before they are referenced when using the DF command (see Compile With Appropriate Options and Multiple Source Files).

/names

Syntax:

/names:*keyword*, **/GNa**, **/GNl**, or **/GNu**

The /names option specifies how source code identifiers and external names are interpreted and the case convention used for external names. This naming convention applies whether names are being defined or referenced. The default is /names:uppercase (same as /GNu).

In the visual development environment, specify the Name Interpretation in the External Procedures or the Fortran Language Compiler Option Category.
The /names options are:

- /names:as_is or /GNa
  Causes the compiler to:
  - Distinguish between uppercase and lowercase letters in source code identifiers (treat uppercase and lowercase letters as different).
  - Distinguish between uppercase and lowercase letters in external names.

- /names:lowercase or /GNl
  Causes the compiler to:
  - Not distinguish between uppercase and lowercase letters in source code identifiers (treat lowercase and uppercase letters as equivalent).
  - Force all letters to be lowercase in external names.

- /names:uppercase or /GNu (default)
  Causes the compiler to:
  - Not distinguish between uppercase and lowercase letters in source code identifiers (treat lowercase and uppercase letters as equivalent).
  - Force all letters to be uppercase in external names.

Instead of using the /names compiler option, consider using the cDEC$ ALIAS directive for the specific name needed.

/nodefine

Syntax:

/nodefine

The /nodefine option requests that all *symbols* specified by the accompanying /define:*symbols* option apply only to the Fortran preprocessor, FPP, and are *not* available to conditional compilation directives (such as the IF

Directive Construct). For example, the following command defines the symbol release as 1, which is available only to FPP:

```
DF /fpp /define:release /nodefine
```

If you specify */define:symbols* and omit /nodefine, *symbols* specified by /define:*symbols* are available to both FPP and conditional compilation directives.

In the visual development environment, specify the Predefined Preprocessor Symbols to FPP Only in the Preprocessor Compiler Option Category.

For more information on FPP, see /fpp.

/[no]object

Syntax:

> **/object**[:*filename*], **/noobject**, or **/Fo***filename*

The /object or /Fo option names the object file *filename*. Specify /noobject to prevent creation of an object file. The default is /object, where the file name is the same as the first source file with a file extension of .OBJ.

If you omit /compile_only (or /c) and specify /object:*filename* or /Fo*filename*, the /object option names the object file *filename*.

If you specify /object:*filename* or /Fo*filename* and specify the /compile_only option, the /object or /Fo option causes multiple Fortran input files (if specified) to be compiled into a single object file. This allows interprocedural optimizations to occur at higher optimization levels, which usually improves run-time performance.

For information on where module files are placed, see /module[:path].

/[no]optimize

Syntax:

> **/optimize**[:*level*], **/nooptimize**, **/Od**, **/Ox**, or **/Oxp**

The /optimize option controls the level of optimization performed by the compiler. To provide efficient run-time performance, Visual Fortran increases compile time in favor of decreasing run time. If an operation can be performed, eliminated, or simplified at compile time, the compiler does so rather than have it done at run time. Also, the size of object file usually increases when certain optimizations occur (such as with more loop unrolling and more inlined procedures).

In the visual development environment, specify the Optimization Level in the General or Optimizations Compiler Option Category. The /optimize options are:

/optimize:0 or /Od	/optimize:1
/optimize:2	/optimize:3
/optimize:4, /Ox, and /Oxp	/optimize:5

The /optimize options:

- /optimize:0 or /Od

  Disables nearly all optimizations. This is the default if you specify /debug (with no keyword). Specifying this option causes certain /warn options to be ignored. The /optimize:0 option is the default in the the visual development environment for a debug configuration. Specifying /Od sets the /optimize:0 and /math_library:check options.

- /optimize:1

  Enables local optimizations within the source program unit, recognition of common subexpressions, and expansion of integer multiplication and division (using shifts).

- /optimize:2

  Enables global optimization. This includes data-flow analysis, code motion, strength reduction and test replacement, split-lifetime analysis, and instruction scheduling. Specifying /optimize:2 includes the optimizations performed by /optimize:1.

- /optimize:3

  Enables additional global optimizations that improve speed (at the cost of extra code size). These optimizations include:

  - Loop unrolling, including instruction scheduling
  - Code replication to eliminate branches
  - Padding the size of certain power-of-two arrays to allow more efficient cache use (see Use Arrays Efficiently)

  Specifying /optimize:3 includes the optimizations performed by /optimize:1 and /optimize:2.

- /optimize:4, /Ox, and /Oxp

  Enables interprocedure analysis and automatic inlining of small procedures (with heuristics limiting the amount of extra code). Specifying /optimize:4 includes the optimizations performed by /optimize:1 /optimize:2, and /optimize:3. For the DF command, /optimize:4 is the default for the command line unless you specify /debug (with no keyword). In the the visual development environment for a release configuration, the default is /optimize:4.

  Specifying /Ox sets: /optimize:4, /math_library:fast, and /assume:nodummy_aliases.

  Specifying /Oxp sets: /optimize:4, /math_library:check, /assume:nodummy_aliases, and /fltconsistency.

- /optimize:5

  On ia32 systems, activates the loop transformation optimizations (also set by /transform_loops). On ia64 systems, activates the loop transformation optimizations (also set by /transform_loops) and the software pipelining optimization (also set by /pipeline (ia64 only)):

  - The loop transformation optimizations are a group of optimizations that apply to array references within loops. These optimizations can improve the performance of the memory system and can apply to multiple nested loops.

    Loop transformation optimizations include loop blocking, loop distribution, loop fusion, loop interchange, loop scalar replacement, and outer loop unrolling. You can specify loop transformation optimizations without software pipelining (see /[no]transform_loops).

  - The software pipelining optimization (ia64 systems only) applies instruction scheduling to certain innermost loops, allowing instructions within a loop to "wrap around" and execute in a different iteration of the loop. This can reduce the impact of long-latency operations, resulting in faster loop execution. Software pipelining also enables the prefetching of data to reduce the impact of cache misses.

    You can specify software pipelining without loop transformation optimizations (see /[no]pipeline (ia64 only)).

  To determine whether using /optimize:5 benefits your particular program, you should compare program execution timings for the same program (or subprogram) compiled at levels /optimize:4 and /optimize:5.

Specifying /optimize:5 includes the optimizations performed by /optimize:1, /optimize:2, /optimize:3, and /optimize:4.

For detailed information on these optimizations, see Optimization Levels: the /optimize Option.

For information about timing your program, see Analyze Program Performance.

To compile your application for efficient run-time performance, see Compile With Appropriate Options and Multiple Source Files.

/[no]pad_source

Syntax:

/pad_source or **/nopad_source**

For fixed-form source files, the /pad_source option requests that source records shorter than the statement field width are to be padded with spaces on the right out to the end of the statement field. This affects the interpretation of character and Hollerith literals that are continued across source records.

In the visual development environment, specify the Pad Fixed-Form Source Records in the Fortran Language Compiler Option Category.

The default is /nopad_source, which causes a warning message to be displayed if a character or Hollerith literal that ends before the statement field ends is continued onto the next source record. To suppress this warning message, specify the /warn:nousage option.

Specifying /pad_source can prevent warning messages associated with /warn:usage.

/[no]pdbfile

Syntax:

/pdbfile[:*filename*], **/nopdbfile**, or **/Fd***filename*

The /pdbfile or /Fd option indicates that any debug information generated by the compiler should be to a program database file, *filename*.PDB. If you omit *filename*, the default file name used is df60.pdb.

In the visual development environment, specify Use Program Database for Debug Information (and optionally specify the Program Database .PDB Path) in the Debug Compiler Option Category.

When full debug information is requested (/debug:full, /debug, or equivalent), the debug information is placed in the PDB file (unless /nopdbfile is specified).

The compiler places debug information in the object file if you specify /nopdbfile or omit both /pdbfile and /debug:full (or equivalent).

/[no]pipeline (ia64 only)

Syntax:

/pipeline or **/nopipeline**

On ia64 systems, the /pipeline (or /optimize:5) option activates the software pipelining optimization. This optimization applies instruction scheduling to certain innermost loops, allowing instructions within a loop to "wrap around" and execute in a different iteration of the loop. This can reduce the impact of long-latency operations, resulting in faster loop execution.

In the visual development environment, specify the Apply Software Pipelining Optimizations in the Optimizations Compiler Option Category.

For this version of Visual Fortran, loops chosen for software pipelining are always innermost loops and do not contain branches, procedure calls, or COMPLEX floating-point data.

Software pipelining also enables the prefetching of data to reduce the impact of cache misses.

Software pipelining is a subset of the optimizations activated by /optimize:5. Instead of specifying both /pipeline and /transform_loops, you can specify /optimize:5.

To specify software pipelining without loop transformation optimizations, do one of the following:

- Specify /optimize:5 with /notransform_loops.
- Specify /pipeline with /optimize:4, /optimize:3, or /optimize:2. This optimization is not performed at optimization levels below /optimize:2.

To determine whether using /pipeline benefits your particular program, you should time program execution for the same program (or subprogram) compiled with and without software pipelining (such as with /pipeline and /nopipeline).

For certain programs that contain loops that exhaust available registers, longer execution times may result with /optimize:5, requiring use of /unroll:*count* to limit loop unrolling. The /pipeline option applies only to ia64 systems.

For more information, see Software Pipelining.

/preprocess_only

Syntax:

/preprocess_only

When used with the /fpp option, the /preprocess_only option runs only the FPP preprocessor and puts the result for each source file in a corresponding .i or .i90 file. The .i or .i90 file does not have line numbers (#) in it.

You need to specify /fpp with this option.

/real_size

Syntax:

/real_size:*size* or **/4R8**

The /real_size or /4R8 option controls the *size* (in bits) of REAL and COMPLEX declarations, constants, functions, and intrinsics. In the visual development environment, specify the Default Real Kind in the Fortran Data Compiler Option Category. The /real_size options are:

- /real_size:32

  Defines REAL declarations, constants, functions, and intrinsics as REAL (KIND=4) (SINGLE PRECISION). It also defines COMPLEX declarations, constants, functions, and intrinsics as COMPLEX(KIND=4) (COMPLEX). This is the default.

- /real_size:64 or /4R8

  Defines REAL declarations, constants, functions, and intrinsics as REAL (KIND=8) (DOUBLE PRECISION). It also defines COMPLEX declarations, constants, functions, and intrinsics as COMPLEX(KIND=8).

Specifying /real_size:64 causes intrinsic functions to produce a REAL(KIND=8) or COMPLEX(KIND=8) result instead of a REAL(KIND=4) or COMPLEX(KIND=4) result, unless the argument is explicitly typed as REAL(KIND=4) or COMPLEX (KIND=4), including CMPLX, FLOAT, REAL, SNGL, and AIMAG. For instance, references to the CMPLX intrinsic produce DCMPLX results (COMPLEX(KIND=8)), unless the argument to CMPLX is explicitly typed as REAL(KIND=4), REAL*4, COMPLEX(KIND=4), or COMPLEX*8. In this case the resulting data type is

COMPLEX(KIND=4).

/[no]recursive

Syntax:

/recursive or **/norecursive**

The /recursive option compiles all procedures (functions and subroutines) for possible recursive execution. Specifying the /recursive option sets the /automatic option. The default is /norecursive.

In the visual development environment, specify Enable Recursive Routines in the Code Generation Compiler Option Category.

/[no]reentrancy

Syntax:

/reentrancy[:*keyword*] or **/noreentrancy**

The /reentrancy or /reentrancy:threads option requests that the compiler generate reentrant code that supports a multithreaded application. In the visual development environment, specify the Enable Reentrancy Support or Disable Reentrancy Support in the Libraries Compiler Option Category.

If you omit /reentrancy, /reentrancy:threads, or /threads, /reentrancy:none (same as /noreentrancy) is used.

Specifying /threads sets /reentrancy:threads, since multithreaded code must be reentrant.

/[no]show

Syntax:

/show:*keyword...* or **/noshow**

The /show option specifies what information is included in a listing. In the visual development environment, specify the Source Listing Options in the Listing File Compiler Option Category. The /show keywords are:

/show:code	/show:include
/show:map	/show:nomap
/show or /show:all	/noshow or /show:none

The /show keywords:

- /show:code

  Includes a machine-language representation of the compiled code in the listing file. The default is /show:nocode. The /show:code and /machine_code options are equivalent.

- /show:include

  Lists any text file included in the source file (unless that source is included using the INCLUDE 'filespec /NOLIST' syntax; see the /vms option). The default is /show:noinclude.

- /show:map (default)

  Includes a symbol map in the listing file.

- /show:nomap

  Do not include a symbol map in the listing file.

- /show or /show:all

  Equivalent to /show:(code,include,map).

- /noshow or /show:none

  Equivalent to /show:(nocode,noinclude,nomap).

The /show option is ignored unless you specify /list[:*file*] or /Fs*file*.

/source

Syntax:

/source:*file* or **/Tf***file*

The /source or /Tf option indicates that the *file* is a Fortran source file with a non-standard file extension (not one of .F, .FOR, or .F90) that needs to be compiled.

The default for any file that does *not* have an extension of .F90 or .f90 is to be a fixed-format Fortran file.

/[no]stand

Syntax:

> **/stand**[:*keyword*], **/nostand**, **/4Ys**, or **/4Ns**

The /stand option issues compile-time messages for language elements that are not standard in the Fortran 90 or Fortran 95 language that can be identified at compile-time. In the visual development environment, specify the Fortran Standards Checking in the Compilation Diagnostics Compiler Option Category.

The /stand options are:

- /stand:f90 or /4Ys

  Specifies that diagnostic messages be generated with a warning-level severity (allows an object file to be created) for extensions to the Fortran 90 standard.

- /stand or /stand:f95

  Specifies that diagnostic messages be generated with a warning-level severity (allows an object file to be created) for extensions to the Fortran 95 standard.

- /stand:none, /nostand, or /4Ns

  Specifies that no messages be issued for language elements that are not standard in the Fortran 90 or Fortran 95 language.

  The same effect occurs if you omit the /stand,
  or /stand:*keyword*, /warn:stderrors, or /4Ys options.

Specify /warn:stderrors to request that diagnostic messages be generated with an error-level severity (instead of warning) to prevent an object file from being created.

Specifying /stand issues warning messages for:

- Obsolescent and deleted features specified by the Fortran standard.
- Syntax extensions to the Fortran 95 standard. Syntax extensions include

nonstandard statements and language constructs.
- Fortran 95 standard-conforming statements that become nonstandard due to the way in which they are used. Data type information and statement locations are considered when determining semantic extensions.
- For fixed-format source files, lines that use tab formatting.

Source statements that do not conform to Fortran language standards are detected by the compiler under the following circumstances:

- The statements contain ordinary syntax and semantic errors.
- A source program containing nonconforming statements is compiled with the /stand or /check options.

Given these circumstances, the compiler is able to detect *most* instances of nonconforming usage. It does not detect all instances because the /stand option does not produce checks for all nonconforming usage at compile time. In general, the unchecked cases of nonconforming usage arise from the following situations:

- The standard violation results from conditions that cannot be checked at compile time.
- The compile-time checking is prone to false alarms.

Most of the unchecked cases occur in the interface between calling and called subprograms. However, other cases are not checked, even within a single subprogram.

The following items are known to be unchecked:

- Use of a data item prior to defining it
- Use of the SAVE statement to ensure that data items or common blocks retain their values when reinvoked
- Association of character data items on the right and left sides of character assignment statements
- Mismatch in order, number, or type in passing actual arguments to subprograms with implicit interfaces
- Association of one or more actual arguments with a data item in a common block when calling a subprogram that assigns a new value to one or more of the arguments

/[no]static

Syntax:

/static or **/nostatic**

The /static option is the same as the /noautomatic option. The default is /static, which causes all local variables to be statically allocated. The /nostatic option is the same as /automatic. In the visual development environment, specify /nostatic as Variables Default to Automatic in the Fortran Data Compiler Option Category.

If you specify /recursive, the /automatic option is set.

/[no]syntax_only

Syntax:

/syntax_only or **/nosyntax_only**

The /syntax_only option requests that only the syntax of the source file be checked. If the /syntax_only option is specified, code generation is suppressed. The default is /nosyntax_only.

/[no]threads

Syntax:

/threads or **/nothreads**

The /threads option requests linking with multithreaded libraries, which creates a multithreaded program or DLL. If you specify /threads, this sets the /reentrancy option.

In the visual development environment, specify one of the Multi-thread library options in Use Fortran Run-Time Libraries list in the Libraries Compiler Option Category.

The default is /nothreads, which links with single-threaded libraries to create a single-threaded program or DLL.

Related options that control the libraries used during linking include:

- /libs
- /winapp
- /fpscomp:libs

/[no]traceback

Syntax:

/traceback or **/notraceback** or **/Zt**

The /traceback option requests that the compiler generate extra information in the object file that allows the display of source file traceback information at run time when a severe error occurs.

Specifying /traceback:

- Provides source file, routine name, and line number correlation information in the text that is displayed when a severe error occurs.
- Will increase the size of the executable program, but has no impact on run-time execution speeds.

For the DF command line and for a release configuration in the visual development environment, the default is /notraceback. For a debug configuration in the visual development environment, the default is /traceback.

If traceback is not specified, the displayed call stack hexadecimal addresses (program counter trace) displayed when a severe error occurs do not list the source file name, routine name, and line number. However, advanced users can locate the cause of the error using a .MAP file (linker option /map) and the hexadecimal addresses of the stack displayed when a severe error occurs (see Using Traceback Information).

In the visual development environment, specify Generate Traceback Information in the Run-Time Compiler Option Category.

The /traceback option functions independently of the /debug option.

If you request traceback, you should also disable incremental linking. For a Debug configuration in the visual development environment for a new project, specifying Traceback turns off incremental linking. When using the command line, specifying /traceback sets /link /incremental:no. You can disable incremental linking either in the Link tab in the Project Settings dialog box or specify DF /link /incremental:no on the command line.

If you omit /traceback (or /Zt), /notraceback is used.

For information about locating run-time errors with traceback information, see Using Traceback Information.

For request traceback information at any time by calling the **TRACEBACKQQ** routine, see Obtaining Traceback Information with TRACEBACKQQ.

To disable the stack traceback report for severe errors, set the FOR_DISABLE_STACK_TRACE environment variable (see Using Traceback Information).

/[no]transform_loops

Syntax:

/transform_loops or **/notransform_loops**

The /transform_loops (or /optimize:5) option activates a group of loop transformation optimizations that apply to array references within loops. These optimizations can improve the performance of the memory system and usually apply to multiple nested loops. The loops chosen for loop transformation optimizations are always *counted loops* (which include DO or IF loops), but not uncounted DO WHILE loops).

In the visual development environment, specify the Apply Loop Transformation Optimizations in the Optimizations Compiler Option Category.

Conditions that typically prevent the loop transformation optimizations from occurring include subprogram references that are not inlined (such as an external function call), complicated exit conditions, and uncounted loops.

The types of optimizations associated with /transform_loops include the following:

- Loop blocking
- Loop distribution
- Loop fusion
- Loop interchange
- Loop scalar replacement
- Outer loop unrolling

The loop transformation optimizations are a subset of optimizations activated by /optimize:5. On ia32 systems, instead of specifying /transform_loops, you can specify /optimize:5. On ia64 systems, instead of specifying both /pipeline and /transform_loops, you can specify /optimize:5.

On ia64 systems, to specify loop transformation optimizations without software pipelining, do one of the following:

- Specify /optimize:5 with /nopipeline.
- Specify /transform_loops with /optimize:4, /optimize:3, or /optimize:2. This optimization is not performed at optimization levels below /optimize:2.

To determine whether using /transform_loops benefits your particular program, you should time program execution for the same program (or subprogram) compiled with and without loop transformation optimizations (such as with /transform_loops and /notransform_loops).

For more information, see Loop Transformations.

/tune

Syntax:

/tune:*keyword*

The /tune option specifies the type of processor-specific machine-code instruction tuning for implementations of the processor architecture in use.

Tuning for a specific implementation can improve run-time performance; it is also possible that code tuned for a specific processor may run slower on another processor. Regardless of the /tune:*keyword* option you use, the generated code runs correctly on all implementations of the processor architecture.

If you omit /tune:*keyword*, /tune:generic is used. In the visual development environment, specify the Optimize For in the Optimizations Compiler Option Category.

For ia32 (32-bit Intel and AMD) systems, the /tune keywords are:

- /tune:generic

  Generates and schedules code (sometimes called blended code) that will execute well for all ia32 systems. This provides generally efficient code for those applications where all ia32 processor generations are likely to be used. This is the default.

- /tune:host

  Generates and schedules code optimized for the processor type in use on the processor system being used for compilation.

- /tune:pn1

  Generates and schedules code optimized for the Pentium (586) processor systems. The pn1 keyword replaces the p5 keyword (specifying /tune:pn1 and /tune:p5 are equivalent).

- /tune:pn2

  Generates and schedules code optimized for Pentium Pro, Pentium II, and AMD K6 processor systems. The pn2 keyword replaces the p6 keyword (specifying /tune:pn2 and /tune:p6 are equivalent).

- /tune:k6

  Generates and schedules code optimized for AMD K6, Pentium Pro, and Pentium II processor systems (/tune:pn2 and /tune:k6 are the same).

- /tune:pn3

  Generates and schedules code optimized for Pentium III, AMD K6_2, and AMD K6_III processor systems. The pn3 keyword replaces the p6p keyword (specifying /tune:pn3 and /tune:p6p are equivalent).

- /tune:k6_2

  Generates and schedules code optimized for AMD K6_2 and AMD K6_III processor systems.

- /tune:k7

  Generates and schedules code optimized for AMD Athlon processor systems.

- /tune:pn4

  Generates and schedules code optimized for Pentium IV processor systems.

Specifying /fast sets /tune:host.

For ia64 (64-bit) systems, specify either /tune:generic or /tune:host (this option is not yet fully implemented for ia64 systems).

The architecture selected by /architecture (code generation option) is the basis for the architecture used by the /tune keyword. For example, you cannot specify a /tune keyword for an architecture older than the one selected by /architecture.

For more information about this option, see Requesting Optimized Code for a Specific Processor Generation.

For information about timing program execution, see Analyze Program Performance.

To control the processor-specific type of machine-code instructions being generated, see the /architecture:keyword option.

/undefine

Syntax:

/undefine:*symbol*

The /undefine option removes any initial definition of *symbol* for the FPP preprocessor.

/unroll

Syntax:

/unroll:*count*

For higher optimization levels, the /unroll option allows you to specify how many times loops are unrolled. If the /unroll option is not specified, the optimizer will choose an unroll amount that minimizes the overhead of prefetching while also limiting code size expansion.

In the visual development environment, specify the Loop Unroll Count in the Optimizations Compiler Option Category.

If the /optimize:3, /optimize:4 (or equivalent), or /optimize:5 options are specified, loop unrolling occurs. The *count* should be an integer in the range 0 to 16. A count value of 0 is used to indicate that the compiler should determine how many times a loop is unrolled (default).

The compiler attempts to unroll certain innermost loops, minimizing the number of branches and grouping more instructions together to allow efficient overlapped instruction execution (instruction pipelining). The best candidates for loop unrolling are innermost loops with limited control flow.

On ia32 systems, specifying a higher value may improve run-time performance of certain applications. For more information, see Loop Unrolling.

You can specify the number of times a specific loop is unrolled by using the *c*DEC$ UNROLL Directive to Control Loop Unrolling.

/[no]vms

Syntax:

/vms or **/novms**

The /vms option causes the run-time system to provide functions like Compaq Fortran 77 for OpenVMS VAX™ Systems (previously called VAX FORTRAN™).

In the visual development environment, specify Enable VMS Compatibility in the Compatibility Compiler Option Category. The /vms option:

- In the absence of other options, sets the following command-line defaults: /check:format, /check:output_conversion, /static, /norecursive, and /names:lowercase.
- When /ccdefault:default is also specified, /vms changes the default carriage control to FORTRAN if the file is formatted and the unit is connected to a terminal.
- Allows use of the **DELETE** statement for relative files. When a record in a relative file is deleted, the first byte of that record is set to a known character (currently '@'). Attempts to read that record later result in ATTACCNON errors. The rest of the record (the whole record when /vms is not set) is set to nulls for unformatted files and spaces for formatted files.
- When an **ENDFILE** is performed on a sequential unit, an actual 1-byte record containing a Ctrl+D (04 hex) is written to the file. When you omit /vms, an internal **ENDFILE** flag is set and the file is truncated. The /vms option does not affect **ENDFILE** on relative files; the file is truncated.
- Changes certain **OPEN** statement BLANK keyword defaults. Changes the default interpretation from BLANK='NULL' to BLANK='ZERO' for an implicit open or internal file **OPEN**. For an explicit **OPEN**, the default is always BLANK='NULL'.
- Changes certain **OPEN** statement effects. If the CARRIAGECONTROL is defaulted, the file is formatted, and the unit is connected to a terminal, then the carriage control defaults to FORTRAN. Otherwise, it defaults to LIST. The /vms option affects the record length for relative organization files. The buffer size is increased by 1 to accommodate the deleted record character.
- LIST and /NOLIST are recognized at the end of the file specification to the **INCLUDE** statement at compile time. If you specified /vms and if the file specification does not include the directory path, the current working directory is used as the default directory path. If you omitted /vms, the directory path is where the file that contains the **INCLUDE** statement resides.
- Changes internal file writes using list-directed I/O. A list-directed write to an internal file results in removal of the first character from the first element; the field length is decremented accordingly.
- The run-time direct access **READ** routine checks the first byte of the retrieved record. If this byte is '@' or NULL ('\0'), then ATTACCNON is returned. The run-time sequential access **READ** routine checks to see if the record it just read is 1 byte long and contains a Ctrl+D (04 hex) or a Ctrl+Z (1A hex). If this is true, it returns EOF.

The default is /novms.

/[no]warn

Syntax:

/warn[:*keyword...*]), **/nowarn**, **/4Yd**, **/4Nd**, **/4Ys**, **/W0**, **/W1**, or **/WX**

The /warn option instructs the compiler to generate diagnostic messages for defined classes of additional checking that can be performed at compile-time. It also can change the severity level of issued compilation messages.

In the visual development environment, specify the Warning Level (/warn:nogeneral, default, or /warn:error) in the General or the Compiler Diagnostic Compiler Option Category. Specify individual Warning Options in the Compiler Diagnostic Compiler Option Category. The /warn options and their visual development environment names are:

/warn:noalignments (Data Alignment)	/warn:argument_checking (Argument Mismatch)
/warn:declarations or /4Yd (Undeclared Variables)	/warn:errors or /WX (Warning Level: Errors)
/warn:nofileopt (Inform when Compiling Files Separately)	/warn:nogeneral (Warning Level: Ignore)
/warn:ignore_loc (Inform When Removing %LOC from an Argument)	/warn:stderror or /4Ys (Treat Fortran Standard Warnings as Errors)
/warn:truncated_source (Truncated Source)	/warn:nouncalled (Uncalled Routines)
/warn:nouninitialized (Uninitialized Variables)	/warn:unused (Unused Variables)
/warn:nousage (Usage)	/warn:all or /warn
/warn:none, /nowarn, or /W0	

If you omit /warn, the defaults are:

- For the DF command: /warn:(alignments,noargument_checking,nodeclarations,noerrors,fileopts, general,noignore_loc,nostderrors,notruncated_source,uncalled,uninitialized,n
- In the visual development environment for a debug configuration, the

default of noargument_checking changes to argument_checking.

- In the visual development environment for a release configuration, the default of fileopts changes to nofileopts.
- For the FL32 command: /warn: (alignments,argument_checking,nodeclarations,noerrors,nofileopts, general,noignore_loc,nostderrors,notruncated_source,uncalled,uninitialized,n

The /warn keywords are:

- /warn:noalignments

  Suppresses warning messages for data that is not naturally aligned. The default is /warn:alignments.

- /warn:argument_checking

  Enables warnings about argument mismatches between callers and callees, when compiled together. The default is /warn:noargument_checking, except in the visual development environment for a debug configuration, where the default is /warn:argument_checking.

- /warn:declarations or /4Yd

  Issues an error message for any undeclared symbols. This option makes the default type of a variable undefined (IMPLICIT NONE) rather than using the default Fortran rules. The default is /warn:nodeclarations or /4Nd.

- /warn:errors or /WX

  Changes the severity of all warning diagnostics into error diagnostics. The default is /warn:noerrors. Specifying /warn:errors (or /WX) sets /warn:stderrors.

- /warn:nofileopt

  Suppresses the display of an informational-level diagnostic message when compiling multiple files separately, which can prevent interprocedure optimizations. The default is /warn:fileopt (displays the message: Some interprocedural optimizations may be disabled when compiling in this mode), except in the visual development environment for a release configuration, where the default is /warn:nofileopt.

- /warn:nogeneral

  Suppresses all informational-level and warning-level diagnostic messages from the compiler. The default is /warn:general or /W1.

- /warn:ignore_loc

  Requests that the compiler issues warnings when %LOC is stripped from an argument. The default is /warn:noignore_loc (does not issue a warning for this condition).

- /warn:stderrors or /4Ys

  Requests Fortran 90 standards checking (see /stand) with error-level compilation messages instead of warning-level messages.
  Specifying /warn:stderrors sets /stand:f90 and is equivalent to /4Ys.

  Specifying /warn:stderrors with /stand:f95 requests error-level messages for extensions to the proposed Fortran 95 standard.

  Specifying /warn:errors sets /warn:stderrors. The default is /warn:nostderrrors.

- /warn:truncated_source

  Requests that the compiler issue a warning diagnostic message when it reads a source line with a statement field that exceeds the maximum column width in fixed-format source files. The maximum column width for fixed-format files is column 72 or 132, depending whether the /extend_source option was specified.
  This option has no effect on truncation; lines that exceed the maximum column width are always truncated. This option does not apply to free-format source files. The default is /warn:notruncated_source.

- /warn:nouncalled

  Suppresses the compiler warning diagnostic message when a statement function is never called. The default is /warn:uncalled.

- /warn:nouninitialized

  Suppresses warning messages for a variable that is used before a value was assigned to it. The default is /warn:uninitialized.

- /warn:unused

  Requests warning messages for a variable that is declared but never used. The default is /warn:nounused.

- /warn:nousage

Suppresses warning messages about questionable programming practices and the use of intrinsic functions that use a two-digit year (year 2000). The questionable programming practices, although allowed, often are the result of programming errors. For example, /warn:usage detects a continued character or Hollerith literal whose first part ends before the statement field ends and appears to end with trailing spaces. The default is /warn:usage. The /pad_source option can prevent warning messages from /warn:usage.

- /warn:all or /warn

  Requests all possible warning messages, but does not set /warn:errors or /warn:stderrors. To enable all the additional checking to be performed and force the severity of the diagnostics to be severe enough to not generate an object file, specify /warn:(all,errors) or /warn:(all,stderrors).

- /warn:none, /nowarn, or /W0

  Suppresses all warning messages.

For example, the following command requests the argument_checking and declarations keywords and accepts the defaults for the other /warn keywords:

```
df /warn:(argument_checking,declarations) testfile.f90
```

/[no]watch

Syntax:

/watch[:*keyword*] or **/nowatch**

The /watch option requests the display of processing information to the console output window. The default is /watch:source. You can request the display of the passes (compiler, linker) with their respective command arguments and/or the input and output files by specifying any of the following /watch keywords:

/watch:cmd	/watch:source
/watch:all or /watch	/nowatch or /watch:none

The /watch options:

- /watch:cmd
  Displays the passes (compiler, linker) with the respective command arguments.

- /watch:source
  Displays the names of sources file(s) being processed. Source file names are listed one per line. This is the default.

- /watch:all or /watch
  Requests /watch:(cmd, source). This displays both pass information and source file names (verbose output).

- /nowatch or /watch:none
  Requests /watch:(nocmd, nosource).

/what

Syntax:

/what

The /what option displays Visual Fortran version number information.

/winapp

Syntax:

/winapp or **/MG**

The /winapp or /MG option requests the creation of a graphics or Fortran Windows application and links against the most commonly used libraries. In the visual development environment, specify the Use Common Windows Libraries in the Libraries Compiler Option Category.

The following related options request libraries:

- /libs
- /[no]threads
- /[no]dbglibs
- /fpscomp:libs

For information on Fortran Windows Applications, including requesting additional link libraries with the `FULLAPI.F90` file, see Creating Windows Applications.

Linker Options and Related Information

You can set Linker options from:

- The DF command line.

When using the DF command line, specify linker options *after* the /LINK option. For example:

```
DF file.f90 file.lib /LINK /NODEFAULTLIB
```

- The LINK command line.

  You can specify linker options and libraries with the LINK command. For example:

  ```
  LINK file.obj file.lib /NODEFAULTLIB
  ```

- Within the Microsoft visual development environment, in the Project menu, Settings dialog box.

  You can specify linker options and libraries by using the Linker tab in the Project menu, Settings dialog box.

The following table describes the Linker options.

Linker Option	**Function**
/ALIGN	Specifies the alignment of each section within the linear address space of the program.
/BASE	Sets a base address for the program, overriding the default location.
/COMMENT	Inserts a comment string into the header of an executable file or DLL, after the array of section headers.
/DEBUG	Creates debugging information for the executable file or DLL.
/DEBUGTYPE	Generates debugging information in one of three ways: Microsoft format (CV), COFF format, or both.
/DEF	Passes a module-definition (.DEF) file to the linker.
/DEFAULTLIB	Adds one or more *libraries* to the list of libraries that LINK searches when resolving references.
/DELAY	Controls the delayed loading of DDLs.
/DELAYLOAD	Causes delayed loading of DLLs.

/DLL	Builds a DLL as the main output file when using the command line.
/DRIVER	Used to build a Windows NT 4 or Windows 2000 kernel mode driver.
/ENTRY	Sets the starting address for an executable file or DLL.
/EXETYPE	Used when building a virtual device driver (requested by using the /VXD option).
/EXPORT	Exports a function from your program.
/FIXED	Tells the operating system to load the program only at its preferred base address.
/FORCE	Informs the linker to create a valid executable file or DLL even if a symbol is referenced but not defined or is multiply defined.
/HEAP	Sets the size of the heap in bytes.
/IMPLIB	Sets the name for the import library that LINK creates when it builds a program that contains exports.
/IMPORT	Does not apply to Visual Fortran.
/INCLUDE	Informs the linker to add a specified symbol to the symbol table.
/INCREMENTAL	Controls how the linker handles incremental linking.
/LARGEADDRESSAWARE	Informs the linker that the application can handle addresses larger than 2 gigabytes.
/LIBPATH	Overrides the environment library path.
/LINK50COMPAT	Generates import libraries in the old (Visual C++ version 5.0) format for backward compatibility.
/MACHINE	Specifies the target platform for the program.
/MAP	Informs the linker to generate a mapfile. You can also specify the file name.

/MAPINFO	Informs the linker to include the specified information in a map file (requested by /MAP).
/MERGE	Combines the first section with the second section and names the resulting section.
/NODEFAULTLIB	Informs the linker to remove all default libraries from the list of libraries it searches when resolving external references. If you specify one or more libraries, the linker only ignores the libraries you have named.
/NOENTRY	Prevents LINK from linking a reference to _main into the DLL.
/NOLOGO	Prevents the display of the copyright message and version number. It also suppresses echoing of command files.
/OPT	Controls the optimizations LINK performs during a build.
/ORDER	Lets you perform optimization by telling LINK to place certain packaged functions into the image in a predetermined order.
/OUT	Overrides the default name and location of the image file that LINK creates.
/PDB	Controls how the linker produces debugging information.
/PDBTYPE	Controls which Program Database (PDB) is used to store the debug type information.
/PROFILE	Creates an output file that can be used with the profiler.
/RELEASE	Sets the checksum in the header of an executable file.
/SECTION	Changes the attributes of a section, overriding the attributes set when the .OBJ file for the section was compiled.
/STACK	Sets the size of the stack in bytes.

/STUB	Attaches an MS-DOS stub program to a Win32 program.
/SUBSYSTEM	Tells the operating system how to run the executable file.
/SWAPRUN	Informs the operating system to first copy the linker output to a swap file, and then run the image from there (Windows NT 4 or Windows 2000).
/VERBOSE	Sends information about the progress of the linking session to the Output window.
/VERSION	Informs the linker to put a version number in the header of the executable file or DLL.
/VXD	Creates a virtual device driver (VxD).
/WARN	Determines the output of LINK warnings.
/WS	Adds the WS_AGGRESSIVE attribute to your application's image.

This table lists the Linker options with the equivalent Microsoft visual development environment category if one is available. Options not listed are usually command-line only and can be entered in the "Common Options" text box of the Project ... Settings dialog box. For instructions on how to work with the Microsoft visual development environment, see Building Programs and Libraries.

Linker Option	**Visual Development Environment Category**
/ALIGN	Command-line only
/BASE	Output Category
/DEBUG	Debug Category
/DEBUGTYPE	Debug Category
/DEF	Command-line only
/DEFAULTLIB	Command-line only
/ENTRY	Output Category
/FORCE	Customize Category

/INCLUDE	Input Category
/INCREMENTAL	Customize Category
/LIBPATH	Input Category
/MAP	Debug Category
/NODEFAULTLIB	Input Category
/NOLOGO	Customize Category
/OUT	Customize Category
/PDB	Customize Category
/PDBTYPE	Debug Category
/PROFILE	General Category
/STACK	Output Category
/VERBOSE	Customize Category
/VERSION	Output Category

Besides discussing linker options individually, this section also discusses Module-Definition Files and Linker Reserved Words.

Setting LINK Options in the Visual Development Environment

You can set linker options in the Microsoft visual development environment by using the Link tab in the Build Settings dialog box. The following tables list the linker options by category in the visual development environment, along with the equivalent command-line options:

General Category	**Command-Line Equivalent**
Output File Name	/OUT:*filename*
Object/Library Modules	*filename* on command line
Generate Debug Info	/DEBUG
Ignore All Default Libraries	/NODEFAULTLIB
Link Incrementally	/INCREMENTAL:{YES|NO}

Generate Mapfile	/MAP
Enable Profiling	/PROFILE

Output Category	**Command-Line Equivalent**
Base Address	/BASE:*address*
Entry-Point Symbol	/ENTRY:*function*
Stack Allocations	/STACK:*reserve*,*commit*
Version Information	/VERSION:*major*.*minor*

Input Category	**Command-Line Equivalent**
Object/Library Modules	*filename* on command line
Ignore Libraries	/NODEFAULTLIB:*library*
Ignore All Default Libraries	/NODEFAULTLIB
Force Symbol References	/INCLUDE:*symbol*
MS-DOS Stub File Name	/STUB:*filename*

Customize Category	**Command-Line Equivalent**
Use Program Database	/PDB:*filename*
Link Incrementally	/INCREMENTAL:{YES|NO}
Program Database Name	/PDB:*filename*
Output File Name	/OUT:*filename*
Force File Output	/FORCE
Print Progress Messages	/VERBOSE
Suppress Startup Banner	/NOLOGO

Debug Category	Command-Line Equivalent
Mapfile Name	/MAP:*filename*
Generate Mapfile	/MAP
Generate Debug Info	/DEBUG
Microsoft Format	/DEBUGTYPE:CV
COFF Format	/DEBUGTYPE:COFF
Both Formats	/DEBUGTYPE:BOTH

Rules for LINK Options

An option consists of an option specifier, either a dash (-) or a forward slash (/), followed by the name of the option. Option names cannot be abbreviated. Some options take an argument, specified after a colon (:). No spaces or tabs are allowed within an option specification, except within a quoted string in the /COMMENT option.

Specify numeric arguments in decimal or C-language notation. (The digits 1-9 specify decimal values, an integer constant preceded by a zero (0) specifies an octal value, and an integer constant preceded by zero and x (0x or 0X) specifies a hexadecimal value.) Option names and their keyword or filename arguments are not case sensitive, but identifiers as arguments are case sensitive.

LINK first processes options specified in the LINK environment variable. Next, LINK processes options in the order specified on the command line and in command files. If an option is repeated with different arguments, the last one processed takes precedence.

Options apply to the entire build. No options can be applied to specific input files.

/ALIGN

Syntax:

/ALIGN:*number*

Specifies the alignment of each section within the linear address space of the program. The *number* argument is in bytes and must be a power of 2. The default is 4K. The linker generates a warning if the alignment produces an invalid image.

/BASE

Syntax:

> **/BASE**:{*address* | @*filename*,*key*}

This option sets a base address for the program, overriding the default location for an executable file (at 0x400000) or a DLL (at 0x10000000). The operating system first attempts to load a program at its specified or default base address. If sufficient space is not available there, the system relocates the program. To prevent relocation, use the /FIXED option.

Specify the preferred base address in the text box (or in the *address* argument on the command line). The linker rounds the specified number up to the nearest multiple of 64K.

Another way to specify the base address is by using a *filename*, preceded by an at sign (@), and a *key* into the file. The *filename* is a text file that contains the locations and sizes of all DLLs your program uses. The linker looks for *filename* in either the specified path or, if no path is specified, in directories named in the LIB environment variable. Each line in *filename* represents one DLL and has the following syntax:

> *key address size* ;*comment*

The *key* is a string of alphanumeric characters and is not case sensitive. It is usually the name of a DLL but it need not be. The *key* is followed by a base *address* in C-notation hexadecimal or decimal and a maximum *size*. All three arguments are separated by spaces or tabs. The linker issues a warning if the specified *size* is less than the virtual address space required by the program. Indicate a *comment* by a semicolon (;). Comments can be on the same or a separate line. The linker ignores all text from the semicolon to the end of the line. The following example shows part of such a file:

```
main   0x00010000   0x08000000   ; for PROJECT.EXE
one    0x28000000   0x00100000   ; for DLLONE.DLL
two    0x28100000   0x00300000   ; for DLLTWO.DLL
```

If the file that contains these lines is called DLLS.TXT, the following example command applies this information.

```
link dlltwo.obj  /dll  /base:dlls.txt,two
```

You can reduce paging and improve performance of your program by assigning base addresses so that DLLs do not overlap in the address space.

An alternate way to set the base address is with the **BASE** argument in a **NAME** or **LIBRARY** module-definition statement. The /BASE and /DLL options together are equivalent to the **LIBRARY** statement. For information on module-definition statements, see Module-Definition Files.

/COMMENT

Syntax:

/COMMENT:["] *comment* ["]

Inserts a comment string into the header of an executable file or DLL, after the array of section headers. The type of operating system determines whether the string is loaded into memory. This comment string, unlike the comment specified with DESCRIPTION in a .DEF file, is not inserted into the data section. Comments are useful for embedding copyright and version information.

To specify a *comment* that contains spaces or tabs, enclose it in double quotation marks ("). LINK removes the quotation marks before inserting the string. If more than one /COMMENT option is specified, LINK concatenates the strings and places a null byte at the end of each string.

/DEBUG

Syntax:

/DEBUG

Creates debugging information for the executable file or DLL.

The linker puts the debugging information into a program database (PDB). It updates the program database during subsequent builds of the program. For details about PDBs, see /PDB.

An executable file or DLL created for debugging contains the name and path of the corresponding PDB. Visual Fortran reads the embedded name and uses the PDB when you debug the program. The linker uses the base name of the program and the extension .PDB to name the PDB, and embeds the path where it was created. To override this default, use /PDB:*filename*.

The object files must contain debugging information. Use the compiler's /Zi (Program Database), /Zd (Line Numbers Only), or /Z7 (C7 Compatible) option. If an object (whether specified explicitly or supplied from a library) was compiled with Program Database, its debugging information is stored in a PDB for the object file, and the name and location of the .PDB file is embedded in the object. The linker looks for the object's PDB first in the absolute path written in the object file and then in the directory that contains the object file. You cannot specify a PDB's filename or location to the linker.

If you have turned off Use Program Database (or specified /PDB:NONE on the command line), or if you have chosen either /DEBUGTYPE:COFF or /DEBUGTYPE:BOTH, the linker does not create a PDB but instead puts the debugging information into the executable file or DLL.

The /DEBUG option changes the default for the /OPT option from REF to NOREF.

/DEBUGTYPE

Syntax:

/DEBUGTYPE:{CV|COFF|BOTH}

This option generates debugging information in one of three ways, Microsoft format (CV), COFF format, or both:

- /DEBUGTYPE:CV

  Visual Fortran requires new-style Microsoft Symbolic Debugging Information in order to read a program for debugging. To select this option in the Microsoft visual development environment, choose the Link tab of the Project Settings dialog box. In the Debug category, select the Microsoft Format button, which is only available if you have checked the Generate Debug Info box.

- /DEBUGTYPE:COFF

  This option generates COFF-style debugging information. Some debuggers require Common Object File Format (COFF) debugging information.

  When you set this option, the linker does not create a PDB; in addition, incremental linking is disabled.

  To select this option in the visual development environment, choose the Link tab of the Project Settings dialog box. In the Debug category, select the COFF Format button, which is only available if you have checked the Generate Debug Info box.

- /DEBUGTYPE:BOTH

  This option generates both COFF debugging information and old-style Microsoft debugging information.

  When you set this option, the linker does not create a PDB; in addition, incremental linking is disabled. The linker must call the CVPACK.EXE tool to process the old-style Microsoft debugging information. CVPACK must be in the same directory as LINK or in a directory in the PATH environment variable.

In the visual development environment, specify this option with the Both Formats button, which is only available if you have selected Generate Debug Info.

If you do not specify /DEBUG, /DEBUGTYPE is ignored. If you specify /DEBUG but not /DEBUGTYPE, the default type is /DEBUGTYPE:CV.

/DEF

Syntax:

/DEF:*filename*

Passes a module-definition (.DEF) file to the linker. Only one .DEF file can be specified to LINK. For details about .DEF files, see Module-Definition Files.

When a .DEF file is used in a build, whether the main output file is an executable file or a DLL, LINK creates an import library (.LIB) and an exports file (.EXP). These files are created regardless of whether the main output file contains exports.

Do not specify this option in the visual development environment; this option is for use only on the command line. To specify a .DEF file, add it to the project along with other files.

/DEFAULTLIB

Syntax:

/DEFAULTLIB:*libraries*...

Adds one or more *libraries* to the list of libraries that LINK searches when resolving references. A library specified with /DEFAULTLIB is searched after libraries specified on the command line and before default libraries named in object files. To specify multiple libraries, type a comma (,) between library names.

Ignore All Default Libraries (/NODEFAULTLIB) overrides /DEFAULTLIB:*library*. Ignore Libraries (/NODEFAULTLIB:*library*) overrides /DEFAULTLIB:*library* when the same *library* name is specified in both.

/DELAY

Syntax:

/DELAY:{unload|nobind}

Controls delayed loading of DDLs:

- /DELAY:unload tells the delay-load helper function to support explicit unloading of the DLL by resetting the IAT to its original form, invalidating IAT pointers and causing them to be overwritten.

- /DELAY:nobind tells the linker not to include a bindable IAT in the final image. The resulting image cannot be statically bound. (Images with bindable IATs may be statically bound prior to execution.)

To specify DLLs to delay load, use the /DELAYLOAD option.

/DELAYLOAD

Syntax:

/DELAYLOAD:*dllname*

Causes delayed loading of DLLs. The *dllname* specifies a DLL to delay load. You can use this option as many times as necessary to specify as many DLLs as you choose. You must link your program with Delayimp.lib or implement your own delay-load helper function.

/DLL

Syntax:

/DLL

Builds a DLL as the main output file. A DLL usually contains exports that can be used by another program. There are three methods for specifying exports, listed in recommended order of use:

- *c*DEC$ ATTRIBUTES DLLEXPORT in the source code
- An /EXPORT specification in a LINK command
- An EXPORTS statement in a module definition (.DEF) file

A program can use more than one method.

An alternate way to build a DLL is with the LIBRARY module-definition statement. The /BASE and /DLL options together are equivalent to the **LIBRARY** statement.

In the visual development environment, you can set this option by choosing Dynamic-Link Library under Project Type in the New Project dialog box.

/DRIVER

Syntax:

/DRIVER[:UPONLY]

Use this option to build a Windows NT 4 or Windows 2000 kernel mode driver. The linker will perform some special optimizations if this option is selected. The UPONLY keyword causes the linker to add the IMAGE_FILE_UP_SYSTEM_ONLY bit to the characteristics in the output header to specify that it is a uniprocessor (UP) driver. The operating system will refuse to load a UP driver on a multiprocessor (MP) system.

/ENTRY

Syntax:

/ENTRY:*function*

This option sets the starting address for an executable file or DLL. Specify a function name that is defined with *c*DEC$ ATTRIBUTES STDCALL. The parameters and return value must be defined as documented in the Win32 API for WinMain (for an .EXE) or DllEntryPoint (for a DLL). It is recommended that you let the linker set the entry point.

By default, the starting address is a function name from the run-time library. The linker selects it according to the attributes of the program, as shown in the following table.

Function Name	Default for
mainCRTStartup	An application using /SUBSYSTEM:CONSOLE; calls **main**
WinMainCRTStartup	An application using /SUBSYSTEM:WINDOWS; calls WinMain, which must be defined with the *c*DEC$ ATTRIBUTES STDCALL attribute

_DllMainCRTStartup	A DLL; calls DllMain (which must be defined with the STDCALL attribute) if it exists

If the /DLL or /SUBSYSTEM option is not specified, the linker selects a subsystem and entry point depending on whether **main** or WinMain is defined.

The functions **main**, WinMain, and DllMain are the three forms of the user-defined entry point.

/EXETYPE

Syntax:

/EXETYPE:DYNAMIC

Used when building a virtual device driver (VxD). A VxD is linked using the /VXD option.

Specify DYNAMIC to create a dynamically-loaded VxD.

/EXPORT

Syntax:

/EXPORT:*entryname*[=*internalname*][, @*ordinal* [, NONAME]] [, DATA]

Lets you export a function from your program to allow other programs to call the function. You can also export data. Exports are usually defined in a DLL.

The *entryname* is the name of the function or data item as it is to be used by the calling program. You can optionally specify the *internalname* as the function known in the defining program; by default, *internalname* is the same as *entryname*. The *ordinal* specifies an index into the exports table in the range 1 - 65535; if you do not specify *ordinal*, LINK assigns one. The NONAME keyword exports the function only as an ordinal, without an *entryname*.

The DATA keyword specifies that the exported item is a data item. The data item in the client program must be declared using DLLIMPORT. (The CONSTANT keyword is supported for compatibility but is not recommended.)

There are three methods for exporting a definition, listed in recommended order of use:

- *c*DEC$ ATTRIBUTES DLLEXPORT in the source code
- An /EXPORT specification in a LINK command
- An EXPORTS statement in a module definition (.DEF) file

All three methods can be used in the same program. When LINK builds a program that contains exports, it also creates an import library, unless an .EXP file is used in the build.

LINK uses decorated forms of identifiers. A "decorated name" is an internal representation of a procedure name or variable name that contains information about where it is declared; for procedures, the information includes how it is called. Decorated names are mainly of interest in mixed-language programming, when calling Fortran routines from other languages.

The compiler decorates an identifier when it creates the object file. If *entryname* or *internalname* is specified to the linker in its undecorated form as it appears in the source code, LINK attempts to match the name. If it cannot find a unique match, LINK issues an error.

Use the DUMPBIN tool described in Examining Files with DUMPBIN to get the decorated form of an identifier when you need to specify it to the linker. Do not specify the decorated form of identifiers declared with the C or STDCALL attributes. For more information on when and how to use decorated names, see Adjusting Naming Conventions in Mixed-Language Programming.

/FIXED

Syntax:

/FIXED

This option tells the operating system to load the program only at its preferred base address. If the preferred base address is unavailable, the operating system does not load the file. For more information on base address, see /BASE.

When you specify /FIXED, LINK does not generate a relocation section in the program. At run-time, if the operating system cannot load the program at that address, it issues an error and does not load the program.

Some Win32 operating systems, especially those that coexist with MS-DOS, frequently must relocate a program. A program created with /FIXED will not run on Win32s® operating systems.

Note: Do not use /FIXED when building device drivers.

/FORCE

Syntax:

/FORCE:[{MULTIPLE|UNRESOLVED}]

Tells the linker to create a valid executable file or DLL even if a symbol is referenced but not defined or is multiply defined.

The /FORCE option can take an optional argument:

- Use /FORCE:MULTIPLE to create an output file whether or not LINK finds more than one definition for a symbol.
- Use /FORCE:UNRESOLVED to create an output file whether or not LINK finds an undefined symbol.

A file created with this option may not run as expected. The linker will not link incrementally with the /FORCE option.

You can select this option in the visual development environment by checking the Force File Output box in the Customize category of the Link tab in the Project Settings dialog box.

/HEAP

Syntax:

/HEAP:*reserve*[,*commit*]

Sets the size of the heap in bytes.

The *reserve* argument specifies the total heap allocation in virtual memory. The default heap size is 1MB. The linker rounds up the specified value to the nearest 4 bytes.

The optional *commit* argument is subject to interpretation by the operating system. In Windows NT 4 and Windows 2000, it specifies the amount of physical memory to allocate at a time. Committed virtual memory causes space to be reserved in the paging file. A higher *commit* value saves time when the application needs more heap space but increases the memory requirements and possibly startup time.

Specify the *reserve* and *commit* values in decimal or C-language notation. (Use the digits 1 - 9 for decimal values, precede octal values with zero (0), and precede hexadecimal values with zero and x (0x or 0X).

/IMPLIB

Syntax:

/IMPLIB:*filename*

Overrides the default name for the import library that LINK creates when it builds a program that contains exports. The default name is formed from the base name of the main output file and the extension .LIB. A program contains exports if one or more of the following is true:

- *c*DEC$ ATTRIBUTES DLLEXPORT in the source code
- An /EXPORT specification in a LINK command
- An EXPORTS statement in a module definition (.DEF) file

LINK ignores the /IMPLIB option when an import library is not being created. If no exports are specified, LINK does not create an import library. If an export (.EXP) file is used in the build, LINK assumes an import library already exists and does not create one. For information on import libraries and export files, see Import Libraries and Export Files in Using Visual Fortran Tools.

/IMPORT

Syntax:

/IMPORT

This option is specific to MACOS and does not apply to Visual Fortran.

/INCLUDE

Syntax:

/INCLUDE:*symbol*

Tells the linker to add a specified symbol to the symbol table.

Specify a *symbol* name in the text box. To specify multiple symbols, specify /INCLUDE:*symbol* once for each symbol.

The linker resolves *symbol* by adding the object that contains the symbol definition to the program. This is useful for including a library object that otherwise would not be linked to the program.

Specifying a symbol in the /INCLUDE option overrides the removal of that symbol by /OPT:REF.

To select this option in the visual development environment, choose the Force Symbol References text box in the Input category of the Link tab of the Project Settings dialog box.

/INCREMENTAL

Syntax:

/INCREMENTAL:{YES|NO}

Controls how the linker handles incremental linking. By default, the linker runs in incremental mode (for exceptions, see the /[no]traceback compiler option).

To prevent incremental linking, clear the Link Incrementally check box in the Customize category (or specify /INCREMENTAL:NO on the command line).

To link incrementally, set the Link Incrementally check box (or specify /INCREMENTAL:YES on the command line). When you specify this option, the linker issues a warning if it cannot link incrementally and then links the program nonincrementally. Certain options and situations override /INCREMENTAL:YES.

Most programs can be linked incrementally. However, some changes are too great, and some options are incompatible with incremental linking. LINK performs a full link if any of the following options are specified:

- Link Incrementally is turned off (/INCREMENTAL:NO)
- COFF Format (/DEBUGTYPE:COFF)
- Both Formats (/DEBUGTYPE:BOTH)
- /OPT:REF is selected.
- /OPT:ICF is selected.
- /ORDER is selected.
- Use Program Database is not selected (/PDB:NONE) when Generate Debug Info (/DEBUG) is selected.

Additionally, LINK performs a full link if any of the following occur:

- The incremental status (.ILK) file is missing. (LINK creates a new .ILK file in preparation for subsequent incremental linking.)
- There is no write permission for the .ILK file. (LINK ignores the .ILK file and links nonincrementally.)
- The .EXE or .DLL output file is missing.
- The timestamp of the .ILK, .EXE, or .DLL is changed.
- A LINK option is changed. Most LINK options, when changed between builds, cause a full link.
- An object (.OBJ) file is added or omitted.
- An object that was compiled with the /Yu /Z7 option is changed.

To select this option in the visual development environment, select the Link Incrementally check box in the Customize category of the Link tab in the Project

Settings dialog box.

/LARGEADDRESSAWARE

Syntax:

/LARGEADDRESSAWARE

Informs the linker that the application can handle addresses larger than 2 gigabytes.

/LIBPATH

Syntax:

/LIBPATH:*dir*

Overrides the environment library path. The linker will first search in the path specified by this option, and then search in the path specified in the LIB environment variable. You can specify only one directory for each /LIBPATH option you enter. If you want to specify more than one directory, you must specify multiple /LIBPATH options. The linker will then search the specified directories in order.

/LINK50COMPAT

Syntax:

/LINK50COMPAT

Generates import libraries in the old (Visual C++ version 5.0) format for backward compatibility.

/MACHINE

Syntax:

/MACHINE:{IX86|IA64}

Specifies the target platform for the program (for Visual Fortran, specify either IX86 or IA64).

Usually, you do not need to specify the /MACHINE option. LINK infers the machine type from the .OBJ files. However, in some circumstances LINK cannot determine the machine type and issues a linker tools error LNK1113. If such an error occurs, specify /MACHINE.

/MAP

Syntax:

/MAP[:*filename*]

This option tells the linker to generate a mapfile. You can optionally specify a map file name to override the default.

The linker names the mapfile with the base name of the program and the extension .MAP. To override the default name, use the *filename* argument.

A map file is a text file that contains the following information about the program being linked:

- The module name, which is the base name of the file
- The timestamp from the program file header (not from the file system)
- A list of groups in the program, with each group's start address (as *section*:*offset*), length, group name, and class
- A list of public symbols, with each address (as *section*:*offset*), symbol name, flat address, and object file where the symbol is defined
- The entry point (as *section*:*offset*)
- A list of fixups

To select this in the visual development environment, select the Generate Mapfile check box in the Debug category of the Link tab in the Project Settings dialog box.

/MAPINFO

Syntax:

/MAPINFO:{EXPORTS|FIXUPS|LINES}

Informs the linker to include the specified information in a map file, which is created if you specify the /MAP option:

- EXPORTS tells the linker to include exported functions.
- FIXUPS tells the linker to include base-relocation information in the mapfile if relocation information exists in the image. Base relocations will be present in the image if you link with /FIXED:NO.
- LINES includes line-number information.

/MERGE

Syntax:

/MERGE:*from=to*

Combines the first section (*from*) with the second section (*to*), naming the resulting section *to*. If the second section does not exist, LINK renames the section *from* as *to*.

The /MERGE option is useful for creating virtual device drivers (VxDs) and overriding the compiler-generated section names.

/NODEFAULTLIB

Syntax:

/NODEFAULTLIB[:*library*]

Tells the linker to remove all default libraries from the list of libraries it searches when resolving external references. If you specify *library*, the linker only ignores the libraries you have named. To specify multiple *libraries*, type a comma (,) between the library names.

The linker resolves references to external definitions by searching first in libraries specified on the command line, then in default libraries specified with the /DEFAULTLIB option, then in default libraries named in object files.

Ignore All Default Libraries (/NODEFAULTLIB) overrides /DEFAULTLIB:*library*. Ignore Libraries (/NODEFAULTLIB:*library*) overrides /DEFAULTLIB:*library* when the same *library* name is specified in both.

To select this in the visual development environment, select the Ignore Libraries or Ignore All Default Libraries check box in the Input category of the Link tab in the Project Settings dialog box.

/NOENTRY

Syntax:

/NOENTRY

This option is required for creating a resource-only DLL.

Use this option to prevent LINK from linking a reference to _main into the DLL.

/NOLOGO

Syntax:

/NOLOGO

The /nologo option prevents display of the copyright message and version number. This option also suppresses echoing of command files.

For the command line and in the visual development environment for a debug configuration, the default is /logo (displays copyright message, version number, and echoing of command files). In the visual development environment for a release configuration, the default is /nologo.

By default, information displayed by /logo is sent by the linker to the Output window. On the command line, it is sent to standard output and can be redirected to a file.

To select this option in the visual development environment, select the Suppress Startup Banner check box in the Customize category of the Link tab in the Project Settings dialog box.

/OPT

Syntax:

/OPT:{REF|NOREF}

Controls the optimizations LINK performs during a build. Optimizations generally decrease the image size and increase the program speed, at a cost of increased link time.

By default, LINK removes unreferenced packaged functions (COMDATs). This optimization is called transitive COMDAT elimination. To override this default and keep unused packaged functions in the program, specify /OPT:NOREF. You can use the /INCLUDE option to override the removal of a specific symbol. It is not possible to create packaged functions with the Visual Fortran compiler. This description is included for mixed-language applications with languages such as Visual C++ that support packaged functions (with the /Gy compiler option).

If you specify the /DEBUG option, the default for /OPT changes from REF to NOREF and all functions are preserved in the image. To override this default and optimize a debugging build, specify /OPT:REF. The /OPT:REF option disables incremental linking.

/ORDER

Syntax:

/ORDER:@*filename*

Lets you perform optimization by telling LINK to place certain packaged functions into the image in a predetermined order. It is not possible to make packaged functions with the Visual Fortran compiler. This description is included for mixed-language applications with languages such as Visual C++ that support packaged functions (with the /Gy compiler option).

LINK places packaged functions in the specified order within each section in the image.

Specify the order in *filename*, which is a text file that lists the packaged functions in the order you want to link them. Each line in *filename* contains the name of one packaged function. Function names are case sensitive. A comment is specified by a semicolon (;) and can be on the same or a separate line. LINK ignores all text from the semicolon to the end of the line.

LINK uses decorated forms of identifiers. A *decorated name* is an internal representation of a procedure name or variable name that contains information about where it is declared; for procedures, the information includes how it is called. Decorated names are mainly of interest in mixed-language programming, when calling Fortran routines from other languages.

The compiler decorates an identifier when it creates the object file. If the name of the packaged function is specified to the linker in its undecorated form as it appears in the source code, LINK attempts to match the name. If it cannot find a unique match, LINK issues an error.

Use the DUMPBIN tool to get the decorated form of an identifier when you need to specify it to the linker. Do not specify the decorated form of identifiers declared with *c*DEC$ ATTRIBUTES C or STDCALL. For more information on when and how to use decorated names, see Adjusting Naming Conventions in Mixed-Language Programming.

If more than one /ORDER specification is used, the last one specified takes effect.

Ordering allows you to optimize your program's paging behavior through swap tuning. Group a function with the functions it calls. You can also group frequently called functions together. These techniques increase the probability that a called function is in memory when it is needed and will not have to be paged from disk.

This option disables incremental linking.

/OUT

Syntax:

/OUT:*filename*

Overrides the default name and location of the image file that LINK creates. By default, LINK forms the filename using the base name of the first file specified and the appropriate extension (.EXE or .DLL).

The /OUT option controls the default base name for a mapfile or import library. For details, see the descriptions of /MAP and /IMPLIB.

/PDB

Syntax:

/PDB[:*filename*]

Controls how the linker produces debugging information. The optional *filename*argument overrides the default filename for the program database. The default filename for the PDB has the base name of the program and the extension .PDB.

By default when you specify /DEBUG, the linker creates a program database (PDB), which holds debugging information. If you have not specified /DEBUG, the linker ignores /PDB.

If you specify /PDB:NONE, the linker does not create a PDB, but instead puts old-style debugging information into the executable file or DLL. The linker then calls the CVPACK.EXE tool, which must be in the same directory as LINK.EXE or in a directory in the PATH environment variable.

Debugging information in a program database must be in Microsoft Format (/DEBUGTYPE:CV). If you choose either COFF Format (/DEBUGTYPE:COFF) or Both Formats (/DEBUGTYPE:BOTH), no PDB is created.

Incremental linking is suppressed if you specify /PDB:NONE.

You can select this option in the visual development environment by selecting the Use Program Database check box in the Customize category of the Link tab in the Project Settings dialog box.

/PDBTYPE

Syntax:

/PDBTYPE:{CON[SOLIDATE]|SEPT[YPES]}

Controls which Program Database (PDB) stores the debug type information.

On the command line, the /PDBTYPE option can take one of the following arguments:

- Use /PDBTYPE:CON[SOLIDATE] to tell the linker to place the debug type information in a single .PDB file. This option is the default. This option cannot be used if /PDB:NONE is specified.
- Use /PDBTYPE:SEPT[YPES] to tell the linker to leave the debug type information distributed in the source (compiler) .PDB files. In the Project Settings dialog box, select Separate Types in the Debug category of the Link tab to specify this linker option.

If SEPT[YPES] is specified, linking can be significantly faster. The advantages are:

- The debugger startup time may be slightly faster.
- Less hard disk space is needed to store data.

The disadvantage is more files are needed for the debugger to find the debug information when debugging.

Use this option when you plan to debug privately. Do not use this option when the debug build is to be used by multiple users.

/PROFILE

Syntax:

/PROFILE

Creates an output file that can be used with the profiler. This option is found only in the General category on the Link tab.

A profiler-ready program has a map file. If it contains debugging information, the information must be stored in the output file instead of a program database file (.PDB file) and must be in Microsoft old-style format.

In the visual development environment, setting Enable Profiling enables the Generate Mapfile option in the General and Debug categories. If you set the Generate Debug option, be sure to choose Microsoft Format in the Debug category.

On the command line, /PROFILE has the same effect as setting the /MAP option; if the /DEBUG option is specified, then /PROFILE also implies the options /DEBUGTYPE:CV and /PDB:NONE. In either case, /PROFILE implies /INCREMENTAL:NO.

You can select this option in the visual development environment by selecting the Enable Profiling check box in the General category of the Link tab in the Project Settings dialog box.

/RELEASE

Syntax:

/RELEASE

Sets the checksum in the header of an executable file.

The operating system requires the checksum for certain files such as device drivers. To ensure compatibility with future operating systems, set the checksum for release versions of your programs.

This option is set by default when you specify the /SUBSYSTEM:NATIVE option.

/SECTION

Syntax:

/SECTION:*name*,[E][C][I][R][W][S][D][K][L][P][X]

Changes the properties of a section, overriding the properties set when the .OBJ file for the section was compiled.

A section in a portable executable (PE) file is roughly equivalent to a segment or the resources in an NE file. Sections contain either code or data. Unlike segments, sections are blocks of contiguous memory with no size constraints. Some sections contain code or data that your program declared and uses directly, while other data sections are created for you by the linker and librarian, and contain information vital to the operating system.

Specify a colon (:) and a section name. The name is case sensitive.

Specify one or more properties for the section. The property characters, listed below, are not case sensitive. You must specify all properties that you want the section to have; an omitted property character causes that property bit to be turned off. The meanings of the property characters are shown below.

Character	Property	Meaning
E	Execute	Allows code to be executed
C	Conforming	Marks the section as conforming
I	IOPL	Marks the section as IOPL
R	Read	Allows read operations on data
W	Write	Allows write operations on data
S	Shared	Shares the section among all processes that load the image
D	Discardable	Marks the section as discardable
K	Cacheable	Marks the section as not cacheable
L	Preload	VxD only; marks the section as preload
P	Pageable	Marks the section as not pageable
X	Memory-resident	VxD only; marks the section as memory-resident

A section that does not have E, R, or W set is probably invalid.

/STACK

Syntax:

> **/STACK**:*reserve*[,*commit*]

Sets the size of the stack in bytes.

The *reserve* argument specifies the total stack allocation in virtual memory. The default stack size is 1MB. The linker rounds up the specified value to the nearest 4 bytes.

The optional *commit* argument is subject to interpretation by the operating system. In Windows NT 4 and Windows 2000, it specifies the amount of physical memory to allocate at a time. Committed virtual memory causes space to be reserved in the paging file. A higher *commit* value saves time when the application needs more stack space but increases the memory requirements and possibly startup time.

Specify the *reserve* and *commit* values in decimal or C-language notation. (Use the digits 1-9 for decimal values, precede octal values with zero (0), and precede hexadecimal values with zero and x (0x or 0X).

An alternate way to set the stack is with the STACKSIZE statement in a .DEF file. **STACKSIZE** overrides Stack Allocations (/STACK) if you specify both. You can change the stack after the executable file is built by using the EDITBIN.EXE tool. For more information, see Editing Files with EDITBIN.

To set these options in the visual development environment, type values in the Reserve and Commit boxes in the Output category of the Link tab in the Project Settings dialog box.

/STUB

Syntax:

/STUB:*filename*

Attaches an MS-DOS stub program to a Win32 program.

A stub program is invoked if the file is executed in MS-DOS. Usually, it displays an appropriate message; however, any valid MS-DOS application can be a stub program.

Specify a *filename* for the stub program after a colon (:). The linker checks *filename* to be sure that it is a valid MS-DOS executable file and issues an error if the file is not valid. The program must be an .EXE file; a .COM file is invalid for a stub program.

If you do not specify /STUB, the linker attaches a default stub program that generates the following message:

```
This program cannot be run in MS-DOS mode.
```

You can select this option in the visual development environment by typing the stub file name in the MS-DOS Stub File Name box in the Input category of the Link tab of the Project Settings dialog box.

/SUBSYSTEM

Syntax:

/SUBSYSTEM:{CONSOLE|WINDOWS|NATIVE|POSIX|WINDOWSCE}
[,*major* [.*minor*]]

Tells the operating system how to run the executable file. The subsystem is specified as follows:

- The CONSOLE subsystem is used for Win32 character-mode applications. Console applications are given a console by the operating system. If main or wmain is defined, CONSOLE is the default.
- The WINDOWS subsystem is appropriate for an application that does not require a console. It creates its own windows for interaction with the user. If WinMain or wWinMain is defined, WINDOWS is the default.
- The NATIVE subsystem is used for device drivers.
- The POSIX subsystem creates an application that runs with the POSIX subsystem in Windows NT 4 or Windows 2000.
- The WINDOWSCE subsystem is not used by Visual Fortran.

The optional *major* and *minor* version numbers specify the minimum required version of the subsystem. The arguments are decimal numbers in the range 0 - 65535. The default is version 3.10 for CONSOLE and WINDOWS and 1.0 for NATIVE.

The choice of subsystem affects the default starting address for the program. For more information, see the /ENTRY option.

/SWAPRUN

Syntax:

/SWAPRUN:{NET|CD}

Tells the operating system to first copy the linker output to a swap file, and then run the image from there. This is a Windows NT 4 or Windows 2000 feature.

If NET is specified, the operating system will first copy the binary image from the network to a swap file and load it from there. This option is useful for running applications over the network. When CD is specified, the operating system will copy the image on a removable disk to a page file and then load it.

/VERBOSE

Syntax:

/VERBOSE[:LIB]

The linker sends information about the progress of the linking session to the Output window. If specified on the command line, the information is sent to standard output and can be redirected to a file.

The displayed information includes the library search process and lists each library and object name (with full path), the symbol being resolved from the library, and the list of objects that reference the symbol.

Adding :LIB to the /VERBOSE option restricts progress messages to those indicating the libraries searched.

You can select this option in the Microsoft visual development environment by filling in the Print Progress Messages box in the Customize category of the Link tab of the Project Settings dialog box.

/VERSION

Syntax:

/VERSION:*major* [.*minor*]

Tells the linker to put a version number in the header of the executable file or DLL.

The *major* and *minor* arguments are decimal numbers in the range 0 - 65535. The default is version 0.0.

An alternate way to insert a version number is with the **VERSION** module-definition statement.

You can select this option in the Microsoft visual development environment by typing version information in the Major and Minor boxes in the Output category of the Link tab of the Project Settings dialog box.

/VXD

Syntax:

/VXD

Creates a virtual device driver (VxD). When this option is specified, the default file name extension changes to .VXD. For details on VxDs, see the Microsoft Windows NT Device Driver Kit.

A .VXD file is not in Common Object File Format, and it cannot be used with DUMPBIN or EDITBIN. It does not contain debugging information. However, you can create a map file when you link a .VXD file.

A .VXD file cannot be incrementally linked.

For related information, see /EXETYPE.

/WARN

Syntax:

/WARN[:*level*]

Allows you to determine the output of LINK warnings. Specify the *level* as one of the following:

level	**Meaning**
0	Suppress all warnings.
1	Displays most warnings. Overrides a /WARN:*level* specified earlier on the LINK command line or in the LINK environment variable. Default if /WARN:*level* is not used.
2	Displays additional warnings. Default if /WARN is specified without *level*.

/WS

Syntax:

/WS:AGGRESSIVE

Adds the WS_AGGRESSIVE property to your application's image. The Windows NT 4 or Windows 2000 loader will recognize this property and aggressively trim the working set of the process when it is not active. Using this option is similar to adding the following call throughout your application:

```
SetProcessWorkingSetSize(hThisProcess, -1, -1)
```

/WS:AGGRESSIVE can be used for applications that must have a low impact on the system's memory pool.

If the speed of your application is important, do not use /WS:AGGRESSIVE without testing the resulting performance implications. Ideal candidates are processes that tend to operate in the background, such as services and screen savers.

Module-Definition Files

A module-definition (.DEF) file is a text file that contains statements that define an executable file or DLL. (These should not be confused with module program units, described in Program Units and Procedures.) The following sections describe the statements in a .DEF file and Rules for Module-Definition Statements discusses rules for DEF files.

Because LINK provides equivalent command-line options for most module-definition statements, a typical program for Win32 does not usually require a .DEF file. In contrast, 16-bit programs for Windows almost *always* must be linked using a .DEF file.

You can use one or more of the following statements in a .DEF file:

- DESCRIPTION
- EXPORTS
- LIBRARY
- NAME
- STACKSIZE
- VERSION

The section describing each module-definition statement gives its command-line equivalent.

Rules for Module-Definition Statements

The following syntax rules apply to all statements in a .DEF file. Other rules that apply to specific statements are described with each statement.

- Statements and attribute keywords *are not* case sensitive. User-specified identifiers *are* case sensitive.

- Use one or more spaces, tabs, or newline characters to separate a statement keyword from its arguments and to separate statements from each other. A colon (:) or equal sign (=) that designates an argument is surrounded by zero or more spaces, tabs, or newline characters.

- A NAME or LIBRARY statement, if used, must precede all other statements.

- Most statements appear only once in the .DEF file and accept one specification of arguments. The arguments follow the statement keyword on the same or subsequent line(s). If the statement is repeated with different arguments later in the file, the latter statement overrides the former.

- The EXPORTS statement can appear more than once in the .DEF file. Each statement can take multiple specifications, which must be separated by one or more spaces, tabs, or newline characters. The statement keyword must appear once before the first specification and can be repeated before each additional specification.

- Comments in the .DEF file are designated by a semicolon (;) at the beginning of each comment line. A comment cannot share a line with a statement, but it can appear between specifications in a multiline statement. (EXPORTS is a multiline statement.)
- Numeric arguments are specified in decimal or in C-language notation.
- If a string argument matches a reserved word, it must be enclosed in double quotation (") marks.

Many statements have an equivalent LINK command-line option. See the Linker Options and Related Information for additional details.

DESCRIPTION

Syntax:

DESCRIPTION "*text*"

This statement writes a string into an .rdata section. Enclose the specified *text* in single or double quotation marks (' or "). To use a literal quotation mark (either single or double) in the string, enclose the string with the other type of mark.

This feature differs from the comment specified with the /COMMENT linker option.

EXPORTS

Syntax:

EXPORTS

This statement makes one or more definitions available as exports to other programs.

EXPORTS marks the beginning of a list of export *definitions*. Each definition must be on a separate line. The EXPORTS keyword can be on the same line as the first definition or on a preceding line. The .DEF file can contain one or more EXPORTS statements.

The syntax for an export definition is:

entryname[=*internalname*] [@*ordinal* [NONAME]] [DATA]

For information on the *entryname*, *internalname*, *ordinal*, NONAME, and DATA arguments, see the /EXPORT option.

There are three methods for exporting a definition, listed in recommended order of use:

- *c*DEC$ ATTRIBUTES DLLEXPORT in the source code
- An /EXPORT specification in a LINK command
- An EXPORTS statement in a .DEF file

All three methods can be used in the same program. When LINK builds a program that contains exports, it also creates an import library, unless the build uses an .EXP file.

LIBRARY

Syntax:

LIBRARY [*library*] [BASE=*address*]

This statement tells LINK to create a DLL. LINK creates an import library at the same time, unless you use an .EXP file in the build.

The *library* argument specifies the internal name of the DLL. (Use the Output File Name (/OUT) option to specify the DLL's output name.)

The BASE=*address* argument sets the base address that the operating system uses to load the DLL. This argument overrides the default DLL location of 0x10000000. See the description of the Base Address (/BASE) option for details about base addresses.

You can also use the /DLL linker option to specify a DLL build, and the /BASE option to set the base address.

NAME

Syntax:

NAME [*application*] [BASE=*address*]

This statement specifies a name for the main output file. An equivalent way to specify an output filename is with the /OUT option, and an equivalent way to set the base address is with the /BASE option. If both are specified, /OUT overrides NAME. See the Base Address (/BASE) and Output File Name (/OUT) options for details about output filenames and base addresses.

STACKSIZE

Syntax:

STACKSIZE *reserve* [,*commit*]

This statement sets the size of the stack in bytes. An equivalent way to set the stack is with the /STACK option. See the /STACK option for details about the *reserve* and *commit* arguments.

VERSION

Syntax:

VERSION *major* [.*minor*]

This statement tells LINK to put a number in the header of the executable file or DLL. The *major* and *minor* arguments are decimal numbers in the range 0 - 65535. The default is version 0.0.

An equivalent way to specify a version number is with the Version Information (/VERSION) option.

Linker Reserved Words

The following table lists words reserved by the linker. You can use these names as arguments in module-definition statements only if you enclose the name in double quotation marks (**"**).

Linker Reserved Words

APPLOADER	INITINSTANCE	PRELOAD
BASE	IOPL	PROTMODE
CODE	LIBRARY	PURE
CONFORMING	LOADONCALL	READONLY
DATA	LONGNAMES	READWRITE
DESCRIPTION	MOVABLE	REALMODE
DEV386	MOVEABLE	RESIDENT

DISCARDABLE	MULTIPLE	RESIDENTNAME
DYNAMIC	NAME	SEGMENTS
EXECUTE-ONLY	NEWFILES	SHARED
EXECUTEONLY	NODATA	SINGLE
EXECUTEREAD	NOIOPL	STACKSIZE
EXETYPE	NONAME	STUB
EXPORTS	NONCONFORMING	VERSION
FIXED	NONDISCARDABLE	WINDOWAPI
FUNCTIONS	NONE	WINDOWCOMPAT
HEAPSIZE	NONSHARED	WINDOWS
IMPORTS	NOTWINDOWCOMPAT	
IMPURE	OBJECTS	
INCLUDE	OLD	

Microsoft Fortran PowerStation Command-Line Compatibility

This section provides compatibility information for FL32 command-line users of Microsoft Fortran PowerStation Version 4. It includes the following topics:

- Using the DF or FL32 Command Line
- Equivalent Visual Fortran Compiler Options

Using the DF or FL32 Command Line

You can use either the DF or FL32 commands to compile (and link) your application. The main difference between the DF and FL32 commands is the defaults set for certain command-line options:

- FL32 requests no optimization (/Od). See /[no]optimize.
- FL32 requests checking of arguments passed to and results from the math library (/math_library:check or /Od). See /[no]math_library.
- FL32 provides minimal debug information (/debug:minimal or /Zd). See /[no]debug.
- FL32 requests full Microsoft Fortran PowerStation compatibility

(/fpscomp:all). See /[no]fpscomp.
- FL32 disallows alternative PARAMETER syntax (/noaltparam). See /[no]altparam.
- FL32 requests record length units for unformatted files to be in bytes (/assume:byterecl). See /assume.
- FL32 requests warnings for mismatched arguments (/warn:argument_checking). See /[no]warn.
- FL32 compiles each source unit individually and retains intermediate files that would otherwise be deleted (/keep). This prevents interprocedure optimizations at higher optimization levels. See /keep.
- FL32 does not display an informational message related to compiling multiple files individually. See /warn:fileopts.
- FL32 requests no inlining (/inline:none). See /[no]inline.
- FL32 places module files in the same directory as the object files. See /module:*path*.

The DF and FL32 commands both:

- Recognize the *same* set of command-line options. For example, the following commands are supported:

  ```
  DF   /Odx test2.for
  FL32 /Odx test2.for
  ```

  Both DF and FL32 command lines allow most Microsoft Fortran PowerStation style options (such as /Ox) and all Visual Fortran options (such as /optimize:4). For a detailed list of equivalent Microsoft Fortran PowerStation style compiler options and Visual Fortran compiler options, see Equivalent Visual Fortran Compiler Options.

- Activate the *same* compiler, the Compaq Fortran compiler.

  For new programs and most existing applications, use the Compaq Fortran compiler (default). The Compaq Fortran compiler and language used by Visual Fortran provides a superset of the Fortran 95 standard with extensions for compatibility with previous versions of Compaq Fortran (DIGITAL Fortran, DEC Fortran), VAX FORTRAN, and Microsoft Fortran PowerStation Version 4.

- Pass options specified after /LINK to the LINK command.

  The LINK command options after /link are passed directly to the Linker. These options are described in Linker Options.

- Allow the use of indirect command files.

  For example, assume the file text.txt contains the following:

```
/pdbfile:testout.pdb /exe:testout.exe /debug:full /optimize:0 test.f90 rest.f
```

Either of the following (DF or FL32) commands executes the contents of file text.txt as an indirect command file to create a debugging version of the executable program and its associated PDB file:

```
DF   @test.txt

FL32 @test.txt
```

To request Microsoft Fortran PowerStation V4 compatibility, specify the /[no]fpscomp option.

For information about using the DF command, see Using the Compiler and Linker from the Command Line.

Equivalent Visual Fortran Compiler Options

The following table lists the Microsoft Fortran PowerStation style options and their Visual Fortran equivalents. The Microsoft Fortran PowerStation options (such as /FAc) are *case-sensitive*; other Visual Fortran options (such as /asmfile) are not case-sensitive.

This table also lists some compiler options that were not supported by Microsoft Fortran PowerStation, but are supported by Visual C++.

Fortran PowerStation Option (and Category)	**Visual Fortran Command-Line Option**
Listing Options	
/FA	Assembly listing. Specify /noasmattributes with /asmfile[:*file*] or /FA.
/FAc	Assembly listing with machine code. Specify /asmattributes:machine with /asmfile[:*file*] or /FAc.
/FAs	Assembly listing with source code. Specify /asmattributes:source with /asmfile[:*file*] or /FAs.
/FAcs	Assembly listing with machine instructions and source code. Specify /asmattributes:all with /asmfile[:*file*] or /FAcs.

/Fa[*file*]	Assembly listing to file *file*. Specify /asmfile[:*file*] with /noasmattributes or specify /Fa[*file*].
/Fc[*file*]	Assembly listing with source and machine code to file *file*. Specify /asmfile[:*file*] with /asmattributes:all or specify /Fc[*file*].
/Fl[*file*]	Assembly listing with machine instructions to file *file*. Specify /asmfile[:*file*] with /asmattributes:machine or specify /Fl[*file*].
/Fs[*file*]	Source listing with compiled code. Specify /list [:*file*] with /show:map or specify /Fs[*file*].
Code Generation Options	
/FR[*file*]	Generates extended Source Browser information. Specify /browser[:*file*] or /FR[*file*].
/G4 /G5	Generates code for specific ia32 chip architectures. Specify /tune:*keyword*.
/Ob2	Automatic inlining of code, use with /Ox. Specify /inline:speed or /Ob2.
/Od	No code optimization (default for FL32 command). Specify /optimize:0 with /math_library:check, or specify /Od.
/Op	Improved floating-point consistency. Specify /fltconsistency or /Op. Applies to ia32 systems only.
/Ox	Full optimization with no error checking. Specify /optimize:4 with /math_library:fast and /assume:nodummy_aliases, or specify /Ox.
/Oxp	Speed optimization and denoted inlining; error checking. Specify /optimize:4 with /assume:nodummy_aliases and (on ia32 systems) /math_library:check with /fltconsistency, or specify /Oxp.
/Zp[*n*]	Packs structures on n-byte boundary (*n* is 1, 2, or 4). Specify /alignment[:*keyword*] or /Zp[*n*]. If you specify /Zp (omit *n*), structures are packed at 8-byte boundaries.

Language Extension Options	
/4L*nn*	Line length for Fortran 90 fixed-form source (*nn* is 72, 80, or 132). Specify /extend_source[:*nn*] or /4L*nn*.
/4Yb or /4Nb	Enable/disable extended error checking. Specify /check[:*keyword*], /4Yb, or /4Nb.
/4Yd or /4Nd	Warnings about undeclared variables. Specify /warn: [no]declarations, /4Yd or /4Nd.
/W0	Suppress warnings. Specify /nowarn or /W0.
/W1	Show warnings (default). Specify /warn:general or /W1.
/WX	Interpret all warnings as errors. Specify /warn:(general,errors) or /WX.
Language Standard, Source Form, and Data Options	
/4Ya or /4Na	Makes all variables AUTOMATIC. Specify /[no]automatic, /[no]static, /4Ya, or /4Na.
/4Yaltparam /4Naltparam	Use the alternate syntax for PARAMETER statements. Specify /[no]altparam, /4Yaltparam, or /4Naltparam.
/4Yf or /4Nf	Use free-form source format. Specify /[no]free, /[no]fixed, /4Yf, or /4Nf.
/4I2	Change default KIND for INTEGER and LOGICAL declarations. Specify /integer_size:*nn* (*nn* is 16 for KIND=2) or /4I2.
/4R8	Change default KIND for REAL declarations. Specify /real_size:*nn* (*nn* is 32 for KIND=4) or /4R8.
/4Ys or /4Ns	Strict Fortran 90 syntax. Specify /stand:f90, /warn:stderrors, /4Ys, or /4Ns.
Compiler Directive Options	
/D*symbol*[=*int*]	Define preprocessor symbol. Specify /define:*symbol*[=*int*] or D*symbol*[=*int*].

/4cc*string*	Treat lines with d or D in column 1 as comments. Specify /d_lines or /4ccd or /4ccD (partial support).
Build Control Options	
/4Yportlib or /4Nportlib	Specify /4Yportlib or /4Nportlib.
/Fd[*file*]	Controls creation of compiler PDB files. Specify /[no]pdbfile[*file*] or /Fd[*file*].
/Fe[*file*]	Specifies file name of executable or DLL file. Specify /exe:*file*, /dll:*file*, or /Fe[*file*].
/Fm[*file*]	Controls creation of link map file. Specify /map [:*file*] or /Fm[*file*].
/Fo[*file*]	Controls creation of object file. Specify /object [:*file*] or /Fo[*file*].
/GNa	Keep external names as is and treat source code identifiers as case sensitive. Specify /names:as_is or /GNa.
/GNl	Make external names lowercase and ignore the case of source code identifiers. Specify /names:lowercase or /GNl.
/GNu	Make external names uppercase and ignore the case of source code identifiers. Specify /names:uppercase or /GNu.
/I*path*	Control search path for module or include files. Specify /[no]include[:*path*] or /I*path*.
/LD	Create dynamic-link library. Specify /dll or /LD.
/MD	Link against multithreaded DLL libraries. Specify /libs:dll with /threads or /MD.
/MDd	Link against multithreaded DLL libraries. Specify /libs:dll with /threads and /dbglibs or specify /MDd.
/MDs	Link against single threaded DLL libraries. Specify /libs:dll or /MDs.

/MG	Link against libraries for windows applications. Specify /winapp or /MG.
/ML	Link against single threaded static libraries. Specify /libs:static or /ML.
/MLd	Link against single threaded static libraries. Specify /libs:static with /dbglibs or /MLd.
/MT	Link against multithreaded static libraries. Specify /libs:static with /threads or /MT.
/MTd	Link against multithreaded static libraries. Specify /libs:static with /threads and /dbglibs or specify /MTd.
/MW	Link against QuickWin multidoc libraries. Specify /libs:qwin or /MW.
/MWs	Link against QuickWin single doc libraries. Specify /libs:qwins or /MWs.
/Tf*file*	Request that *file* be treated as a Fortran source file. Specify /source:*filename* or /Tf*file*.
/V"*string*"	Place *string* in object file. Specify /bintext:*string* or /V"*string*".
/Z7	Request full debug information in object file. Specify /debug:full with /nopdbfile or /Z7.
/Zd	Request minimal debug information. Specify /debug:minimal with /pdbfile or /Zd.
/Zi	Request full debug information and create PDB file. Specify /debug:full with /pdbfile or /Zi.
/Zla	Do not insert *any* library names in object file. Specify /nolibdir or /Zla.
/Zl	Do not insert *default* library names in object file. Specify /libdir:noautomatic or /Zl.
/Zs	Perform syntax check only (no object). Specify /syntax_only or /Zs.

/Zt	Requests traceback information (run-time program counter to source file line correlation). Specify /traceback or /Zt.
/link [option]	Begin specifying linker options. Specify /link [option].
Command-Line Specific Options	
/?, /help	Display command help. Specify /? or /help.
/nologo	Prevent display of copyright information. Specify /nologo.

Debugging Fortran Programs

Although you can use the command line to develop your programs, Visual Fortran programs are typically debugged in the Microsoft visual development environment integrated debugger.

This chapter discusses how to use the integrated debugger to debug Visual Fortran programs. The following topics are discussed:

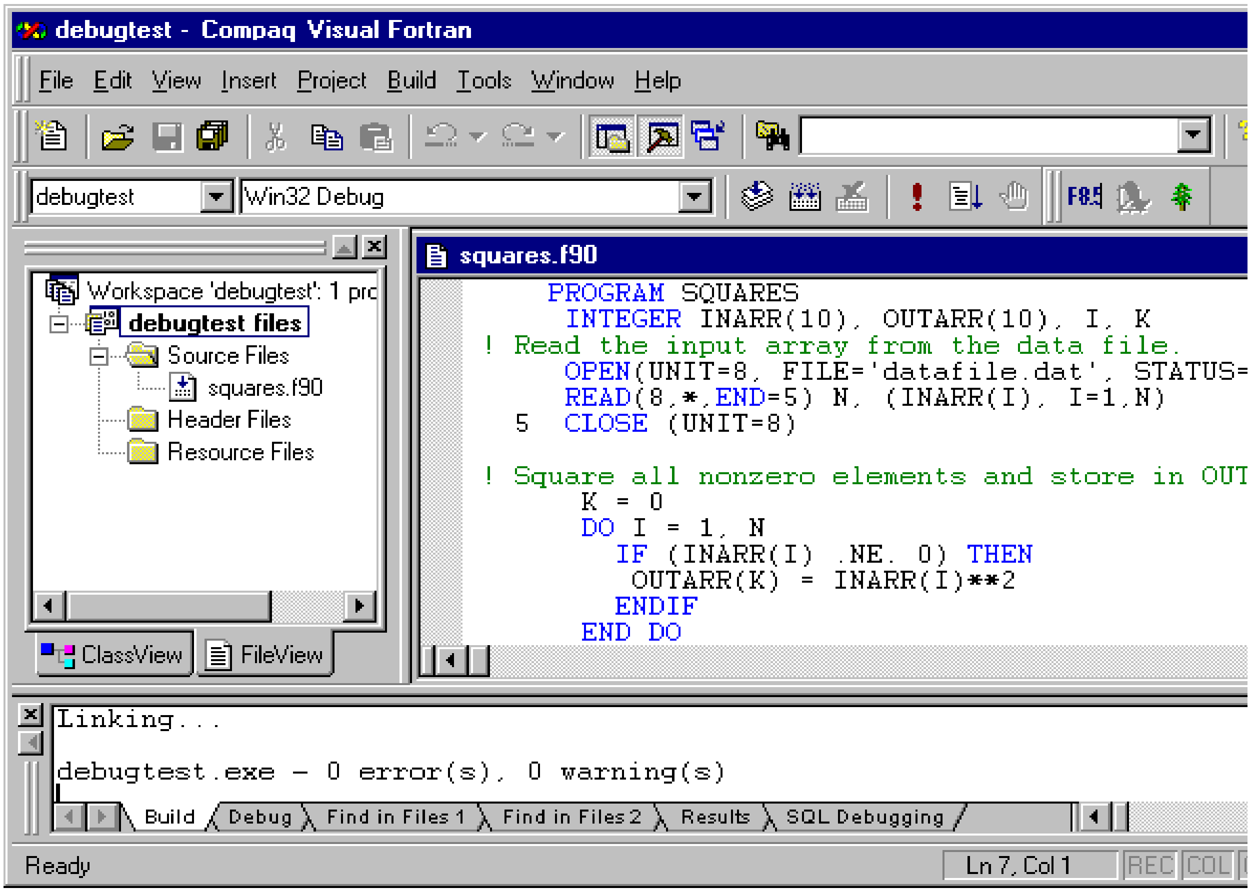
Preparing Your Program for Debugging

This section describes preparing your program for debugging:

- When developing your application with the Microsoft visual development environment
- When developing your application with the command-line environment

To prepare your program for debugging when using the visual development environment:

1. Start the visual development environment (click Developer Studio in the Compaq Visual Fortran program folder).
2. Open the appropriate Workspace (File menu, either Open Workspaces or Recent Workspaces).
3. Click the FileView pane.
4. To edit the source file to be debugged, double-click on the file name.
5. Click the Project name. The screen might appear as follows (the ClassView tab only appears if Visual C++ is also installed):



6. In the Build menu, click Set Active Configuration and select the debug configuration.

7. To check your project settings for compiling and linking, in the Project menu, click Settings, then click the Fortran tab. Similarly, to check the debug options set for your program (such as program arguments or working directory), click the Debug tab in the Project Settings dialog box.

8. To compile your program:
   - Click (select) the source file to be compiled
   - In the Build menu, click Compile *filename*

9. Eliminate any compiler diagnostic messages in the text editor and recompile if needed.

10. To build your application, in the Build menu, click Build *file*.EXE.

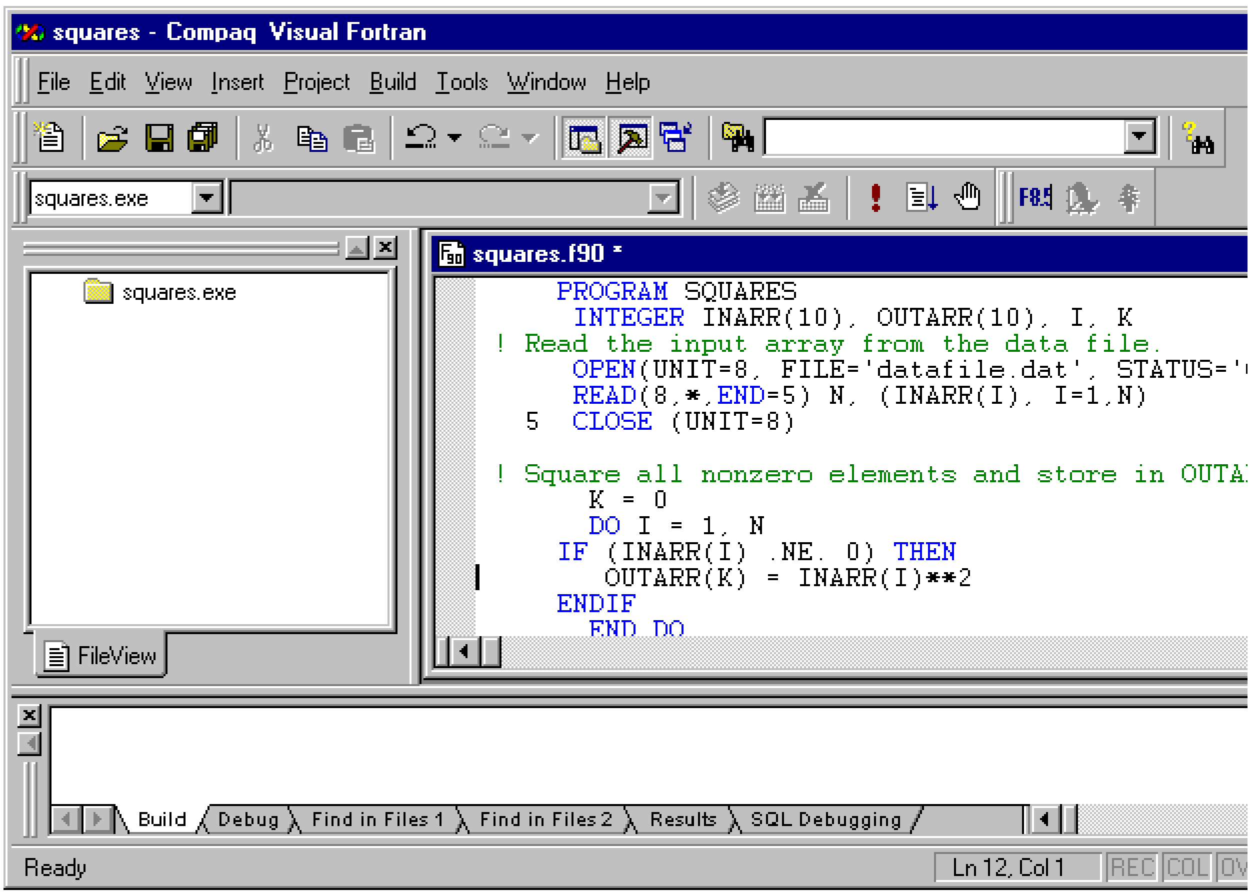
11. Set breakpoints in the source file and debug the program, as described in Debugging the Squares Example Program.

To prepare your program for debugging when using the command line (DF command):

1. Correct any compilation and linker errors.
2. In a command window (such as the Fortran command window available from the Visual Fortran program folder), compile and link the program with full debug information and no optimization:

```
DF /debug:full /nooptimize file.f90
```

3. Start the visual development environment.
4. In the File menu, click the Open Workspace item. Specify the file name of the executable (.EXE) file to be debugged.
5. In the File menu, click Open. Specify the name of the source file (such as .F90 or .FOR) that corresponds to the file being debugged. The text editor window appears. Your screen might appear as follows:



6. Set breakpoints in the source file and debug the program, as described in Debugging the Squares Example Program.

To add Source Browser Information to your debug configuration, see Source Browser Information for a Configuration.

Debugging the Squares Example Program

The following program (SQUARES) uses the Fortran Console project type. The

SQUARES program reads formatted data from the file `datafile.dat` and displays the calculated results. With the source code shown below, it does not generate the expected results:

```
    PROGRAM SQUARES
       INTEGER INARR(10), OUTARR(10), I, K
 ! Read the input array from the data file.
       OPEN(UNIT=8, FILE='datafile.dat', STATUS='OLD')
       READ(8,*,END=5) N, (INARR(I), I=1,N)
   5   CLOSE (UNIT=8)

 ! Square all nonzero elements and store in OUTARR.
       K = 0
       DO I = 1, N
         IF (INARR(I) .NE. 0) THEN
 ! Is the error in this DO loop?
            OUTARR(K) = INARR(I)**2
         ENDIF
       END DO

 ! Print the squared output values.  Then stop.
       PRINT 20, N
   20  FORMAT (' Total number of elements read is',I4)
       PRINT 30, K
   30  FORMAT (' Number of nonzero elements is',I4)
       DO, I=1,K
         PRINT 40, I, OUTARR(K)
   40    FORMAT(' Element', I4, ' has value',I6)
       END DO
   END PROGRAM SQUARES
```

The formatted file `datafile.dat` currently contains one record that includes the following:

- An INTEGER count of the number of array elements, value 4
- The values for each of the four INTEGER array elements

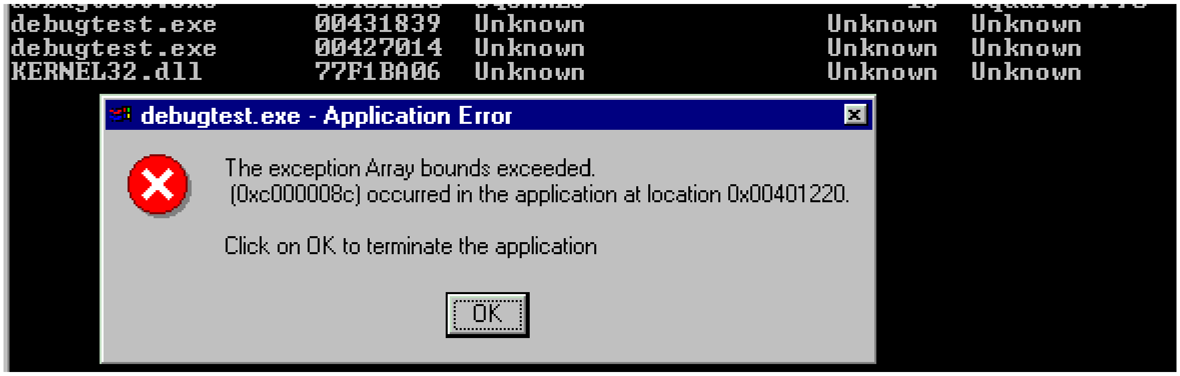
To view the values of this formatted data file in the Microsoft visual development environment, use the Open item in the File menu.

When executed *without* array bounds checking (set by the /check:nobounds option), the output appears as follows:

```
 Total number of elements read is   4
 Number of nonzero elements is   0
Press any key to continue
```

When the program was executed *with* array bounds checking on, the output appears as follows:

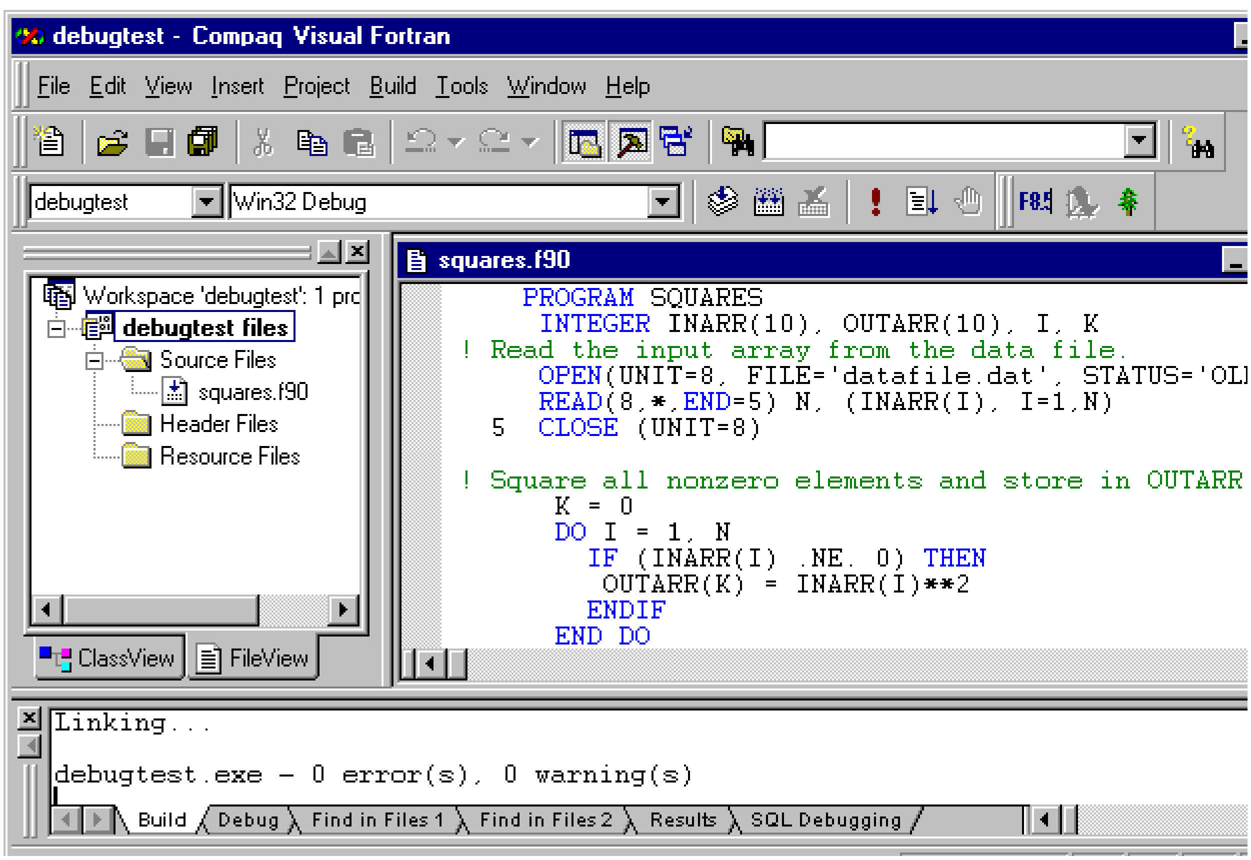
```
"D:\Program Files\Microsoft Visual Studio\Common\MSDEV98\My Projects\debugtest\Debug\debu
forrtl: severe (161): Program Exception - array bounds exceeded
Image              PC          Routine            Line        Source
debugtest.exe      00401220    SQUARES              15   squares.f90
```



You can either build this program from the command line or within the visual development environment (see Preparing Your Program for Debugging). This example assumes a project workspace already exists.

► To debug this program:

1. From the Compaq Visual Fortran program folder, click Developer Studio to start the visual development environment.
2. In the File menu, click Open Workspace.
3. Click the FileView pane in the Workspace window. If the Workspace window is not displayed, click Workspace in the View menu.
4. Edit the file `squares.f90`: double-click its file name in the FileView pane. The screen appears as follows:



The following toolbars are shown:

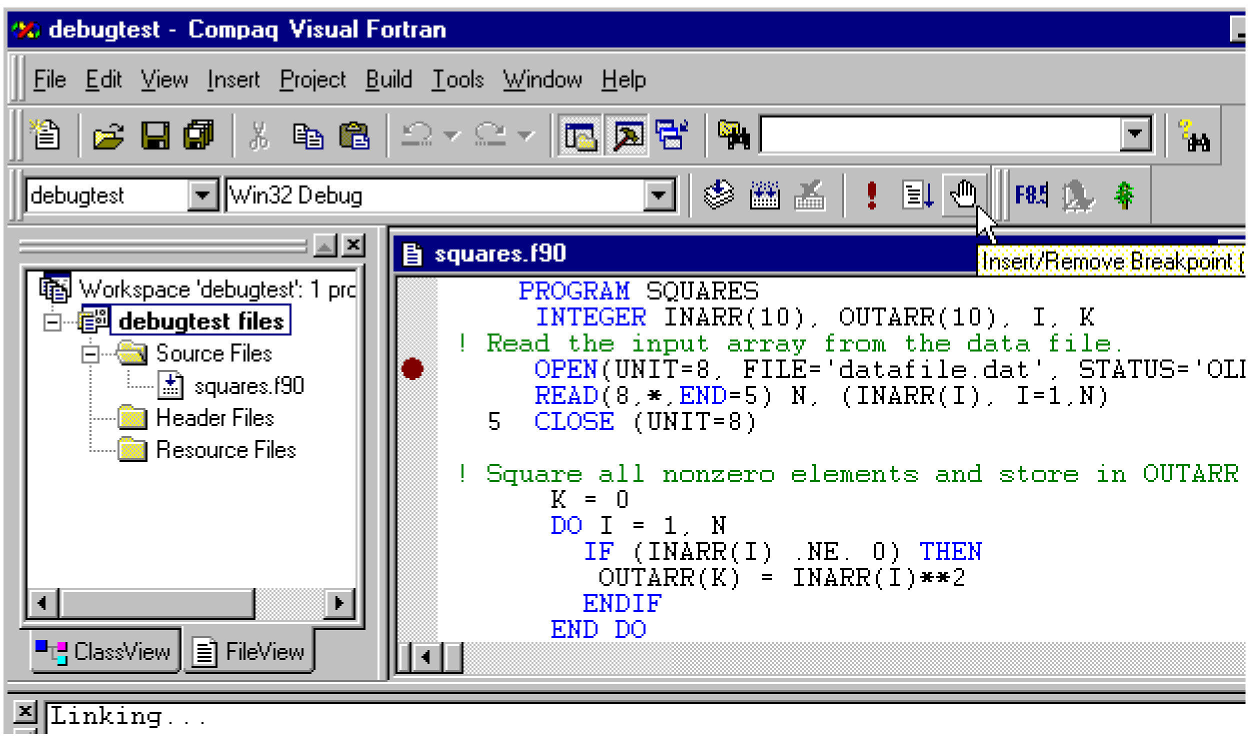
- Build toolbar
- Standard toolbar
- Fortran toolbar

To change the displayed toolbars, select Customize in the Tools menu and click the Toolbars tab. You can move toolbars by dragging the anchor (double vertical line on the left of the toolbar).

5. Click the first executable line to set the cursor position. In this case, click the beginning of the OPEN statement line:

```
OPEN(UNIT=8, FILE='datafile.dat', STATUS='OLD')
```

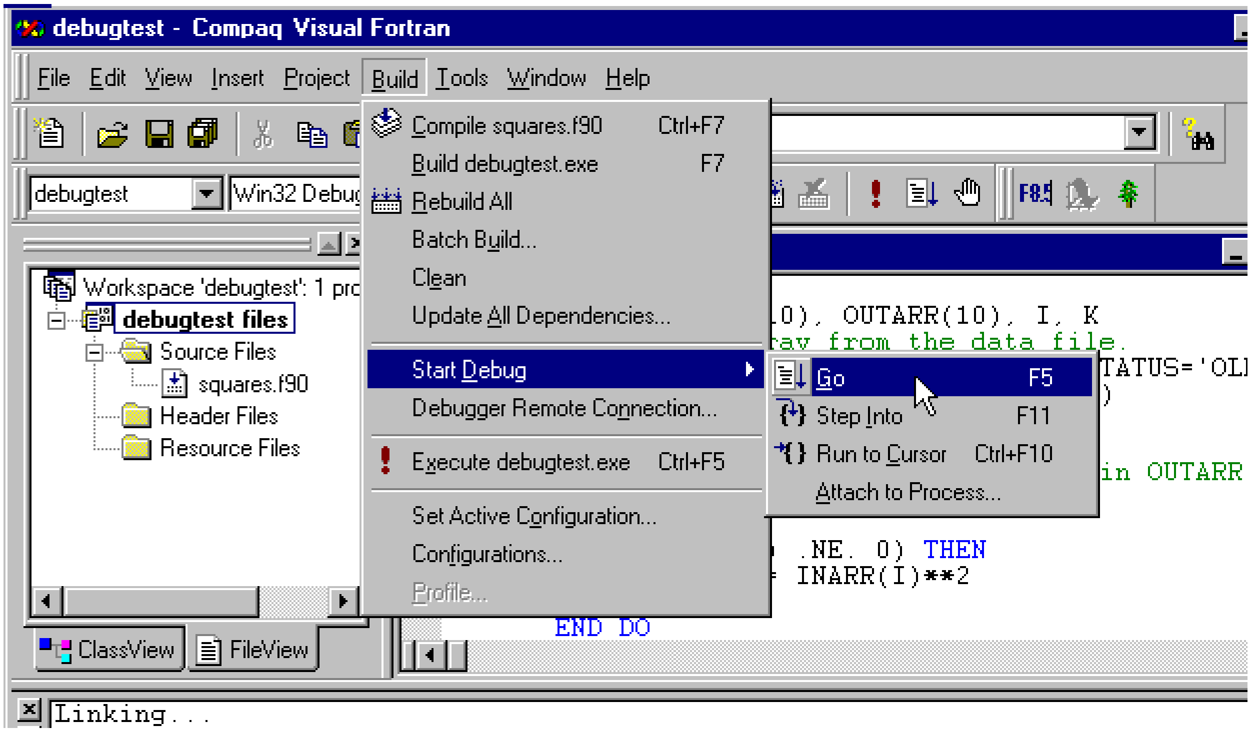
6. Click the Set/Remove Breakpoint (open hand symbol) button in the Build toolbar:



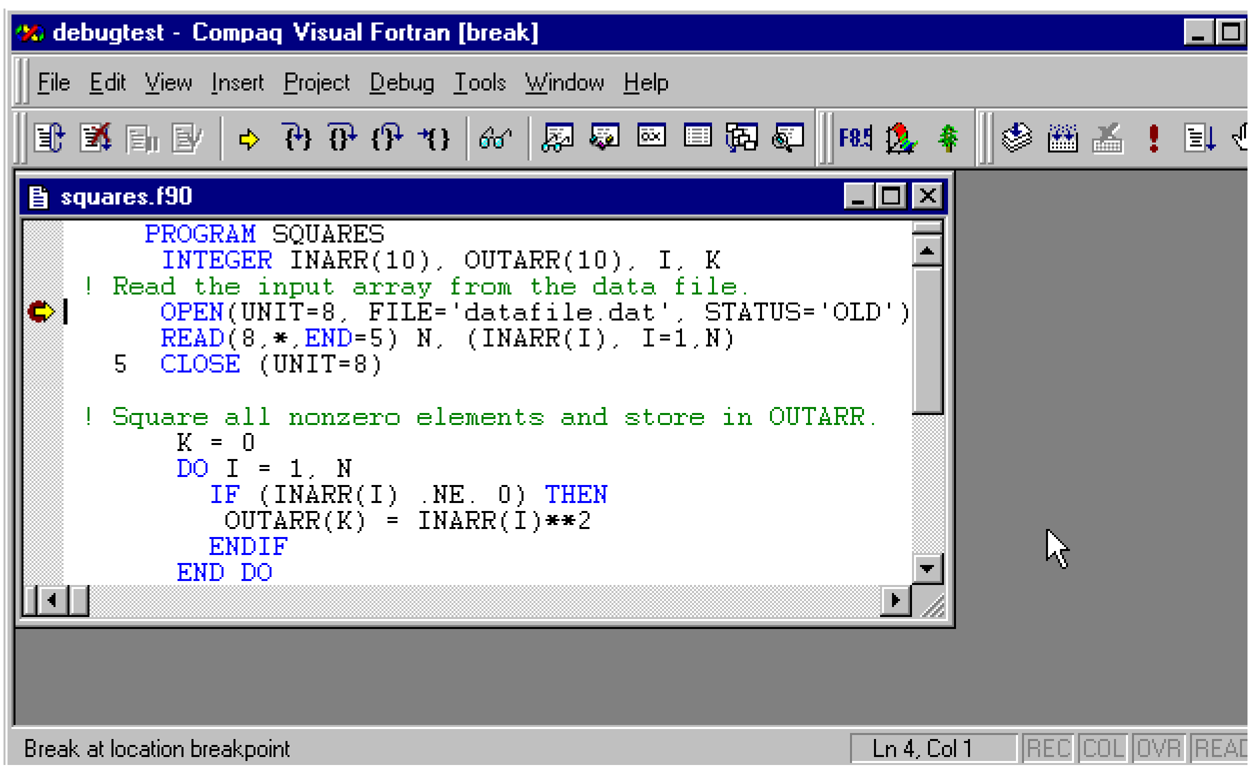
The red circle in the left margin of the text editor/debugger window shows where a breakpoint is set.

7. This example assumes you have previously built your application (see Preparing Your Program for Debugging).

   In the Build menu, click the Start Debug, Go item:



8. The debugger is now active. The current position is marked by a yellow arrow at the first executable line (the initial breakpoint):

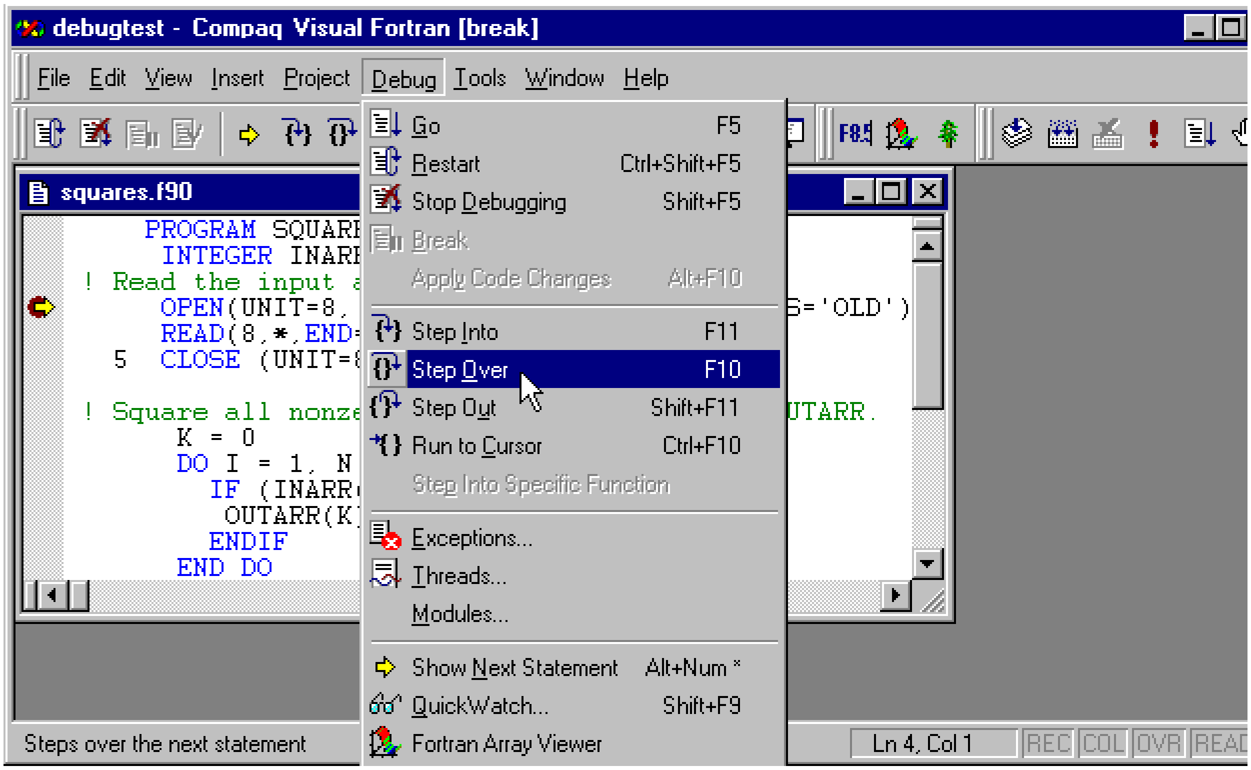


The Debug menu appears on the visual development environment title bar in place of the Build menu. If not displayed previously, the Debug toolbar appears.

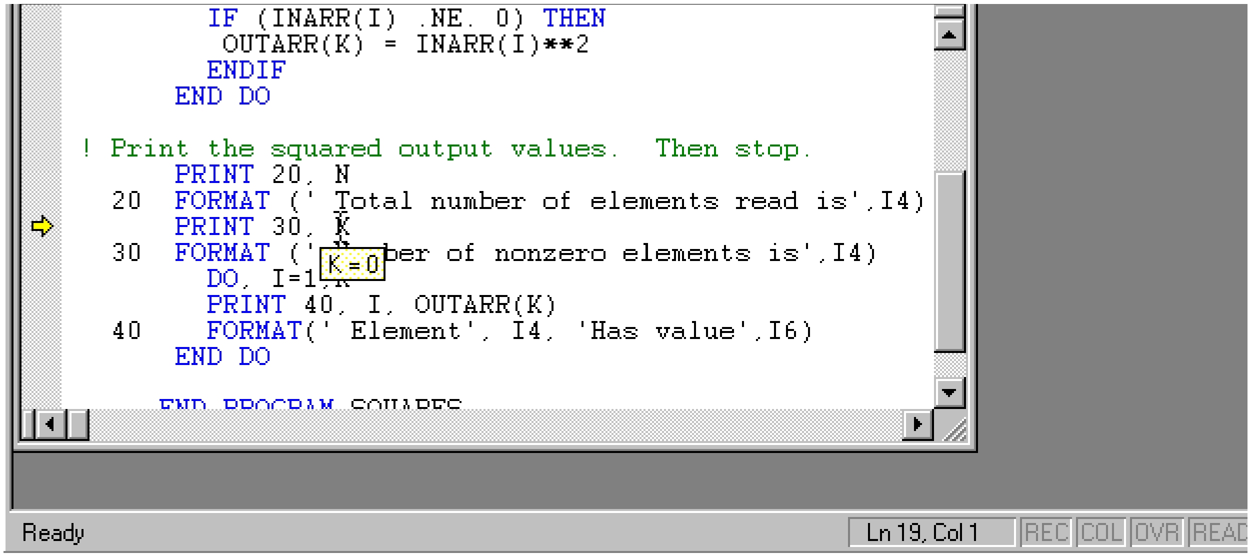
If needed, you can set another breakpoint, position the cursor at the line where you want to add or remove a breakpoint and do either of the following:

- In the Build toolbar, click the Set/Remove Breakpoint button.
- In the Edit menu, click Breakpoints. A dialog box allows you to set or clear breakpoints, evaluate expressions, and perform other functions.

Step through the lines of source code. You can do this with the Debug menu item Step Over (as shown) or the Step Over button on the Debug toolbar:



9. Repeat the Step Over action and follow program execution into the DO loop. Repeat the Step Over action until you are at the end of the program. Position the cursor over the variable K to view its value (called Data Tips):



The error seems related to the value of variable K!

10. In the text editor, add the line K = K + 1 as follows:

```
! Square all nonzero elements and store in OUTARR.
      K = 0
      DO I = 1, N
        IF (INARR(I) .NE. 0) THEN
        K = K + 1        ! add this line
        OUTARR(K) = INARR(I)**2
        ENDIF
      END DO
```

11. You have modified the source, so you need to rebuild the application:
    - In the Debug menu, click Stop Debugging
    - In the Build menu, click Build Squares.exe
    - In the Build menu, click Execute Squares.exe or click the exclamation point (!) on the Build toolbar.

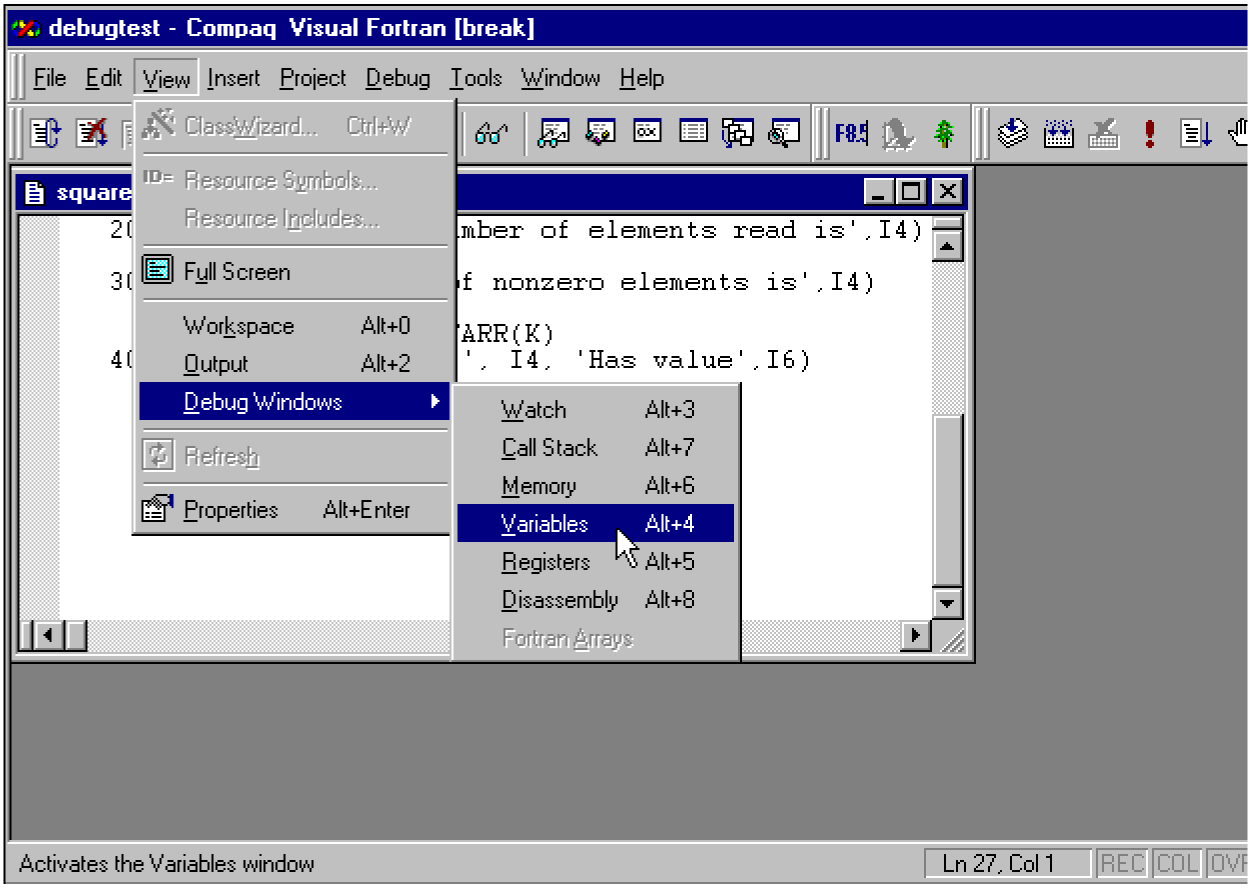
The output screen appears as follows:

```
 Total number of elements read is    4
 Number of nonzero elements is    4
 Element    1 has value      9
 Element    2 has value      4
 Element    3 has value     25
 Element    4 has value      4
Press any key to continue_
```

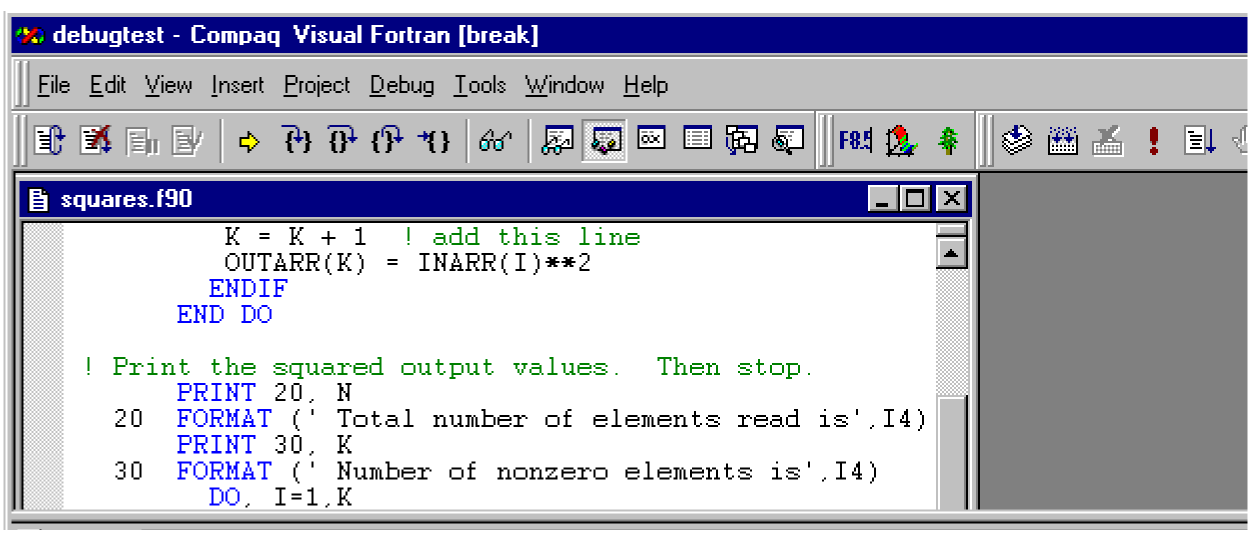
12. Although the program generates better results, you can examine the values of both the input array INARR (read from the file) and the output array OUTARR that the program calculates. In the text editor window, the previously set breakpoint remains set.

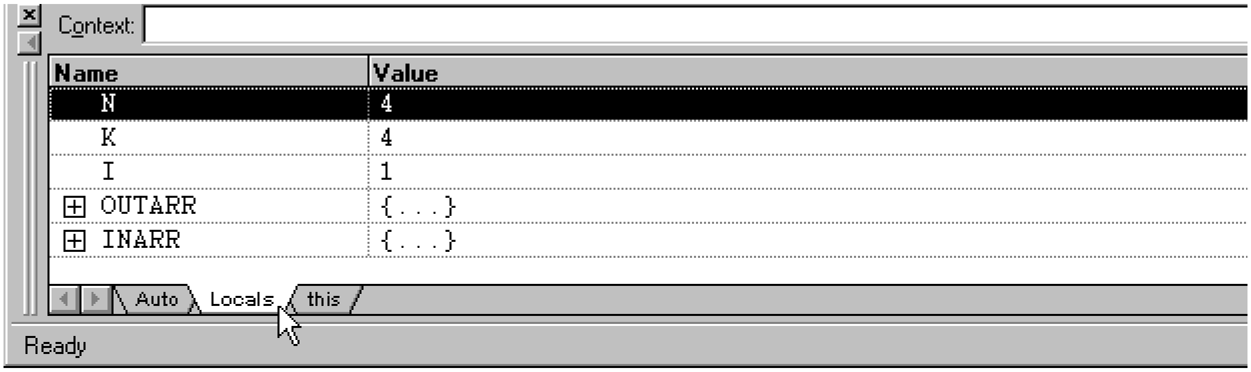
In the Build menu, click the Start Debug, Go item.

13. To view the values of certain variables as the program executes, we need to display the Variables or the Watch window. In the View menu, click the Debug Windows, Variables window item:



14. In the Variables window, click the Locals tab to display the values of your local variables:

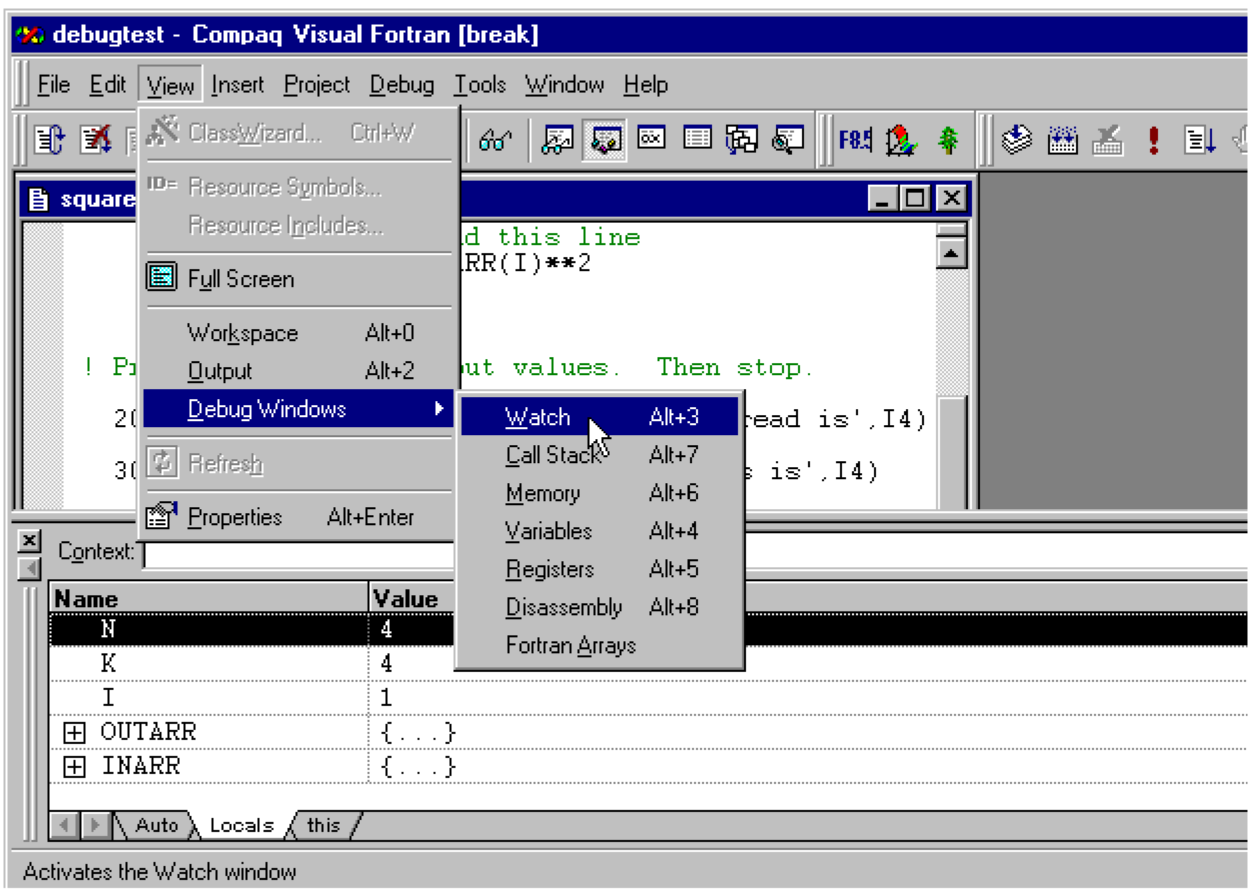




You can view the values of the local variables by using the Locals tab, including the arrays (click the plus sign).

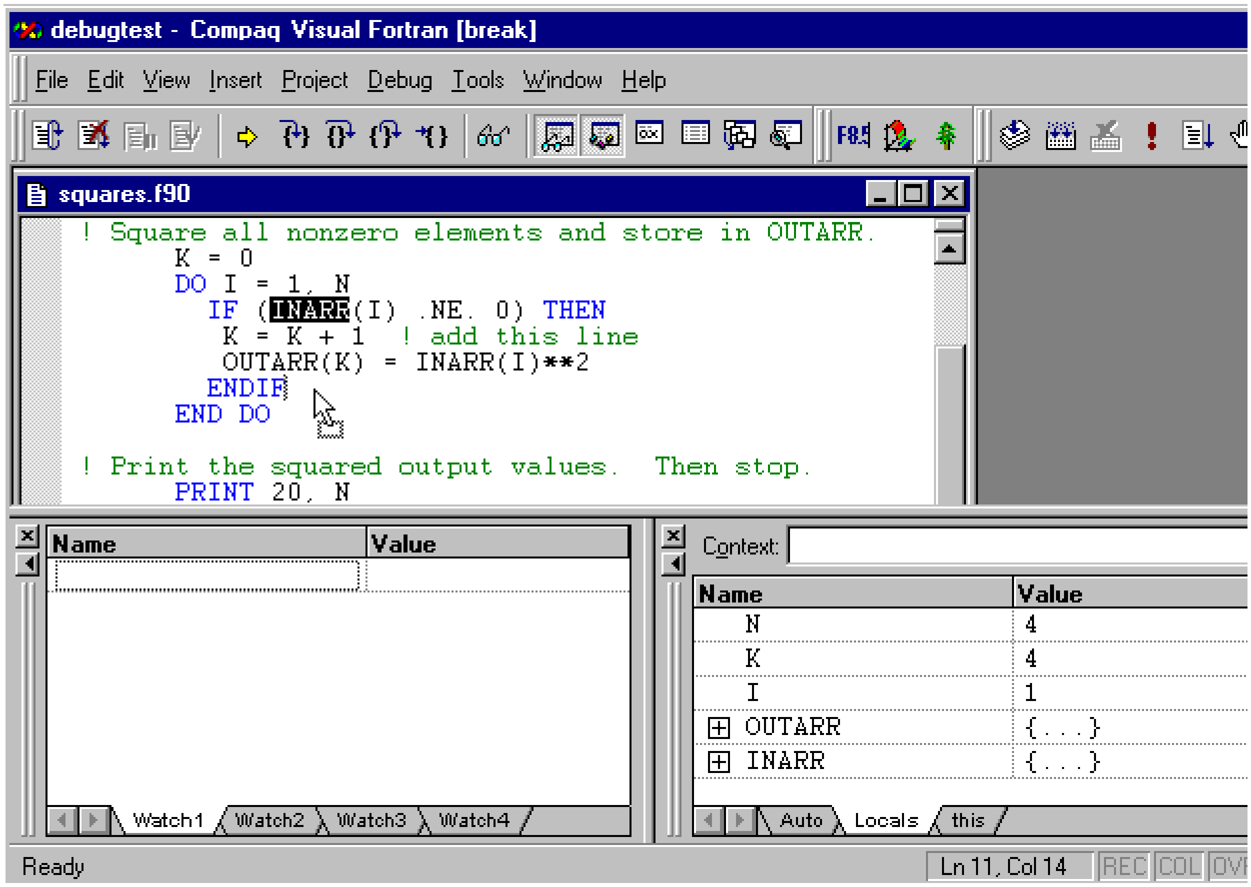
The Variables window displays a Context menu (after the word `Context:`). The Context menu can help you debug exceptions.

The Locals tab does not let you display module variables or other non-local variables. To display non-local variables, display the Watch window:



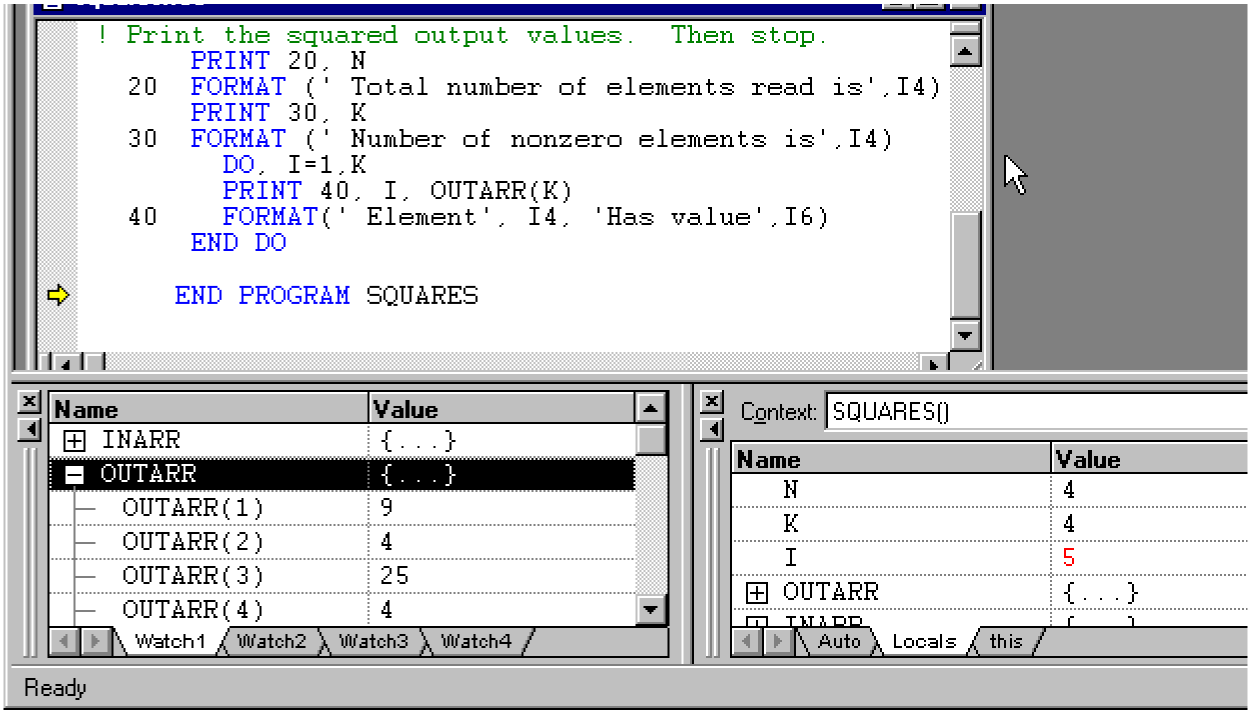
15. Although this example does not use module variables or non-local variables, you can drag a variable name into the Watch window so the variable can be displayed. The Watch window allows you to display expressions.

    In the text editor window, select the variable name INARR (without its subscript syntax), drag it, and drop it into the Watch window:



16. Also drag the OUTARR array name to the Watch window. Click the Plus sign (+) to the left of the OUTARR variable's name to display the values of its array elements.
17. Execute lines of the program by using the Step Over button on the Debug toolbar. As the program executes, you can view the values of scalar variables with the data tips feature and view the values of arrays (or other variables) in the Watch window.

    When the program completes execution, the screen appears as follows:



If a Disassembly window (shows disassembled code with source-code symbols) unintentionally appears, click the Step Out button on the debugger toolbar (or select the Step Out item in the Debug menu) as needed to dismiss the Disassembly window.

If you have the Visual Fortran Professional or Enterprise Edition, you can use the Array Viewer to display and graph multidimensional array element values.

For more information:

- On using breakpoints, see Using Breakpoints in the Debugger.
- On viewing different types of Fortran data, see Viewing Fortran Data Types in the Debugger.
- On displaying array values in the Array Viewer, see Using the Array Viewer in the Debugger.
- On locating errors in your program, see Locating Run-Time Errors in the Debugger.
- On additional debugger capabilities, see the Debugger section of the *Visual C++ Users Guide*.

Using Breakpoints in the Debugger

The Developer Studio debugger lets you set breakpoints at certain locations, when certain conditions are met at a certain location, or when a variable changes its value. This section discusses the following topics:

Viewing and Using Location Breakpoints

To view the breakpoints currently set:

1. In the Edit menu, click Breakpoints.
2. Scroll up or down in the Breakpoints list to view the breakpoints. Enabled breakpoints have a check mark in the check box and disabled breakpoints have an empty check box. The Edit Breakpoints dialog box displays all types of breakpoints (not just location breakpoints).

Alternatively, for smaller programs you can view location breakpoints set in the text editor window. Enabled location breakpoints are identified as a red circle in the left margin (see Debugging the Squares Example Program). Disabled location breakpoints are identified as a hollow circle in the left margin. You can also remove a breakpoint.

To set a location breakpoint:

1. After you open the project workspace, open the source file within which you will set a location breakpoint in the text editor (double-click the file name in the FileView pane).
2. In a text editor window (or in the Call Stack or Disassembly window), click the line at which you want to enable a location breakpoint.
3. Do one of the following:
   - Click the Insert/Remove Breakpoint button (open hand symbol) button in the Build toolbar or press the F9 key. When you set a breakpoint, it is enabled by default.
   - Right click on that line, and select Insert/Remove Breakpoint from the pop-up menu.
   - In the Edit menu, select Breakpoints. In the Location tab, click the arrow to the right of the Break At field. Click the displayed line number. Click OK.

To disable or enable a location breakpoint:

1. In a text editor window (or in the Call Stack or Disassembly window), click the line containing the location breakpoint you want to disable.
2. Do one of the following:
   - Right click on that line, and select Disable Breakpoint or Enable Breakpoint from the pop-up menu.
   - In the Edit menu, select Breakpoints. Click on the check box for that

-
  breakpoint so it is unchecked (disabled) or checked (enabled). Click OK.

To remove a location breakpoint:

1. In a text editor window (or in the Call Stack or Disassembly window), click the line containing the location breakpoint you want to remove.
2. Do one of the following:
   - Click the Insert/Remove Breakpoint button (open hand symbol) button in the Build toolbar or press the F9 key. If the breakpoint was originally disabled, click the Insert/Remove Breakpoint button or press F9 again to remove it.
   - Right click on that line, and select Remove Breakpoint from the pop-up menu.
   - In the Edit menu, select Breakpoints. In the Location tab, click (select) the breakpoint to be removed and click the Remove button. Click OK.

To view the source code where a location breakpoint is set:

1. In the Edit menu, select Breakpoints.
2. In the Breakpoints list, click (select) a location breakpoint.
3. Click the Edit Code button (upper right corner).

   This action takes you to the source code for a breakpoint set at a line number or function (or subroutine) name. In the case of function (or subroutine) names, the debugger must be running for this to work.

To remove all breakpoints:

1. In the Edit menu, select Breakpoints. Click on the Remove All button. Click OK.

Setting Location Condition Breakpoints

Like a location breakpoint, a location condition breakpoint occurs only at a certain location. Instead of the break always occurring when the program executes at that location, a location condition breakpoint occurs when the program executes at that location *and* the specified condition is met (such as when the value of an array element is greater than 1). The following procedure applies to source code within the current scope.

Unlike location breakpoints, location condition breakpoints must be set only using the Edit Breakpoints dialog box:

To set a location condition breakpoint:

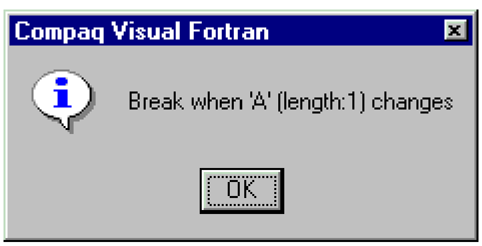
1. In a text editor window (or in the Call Stack or Disassembly window), click the line at which you want to enable a location condition breakpoint.
2. Do the following:
   - In the Edit menu, select Breakpoints.
   - In the Location tab, click the arrow to the right of the Break At field.
   - Click the displayed line number.
   - Click the Condition button to display the Condition Breakpoint dialog box.
   - Type the desired condition, such as:

     ```
     A(1) .gt. 0
     ```

   - Click OK to dismiss the Condition Breakpoint dialog.
   - Click OK

To disable, enable, and remove a location condition breakpoint, follow the general procedures for a location breakpoint. Under certain conditions, the debugger may disable the location condition breakpoint. In this case, you should either try to enable it or remove and set it again.

When the program is run and if the specified condition occurs at the chosen location, a message box similar to the following appears:



Using Data Breakpoints (Current Scope)

A data breakpoint displays a message box when the value of a variable changes or when a specified condition is met. Unlike a location condition breakpoint, data breakpoints are not associated with a specific source location. The following procedure applies to debugging the current routine (current scope).

To set a data breakpoint:

1. In the Edit menu, select Breakpoints.
2. Click the Data tab.
3. Either type the variable name alone if you want a data breakpoint to occur whenever its value changes or type the desired condition, such as:

   ```
   A(1) .eq. 0
   ```

4. Click OK to dismiss the Breakpoint dialog.

To disable, enable, or remove a data breakpoint, do one of the following:

1. In the Edit menu, select Breakpoints.
2. To disable or enable the data breakpoint, use the check box to the left of the data breakpoint (check indicates enabled).
3. To remove a data breakpoint, click (select) the data breakpoint and click the Remove button.

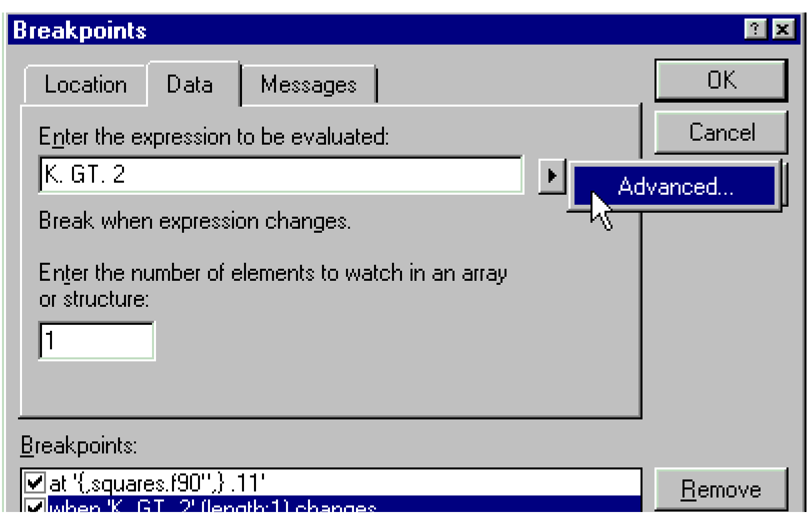
Under certain conditions, the debugger may disable the data breakpoint. In this case, you should either try to enable it or remove and set it again.

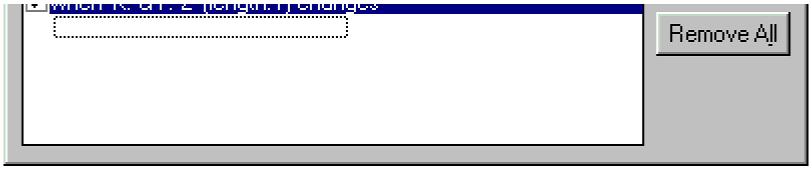
Setting Advanced Data Breakpoints

You can request that your program stop execution when a specific variable is set to a specific logical expression (data breakpoint or watchpoint). To properly instruct the debugger to watch for a change of a certain data value (variable), you should specify the routine name (scope) within which the data value condition will be watched. When the data value condition for the variable occurs within the specified scope, a message box window is displayed informing you that the condition has been met.

To set a data breakpoint for a specific local variable:

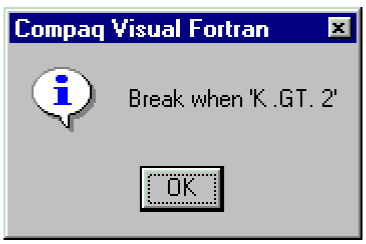
1. In the Edit menu, select Breakpoints.
2. Click the Data tab
3. Enter the logical expression to be evaluated, such as K .GT. 2
4. Unless the data value being watched is in the main program code, specify the scope of the data breakpoint as follows:
   - Click the right arrow (to the right of the expression) to display the Advanced pop-up menu:





- Click Advanced and specify the routine (function) name within which the data expression will be watched.
- Click OK

5. Start the debugger (Build menu). Consider displaying the source file associated with the data expression being watched.
6. If you have previously set an initial breakpoint for the program, in the Debug menu, click Go. Execution stops at the initial breakpoint.
7. In the Debug menu, click Go. Execution continues until the specified data value expression is met. A message box similar to the following appears when the specified data expression is met:



8. You can now view the source line just executed, examine current variable values, execute the next instruction, and so on to help you better understand that part of your program. If the error is related to an I/O statement, also see Viewing the Call Stack and Context Menu.

Some limitations with the current implementation:

- Setting data breakpoints on array elements is not fully supported.
- Under certain conditions, before you run the program again, you may need remove the original data breakpoint and set the data breakpoint again.

Viewing Fortran Data Types in the Debugger

The following general suggestions apply to different types of Fortran data:

- For scalar (nonarray) data, use the data tips (leave pointer on a variable name) feature or use the Local Variables window.
- For single-dimension array data, derived-type data, record structure data, and COMPLEX data, use the Local Variables window or the Watch window.
- For multidimension array data, use the Local Variables window, the Watch window, or (Professional and Enterprise Editions) the Array Viewer.
- For common blocks in a DLL, move (drag) the name of the common block

to the Watch window. You will be able to view the common block fields like any other structure.

For information on using Data Tips, the Local Variables window, or a Watch window, see Debugging the Squares Example Program.

For information on using the Array Viewer in the debugger, see Using the Array Viewer in the Debugger.

The following sections apply to using the Watch window:

- Specifying Array Sections
- Specifying Module Variables
- Specifying Format Specifiers

To display the Watch window:

1. In the View menu, point at (or click) Debug Windows
2. In the submenu, click Watch

Specifying Array Sections

You can specify array sections in a watch window. For example, consider an array declared as:

```
integer foo(10)
```

You can specify the following statement in a watch window to see the 2nd, 5th, and 8th elements:

```
foo(2:10:3)
```

When working with character arrays, this syntax may be combined with a substring specification. Consider the following array declaration:

```
character*8 chr_arr(10)
```

You can specify the following statement in a watch window to display the substring made up of character 3 through 8 of array elements 2 through 5:

```
chr_arr(2:5)(3:8)
```

This support is available for arrays of any type, including array pointers, assumed-shape, allocatable, and assumed-size arrays.

Any valid integer expression can be used when specifying lower bound, upper bound, or stride. If the lower bound is omitted, the array lower bound is used. If the upper bound is omitted, the array upper bound is used. For example, consider the following declaration:

```
integer foo(10)
```

To display:

- Elements 1 through 8, specify `foo(:8)`
- Elements 5 through 10, specify `foo(5:)`
- All 10 elements, specify `foo(:)`

Specifying Module Variables

To view a module variable in the Watch window, specify the module name, followed by "::", followed by the variable name.

For example, to watch variable "bar" of module "foo", specify the following expression:

```
foo::bar
```

Specifying Format Specifiers

You can use format specifiers in Watch windows to display variables in different data formats.

For example, given a REAL variable 'foo' in a program, it is now possible to see 'foo' in different floating point notation (by typing "foo,f" "foo,g" or "foo,e" in a Watch window) or as an integer (""foo,i" or "foo,d"), a hexadecimal value ("foo,x"), an an octal value ("foo,o"), and so on.

You can change the display format of variables in the Watch window using the formatting symbols in the following table:

Symbol	**Format**	**Value**	**Displays**
d,i	*signed* decimal integer	0xF000F065	-268373915
o	*unsigned* octal integer	0xF065	0170145
x,X	Hexadecimal integer	61541 (decimal)	#0000F065
f	*signed* floating-point	3./2.	1.5000000
e	*signed* scientific notation	3./2.	0.1500000E+01
g	*signed* floating-point or *signed*	3./2.	1.500000

	scientific notation, whichever is shorter		
c	Single character	0x0065	'e'
s	String	0x0012fde8	"Hello world"

To use a formatting symbol, type the variable name, followed by a comma and the appropriate symbol. For example, if `var` has a value of `0x0065`, and you want to see the value in character form, type `var,c` in the Name column on the tab of the Watch window. When you press ENTER, the character-format value appears:

```
var,c = 'e'
```

You can use the formatting symbols shown in the following table to format the contents of memory locations:

Symbol	Format	Displays
ma	64 ASCII characters	0x0012ffac .4...0...".0W&.......1W&.0.:W..1....".1.JO&.1.2..".1.
m	16 bytes in hexadecimal, followed by 16 ASCII characters	0x0012ffac B3 34 CB 00 84 30 94 80 FF 22 8A 30 57 26 00 00 .4...0...".0W&..
mb	16 bytes in hexadecimal, followed by 16 ASCII characters	0x0012ffac B3 34 CB 00 84 30 94 80 FF 22 8A 30 57 26 00 00 .4...0...".0W&..
mw	8 words	0x0012ffac 34B3 00CB 3084 8094 22FF 308A 2657 0000
md	4 doublewords	0x0012ffac 00CB34B3 80943084 308A22FF 00002657

With the memory location formatting symbols, you can type any value or expression that evaluates to a location.

A formatting character can follow an expression also:

```
rep+1,x
alps[0],mb
```

```
xloc,g
count,d
```

Note: You can apply formatting symbols to structures, arrays, pointers, and objects as unexpanded variables only. If you expand the variable, the specified formatting affects all members. You cannot apply formatting symbols to individual members.

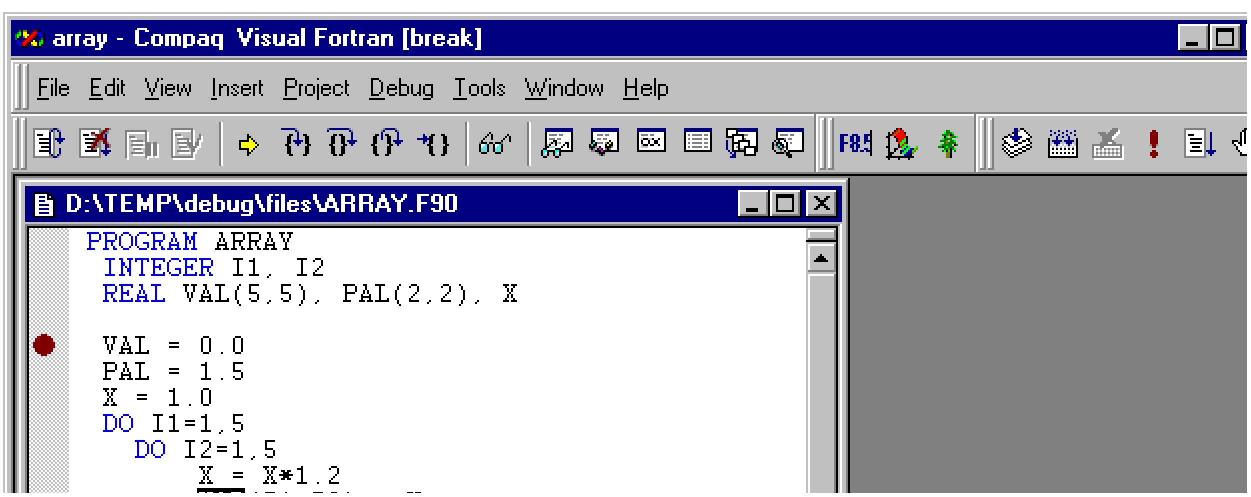
Using the Array Viewer in the Debugger

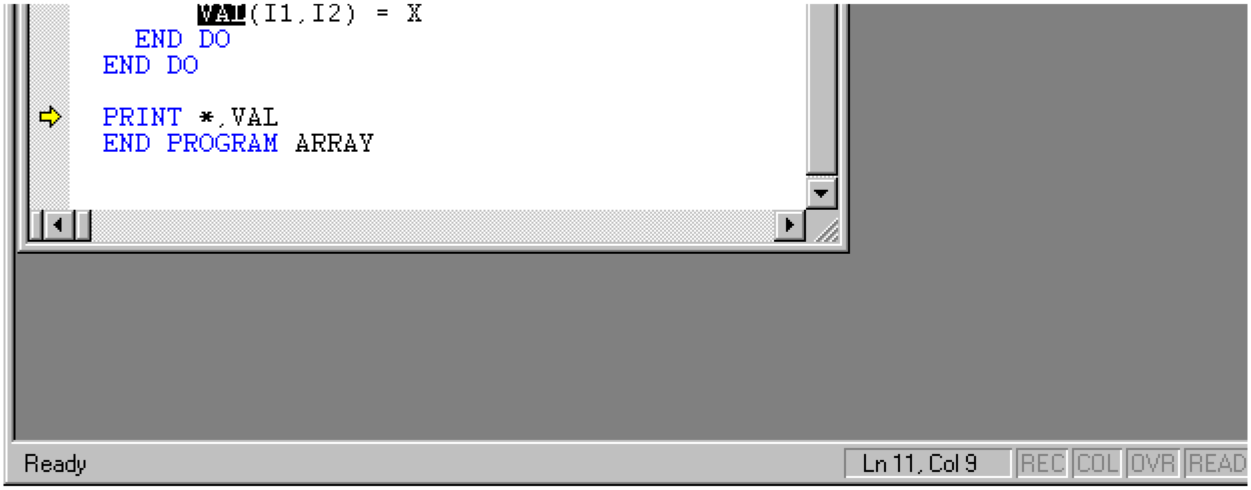
If you have the Professional or Enterprise Edition, you can use the Array Viewer in the debugger. Consider the following example program:

```
PROGRAM ARRAY
  INTEGER I1, I2
  REAL VAL(5,5), X

  VAL = 0.0
  X = 1.0
  DO I1 = 1,5
    DO I2 = 1,5
       X = X*1.2
       VAL(I1,I2) = X
    END DO
  END DO

  PRINT *,VAL
END PROGRAM ARRAY
```

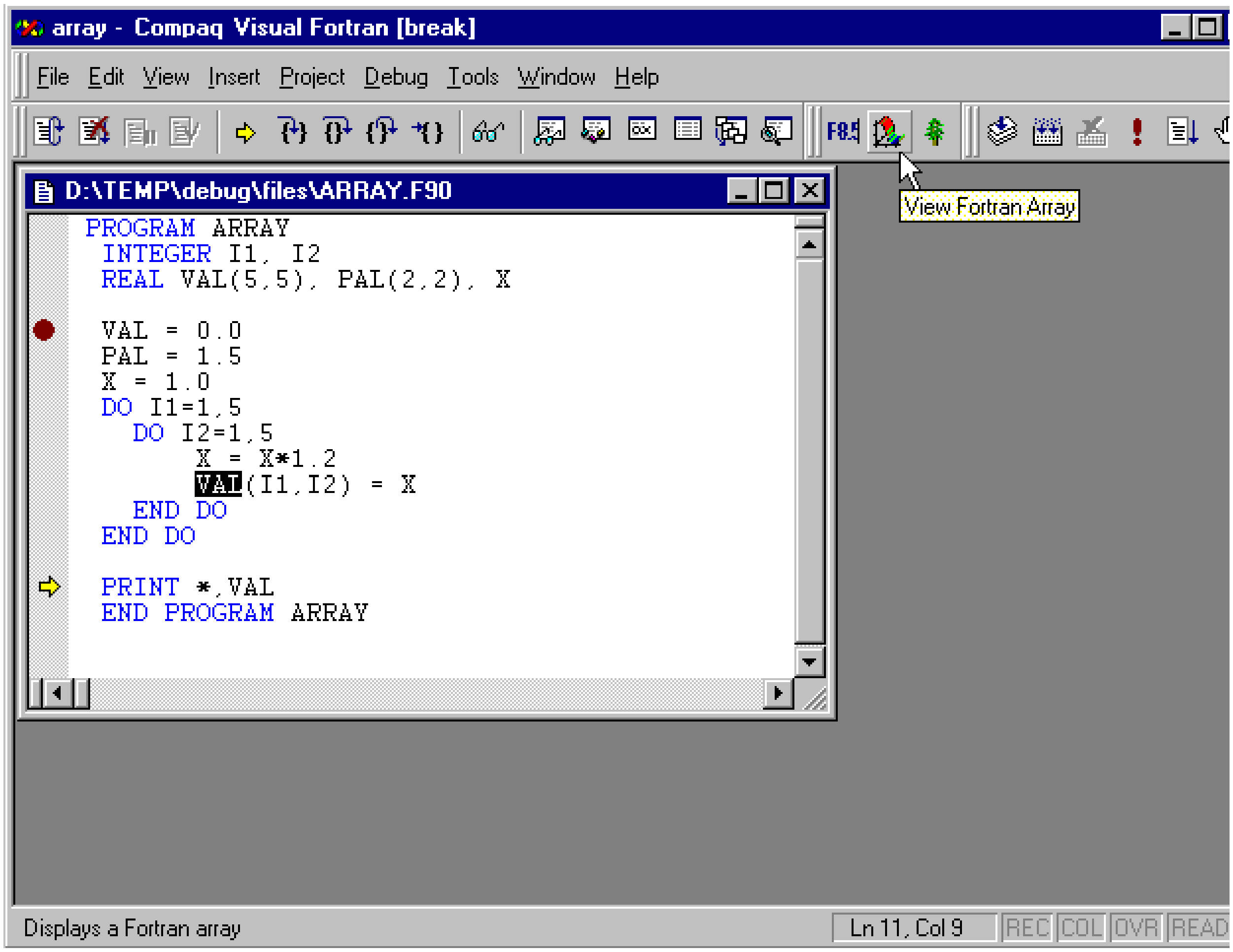
To use the Array Viewer in the debugger:

1. Start the debugger (see Debugging the Squares Example Program)
2. Step through the parts of the program that generate the values of the array you want to view, perhaps after stopping program execution at a certain breakpoint.
3. Select (click) the name of the array you want to view in the Array Viewer. For example:





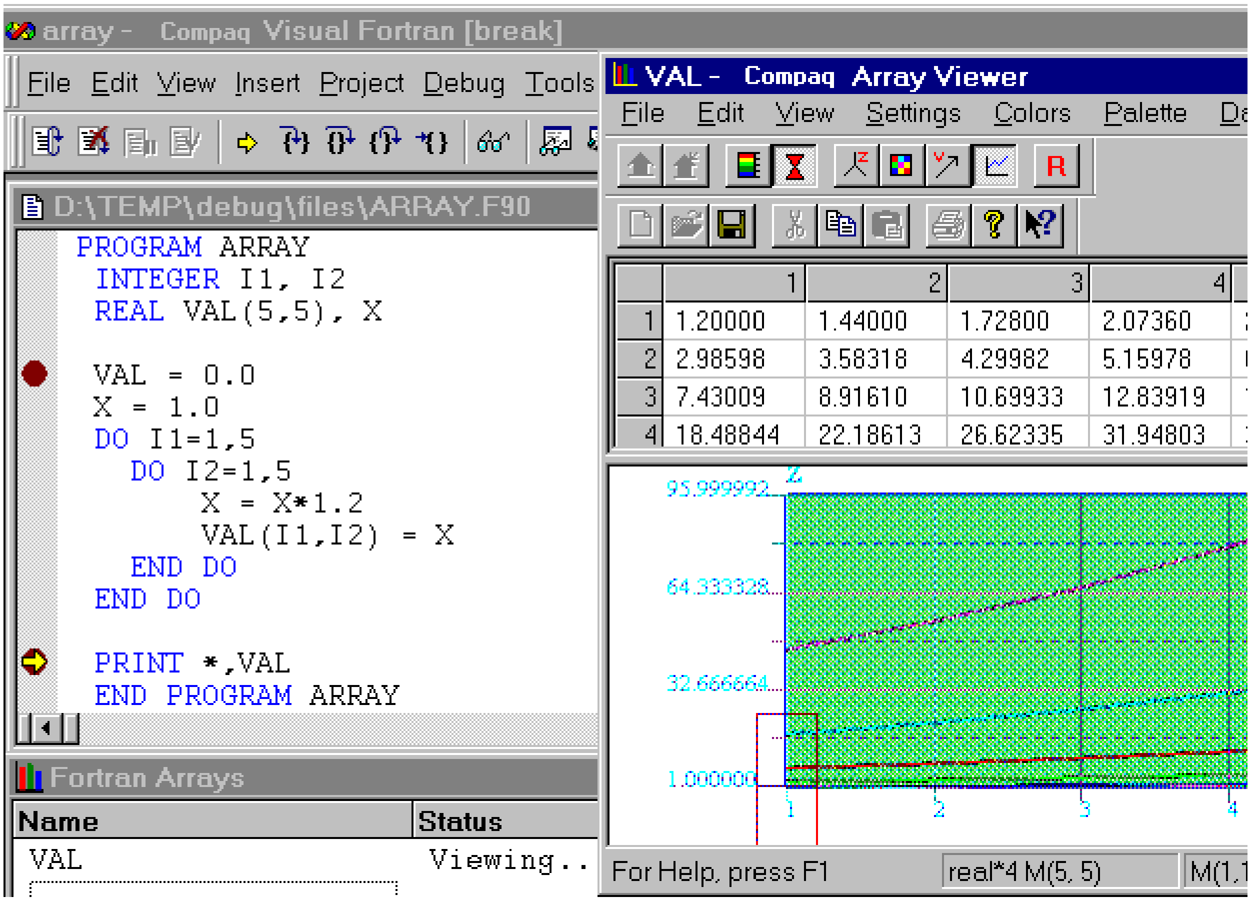
4. In the Debug menu, click Fortran Array Viewer or click the Array Viewer button in the Fortran toolbar:



To display the Fortran toolbar:

1. In the Tools menu, select Customize.
2. Click the Toolbars tab.
3. Set the Fortran toolbar check box.

The Array Viewer as well as a Fortran Arrays window appears:



In the upper part (data window), Array Viewer displays the values of the array elements for VAL.

In the lower part (graph window), the view shown for array VAL is a two-dimensional view. You can also display other types of views, such as a height plot (in the View menu, click Height Plot).

Initially, the Fortran Arrays window shows the current array being displayed and its status.

5. After your program changes the data in the Array being viewed, you can:
   - Refresh the current Array Viewer data and graph by double-clicking the array name in the Fortran Array window.
   - Create another instance of Array Viewer with an updated view of the data by clicking the Fortran Arrays button in the Fortran toolbar. The second instance may contain different value limits on the graph.

6. The Fortran Arrays window allows you to:

To Do This:	**In the Fortran Arrays Window, Do This:**

Display a different array in the existing Array Viewer	Click the Name column and type an array name
Display a different array in a new instance of the Array Viewer	Click in the last row of the Name column, type the array name, and press Enter (Return). A new instance of Array Viewer appears for the specified array.
Update the displayed array's values	Double-click the line for the array
Discontinue using the Array Viewer (removes the name from the Fortran Arrays window)	Either stop the debugger (Debug menu, Stop Debugging item) or repeatedly select the array name and click the Delete key.
Create a detached instance of Array Viewer (not associated with the debugger)	Click on an array in the Name column and press the Escape (Esc) key. This removes the array name from the Fortran Arrays window and creates a detached instance of the Array Viewer that remains after the debugging session ends.

For more information on using the Array Viewer:

- When using the Array Viewer, in the Help menu, click Help Topics.
- Read the Array Visualizer HTML Help documentation.

Locating Run-Time Errors in the Debugger

For many types of errors, using the Debugger can help you isolate the cause of errors. This section discusses the following topics:

- Effect of Certain Compiler Options
- Debugging an Exception
- Viewing the Call Stack and Using the Context Menu

Effect of Certain Compiler Options

Be aware that your program must use compiler options that allow the debugger to catch the appropriate error conditions:

- The /check:*keyword* options generate extra code to catch certain conditions at run-time. For example, if you do not specify Array and Substring Bounds checking (/check:bounds), the debugger will not catch and stop at array or character string bounds errors.
- If you specify the /fpe:3 compiler option, certain floating-point exceptions will not be caught, since this setting allows IEEE exceptional values and program continuation. In contrast, specifying /fpe:0 stops execution when an exceptional value (such as a NaN) is generated or when attempting to use a denormalized number, which usually allows you to localize the cause of the error.

In most cases, your program will automatically stop at the point where the exception occurs, allowing you to view the source code and values of variables. If the error is related to an I/O statement, see Viewing the Call Stack and Using the Context Menu.

Debugging an Exception

You can request that the program always stop when a certain type of exception occurs. Certain exceptions are caught by default by the Visual Fortran run-time library, so your program stops in the run-time library code. In most cases, you want the program to instead stop in your program's source code.

To change how an exception is handled in the debugger:

1. Start the debugger and stop execution at the initial breakpoint.
2. In the Debug menu, click Exceptions
3. View the displayed exceptions.
4. Select each type of exception to be changed and change it from "Stop if not handled" to "Stop Always"
5. Continue program execution by clicking Go in the Debug menu.
6. When the exception occurs, you can now view the source line being executed, examine current variable values, execute the next instruction, and so on to help you better understand that part of your program. If the error is related to an I/O statement, also see Viewing the Call Stack and Using the Context Menu.
7. After you locate the error and correct the program, consider whether you want to reset the appropriate type of exception to "Stop if not handled" before you debug the program again.

For machine exceptions, you can use the just-in-time debugging feature to debug your programs as they run outside of the visual development environment, if both of the following items have been set:

- In the Tools menu Options item, the Debug tab has the checkbox for Just-In Time debugging set.
- The FOR_IGNORE_EXCEPTIONS environment variable is set to TRUE.

Viewing the Call Stack and Using the Context Menu

If you want to view where in the hierarchy of routines your program in currently executing, such as after your program stops at the point where an exception occurs, you can view the Call Stack window and Context menu in the debugger:

1. Start the debugger and stop at a breakpoint
2. In the View menu, click Debug Windows
3. In the submenu, click Call Stack

A severe unhandled I/O programming error (such as an End-of-File condition) can occur while the program is executing in the debugger. When this occurs, the Fortran run-time system will raise a debug event automatically to stop program execution, allowing display of the Call Stack Display.

When the severe unhandled I/O error occurs in the debugger:

- An information box is displayed that contains:

  `User breakpoint called from code at 0x`*`nnnnnnn`*

- A window appears with your cursor in NTDLL disassembly code

Click OK to dismiss the information box.

Scanning down the Call Stack display, there will be a few frames from NTDLL and the Fortran run-time system displayed, and then the actual Fortran routine with the I/O statement that caused the error. In the Context menu, select the Fortran routine to display the Fortran code. The green arrow points to the I/O statement that caused the error.

You can view the Context menu (after `Context:`) to help locate the source code line that executed the I/O statement. The Context menu appears in the top of the Variables window (see Debugging the Squares Example Program). Use the Context menu to select the viewing context for the routine (use the arrow at the right to display selections).

This action all occurs after the error message and traceback information has been displayed. The error message and traceback information is available in the program output window. To view the program output window, either iconize (minimize) the visual development environment or click the icon for the output window in the task bar. You should not need the stack dump because you have the Call Stack window in the visual development environment, but the error the Call Stack window in the visual development environment, but the error message with the file name might be useful to see.

For more information:

- On locating exceptions and the compiler options needed, see Locating Run-Time Errors
- On using traceback information, see Using Traceback Information

Performance: Making Programs Run Faster

This chapter discusses the following topics related to improving run-time performance of Visual Fortran programs:

- Software Environment and Efficient Compilation
  Important software environment suggestions that apply to nearly all applications, including using the most recent version of the compiler, related performance tools, and efficient ways to compile using the DF command or the visual development environment
- Analyze Program Performance
  Analyzing program performance, including using profiling tools
- Data Alignment Considerations
  Guidelines related to avoiding unaligned data
- Use Arrays Efficiently
  Guidelines for efficient array use
- Improve Overall I/O Performance
  Guidelines related to improving overall I/O performance
- Additional Source Code Guidelines for Run-Time Efficiency
  Additional performance guidelines related to source code
- Optimization Levels: the /optimize:*num* Option
  Understanding the compiler /optimize:*num* optimization level options and the types of optimizations performed
- Other Options Related to Optimization
  Understanding other compiler optimization options (besides the /optimize:*num* options)
- Compiler Directives Related to Performance
  Discuss the source directives (*c*DEC$ prefix) related to performance that can be used in place of compiler options or to provide more control of certain optimizations

Software Environment and Efficient Compilation

Before you attempt to analyze and improve program performance, you should:

- Obtain and install the latest version of Visual Fortran, along with performance products that can improve application performance.
- Use the DF command and its options in a manner that lets the Visual Fortran compiler perform as many optimizations as possible to improve run-time performance.
- Use certain performance capabilities provided by the operating system.

For more information:

- Install the Latest Version of Visual Fortran and Performance Products

- Compile With Appropriate Options and Multiple Source Files

Install the Latest Version of Visual Fortran and Performance Products

To ensure that your software development environment can significantly improve the run-time performance of your applications, obtain and install the following optional software products:

- The latest version of Visual Fortran

  New releases of the Visual Fortran compiler and its associated run-time libraries may provide new features that improve run-time performance.

  For information on more recent Visual Fortran releases and other information about Visual Fortran, access the Compaq Fortran web page.

  If you have the appropriate technical support contract, you can also contact the Compaq technical support center for information on new releases (see "Visual Fortran Technical Support" in *Compaq Visual Fortran Installing and Getting Started*).

- Performance profiling tools

  The visual development environment profiling tools allow function and line profiling. For more information on profiling, see Analyze Program Performance.

- System-wide performance products

  Other products are not specific to a particular programming language or application, but can improve system-wide performance, such as minimizing disk device I/O and handling capacity planning.

  When running large programs, such as those accessing large arrays, adequate process limits and virtual memory (paging file) space as well as proper system tuning are especially important.

Compile With Appropriate Options and Multiple Source Files

During the earlier stages of program development (such as for the debug configuration in the visual development environment), you can use compilation with minimal optimization. For example:

```
DF /compile_only /optimize:1  sub2.f90
DF /compile_only /optimize:1  sub3.f90
DF /exe:main.exe /debug /optimize:0  main.f90 sub2.obj sub3.obj
```

During the later stages of program development (such as for the release configuration), you should:

- Avoid using incremental linking.
- Specify multiple source files together and use an optimization level of at least /optimize:4 on the DF command line to allow more interprocedural optimizations to occur. For instance, the following command compiles all three source files together using the default level of optimization (/optimize:4):

```
DF /exe:main.exe main.f90  sub2.f90  sub3.f90
```

- When using the visual development environment, consider reducing the number of top-level source files by copying your application to a separate project. The separate project should use only one (or a few) top-level Fortran source files that contain INCLUDE statements for the other source files. Or, you can build your application from the command line, which allows many source files to be compiled together with a single command. For information on creating (exporting) makefile for command-line use, see Files in a Project; for information about using NMAKE, see Building Projects with NMAKE.

Compiling multiple source files together lets the compiler examine more code for possible optimizations, which results in:

- Inlining more procedures
- More complete data flow analysis
- Reducing the number of external references to be resolved during linking

When compiling all source files together is not feasible (such as for very large programs), consider compiling related source files together using multiple DF commands rather than compiling source files individually.

If you use the /compile_only option to prevent linking, also use the /object:*file* option so that multiple sources files are compiled into a single object file, allowing more optimizations to occur.

Visual Fortran performs certain optimizations unless you specify the appropriate DF command-line options or corresponding visual development environment options in the Optimization category of the Fortran tab (see Categories of Compiler Options). Additional optimizations can be enabled or disabled using DF command options or in the visual development environment Project Settings dialog box Fortran tab.

The following table shows DF options that can directly improve run-time performance on both ia32 and ia64 systems. Most of these options do not affect the accuracy of the results, while others improve run-time performance but can change some numeric results.

Options Related to Run-Time Performance

Option Names	**Description**
/align: *keyword*	Controls whether padding bytes are added between data derived-type data, and Compaq Fortran record structures naturally aligned.
/architecture: *keyword*	Requests code generation for a specific chip generation. C chip generations use new instructions that provide impro applications, but those instructions are not supported by
/fast	Sets the following performance-related options: records, sequence), /architecture:host /assume:noaccura (which changes the default of /check:[no]power), and
/assume:noaccuracy_sensitive	Allows the compiler to reorder code based on algebraic id performance, enabling certain optimizations. The numeric different from the default (accuracy_sensitive) because o are rounded. This slight difference in numeric results is a
/assume:buffered_io	Allows records that are otherwise written (flushed) to disk (default) to be accumulated in the buffer and written as a usually makes disk I/O more efficient by writing larger bl often.
/inline:all	Inlines every call that can possibly be inlined while gener recursive routines are not inlined to prevent infinite loops
/inline:speed	Inlines procedures that will improve run-time performanc increase in program size.
/inline:size	Inlines procedures that will improve run-time performanc in program size. This type of inlining occurs with optimiza or /optimize:5.
/math_library:fast	On ia32 systems, requests that arguments to the math li to improve performance.

/optimize:*level*	Controls the optimization level and thus the types of opti default optimization level is /optimize:4 (except in the vis for a debug configuration), unless you specify /debug, wh to /optimize:0 (no optimizations). Use /optimize:5 to acti optimizations and (on ia64 systems) the software pipelini
/pipeline (ia64 only)	Activates the software pipelining optimization (a subset o systems.
/transform_loops	Activates a group of loop transformation optimizations (a
/tune:*keyword*	Specifies the target processor generation (chip) architect be run, allowing the optimizer to make decisions about in needed to create the most efficient code. Keywords allow processor generation type, multiple processor generation generation type currently in use during compilation. Rega *keyword*, the generated code compiled on ia32 systems w implementations of the ia32 architecture.
/unroll:*num*	Specifies the number of times a loop is unrolled (level /optimize:3 or higher. If you omit /unroll: *num* many times loops are unrolled. Primarily on ia32 systems limit may improve run-time performance for certain appli

The following table lists options that can slow program performance on ia32 and ia64 systems. Some applications that require floating-point exception handling might need to use a different /fpe:*n* option. Other applications might need to use the /assume:dummy_aliases or /vms options for compatibility reasons. Other options listed in the table are primarily for troubleshooting or debugging purposes.

Options that Slow Run-Time Performance

Option Names	**Description**	**For More Information**
/assume:dummy_aliases	Forces the compiler to assume that dummy (formal) arguments to procedures share memory locations with other dummy arguments or with variables shared through use association, host association, or common block use. These program semantics slow performance, so	See Dummy Aliasing Assumption

	you should specify /assume: dummy_aliases only for the called subprograms that depend on such aliases. The use of dummy aliases violates the FORTRAN 77 and Fortran 90 standards but occurs in some older programs.	
/compile_only	If you use /compile_only when compiling multiple source files, also specify /object:*file* to compile many source files together into one object file. Separate compilations prevent certain interprocedural optimizations, the same as using multiple DF commands or using /compile_only *without* the /object:*file* option.	See Compile With Appropriate Options and Multiple Source Files
/check:bounds	Generates extra code for array bounds checking at run time.	See /check
/check:overflow	Generates extra code to check integer calculations for arithmetic overflow at run time. Once the program is debugged, you may want to omit this option to reduce executable program size and slightly improve run-time performance.	See /check
/fpe:*n* values	On ia32 systems, /fpe:3 provides the best performance. Using /fpe:0 slows program execution. On ia64 systems, using /fpe:0 provides the best performance. Using /fpe:3 slows program execution.	See /fpe
/debug:full, /debug, or equivalent	Generates extra symbol table information in the object file. Specifying /debug also reduces the default level of optimization to /optimize:0.	See /debug

/inline: none /inline: manual	Prevents the inlining of all procedures (except statement functions).	See Controlling the Inlining of Procedures
/optimize:0, /optimize:1, /optimize:2, or /optimize:3	Reduces the optimization level (and types of optimizations). Use during the early stages of program development or when you will use the debugger.	See /[no] optimize and Optimization Levels: the /optimize Option
/vms	Controls certain VMS-related run-time defaults, including alignment. If you specify the /vms option, you may need to also specify the /align:records option to obtain optimal run-time performance.	See /[no]vms

For more information:

- On compiling multiple files, see Compiling and Linking for Optimization.

Analyze Program Performance

This section describes how you can analyze program performance using timings and profiling tools.

Along with profiling, you can consider generating a listing file with annotations of optimizations, by specifying the /list and /annotations:*keyword* options (Listing category in the Project Settings dialog box).

Before you analyze program performance, make sure any errors you might have encountered during the early stages of program development have been corrected. Only profile code that is stable and has been debugged.

The following topics are covered:

- Timing Your Application
- Profiling and Performance Tools

Timing Your Application

The following considerations apply to timing your application:

- Run program timings when other users are not active. Your timing results can be affected by one or more CPU-intensive processes also running while doing your timings.
- Try to run the program under the same conditions each time to provide the most accurate results, especially when comparing execution times of a previous version of the same program. Use the same system (processor model, amount of memory, version of the operating system, and so on) if possible.
- If you do need to change systems, you should measure the time using the same version of the program on both systems, so you know each system's effect on your timings.
- For programs that run for less than a few seconds, run several timings to ensure that the results are not misleading. Certain overhead functions like loading DLLs might influence short timings considerably.
- If your program displays a lot of text, consider redirecting the output from the program. Redirecting output from the program will change the times reported because of reduced screen I/O.

Methods of Timing Your Application

To perform application timings, use a version of the `TIME` command in a .BAT file (or the function timing profiling option). You might consider modifying the program to call routines within the program to measure execution time (possibly using conditionally compiled lines). For example:

- Compaq Fortran intrinsic procedures, such as CPU_TIME, SYSTEM_CLOCK, DATE_AND_TIME, and TIME.
- Library routines, such as ETIME or TIME.

Visual Fortran programs created in a Windows 98, Windows Me, or Windows 95 development environment can be run and analyzed on Windows NT 4 or Windows 2000 systems. Whenever possible, perform detailed performance analysis on a system that closely resembles the system(s) that will used for actual application use.

Sample Command Procedure that Uses TIME and Performance Monitor

The following example shows a .BAT command procedure that uses the `TIME` command and the Performance Monitor (`perfmon`) tool available on Windows NT 4 and Windows 2000 systems. The `kill` command that stops the `perfmon` tool is included on the Windows NT Resource kit; if the `kill` tool is not available on your system, manually end the `perfmon` task by using the task manager.

This .BAT procedure assumes that the program to be timed is `myprog.exe`.

Before using this batch file, start the performance monitor to setup logging of the statistics that you are interested in:

1. At the DOS prompt type: `Perfmon`
2. In the View menu, select Log
3. In the Edit menu, select Add to Log and select some statistics
4. In the Options menu, select Log. In the dialog box:
   - Name the log file. The following .BAT procedure assumes that you have named the logfile `myprog.log`.
   - Consider adjusting the Log Interval.
   - As the last step, be sure to select "Start Log".
5. In the File menu, select Save Workspace to save the setup information. The following .BAT procedure assumes you have saved the workspace as `my_perfmon_setup.pmw`.

The command procedure follows:

```
echo off
rem  Sample batch file to record performance statistics for later analysis.
rem  This .bat file assumes that you have the utility "kill" available, which
rem  is distributed with the NT resource kit.

rem Delete previous logs, then start up the Performance Monitor.
rem We use start so that control returns instantly to this batch file.
del myprog.log
start perfmon my_perfmon_setup.pmw

rem print the time we started
time <nul | findstr current

rem start the program we are interested in, this time using
rem cmd /c so that the batch file waits for the program to finish.
echo on
cmd /c myprog.exe
echo off

rem print the time we stopped
time <nul | findstr current

rem all done logging statistics
kill perfmon
rem if kill is not available, end the perfmon task manually
```

After the run, analyze your data by using Performance Monitor:

1. If it is not currently running, start Performance Monitor.
2. In the View menu, select Chart.
3. In the Options menu, select Data From and specify the name of the logfile.
4. In the Edit menu, select Add To Chart to display the counters.

For more information:

- About the optimizations that improve application performance without source code modification, see Compile With Appropriate Options and

Multiple Source Files.
- About profiling your application, see Profiling and Performance Tools.

Profiling and Performance Tools

To generate profiling information, you use the compiler, linker, and the profiler from either the visual development environment or the command line.

Select those parts of your application that make the most sense to profile. For example, routines that perform user interaction may not be worth profiling. Consider profiling routines that perform a series of complex calculations or call multiple user-written subprograms.

Profiling identifies areas of code where significant program execution time is spent. It can also show areas of code that are not executed. Visual Fortran programs created in a Windows ia32 development environment can be run and analyzed on a Windows NT 4, Windows 2000, Windows 98, Windows Me, or Windows 95 system. Whenever possible, perform detailed performance analysis on a system that closely resembles the system(s) that will be used to run the actual application.

For detailed information about profiling from the command line, see Profiling Code from the Command Line.

There are two main types of profiling: **function profiling** and **line profiling**.

Function Profiling

Function profiling helps you locate areas of inefficient code. It can show:

- The time spent in functions and the number of times a function was called (function timing).
- Only the number of times a function was called (function counting).
- A list of functions executed or not executed (function coverage).
- Information about the stack when each function is called (function attribution).

Function profiling does not require debug information (it obtains addresses from a .MAP file). Since function profiling (except function attribution) uses the stack, routines that modify the stack cannot be profiled. Exclude object files for routines that modify the stack.

To perform function profiling:

1. In the Project menu, select Settings.
2. Click the Link tab.
3. In the General category, click the Enable profiling checkbox (this turns off

incremental linking).
4. In the General category, click the Generate mapfile checkbox.
5. Click OK to accept the current project settings.
6. Build your application.
7. After building your application, profile your project.

Line Profiling

Line profiling collects more information than function profiling. It shows how many times a line is executed and whether certain lines are not executed. Line profiling requires debug information.

To perform line profiling:

1. In the Project menu, select Settings.
2. Click the Link tab.
3. In the General category, click the Enable profiling checkbox (this turns off incremental linking).
4. In the General category, click the Generate debug information checkbox.
5. Click on the Fortran tab.
6. In the category drop-down list, select Debug.
7. In the Debugging level drop-down list, select Full.
8. In the Debugging level drop-down list, click the Use Program Database for Debug Information checkbox.
9. Click OK to accept the current project settings.
10. Build your application
11. After building your application, profile your project.

Performance Tools

Tools that you can use to analyze performance include:

- Process Viewer (Pview) lets you view process and thread characteristics.
- Spy++ provides a graphical view of system use.
- On Windows NT or Windows 2000 systems, the Windows Performance Monitor can help identify performance bottlenecks.
- Other performance tools are available in the Microsoft Win32 SDK (see the online *Platform SDK* Tools Guide, Tuning section in HTML Help Viewer).

You can also purchase separate products to perform performance analysis and profiling.

Efficient Source Code

Once you have determined those sections of code where most of the program execution time is spent, examine these sections for coding efficiency. Suggested guidelines for improving source code efficiency are provided in the following sections:

- Data Alignment Considerations
- Use Arrays Efficiently
- Improve Overall I/O Performance
- Additional Source Code Guidelines for Run-Time Efficiency

For information about timing your application and for an example command procedure that uses the Windows NT Performance Monitor, see Timing Your Application.

Data Alignment Considerations

For optimal performance with most cases, make sure your data is aligned naturally. If you must use 1- or 2-byte integer or logical data, in some cases specifying 4- or 8-byte alignment provides better performance (see Ordering Data Declarations to Avoid Unaligned Data).

A natural boundary is a memory address that is a multiple of the data item's size (data type sizes are described in Data Representation). For example, a REAL (KIND=8) data item aligned on natural boundaries has an address that is a multiple of 8. An array is aligned on natural boundaries if all of its elements are so aligned.

All data items whose starting address is on a natural boundary are *naturally aligned*. Data not aligned on a natural boundary is called *unaligned data*.

Although the Visual Fortran compiler naturally aligns individual data items when it can, certain Compaq Fortran statements (such as EQUIVALENCE) can cause data items to become unaligned (see Causes of Unaligned Data and Ensuring Natural Alignment).

Although you can use the DF command /align: *keyword* options to ensure naturally aligned data, you should check and consider reordering data declarations of data items within common blocks and structures. Within each common block, derived type, or record structure, carefully specify the order and sizes of data declarations to ensure naturally aligned data. Start with the largest size numeric items first, followed by smaller size numeric items, and then nonnumeric (character) data.

The following sections discuss data alignment considerations in more detail:

- Causes of Unaligned Data and Ensuring Natural Alignment
- Checking for Inefficient Unaligned Data
- Ordering Data Declarations to Avoid Unaligned Data
- Options Controlling Alignment

Causes of Unaligned Data and Ensuring Natural Alignment

Common blocks (**COMMON** statement), derived-type data, and Compaq Fortran record structures (**RECORD** statement) usually contain multiple items within the context of the larger structure.

The following declarations can force data to be unaligned:

- Common blocks (**COMMON** statement)

  The order of variables in the **COMMON** statement determines their storage order.

  Unless you are sure that the data items in the common block will be naturally aligned, specify either the /align:commons or /align:dcommons option, depending on the largest data size used.

  For examples and more information, see Arranging Data in Common Blocks.

- Derived-type (user-defined) data

  Derived-type data members are declared after a TYPE statement.

  If your data includes derived-type data structures, unless you are sure that the data items in derived-type data structures will be naturally aligned, use the /align:records option (default).

  If you omit the SEQUENCE statement, the /align:records option ensures all data items are naturally aligned.

  If you specify the **SEQUENCE** statement, the /align:records option is prevented from adding necessary padding to avoid unaligned data (data items are packed) unless you also specify the /align:sequence option. When you use **SEQUENCE**, you should specify a data declaration order such that all data items are naturally aligned or specify /align:sequence.

  For an example and more information, see Arranging Data Items in Derived-Type Data.

- Compaq Fortran record structures (**RECORD** and **STRUCTURE** statements)

  Compaq Fortran record structures usually contain multiple data items. The order of variables in the STRUCTURE statement determines their storage order. The **RECORD** statement names the record structure.

If your data includes Compaq Fortran record structures, you should use the /align:records option (default), unless you are sure that the data items in derived-type data and Compaq Fortran record structures will be naturally aligned.

For examples and more information, see Arranging Data Items in Compaq Fortran Record Structures.

- Equivalenced data

  EQUIVALENCE statements can force unaligned data or cause data to span natural boundaries.

To avoid unaligned data in a common block, derived-type data, or record structures, use one or both of the following:

- For new programs or for programs where the source code declarations can be modified easily, plan the order of data declarations with care. For example, you should order variables in a **COMMON** statement such that numeric data is arranged from largest to smallest, followed by any character data (see the data declaration rules in Ordering Data Declarations to Avoid Unaligned Data). Consider using explicit-length declarations, such as INTEGER(KIND=8) instead of INTEGER, which uses default kind. This prevents command-line options like /real_size and /integer_size from changing the length of INTEGER, LOGICAL, REAL, and COMPLEX declarations, which may change alignment.
- For existing programs where source code changes are not easily done or for array elements containing derived-type or record structures, you can use command line options to request that the compiler align numeric data by adding padding spaces where needed.

Other possible causes of unaligned data include unaligned actual arguments and arrays that contain a derived-type structure or Compaq Fortran record structure.

When actual arguments from outside the program unit are not naturally aligned, unaligned data access will occur. Compaq Fortran assumes all passed arguments are naturally aligned and has no information at compile time about data that will be introduced by actual arguments during program execution.

For arrays where each array element contains a derived-type structure or Compaq Fortran record structure, the size of the array elements may cause some elements (but not the first) to start on an unaligned boundary.

Even if the data items are naturally aligned within a derived-type structure without the **SEQUENCE** statement or a record structures, the size of an array element might require use of /align options to supply needed padding to avoid some array elements being unaligned.

If you specify /align:norecords, no padding bytes are added between array elements. If array elements each contain a derived-type structure with the **SEQUENCE** statement, array elements are packed without padding bytes regardless of the DF command options specified. In this case, some elements will be unaligned.

When /align:records option is in effect, the number of padding bytes added by the compiler for each array element is dependent on the size of the largest data item within the structure. The compiler determines the size of the array elements as an exact multiple of the largest data item in the derived-type structure without the **SEQUENCE** statement or a record structure. The compiler then adds the appropriate number of padding bytes.

For instance, if a structure contains an 8-byte floating-point number followed by a 3-byte character variable, each element contains five bytes of padding (16 is an exact multiple of 8). However, if the structure contains one 4-byte floating-point number, one 4-byte integer, followed by a 3-byte character variable, each element would contain one byte of padding (12 is an exact multiple of 4).

For more information:

On the /align options, see Options Controlling Alignment.

Checking for Inefficient Unaligned Data

During compilation, the Visual Fortran compiler naturally aligns as much data as possible. Exceptions that can result in unaligned data are described in Causes of Unaligned Data and Ensuring Natural Alignment.

Because unaligned data can slow run-time performance, it is worthwhile to:

- Double-check data declarations within common block, derived-type data, or record structures to ensure all data items are naturally aligned (see the data declaration rules in Ordering Data Declarations to Avoid Unaligned Data). Using modules to contain data declarations can ensure consistent alignment and use of such data.
- Avoid the EQUIVALENCE statement or use it in a manner that cannot cause unaligned data or data spanning natural boundaries.
- Ensure that passed arguments from outside the program unit are naturally aligned.
- Check that the size of array elements containing at least one derived-type data or record structure cause array elements to start on aligned boundaries (see Causes of Unaligned Data and Ensuring Natural Alignment).

During compilation, warning messages are issued for any data items that are known to be unaligned (unless you specify the /warn:noalignments option).

Ordering Data Declarations to Avoid Unaligned Data

For new programs or when the source declarations of an existing program can be easily modified, plan the order of your data declarations carefully to ensure the data items in a common block, derived-type data, record structure, or data items made equivalent by an **EQUIVALENCE** statement will be naturally aligned.

Use the following rules to prevent unaligned data:

- Always define the largest size numeric data items first.
- If your data includes a mixture of character and numeric data, place the numeric data first.
- Add small data items of the correct size (or padding) before otherwise unaligned data to ensure natural alignment for the data that follows.

When declaring data, consider using explicit length declarations, such as specifying a KIND parameter. For example, specify INTEGER(KIND=4) (or INTEGER(4)) rather than INTEGER. If you do use a default length (such as INTEGER, LOGICAL, COMPLEX, and REAL), be aware that the compiler options /integer_size:*num* and /real_size:*num* can change the size of an individual field's data declaration size and thus can alter the data alignment of a carefully-planned order of data declarations.

Using the suggested data declaration guidelines minimizes the need to use the /align options to add padding bytes to ensure naturally aligned data. In cases where the /align options are still needed, using the suggested data declaration guidelines can minimize the number of padding bytes added by the compiler:

- Arranging Data Items in Common Blocks
- Arranging Data Items in Derived-Type Data
- Arranging Data Items in Compaq Fortran Record Structures

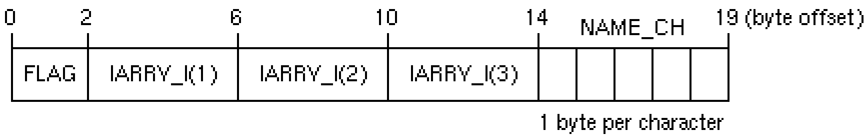
Arranging Data Items in Common Blocks

The order of data items in a **COMMON** statement determine the order in which the data items are stored. Consider the following declaration of a common block named X:

```
LOGICAL (KIND=2) FLAG
INTEGER          IARRY_I(3)
CHARACTER(LEN=5) NAME_CH
COMMON /X/ FLAG, IARRY_I(3), NAME_CH
```

As shown in the following figure, if you omit the alignment compiler options, the common block will contain unaligned data items beginning at the first array element of IARRY_I.

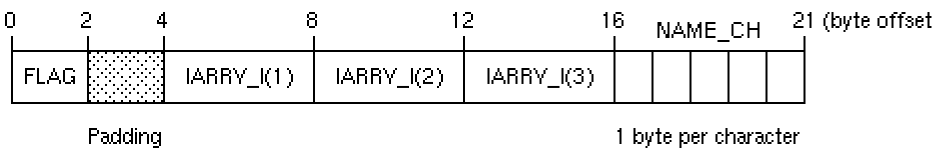
Common Block with Unaligned Data



ZK-6659A-GE

As shown in the following figure, if you compile the program units that use the common block with the /align:commons options, data items will be naturally aligned.

Common Block with Naturally Aligned Data



ZK-6660A-GE

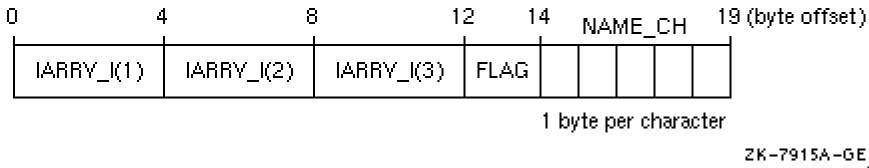
Because the common block X contains data items whose size is 32 bits or smaller, specify /align:commons. If the common block contains data items whose size might be larger than 32 bits (such as REAL (KIND=8) data), use /align:dcommons.

If you can easily modify the source files that use the common block data, define the numeric variables in the COMMON statement in descending order of size and place the character variable last to provide more portability and ensure natural alignment without padding or the DF command options /align:commons or /align:dcommons:

```
LOGICAL (KIND=2) FLAG
INTEGER          IARRY_I(3)
CHARACTER(LEN=5) NAME_CH
COMMON /X/ IARRY_I(3), FLAG, NAME_CH
```

As shown in the following figure, if you arrange the order of variables from largest to smallest size and place character data last, the data items will be naturally aligned.

Common Block with Naturally Aligned Reordered Data



When modifying or creating all source files that use common block data, consider placing the common block data declarations in a module so the declarations are consistent. If the common block is not needed for compatibility (such as file storage or Compaq Fortran 77 use), you can place the data declarations in a module without using a common block.

Arranging Data Items in Derived-Type Data

Like common blocks, derived-type data may contain multiple data items (members).

Data item components within derived-type data will be naturally aligned on up to 64-bit boundaries, with certain exceptions related to the use of the **SEQUENCE** statement and DF options.

Compaq Visual Fortran stores a derived data type as a linear sequence of values, as follows:

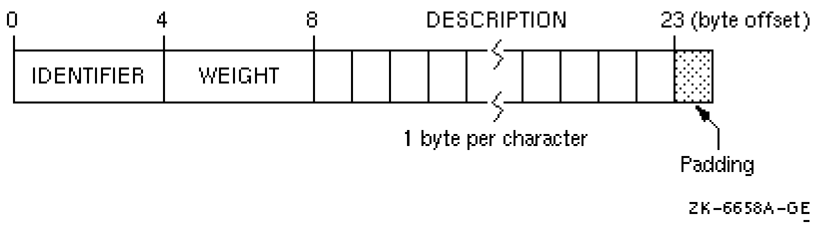
- If you specify the **SEQUENCE** statement, the first data item is in the first storage location and the last data item is in the last storage location. The data items appear in the order in which they are declared. If you omit the /align:sequence option, data declarations must be carefully specified to naturally align data.
- If you omit the **SEQUENCE** statement, Compaq Fortran adds the padding bytes needed to naturally align data item components, unless you specify the /align:norecords option.

Consider the following declaration of array CATALOG_SPRING of derived-type PART_DT:

```
MODULE DATA_DEFS
  TYPE PART_DT
    INTEGER           IDENTIFIER
    REAL              WEIGHT
    CHARACTER(LEN=15) DESCRIPTION
  END TYPE PART_DT
  TYPE (PART_DT) CATALOG_SPRING(30)
  .
  .
  .
END MODULE DATA_DEFS
```

As shown in the following figure, the largest numeric data items are defined first and the character data type is defined last. There are no padding characters between data items and all items are naturally aligned. The trailing padding byte is needed because CATALOG_SPRING is an array; it is inserted by the compiler when the /align:records option is in effect.

Derived-Type Naturally Aligned Data (in CATALOG_SPRING())



Arranging Data Items in Compaq Fortran Record Structures

Record structures are a Compaq language extension to the FORTRAN 77, Fortran 90, and Fortran 95 Standards. Record structures use the **RECORD** statement and optionally the **STRUCTURE** statement, which are also Compaq Fortran language extensions. The order of data items in a **STRUCTURE** statement determine the order in which the data items are stored.

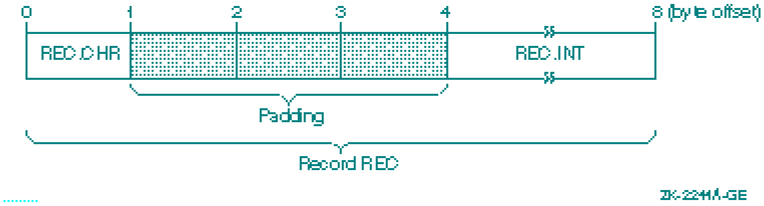
Compaq Fortran stores a record in memory as a linear sequence of values, with the record's first element in the first storage location and its last element in the last storage location. Unless you specify /align:norecords, padding bytes are added if needed to ensure data fields are naturally aligned.

The following example contains a structure declaration, a **RECORD** statement, and diagrams of the resulting records as they are stored in memory:

```
STRUCTURE /STRA/
  CHARACTER*1 CHR
  INTEGER*4 INT
END STRUCTURE
   .
   .
   .
RECORD /STRA/ REC
```

The following figure shows the memory diagram of record REC for naturally aligned records.

Memory Diagram of REC for Naturally Aligned Records



Options Controlling Alignment

The following options control whether the Visual Fortran compiler adds padding (when needed) to naturally align multiple data items in common blocks, derived-type data, and Compaq Fortran record structures:

- The /align:commons option

  Requests that data in common blocks be aligned on up to 4-byte boundaries, by adding padding bytes as needed. Unless you specify /fast, the default is /align:nocommons or arbitrary byte alignment of common block data. In this case, unaligned data can occur unless the order of data items specified in the COMMON statement places the largest numeric data item first, followed by the next largest numeric data (and so on), followed by any character data.

- The /align:dcommons option

  Requests that data in common blocks be aligned on up to 8-byte boundaries, by adding padding bytes as needed. Unless you specify /fast, the default is /align:nocommons or arbitrary byte alignment of data items in a common data.

  Specify the /align:dcommons option for applications that use common blocks, unless your application has no unaligned data or, if the application might have unaligned data, all data items are four bytes or larger. For applications that use common blocks where all data items are four bytes or smaller, you can specify /align:commons instead of /align:dcommons.

- The /align:norecords option

  Requests that multiple data items in derived-type data and record structures (a Compaq Fortran extension) be aligned arbitrarily on byte boundaries instead of being naturally aligned. The default is /align:records.

- The /align:records option

  Requests that multiple data items in record structures and derived-type data without the **SEQUENCE** statement be naturally aligned, by adding padding bytes as needed. The default is /align:records.

- The /align:sequence option

  Controls alignment of derived types with the **SEQUENCE** statement. Specifying the /align:sequence option means that derived types with the **SEQUENCE** statement obey whatever alignment rules are currently in use.

Consequently, since /align:records is a default value, then /align:sequence alone on the command line will cause the fields in these derived types to be naturally aligned. Specifying /fast implies /align:sequence.

- The /align:nosequence option

  Controls alignment of derived types with the **SEQUENCE** statement. The default /align:nosequence option means that derived types with the **SEQUENCE** statement are packed regardless of any other alignment rules.

The default behavior is that multiple data items in derived-type data and record structures *will* be naturally aligned; data items in common blocks will *not* be naturally aligned (/align:records) with /align:nocommons. In derived-type data, using the **SEQUENCE** statement without specifying /align:sequence prevents /align:records from adding needed padding bytes to naturally align data items.

Use Arrays Efficiently

The way arrays are accessed and passed as arguments can have a significant impact on run-time performance, especially when using large arrays. This section discusses the following topics:

- Accessing Arrays Efficiently
- Passing Array Arguments Efficiently

Accessing Arrays Efficiently

Many of the array access efficiency techniques described in this section are applied automatically by the Visual Fortran loop transformation optimizations (set at /optimization:5).

Several aspects of array access can improve run-time performance:

- The fastest array access occurs when contiguous access to the whole array or most of an array occurs. Perform one or a few array operations that access all of the array or major parts of an array rather than numerous operations on scattered array elements.

  Rather than use explicit loops for array access, use elemental array operations, such as the following line that increments all elements of array variable A:

  ```
  A = A + 1.
  ```

  When reading or writing an array, use the array name and not a **DO** loop or an implied **DO**-loop that specifies each element number. Fortran 90 array syntax allows you to reference a whole array by using its name in an expression. For example:

```
REAL ::  A(100,100)
A = 0.0
A = A + 1.            ! Increment all elements of A by 1
.
.
.
WRITE (8) A           ! Fast whole array use
```

Similarly, you can use derived-type array structure components, such as:

```
TYPE X
  INTEGER A(5)
END TYPE X
.
.
.
TYPE (X) Z
WRITE (8) Z%A     ! Fast array structure component use
```

- Make sure multidimensional arrays are referenced using proper array syntax and are traversed in the "natural" ascending order *column major* for Fortran. With column-major order, the leftmost subscript varies most rapidly with a stride of one. Whole array access uses column-major order.

  Avoid *row-major* order, as is done by C, where the rightmost subscript varies most rapidly.

  For example, consider the nested **DO** loops that access a two-dimension array with the J loop as the innermost loop:

```
INTEGER  X(3,5), Y(3,5), I, J
Y = 0
DO I=1,3                   ! I outer loop varies slowest
  DO J=1,5                 ! J inner loop varies fastest
    X (I,J) = Y(I,J) + 1  ! Inefficient row-major storage order
  END DO                   ! (rightmost subscript varies fastest)
END DO
.
.
.
END PROGRAM
```

  Because J varies the fastest and is the second array subscript in the expression X (I,J), the array is accessed in row-major order.

  To make the array accessed in natural column-major order, examine the array algorithm and data being modified.

  Using arrays X and Y, the array can be accessed in natural column-major order by changing the nesting order of the **DO** loops so the innermost loop variable corresponds to the leftmost array dimension:

```
INTEGER  X(3,5), Y(3,5), I, J
Y = 0

DO J=1,5                  ! J outer loop varies slowest
  DO I=1,3                ! I inner loop varies fastest
    X (I,J) = Y(I,J) + 1  ! Efficient column-major storage order
  END DO                  ! (leftmost subscript varies fastest)
END DO
 .
 .
 .
END PROGRAM
```

Fortran whole array access (*X*= *Y* + *1*) uses efficient column major order. However, if the application requires that J vary the fastest or if you cannot modify the loop order without changing the results, consider modifying the application program to use a rearranged order of array dimensions. Program modifications include rearranging the order of:

- Dimensions in the declaration of the arrays X(5,3) and Y(5,3)
- The assignment of X(J,I) and Y(J,I) within the DO loops
- All other references to arrays X and Y

In this case, the original **DO** loop nesting is used where J is the innermost loop:

```
INTEGER  X(5,3), Y(5,3), I, J
Y = 0
DO I=1,3                  ! I outer loop varies slowest
  DO J=1,5                ! J inner loop varies fastest
    X (J,I) = Y(J,I) + 1  ! Efficient column-major storage order
  END DO                  ! (leftmost subscript varies fastest)
END DO
.
.
.
END PROGRAM
```

Code written to access multidimensional arrays in row-major order (like C) or random order can often make inefficient use of the CPU memory cache. For more information on using natural storage order during record I/O operations, see Write Array Data in the Natural Storage Order.

- Use the available Fortran 95/90 array intrinsic procedures rather than creating your own.

  Whenever possible, use Fortran 95/90 array intrinsic procedures instead of creating your own routines to accomplish the same task. Fortran 95/90 array intrinsic procedures are designed for efficient use with the various Visual Fortran run-time components.

Using the standard-conforming array intrinsics can also make your program more portable.

- With multidimensional arrays where access to array elements will be noncontiguous, avoid left-most array dimensions that are a power of two (such as 256, 512). At higher levels of optimization (/optimize=3 or higher), the compiler pads certain power-of-two array sizes to minimize possible inefficient use of the cache.

  Because the *cache sizes* are a power of two, *array dimensions* that are also a power of two may make inefficient use of cache when array access is noncontiguous.

  One work-around is to increase the dimension to allow some unused elements, making the leftmost dimension larger than actually needed. For example, increasing the leftmost dimension of A from 512 to 520 would make better use of cache:

```
REAL A (512,100)
DO I = 2,511
  DO J = 2,99
    A(I,J)=(A(I+1,J-1) + A(I-1, J+1)) * 0.5
  END DO
END DO
```

  In this code, array A has a leftmost dimension of 512, a power of two. The innermost loop accesses the rightmost dimension (row major), causing inefficient access. Increasing the leftmost dimension of A to 520 (REAL A (520,100)) allows the loop to provide better performance, but at the expense of some unused elements.

  Because loop index variables I and J are used in the calculation, changing the nesting order of the **DO** loops changes the results.

- To minimize data storage and memory cache misses with arrays, use 32-bit data rather than 64-bit data, unless you require the greater range and precision of double precision floating-point numbers or the numeric range of 8-byte integers.

For more information:

On arrays and their data declaration statements, see Arrays.

Passing Array Arguments Efficiently

In Fortran 95/90, there are two general types of array arguments:

- Explicit-shape arrays were used with FORTRAN 77. These arrays have a fixed rank and extent that is known at compile time. Other dummy argument (receiving) arrays that are not deferred-shape (such as assumed-size arrays) can be grouped with explicit-shape array arguments in the following discussion.
- Deferred-shape arrays were introduced with Fortran 90. Types of deferred-shape arrays include array pointers and allocatable arrays. Assumed-shape array arguments generally follow the rules about passing deferred-shape array arguments.

When passing arrays as arguments, either the starting (base) address of the array or the address of an array descriptor is passed:

- When using explicit-shape (or assumed-size) arrays to receive an array, the starting address of the array is passed.
- When using deferred-shape or assumed-shape arrays to receive an array, the address of the array descriptor is passed (the compiler creates the array descriptor).

Passing an assumed-shape array or array pointer to an explicit-shape array can slow run-time performance, since the compiler needs to create an array temporary for the entire array. The array temporary is created because the passed array may not be contiguous and the receiving (explicit-shape) array requires a contiguous array. When an array temporary is created, the size of the passed array determines whether the impact on slowing run-time performance is slight or severe.

The following table summarizes what happens with the various combinations of array types. The amount of run-time performance inefficiency depends on the size of the array.

	Output Argument Array Types	
Input Argument Array Types	**Explicit-Shape Arrays**	**Deferred-Shape and Assumed-Shape Arrays**
Explicit-Shape Arrays	Very efficient. Does not use an array temporary. Does not pass an array descriptor. Interface block optional.	Efficient. Only allowed for assumed-shape arrays (not deferred-shape arrays). Does not use an array temporary. Passes an array descriptor. Requires an interface block.

Deferred-Shape and Assumed-Shape Arrays	When passing an allocatable array, very efficient. Does not use an array temporary. Does not pass an array descriptor. Interface block optional. When not passing an allocatable array, not efficient. Instead use allocatable arrays whenever possible. Uses an array temporary. Does not pass an array descriptor. Interface block optional.	Efficient. Requires an assumed-shape or array pointer as dummy argument. Does not use an array temporary. Passes an array descriptor. Requires an interface block.

Improve Overall I/O Performance

Improving overall I/O performance can minimize both device I/O and actual CPU time. The techniques listed in this section can greatly improve performance in many applications.

A *bottleneck* limits the maximum speed of execution by being the slowest process in an executing program. In some programs, I/O is the bottleneck that prevents an improvement in run-time performance. The key to relieving I/O bottlenecks is to reduce the actual amount of CPU and I/O device time involved in I/O. Bottlenecks may be caused by one or more of the following:

- A dramatic reduction in CPU time without a corresponding improvement in I/O time results in an I/O bottleneck.
- By such coding practices as:
  - Unnecessary formatting of data and other CPU-intensive processing
  - Unnecessary transfers of intermediate results
  - Inefficient transfers of small amounts of data
  - Application requirements

Improved coding practices can minimize actual device I/O, as well as the actual CPU time.

You can also consider solutions to system-wide problems like minimizing device I/O delays.

The following sections discuss I/O performance considerations in more detail:

- Use Unformatted Files Instead of Formatted Files
- Write Whole Arrays or Strings
- Write Array Data in the Natural Storage Order

- Use Memory for Intermediate Results
- Enable Implied-DO Loop Collapsing
- Use of Variable Format Expressions
- Efficient Use of Record Buffers and Disk I/O
- Specify RECL
- Use the Optimal Record Type

Use Unformatted Files Instead of Formatted Files

Use unformatted files whenever possible. Unformatted I/O of numeric data is more efficient and more precise than formatted I/O. Native unformatted data does not need to be modified when transferred and will take up less space on an external file.

Conversely, when writing data to formatted files, formatted data must be converted to character strings for output, less data can transfer in a single operation, and formatted data may lose precision if read back into binary form.

To write the array *A(25,25)* in the following statements, S_1 is more efficient than S_2:

```
S1          WRITE (7) A

S2          WRITE (7,100) A
      100   FORMAT (25(' ',25F5.21))
```

Although formatted data files are more easily ported to other systems, Visual Fortran can convert unformatted data in several formats (see Converting Unformatted Numeric Data).

Write Whole Arrays or Strings

The general guidelines about array use discussed in Use Arrays Efficiently also apply to reading or writing an array with an I/O statement.

To eliminate unnecessary overhead, write whole arrays or strings at one time rather than individual elements at multiple times. Each item in an I/O list generates its own calling sequence. This processing overhead becomes most significant in implied-DO loops. When accessing whole arrays, use the array name (Fortran 95/90 array syntax) instead of using implied-DO loops.

Write Array Data in the Natural Storage Order

Use the *natural* ascending storage order whenever possible. This is column-major order, with the leftmost subscript varying fastest and striding by 1 (see Use Arrays Efficiently). If a program must read or write data in any other order, efficient block moves are inhibited.

If the whole array is not being written, natural storage order is the best order possible.

If you must use an *unnatural* storage order, in certain cases it might be more efficient to transfer the data to memory and reorder the data before performing the I/O operation.

Use Memory for Intermediate Results

Performance can improve by storing intermediate results in memory rather than storing them in a file on a peripheral device. One situation that may not benefit from using intermediate storage is when there is a disproportionately large amount of data in relation to physical memory on your system. Excessive page faults can dramatically impede virtual memory performance.

Enable Implied-DO Loop Collapsing

DO loop collapsing reduces a major overhead in I/O processing. Normally, each element in an I/O list generates a separate call to the Compaq Fortran RTL. The processing overhead of these calls can be most significant in implied-DO loops.

Compaq Fortran reduces the number of calls in implied-DO loops by replacing up to seven nested implied-DO loops with a single call to an optimized run-time library I/O routine. The routine can transmit many I/O elements at once.

Loop collapsing can occur in formatted and unformatted I/O, but only if certain conditions are met:

- The control variable must be an integer. The control variable cannot be a dummy argument or contained in an **EQUIVALENCE** or **VOLATILE** statement. Compaq Fortran must be able to determine that the control variable does not change unexpectedly at run time.
- The format must not contain a variable format expression.

For more information:

- See the VOLATILE attribute and statement.
- On loop optimizations, see Optimization Levels: the /optimize:*num* Option.

Use of Variable Format Expressions

Variable format expressions (a Compaq Fortran extension) is a numeric expression enclosed in angle brackets (< >) that can be used in a **FORMAT** statement. Variable format expressions (VFEs) are almost as flexible as run-time formatting, but they are more efficient because the compiler can eliminate run-time parsing of the I/O format. Only a small amount of processing and the actual data transfer are required during run time.

On the other hand, run-time formatting can impair performance significantly. For example, in the following statements, S_1 is more efficient than S_2 because the formatting is done once at compile time, not at run time:

```
S1        WRITE (6,400) (A(I), I=1,N)
    400   FORMAT (1X, <N> F5.2)
                     .
                     .
                     .
S2        WRITE (CHFMT,500) '(1X,',N,'F5.2)'
    500   FORMAT (A,I3,A)
          WRITE (6,FMT=CHFMT) (A(I), I=1,N)
```

Efficient Use of Record Buffers and Disk I/O

Records being read or written are transferred between the user's program buffers and one or more disk block I/O buffers, which are established when the file is opened by the Compaq Fortran run-time system. Unless very large records are being read or written, multiple logical records can reside in the disk block I/O buffer when it is written to disk or read from disk, minimizing physical disk I/O.

You can specify the size of the disk block I/O buffer by using the OPEN Statement BLOCKSIZE specifier. If you omit the BLOCKSIZE specifier in the **OPEN** statement, it is set for optimal I/O use with the type of device the file resides on.

The default for BUFFERCOUNT is 1. Any experiments to improve I/O performance should increase the BUFFERCOUNT value and not the BLOCKSIZE value, to increase the amount of data read by each disk I/O.

If the OPEN statement includes the BUFFERCOUNT and BLOCKSIZE specifiers, their product is the size in bytes of the internal buffer. If these are not specified, the default size is 1024 bytes if /fpscomp:general (or /fpscomp:all) was specified and 8192 bytes if it was omitted. This internal buffer will grow to hold the largest single record but will never shrink.

For disk writes, the **OPEN** statement BUFFERED specifier, the /assume:buffered_io option, or the FORT_BUFFERED run-time environment variable lets you control whether records written are written (flushed) to disk as each record is written (default) or accumulated in the buffer.

Unless you set the FORT_BUFFERED environment variable to TRUE, the default is BUFFERED='NO' and /assume:nobuffered_io for all I/O, in which case, the

Fortran run-time system empties its internal buffer for each **WRITE** (or similar record output statement).

If you specify BUFFERED='YES', specify /assume:buffered_io, or at run-time set the FORT_BUFFERED environment variable to TRUE, for disk devices the internal buffer will be filled, possibly by many record output statements (**WRITE**), before it is written to disk.

The **OPEN** statement BUFFERED specifier takes precedence over the /assume:[no]buffered_io option. If neither are set (default), the FORT_BUFFERED environment variable is tested at run-time.

The **OPEN** statement BUFFERED specifier applies to a specific logical unit. In contrast, the /assume:[no]buffered_io option and the FORT_BUFFERED environment variable apply to all Fortran units.

Using buffered writes usually makes disk I/O more efficient by writing larger blocks of data to the disk less often. However, a system failure when using buffered writes can cause records to be lost, since they might *not* yet have been written to disk (such records would have written to disk with the default unbuffered writes).

Specify RECL

The sum of the record length (RECL specifier in an OPEN statement) and its overhead is a multiple or divisor of the blocksize, which is device specific. For example, if the BLOCKSIZE is 8192 then RECL might be 24576 (a multiple of 3) or 1024 (a divisor of 8).

The RECL value should fill blocks as close to capacity as possible (but not over capacity). Such values allow efficient moves, with each operation moving as much data as possible; the least amount of space in the block is wasted. Avoid using values larger than the block capacity, because they create very inefficient moves for the excess data only slightly filling a block (allocating extra memory for the buffer and writing partial blocks are inefficient).

The RECL value unit for formatted files is always 1-byte units. For unformatted files, the RECL unit is 4-byte units, unless you specify the /assume:byterecl option to request 1-byte units.

When porting unformatted data files from non-Compaq systems, see Converting Unformatted Numeric Data.

Use the Optimal Record Type

Unless a certain record type is needed for portability reasons, choose the most efficient type, as follows:

- For sequential files of a consistent record size, the fixed-length record type gives the best performance.
- For sequential unformatted files when records are not fixed in size, the variable-length record type gives the best performance, particularly for **BACKSPACE** operations.
- For sequential formatted files when records are not fixed in size, the Stream_LF record type gives the best performance.

For more information:

- On **OPEN** statement specifiers and defaults, see OPEN Statement and OPEN.
- On Visual Fortran data files, see Devices and Files.

Additional Source Code Guidelines for Run-Time Efficiency

In addition to data alignment and the efficient use of arrays and I/O, other source coding guidelines can be implemented to improve run-time performance.

The amount of improvement in run-time performance is related to the number of times a statement is executed. For example, improving an arithmetic expression executed within a loop many times has the potential to improve performance, more than improving a similar expression executed once outside a loop.

Suggested guidelines for improving source code efficiency are provided in the following sections:

- Avoid Small Integer and Small Logical Data Items (ia64 only)
- Avoid Mixed Data Type Arithmetic Expressions
- Use Efficient Data Types
- Avoid Using Slow Arithmetic Operators
- Avoid EQUIVALENCE Statement Use
- Use Statement Functions and Internal Subprograms
- Code DO Loops for Efficiency

Avoid Small Integer and Small Logical Data Items (ia64 only)

To minimize data storage and memory cache misses with arrays, use 32-bit data rather than 64-bit data, unless you require the greater range and precision of double precision floating-point numbers or the numeric range of 8-byte integers.

On ia64 systems, avoid using integer or logical data less than 32 bits (KIND=4).

Accessing a 16-bit (KIND=2) or 8-bit (KIND=1) data type can result in a sequence of machine instructions to access the data, rather than a single, efficient machine instruction for a 32-bit data item.

Avoid Mixed Data Type Arithmetic Expressions

Avoid mixing integer and floating-point (REAL) data in the same computation. Expressing all numbers in a floating-point arithmetic expression (assignment statement) as floating-point values eliminates the need to convert data between fixed and floating-point formats. Expressing all numbers in an integer arithmetic expression as integer values also achieves this. This improves run-time performance.

For example, assuming that I and J are both INTEGER variables, expressing a constant number (2.) as an integer value (2) eliminates the need to convert the data:

Original Code:

```
INTEGER I, J
I= J / 2.
```

Efficient Code:

```
INTEGER I, J
I= J / 2
```

For applications with numerous floating-point operations, consider using the /assume: accuracy_sensitive option (see Arithmetic Reordering Optimizations) if a small difference in the result is acceptable.

You can use different *sizes* of the same general data type in an expression with minimal or no effect on run-time performance. For example, using REAL, DOUBLE PRECISION, and COMPLEX floating-point numbers in the same floating-point arithmetic expression has minimal or no effect on run-time performance.

Use Efficient Data Types

In cases where more than one data type can be used for a variable, consider selecting the data types based on the following hierarchy, listed from most to least efficient:

- On ia32 systems:
  - Integer of four bytes, expressed as **INTEGER**(4) or **INTEGER***4
  - Single-precision real, expressed explicitly as **REAL**, **REAL**(KIND=4), or **REAL***4
  - Double-precision real, expressed explicitly as **DOUBLE PRECISION**, **REAL**(KIND=8), or **REAL***8
  - Integer of eight bytes, expressed as **INTEGER**(8) or **INTEGER***8
- On ia64 systems:

- Integer of four or eight bytes (also see Avoid Small Integer and Small Logical Data Items (ia64 only))
- Single-precision real, expressed explicitly as **REAL**, **REAL**(KIND=4), or **REAL***4
- Double-precision real, expressed explicitly as **DOUBLE PRECISION**, **REAL**(KIND=8), or **REAL***8

However, keep in mind that in an arithmetic expression, you should avoid mixing integer and floating-point (**REAL**) data (see Avoid Mixed Data Type Arithmetic Expressions).

Avoid Using Slow Arithmetic Operators

Before you modify source code to avoid slow arithmetic operators, be aware that optimizations convert many slow arithmetic operators to faster arithmetic operators. For example, the compiler optimizes the expression H=J**2 to be H=J*J.

Consider also whether replacing a slow arithmetic operator with a faster arithmetic operator will change the accuracy of the results or impact the maintainability (readability) of the source code.

Replacing slow arithmetic operators with faster ones should be reserved for critical code areas. The following hierarchy lists the Compaq Fortran arithmetic operators, from fastest to slowest:

- Addition (+), subtraction (-), and floating-point multiplication (*)
- Integer multiplication (*)
- Division (/)
- Exponentiation (**)

Avoid EQUIVALENCE Statement Use

Avoid using **EQUIVALENCE** statements; they can:

- Force unaligned data or cause data to span natural boundaries.
- Prevent certain optimizations, including:
  - Global data analysis under certain conditions (see Global Optimizations)
  - Implied-DO loop collapsing when the control variable is contained in an **EQUIVALENCE** statement

Use Statement Functions and Internal Subprograms

Whenever the Visual Fortran compiler has access to the use and definition of a subprogram during compilation, it may choose to inline the subprogram. Using statement functions and internal subprograms maximizes the number of subprogram references that will be inlined, especially when multiple source files are compiled together at optimization level /optimize:4 or /optimize:5 (or an appropriate /inline keyword was specified).

For more information, see Compile With Appropriate Options and Multiple Source Files.

Code DO Loops for Efficiency

Minimize the arithmetic operations and other operations in a **DO** loop whenever possible. Moving unnecessary operations outside the loop will improve performance (for example, when the intermediate nonvarying values within the loop are not needed).

For more information:

- On loop optimizations, see Loop Transformations, and Controlling Loop Unrolling, and Software Pipelining (ia64 only).
- On the **DO** statement, see DO in the A-Z Summary in the *Language Reference*

Optimization Levels: the /optimize Option

Visual Fortran performs many optimizations by default. You do not have to recode your program to use them. However, understanding how optimizations work helps you remove any inhibitors to their successful function.

If an operation can be performed, eliminated, or simplified at compile time, Visual Fortran does so, rather than have it done at run time. The time required to compile the program usually increases as more optimizations occur.

The program will likely execute faster when compiled at /optimize:4, but will require more compilation time than if you compile the program at a lower level of optimization.

The size of object files varies with the optimizations requested. Factors that can increase object file size include an increase of loop unrolling or procedure inlining.

The following table lists the levels of Visual Fortran optimization with different /optimize:*num* options (for example, /optimize:0 specifies no selectable optimizations); some optimizations always occur. All levels of optimizations available on the architecture can be specified using /optimize:5. On ia32 systems, /optimize:5 includes loop transformations; on ia64 systems, /optimize:5 includes loop transformations and software pipelining.

Levels of Optimization with Different /optimize:*num* Options

Optimization Type	/optimize:0	/optimize:1	/optimize:2	/optimize:3	/optimize:4
Software pipelining					
Loop transformation					
Automatic inlining					x
Additional global optimizations				x	x
Global optimizations			x	x	x
Local (minimal) optimizations		x	x	x	x

The default for the command line and in the visual development environment for a release configuration is /optimize:4. In the visual development environment for a debug configuration, the default is /optimize:0. However, when /debug is specified, the default is /optimize:0 (no optimizations).

In the table, the following terms are used to describe the levels of optimization (described in detail in the following sections:

- *Local (minimal) optimizations* (/optimize:1) or higher occur within the source program unit and include recognition of common subexpressions and the expansion of multiplication and division.
- *Global optimizations* (/optimize:2) or higher include such optimizations as data-flow analysis, code motion, strength reduction, split-lifetime analysis, and instruction scheduling.
- *Additional global optimizations* (/optimize:3) or higher improve speed at the cost of extra code size. These optimizations include loop unrolling, code replication to eliminate branches, and padding certain power-of-two array sizes for more efficient cache use.
- *Automatic inlining* (/optimize:4) or higher applies interprocedure analysis and inline expansion of small procedures, usually by using heuristics that limit extra code size.

- *Loop transformation and software pipelining* (/optimize:5), include a group of loop transformation optimizations and, on ia64 systems, also include the software pipelining optimization. The loop transformation optimizations apply to array references within loops and can apply to multiple nested loops. Loop transformation optimizations can improve the performance of the memory system.

  On ia64 systems, software pipelining applies instruction scheduling to certain innermost loops, allowing instructions within a loop to "wrap around" and execute in a different iteration of the loop. This can reduce the impact of long-latency operations, resulting in faster loop execution. Software pipelining also enables the prefetching of data to reduce the impact of cache misses.

The following sections discuss I/O performance considerations in more detail:

- Optimizations Performed at All Optimization Levels
- Local (Minimal) Optimizations
- Global Optimizations
- Additional Global Optimizations
- Automatic Inlining
- Loop Transformation and Software Pipelining

Optimizations Performed at All Optimization Levels

The following optimizations occur at any optimization level (/optimize:0 through /optimize:5):

- Space optimizations

  Space optimizations decrease the size of the object or executing program by eliminating unnecessary use of memory, thereby improving speed of execution and system throughput. Visual Fortran space optimizations are as follows:

  - Constant Pooling

    Only one copy of a given constant value is ever allocated memory space. If that constant value is used in several places in the program, all references point to that value.

  - Dead Code Elimination

    If operations will never execute or if data items will never be used, Visual Fortran eliminates them. Dead code includes unreachable code and code that becomes unused as a result of other optimizations, such as value propagation.

- Inlining arithmetic statement functions and intrinsic procedures

  Regardless of the optimization level, Visual Fortran inserts arithmetic statement functions directly into a program instead of calling them as functions. This permits other optimizations of the inlined code and eliminates several operations, such as calls and returns or stores and fetches of the actual arguments. For example:

  ```
  SUM(A,B) = A+B
      .
      .
      .
  Y = 3.14
  X = SUM(Y,3.0)   ! With value propagation, becomes: X = 6.14
  ```

  Many intrinsic procedures are automatically inlined.

  Inlining of other subprograms, such as contained subprograms, occurs at optimization level /optimize:4 or /optimize:5 (or when you specify appropriate /inline keywords at /optimize:1 or higher).

- Implied-DO loop collapsing

  DO loop collapsing reduces a major overhead in I/O processing. Normally, each element in an I/O list generates a separate call to the Visual Fortran RTL. The processing overhead of these calls can be most significant in implied-DO loops.

  If Visual Fortran can determine that the format will not change during program execution, it replaces the series of calls in up to seven nested implied-DO loops with a single call to an optimized RTL routine (see Enable Implied-Do Loop Collapsing). The optimized RTL routine can transfer many elements in one operation.

  Visual Fortran collapses implied-DO loops in formatted and unformatted I/O operations, but it is more important with unformatted I/O, where the cost of transmitting the elements is a higher fraction of the total cost.

- Array temporary elimination and **FORALL** statements

  Certain array store operations are optimized. For example, to minimize the creation of array temporaries, Visual Fortran can detect when no overlap occurs between the two sides of an array assignment. This type of optimization occurs for some assignment statements in FORALL constructs.

  Certain array operations are also candidates for loop unrolling optimizations (see Loop Unrolling).

Local (Minimal) Optimizations

To enable local optimizations, use /optimize:1 or a higher optimization level /optimize:2, /optimize:3, /optimize:4, or /optimize:5.

To prevent local optimizations, specify the /optimize:0 option.

The following sections discuss the local optimizations:

- Common Subexpression Elimination
- Integer Multiplication and Division Expansion
- Compile-Time Operations
- Value Propagation
- Dead Store Elimination
- Register Usage
- Mixed Real/Complex Operations

Common Subexpression Elimination

If the same subexpressions appear in more than one computation and the values do not change between computations, Visual Fortran computes the result once and replaces the subexpressions with the result itself:

```
DIMENSION A(25,25), B(25,25)
A(I,J) = B(I,J)
```

Without optimization, these statements can be coded as follows:

```
t1 = ((J-1)*25+(I-1))*4
t2 = ((J-1)*25+(I-1))*4
A(t1) = B(t2)
```

Variables t1 and t2 represent equivalent expressions. Visual Fortran eliminates this redundancy by producing the following:

```
t = ((J-1)*25+(I-1))*4
A(t) = B(t)
```

Integer Multiplication and Division Expansion

Expansion of multiplication and division refers to bit shifts that allow faster multiplication and division while producing the same result. For example, the integer expression (I*17) can be calculated as I with a 4-bit shift plus the original value of I. This can be expressed using the Compaq Fortran ISHFT intrinsic function:

```
J1 = I*17
J2 = ISHFT(I,4) + I     ! equivalent expression for I*17
```

The optimizer uses machine code that, like the **ISHFT** intrinsic function, shifts bits to expand multiplication and division by literals.

Compile-Time Operations

Visual Fortran does as many operations as possible at compile time rather than having them done at run time.

Constant Operations

Visual Fortran can perform many operations on constants (including **PARAMETER** constants):

- Constants preceded by a unary minus sign are negated.
- Expressions involving +, -, *, or / operators are evaluated; for example:

  ```
  PARAMETER (NN=27)
  I = 2*NN+J            ! Becomes: I = 54 + J
  ```

  Evaluation of some constant functions and operators is performed at compile time. This includes certain functions of constants, concatenation of string constants, and logical and relational operations involving constants.

- Lower-ranked constants are converted to the data type of the higher-ranked operand:

  ```
  REAL X, Y
  X = 10 * Y           ! Becomes: X = 10.0 * Y
  ```

- Array address calculations involving constant subscripts are simplified at compile time whenever possible:

  ```
  INTEGER I(10,10)
  I(1,2) = I(4,5)      ! Compiled as a direct load and store
  ```

Algebraic Reassociation Optimizations

Visual Fortran delays operations to see whether they have no effect or can be transformed to have no effect. If they have no effect, these operations are removed. A typical example involves unary minus and .NOT. operations:

```
X = -Y * -Z           ! Becomes: Y * Z
```

Value Propagation

Visual Fortran tracks the values assigned to variables and constants, including those from **DATA** statements, and traces them to every place they are used. Visual Fortran uses the value itself when it is more efficient to do so.

When compiling subprograms, Visual Fortran analyzes the program to ensure that propagation is safe if the subroutine is called more than once.

Value propagation frequently leads to more value propagation. Visual Fortran can eliminate run-time operations, comparisons and branches, and whole statements.

In the following example, constants are propagated, eliminating multiple operations from run time:

Original Code

```
    PI = 3.14
    .
    .
    .
    PIOVER2 = PI/2
    .
    .
    .
    I = 100
    .
    .
    .
    IF (I.GT.1) GOTO 10

10  A(I) = 3.0*Q
```

Optimized Code

```
    .
    .
    .
    PIOVER2 = 1.57
    .
    .
    .
    I = 100
    .
    .
    .
10  A(100) = 3.0*Q
```

Dead Store Elimination

If a variable is assigned but never used, Visual Fortran eliminates the entire assignment statement:

```
X = Y*Z
  .
  .
  .      !If X is not used in between,  X=Y*Z is eliminated.

X = A(I,J)* PI
```

Some programs used for performance analysis often contain such unnecessary operations. When you try to measure the performance of such programs compiled with Visual Fortran, these programs may show unrealistically good performance results. Realistic results are possible only with program units using their results in output statements.

Register Usage

A large program usually has more data that would benefit from being held in registers than there are registers to hold the data. In such cases, Visual Fortran typically tries to use the registers according to the following descending priority list:

1. For temporary operation results, including array indexes
2. For variables
3. For addresses of arrays (base address)
4. All other usages

Visual Fortran uses heuristic algorithms and a modest amount of computation to attempt to determine an effective usage for the registers.

Holding Variables in Registers

Because operations using registers are much faster than using memory, Visual Fortran generates code that uses the integer and floating-point registers instead of memory locations. Knowing when Visual Fortran uses registers may be helpful when doing certain forms of debugging.

Visual Fortran uses registers to hold the values of variables whenever the Fortran language does not require them to be held in memory, such as holding the values of temporary results of subexpressions, even if /optimize:0 (no optimization) was specified.

Visual Fortran may hold the same variable in different registers at different points in the program:

```
V = 3.0*Q
  .
  .
  .
X = SIN(Y)*V
  .
  .
  .
V = PI*X
  .
  .
  .
Y = COS(Y)*V
```

Visual Fortran may choose one register to hold the first use of *V* and another register to hold the second. Both registers can be used for other purposes at points in between. There may be times when the value of the variable does not exist anywhere in the registers. If the value of *V* is never needed in memory, it might not ever be assigned.

Visual Fortran uses registers to hold the values of I, J, and K (so long as there are no other optimization effects, such as loops involving the variables):

```
A(I) = B(J) + C(K)
```

More typically, an expression uses the same index variable:

```
A(K) = B(K) + C(K)
```

In this case, K is loaded into only one register, which is used to index all three arrays at the same time.

Mixed Real/Complex Operations

In mixed REAL/COMPLEX operations, Visual Fortran avoids the conversion and performs a simplified operation on:

- Add (+), subtract (-), and multiply (*) operations if either operand is REAL
- Divide (/) operations if the divisor is REAL

For example, if variable R is REAL and A and B are COMPLEX, no conversion occurs with the following:

```
COMPLEX A, B
   .
   .
   .
B = A + R
```

Global Optimizations

To enable global optimizations, use /optimize:2 or a higher optimization level. Using /optimize:2 or higher also enables local optimizations (/optimize:1).

Global optimizations include:

- Data-flow analysis
- Split lifetime analysis
- Strength reduction (replaces a CPU-intensive calculation with one that uses fewer CPU cycles)
- Code motion (also called code hoisting)
- Instruction scheduling

Data-flow and split lifetime analysis (global data analysis) traces the values of variables and whole arrays as they are created and used in different parts of a program unit. During this analysis, Visual Fortran assumes that any pair of array references to a given array might access the same memory location, unless constant subscripts are used in both cases.

To eliminate unnecessary recomputations of invariant expressions in loops, Visual Fortran hoists them out of the loops so they execute only once.

Global data analysis includes which data items are selected for analysis. Some data items are analyzed as a group and some are analyzed individually. Visual Fortran limits or may disqualify data items that participate in the following constructs, generally because it cannot fully trace their values.

Data items in the following declarations can make global optimizations less effective:

- VOLATILE declarations

  VOLATILE declarations are needed to use certain run-time features of the operating system. Declare a variable as **VOLATILE** if the variable can be accessed using rules in addition to those provided by the Fortran 95/90 language. Examples include:

  - **COMMON** data items or entire common blocks that can change value by means other than direct assignment or during a routine call. For such applications, you must declare the variable or the **COMMON** block to which it belongs as volatile.
  - An address not saved by the **%LOC** built-in function.
  - Variables read or written by a signal handler, including those in a common block or module.

  As requested by the **VOLATILE** statement, Visual Fortran disqualifies any volatile variables from global data analysis.

- Subroutine calls or external function references

  Visual Fortran cannot trace data flow in a called routine that is not part of the program unit being compiled, unless the same DF command compiled multiple program units (see Compile With Appropriate Options and Multiple Source Files). Arguments passed to a called routine that are used again in a calling program are assumed to be modified, unless the proper INTENT is specified in an interface block (the compiler must assume they are referenced by the called routine).

- Common blocks

  Visual Fortran limits optimizations on data items in common blocks. If common block data items are referenced inside called routines, their values might be altered. In the following example, variable I might be altered by FOO, so Visual Fortran cannot predict its value in subsequent references.

  ```
  COMMON /X/ I

  DO J=1,N
     I = J
  ```

```
      CALL FOO
      A(I) = I
   ENDDO
```

- Variables in Fortran 90 modules

  Visual Fortran limits optimizations on variables in Fortran 90 modules. Like common blocks, if the variables in Fortran 90 modules are referenced inside called routines, their values might be altered.

- Variables referenced by a %LOC built-in function or variables with the TARGET attribute

  Visual Fortran limits optimizations on variables indirectly referenced by a **%LOC** function or on variables with the **TARGET** attribute, because the called routine may dereference a pointer to such a variable.

- Equivalence groups

  An *equivalence group* is formed explicitly with the EQUIVALENCE statement or implicitly by the COMMON statement. A program section is a particular common block or local data area for a particular routine. Visual Fortran combines equivalence groups within the same program section and in the same program unit.

  The equivalence groups in separate program sections are analyzed separately, but the data items within each group are not, so some optimizations are limited to the data within each group.

Additional Global Optimizations

To enable additional global optimizations, use /optimize:3 or a higher optimization level. Using /optimize:3 or higher also enables local optimizations (/optimize:1) and global optimizations (/optimize:2).

Additional global optimizations improve speed at the cost of longer compile times and possibly extra code size. These optimizations include:

- Loop unrolling, including instruction scheduling (see Loop Unrolling)
- Code replication to eliminate branches (see Code Replication to Eliminate Branches)
- Padding the size of certain power-of-two arrays to allow more efficient cache use (see Use Arrays Efficiently)

Loop Unrolling

At optimization level /optimize:3 or above, Visual Fortran attempts to unroll certain innermost loops, minimizing the number of branches and grouping more instructions together to allow efficient overlapped instruction execution (instruction pipelining). The best candidates for loop unrolling are innermost loops with limited control flow.

As more loops are unrolled, the average size of basic blocks increases. Loop unrolling generates multiple copies of the code for the loop body (loop code iterations) in a manner that allows efficient instruction pipelining.

The loop body is replicated some number of times, substituting index expressions. An initialization loop might be created to align the first reference with the main series of loops. A remainder loop might be created for leftover work.

The number of times a loop is unrolled can be determined either by the optimizer or by using the /unroll option, which can specify the limit for loop unrolling. Unless the user specifies a value, the optimizer optimizer will choose an unroll amount that minimizes the overhead of prefetching while also limiting code size expansion.

Array operations are often represented as a nested series of loops when expanded into instructions. The innermost loop for the array operation is the best candidate for loop unrolling (like **DO** loops). For example, the following array operation (once optimized) is represented by nested loops, where the innermost loop is a candidate for loop unrolling:

```
A(1:100,2:30) = B(1:100,1:29) * 2.0
```

Code Replication to Eliminate Branches

In addition to loop unrolling and other optimizations, the number of branches are reduced by replicating code that will eliminate branches. Code replication decreases the number of basic blocks (a stream of instructions entered only at the beginning and exited only at the end) and increases instruction-scheduling opportunities.

Code replication normally occurs when a branch is at the end of a flow of control, such as a routine with multiple, short exit sequences. The code at the exit sequence gets replicated at the various places where a branch to it might occur.

For example, consider the following unoptimized routine and its optimized equivalent that uses code replication, where R0 (EAX on ia32 systems) is register 0:

Unoptimized Instructions	Optimized (Replicated) Instructions

<pre>   .
       .
       .
       branch to exit1
       .
       .
       .
       branch to exit1
       .
       .
       .
exit1: move 1 into R0
        return</pre>
	<pre>.
	.
	.
	move 1 into R0
	return
	.
	.
	.
	move 1 into R0
	return
	.
	.
	.
	move 1 into R0
	return</pre>

Similarly, code replication can also occur within a loop that contains a small amount of shared code at the bottom of a loop and a case-type dispatch within the loop. The loop-end test-and-branch code might be replicated at the end of each case to create efficient instruction pipelining within the code for each case.

Automatic Inlining

To enable optimizations that perform automatic inlining, use /optimize:4 (or /optimize:5). Using /optimize:4 also enables local optimizations (/optimize:1), global optimizations (/optimize:2), and additional global optimizations (/optimize:3).

To request inlining at lower optimization levels (/optimize:1, /optimize:2, or /optimize:3), use the /inline option.

The default is /optimize:4 (unless /debug is specified), except in the visual development environment for a debug configuration.

Interprocedure Analysis

Compiling multiple source files at optimization level /optimize:4 or higher lets the compiler examine more code for possible optimizations, including multiple program units. This results in:

- Inlining more procedures
- More complete global data analysis
- Reducing the number of external references to be resolved during linking

As more procedures are inlined, the size of the executable program and compile times may increase, but execution time should decrease.

Inlining Procedures

Inlining refers to replacing a subprogram reference (such as a **CALL** statement or function invocation) with the replicated code of the subprogram. As more procedures are inlined, global optimizations often become more effective.

The optimizer inlines small procedures, limiting inlining candidates based on such criteria as:

- Estimated size of code
- Number of call sites
- Use of constant arguments

You can specify:

- One of the /optimize options to control the optimization level. For example, specifying /optimize:4 or /optimize:5 enables interprocedure optimizations.

  Different /optimize options set different /inline:*keyword* options. For example, /optimize:4 sets /inline:speed.

- One of the /inline options to directly control the inlining of procedures (see Controlling the Inlining of Procedures). For example, /inline:speed inlines more procedures than /inline:size. Certain /inline keywords require /optimize:1 or higher.

Loop Transformation and Software Pipelining

A group of optimizations known as loop transformation optimizations and software pipelining with its associated additional software dependence analysis are enabled by using the /optimize:5 option. In certain cases, this improves run-time performance.

The loop transformation optimizations apply to array references within loops and can apply to multiple nested loops. These optimizations can improve the performance of the memory system.

On ia64 systems, software pipelining applies instruction scheduling to certain innermost loops, allowing instructions within a loop to "wrap around" and execute in a different iteration of the loop. This can reduce the impact of long-latency operations, resulting in faster loop execution.

Software pipelining also enables the prefetching of data to reduce the impact of cache misses.

For more information:

- On loop transformations, see Loop Transformations.
- On software pipelining, see Software Pipelining (ia64 only).

Loop Transformations

The loop transformation optimizations are enabled by using the /transform_loops option or the /optimize:5 option. Loop transformation attempts to improve performance by rewriting loops to make better use of the memory system. By rewriting loops, the loop transformation optimizations can increase the number of instructions executed, which can degrade the run-time performance of some programs.

To request loop transformation optimizations without software pipelining, do one of the following:

- Specify /optimize:5 with /nopipeline.
- Specify /transform_loops with /optimize:4, /optimize:3, or /optimize:2. This optimization is not performed at optimization levels below /optimize:2.

The loop transformation optimizations apply to array references within loops. These optimizations can improve the performance of the memory system and usually apply to multiple nested loops. The loops chosen for loop transformation optimizations are always *counted loops*. Counted loops are those loops that use a variable to count iterations in a manner that the number of iterations can be determined before entering the loop. For example, most DO loops are counted loops.

Conditions that typically prevent the loop transformation optimizations from occurring include subprogram references that are not inlined (such as an external function call), complicated exit conditions, and uncounted loops.

The types of optimizations associated with /transform_loops include the following:

- Loop blocking

  Can minimize memory system use with multidimensional array elements by completing as many operations as possible on array elements currently in the cache. Also known as loop tiling.

- Loop distribution

  Moves instructions from one loop into separate, new loops. This can reduce the amount of memory used during one loop so that the remaining memory may fit in the cache. It can also create improved opportunities for loop blocking.

- Loop fusion

  Combines instructions from two or more adjacent loops that use some of the same memory locations into a single loop. This can avoid the need to load those memory locations into the cache multiple times and improves opportunities for instruction scheduling.

- Loop interchange

  Changes the nesting order of some or all loops. This can minimize the stride of array element access during loop execution and reduce the number of memory accesses needed. Also known as loop permutation.

- Scalar replacement

  Replaces the use of an array element with a scalar variable under certain conditions.

- Outer loop unrolling

  Unrolls the outer loop inside the inner loop under certain conditions to minimize the number of instructions and memory accesses needed. This also improves opportunities for instruction scheduling and scalar replacement.

For more information:

On the interaction of compiler options and timing programs compiled with the loop transformation optimizations, see /[no]transform_loops.

Software Pipelining (ia64 only)

Software pipelining and additional software dependence analysis are enabled by using the /pipeline option or by the /optimize:5 option. Software pipelining in certain cases improves run-time performance.

The software pipelining optimization applies instruction scheduling to certain innermost loops, allowing instructions within a loop to "wrap around" and execute in a different iteration of the loop. This can reduce the impact of long-latency operations, resulting in faster loop execution.

Loop unrolling (enabled at /optimize:3 or above) *cannot* schedule across iterations of a loop. Because software pipelining *can* schedule across loop iterations, it can perform more efficient scheduling to eliminate instruction stalls within loops.

For instance, if software dependence analysis of data flow reveals that certain calculations can be done before or after that iteration of the loop, software pipelining reschedules those instructions ahead of or behind that loop iteration, at places where their execution can prevent instruction stalls or otherwise improve performance.

Software pipelining also enables the prefetching of data to reduce the impact of cache misses.

Software pipelining can be more effective when you combine /pipeline (or /optimize:5) with the appropriate /tune *keyword* for the target processor generation (see Requesting Optimized Code for a Specific Processor Generation).

To specify software pipelining without loop transformation optimizations, do one of the following:

- Specify /optimize:5 with /notransform_loops.
- Specify /pipeline with /optimize:4, /optimize:3, or /optimize:2. This optimization is not performed at optimization levels below /optimize:2.

For this version of Visual Fortran, loops chosen for software pipelining:

- Are always innermost loops (those executed the most).
- Do not contain branches or procedure calls.
- Do not use COMPLEX floating-point data.

By modifying the unrolled loop and inserting instructions as needed before and/or after the unrolled loop, software pipelining generally improves run-time performance, except where the loops contain a large number of instructions with many existing overlapped operations. In this case, software pipelining may not have enough registers available to effectively improve execution performance. Run-time performance using /optimize:5 (or /pipeline) may not improve performance, as compared to using /optimize:4.

For programs that contain loops that exhaust available registers, longer execution times may result with /optimize:5 or /pipeline. In cases where performance does not improve, consider compiling with the /unroll:1 option along with /optimize:5 or /pipeline, to possibly improve the effects of software pipelining.

For more information:

- On the interaction of command-line options and timing programs compiled with software pipelining, see /[no]pipeline.

Other Options Related to Optimization

In addition to the /optimize options (discussed in Optimization Levels: the /optimize Option), several other compiler options can prevent or facilitate improved optimizations, as discussed in the following sections:

- Options Set by the /fast Option
- Controlling Loop Unrolling
- Controlling the Inlining of Procedures
- Arithmetic Reordering Optimizations
- Dummy Aliasing Assumption
- Requesting Optimized Code for a Specific Processor Generation
- Requesting Code Generation for a Specific Processor Generation
- Loop Transformation
- Software Pipelining (ia64 only)

Options Set by the /fast Option

Specifying the /fast option sets the following options:

- /align:(dcommons,records,sequence) (see Data Alignment Considerations)
- /assume:noaccuracy_sensitive (see Arithmetic Reordering Optimizations)
- /architecture:host (see Requesting Code Generation for a Specific Processor Generation)
- /math_library:fast (see /math_library)
- /tune:host (see Requesting Optimized Code for a Specific Processor Generation)

Controlling Loop Unrolling

You can specify the number of times loops are unrolled by using the /unroll option. You can control the number of times a specific loop is unrolled by using the *c*DEC$ UNROLL Directive to Control Loop Unrolling.

Although unrolling loops usually improves run-time performance, the size of the executable program may increase.

On ia64 systems, the /unroll: *num* option can also influence the run-time results of software pipelining optimizations performed when you specify /optimize:5 or /pipeline.

For more information:

On loop unrolling, see Loop Unrolling.

Controlling the Inlining of Procedures

To specify the types of procedures to be inlined, use the /inline options. Also, compile multiple source files together and specify an adequate optimization level, such as /optimize:4.

If you omit /noinline and the /inline options, the optimization level /optimize option used determines the types of procedures that are inlined.

The /inline options are as follows:

- /inline:none (same as /noinline)

  Inlines statement functions but not other procedures. This type of inlining occurs if you specify /optimize:0 or /optimize:1 and omit /inline options.

- /inline:manual

  Inlines statement functions but not other procedures. This type of inlining occurs if you specify /optimize:2 or /optimize:3 and omit /inline options.

- /inline:size

  In addition to inlining statement functions, inlines any procedures that the Visual Fortran optimizer expects will improve run-time performance with no likely significant increase in program size.

- /inline:speed

  In addition to inlining statement functions, inlines any procedures that the Visual Fortran optimizer expects will improve run-time performance with a likely significant increase in program size. This type of inlining occurs if you specify /optimize:4 or /optimize:5 and omit /inline options.

- /inline:all

  Inlines every call that can possibly be inlined while generating correct code, including the following:

  - Statement functions (always inlined)
  - Any procedures that Visual Fortran expects will improve run-time performance with a likely significant increase in program size.
  - Any other procedures that can possibly be inlined and generate correct code. Certain recursive routines are not inlined to prevent

infinite expansion.

For information on the inlining of other procedures (inlined at optimization level /optimize:4 or higher), see Inlining Procedures.

Maximizing the types of procedures that are inlined usually improves run-time performance, but compile-time memory usage and the size of the executable program may increase.

To determine whether using /inline:all benefits your particular program, time program execution for the same program compiled with and without /inline:all.

Arithmetic Reordering Optimizations

If you use the /assume:noaccuracy_sensitive option, Compaq Visual Fortran may reorder code (based on algebraic identities) to improve performance. For example, the following expressions are mathematically equivalent but may not compute the same value using finite precision arithmetic:

```
X = (A + B) + C

X = A + (B + C)
```

The results can be slightly different from the default /assume:accuracy_sensitive because of the way intermediate results are rounded. However, the /assume:noaccuracy_sensitive results are not categorically less accurate than those gained by the default. In fact, dot-product summations using /assume:noaccuracy_sensitive can produce more accurate results than those using /assume:accuracy_sensitive.

The effect of /assume:noaccuracy_sensitive is important when Compaq Fortran hoists divide operations out of a loop. If /assume:noaccuracy_sensitive is in effect, the unoptimized loop becomes the optimized loop:

Unoptimized Code	**Optimized Code**

`DO I=1,N`
`.`
`.`
`.`
`B(I)= A(I)/V`
`END DO`
	`T= 1/V`
	`DO I=1,N`
	`.`
	`.`
	`.`
	`B(I)= A(I)*T`
	`END DO`

The transformation in the optimized loop increases performance significantly, and loses little or no accuracy. However, it does have the potential for raising overflow or underflow arithmetic exceptions.

Dummy Aliasing Assumption

Some programs compiled with Visual Fortran (or Compaq Fortran and Compaq Fortran 77 on other platforms) may have results that differ from the results of other Fortran compilers. Such programs may be aliasing dummy arguments to each other or to a variable in a common block or shared through use association, and at least one variable access is a store.

This program behavior is prohibited in programs conforming to the Fortran 90 standard, but not by Visual Fortran. Other versions of Fortran allow dummy aliases and check for them to ensure correct results. However, Visual Fortran assumes that no dummy aliasing will occur, and it can ignore potential data dependencies from this source in favor of faster execution.

The Visual Fortran default is safe for programs conforming to the Fortran 90 standard. It will improve performance of these programs because the standard prohibits such programs from passing overlapped variables or arrays as actual arguments if either is assigned in the execution of the program unit.

The /assume:dummy_aliases option allows dummy aliasing. It ensures correct results by assuming the exact order of the references to dummy and common variables is required. Program units taking advantage of this behavior can produce inaccurate results if compiled with /assume:nodummy_aliases.

The following example is taken from the DAXPY routine in the FORTRAN 77 version of the Basic Linear Algebra Subroutines (BLAS).

Using the /assume:dummy_aliases Option

```
      SUBROUTINE DAXPY(N,DA,DX,INCX,DY,INCY)

C     Constant times a vector plus a vector.
C     uses unrolled loops for increments equal to 1.

      DOUBLE PRECISION DX(1), DY(1), DA
      INTEGER I,INCX,INCY,IX,IY,M,MP1,N
C
      IF (N.LE.0) RETURN
      IF (DA.EQ.0.0) RETURN
      IF (INCX.EQ.1.AND.INCY.EQ.1) GOTO 20

C     Code for unequal increments or equal increments
C     not equal to 1.
      .
      .
      .
      RETURN
C     Code for both increments equal to 1.
C     Clean-up loop

20    M = MOD(N,4)
      IF (M.EQ.0) GOTO 40
```

```
      DO I=1,M
          DY(I) = DY(I) + DA*DX(I)
      END DO

      IF (N.LT.4) RETURN
40    MP1 = M + 1
      DO I = MP1, N, 4
          DY(I) = DY(I) + DA*DX(I)
          DY(I + 1) = DY(I + 1) + DA*DX(I + 1)
          DY(I + 2) = DY(I + 2) + DA*DX(I + 2)
          DY(I + 3) = DY(I + 3) + DA*DX(I + 3)
      END DO

      RETURN
      END SUBROUTINE
```

The second DO loop contains assignments to DY. If DY is overlapped with DA, any of the assignments to DY might give DA a new value, and this overlap would affect the results. If this overlap is desired, then DA must be fetched from memory each time it is referenced. The repetitious fetching of DA degrades performance.

Linking Routines with Opposite Settings

You can link routines compiled with the /assume:dummy_aliases option to routines compiled with /assume:nodummy_aliases. For example, if only one routine is called with dummy aliases, you can use /assume:dummy_aliases when compiling that routine, and compile all the other routines with /assume:nodummy_aliases to gain the performance value of that option.

Programs calling DAXPY with DA overlapping DY do not conform to the FORTRAN 77 and Fortran 90 standards. However, they are accommodated if /assume:dummy_aliases was used to compile the DAXPY routine.

Requesting Optimized Code for a Specific Processor Generation

You can specify the types of optimized code to be generated by using the /tune option. Tuning for a specific implementation can improve run-time performance; it is also possible that code tuned for a specific target may run slower on another target.

On ia32 systems, regardless of the specified *keyword* for /tune, the generated code will run correctly on all implementations of the ia32 architecture. Specifying the correct keyword for /tune for the target ia32 processor generation type usually slightly improves run-time performance.

The /tune keywords are described in /tune.

The combination of the specified keyword for /tune and the type of processor generation used has no effect on producing the expected correct program results. To request a specific set of instructions for an ia32 architecture generation, see the /architecture option.

Requesting Code Generation for a Specific Processor Generation

The /architecture (/arch) option determines the type of code that will be generated for this program. On an ia32 system, you can specify whether the code to be generated can be run:

- On Pentium 4 processor systems only, by generating code using the base set of Pentium instructions plus MMX, SSE, and SSE2 instruction extensions.
- On AMD Athlon processor systems only, by generating code using the base set of Pentium instructions plus MMX, SSE, 3DNow, and Enhanced 3DNow instruction extensions.
- On AMD K6_2, AMD K6_III, and AMD Athlon processor systems only, by generating code using the base set of Pentium instructions plus MMX, SSE, and 3DNow instruction extensions.
- On Intel Pentium III and Pentium 4 processor systems, and AMD K6_2, AMD K6_III, and AMD Athlon processor systems only, by generating code using the base set of Pentium instructions plus MMX and SSE instruction extensions.
- On Intel Pentium Pro, Pentium II, and higher Intel processor systems, and AMD K6 and higher AMD processor systems only, by generating code using the base set of Pentium instructions plus MMX instruction extensions.
- On Pentium (586) and higher Intel and AMD systems only, by generating code using the base set of Pentium instructions.
- On all ia32 Intel and AMD systems, by generating code using a generic blend of instructions that runs with moderate efficiency on all Intel and AMD systems.

You can also request that the type of generated code be determined by the host system being used to compile the application.

For an ia64 system, request either the type of host system being used for compilation or request generic blend of instructions.

The /arch:*keyword* option uses the same keywords as the /tune:*keyword* option.

For more information:

- See /architecture.

Compiler Directives Related to Performance

Certain compiler source directives (*c*DEC$ prefix) can be used in place of some performance-related compiler options and provide more control of certain optimizations, as discussed in the following sections:

- Using the cDEC$ OPTIONS Directive
- Using the cDEC$ UNROLL Directive to Control Loop Unrolling
- Using the cDEC$ IVDEP Directive to Control Certain Loop Optimizations

Using the *c*DEC$ OPTIONS Directive

The *c***DEC$ OPTIONS** directive allows source code control of the alignment of fields in record structures and data items in common blocks. The fields and data items can be naturally aligned (for performance reasons) or they can be packed together on arbitrary byte boundaries.

Using this directive is an alternative to the compiler option /[no]alignment, which affects the alignment of all fields in record structures and data items in common blocks in the current program unit.

For more information:

- See the OPTIONS Directive.

Using the *c*DEC$ UNROLL Directive to Control Loop Unrolling

The *c***DEC$ UNROLL** directive allows you to specify the number of times certain counted **DO** loops will be unrolled. Place the *c***DEC$ UNROLL** directive before the **DO** loop you want to control the unrolling of.

Using this directive for a specific loop overrides the value specified by the compiler option /unroll for that loop. The value specified by /unroll affects how many times all loops not controlled by their respective *c***DEC$ UNROLL** directives are unrolled.

For more information:

- See the UNROLL Directive.

Using the *c*DEC$ IVDEP Directive to Control Certain Loop Optimizations

The *c***DEC$ IVDEP** directive allows you to help control certain optimizations related to dependence analysis in a **DO** loop. Place the *c***DEC$ IVDEP** directive before the **DO** loop you want to help control the optimizations for. Not all **DO** loops should use this directive.

The *c***DEC$ IVDEP** directive tells the optimizer to begin dependence analysis by assuming all dependences occur in the same forward direction as their appearance in the normal scalar execution order. This contrasts with normal compiler behavior, which is for the dependence analysis to make no initial assumptions about the direction of a dependence.

For more information:

- See the IVDEP Directive.

Using QuickWin

This chapter introduces the major categories of QuickWin library routines. It gives an overview of QuickWin features and their use in creating and displaying graphics, and customizing your QuickWin applications with custom menus and mouse routines. Drawing Graphics Elements, and Using Fonts from the Graphics Library cover graphics and fonts in more detail.

The Visual Fortran QuickWin run-time library helps you turn graphics programs into simple Windows applications. Though the full capability of Windows is not available through QuickWin, QuickWin is simpler to learn and to use. QuickWin applications do support pixel-based graphics, real-coordinate graphics, text windows, character fonts, user-defined menus, mouse events, and editing (select/copy/paste) of text, graphics, or both.

In Visual Fortran, graphics programs must be either Fortran QuickWin, Fortran Standard Graphics, Fortran Windows, or use OpenGL routines. Fortran Standard Graphics Applications are a subset of QuickWin that support only one window.

You can choose the Fortran QuickWin or Standard Graphics application type from the drop-down list of available project types when you create a new project in the visual development environment. Or you can use the /libs:qwin compiler option for Fortran QuickWin or the /libs:qwins compiler option for Fortran Standard Graphics.

Note that Fortran QuickWin and Standard Graphics applications cannot be DLLs, and QuickWin and Standard Graphics cannot be linked with run-time routines that are in DLLs. This means that the /libs:qwin option and the /libs:dll with /threads options cannot be used together.

You can access the QuickWin routines library from Visual Fortran as well as other languages that support the Fortran calling conventions. The graphics package supports all video modes supported by Windows 2000, Windows NT 4, Windows Me, Windows 98, and Windows 95.

A program using the QuickWin routines must explicitly access the QuickWin graphics library routines with the statement **USE DFLIB** (see USE Statement Needed for Fortran QuickWin Applications).

This section includes the following topics:

- Capabilities of QuickWin
- Comparing QuickWin with Windows-Based Applications
- Using Win32 with QuickWin
- Types of QuickWin Programs

Capabilities of QuickWin

You can use the QuickWin library to do the following:

- Compile console programs into simple applications for Windows.
- Minimize and maximize QuickWin applications like any Windows-based application.
- Call graphics routines.
- Load and save bitmaps.
- Select, copy and paste text, graphics, or a mix of both.
- Detect and respond to mouse clicks.
- Display graphics output.
- Alter the default application menus or add programmable menus.
- Create custom icons.
- Open multiple child windows.

Comparing QuickWin with Windows-Based Applications

QuickWin does not provide the total capability of Windows. Although you can call many Win32 APIs (Application Programming Interface) from QuickWin and console programs, many other Win32 APIs (such as GDI functions) should be called only from a full Windows application. You need to use Windows-based applications, not QuickWin, if any of the following applies:

- Your application has an OLE (Object Linking and Embedding) container.
- You want direct access to GDI (Graphical Data Interface) functions.
- You want to add your own customized Help information to QuickWin Help.
- You want to create something other than a standard SDI (Single Document Interface) or MDI (Multiple Document Interface) application. (For example, if you want your application to have a dialog such as Windows' Calculator in the client area.)
- You want to use a modeless dialog box rather than a modal dialog box.

Using Win32 with QuickWin

You can convert the unit numbers of QuickWin windows to Win32 handles with the GETHWNDQQ QuickWin function. You should not use Windows GDI to draw on QuickWin windows because QuickWin keeps a window buffer and the altered window would be destroyed on redraw. You can use Windows subclassing to intercept graphics messages bound for QuickWin before QuickWin receives them.

See the sample program POKER in the Visual Fortran Samples `...\DF98\SAMPLES\QUICKWIN\POKER` folder for a demonstration of this technique.

Types of QuickWin Programs

You can creates a Fortran Standard Graphics application or a Fortran QuickWin application, depending on the project type you choose. Fortran Standard Graphics (QuickWin single document) applications support only one window and do not support programmable menus. Fortran QuickWin applications support multiple windows and user-defined menus. Any Fortran program, whether it contains graphics or not, can be compiled as a QuickWin application. You can use the Microsoft visual development environment to create, debug, and execute Fortran Standard Graphics programs and Fortran QuickWin programs.

To build a Fortran QuickWin application in the visual development environment, select Fortran Standard Graphics or Quickwin Application from the list of available project types displayed when you create a new project. In the dialog box, specify a Fortran Quickwin multiple-window project.

To build a Fortran Standard Graphics application in the visual development environment, select Fortran Standard Graphics or Quickwin Application from the list of available project types. In the dialog box, specify a Fortran Standard Graphics single-window project.

To build a Fortran QuickWin application from the command line, use the /libs:qwin option. For example:

```
DF /libs=qwin qw_app.f90
```

To build a Fortran Standard Graphics application from the command line, use the /libs:qwins option. For example:

```
DF /libs=qwins stdg_app.f90
```

For information about building projects in the visual development environment, see Building Programs and Libraries.

Some of the QuickWin project Visual Fortran Samples are in folders in ...DF98 \SAMPLES\QUICKWIN.

The following sections discuss the two types of QuickWin applications:

- Fortran Standard Graphics Application
- Fortran QuickWin Application

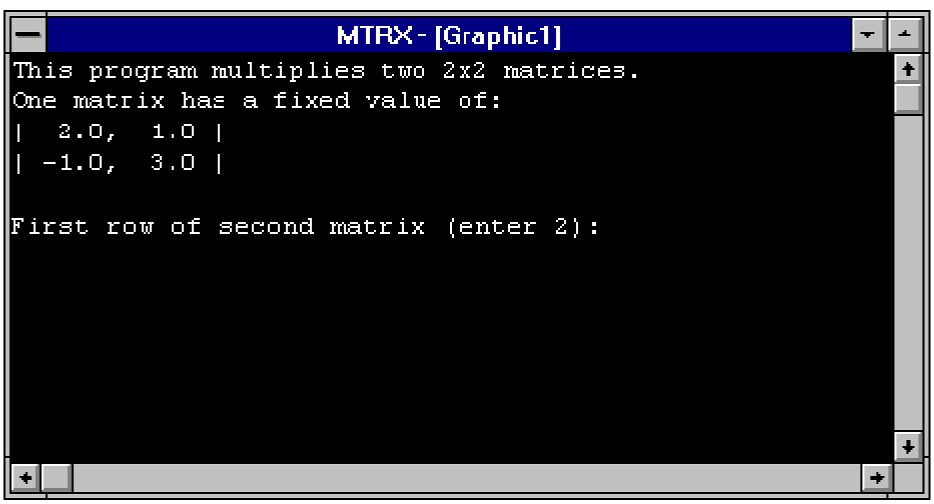
Fortran Standard Graphics Applications

A Fortran standard graphics application has a single maximized application window covering the entire screen area, whose appearance resembles a MS-DOS screen without scrolls bars or menus. The Esc key can be used to exit a program that does otherwise terminate. When the Esc key is pressed, the frame window appears with a border, title bar, scroll bars, and a menu item in the upper-left corner that allows you to close the application.

Programmable menus and multiple child windows cannot be created in this mode.

The following figure shows a typical Fortran Standard Graphics application, which resembles an MS-DOS application running in a window.

MTRX.F90 Compiled as a Fortran Standard Graphics Application

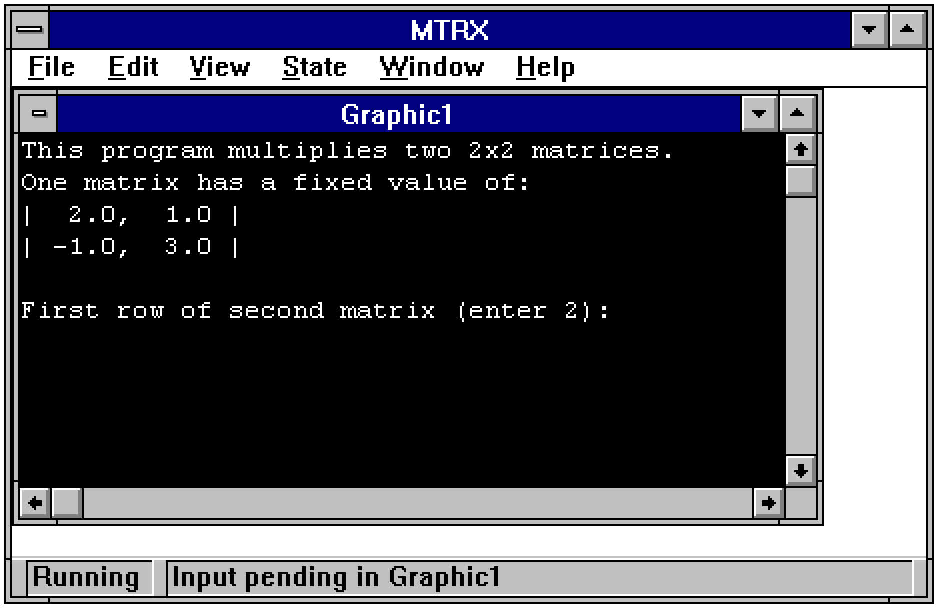


Fortran QuickWin Graphics Applications

The following shows a typical Fortran QuickWin application. The frame window has a border, title bar, scroll bars, and default menu bar. You can modify, add, or delete the default menu items, respond to mouse events, and create multiple child windows within the frame window using QuickWin enhanced features. Routines to create enhanced features are listed in Enhancing QuickWin

Applications. Using these routines to customize your QuickWin application is described in Customizing QuickWin Applications.

MTRX.FOR Compiled as a QuickWin Application



Some of the Fortran QuickWin applications provided as Samples include PLATFORM and POLYDRAW (see the respective folders in ...`\DF98\SAMPLES\ADVANCED\WIN32`).

The QuickWin User Interface

All QuickWin applications create an application or frame window; child windows are optional. Fortran Standard Graphics applications and Fortran QuickWin applications have these general characteristics:

- Window contents can be copied as bitmaps or text to the Clipboard for printing or pasting to other applications. In Fortran QuickWin applications, any portion of the window can be selected and copied.
- Vertical and horizontal scroll bars appear automatically, if needed.
- The base name of the application's .EXE file appears in the window's title bar.
- Closing the application window terminates the program.

In addition, the Fortran QuickWin application has a status bar and menu bar. The status bar at the bottom of the window reports the current status of the window program (for example, running or input pending).

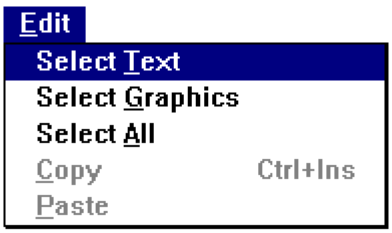
Default QuickWin Menus shows the default QuickWin menus.

Default QuickWin Menus

The default MDI (Multiple Document Interface) menu bar has six menus: File, Edit, View, State, Window, and Help.

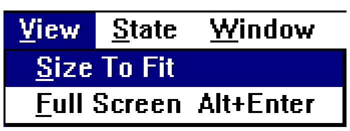
File Menu

Edit Menu



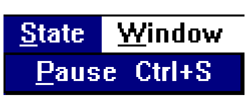
For instructions on using the Edit options within QuickWin see Editing Text and Graphics from the QuickWin Edit Menu.

View Menu

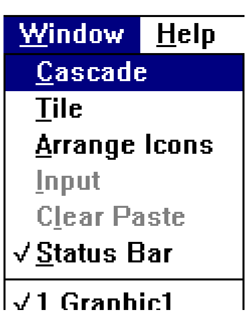


The resulting graphics might appear somewhat distorted whenever the logical graphics screen is enlarged or reduced with the Size to Fit and Full Screen commands. While in Full Screen or Size To Fit mode, cursors are not scaled.

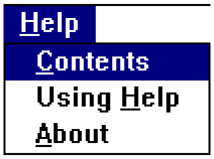
State Menu



Window Menu



Help Menu



For instructions on replacing the About default information within the Help menu with your own text message, see Defining an About Box.

For instructions on how to create custom QuickWin menus, see Customizing QuickWin Applications.

USE Statement Needed for Fortran QuickWin Applications

A program using the Fortran QuickWin or Standard Graphics features must explicitly access the QuickWin graphics library routines with the statement **USE DFLIB**.

Any program using the QuickWin features must include the statement **USE DFLIB** to access the QuickWin graphics library. The DFLIB.MOD module file contains subroutine and function declarations in **INTERFACE** statements, derived-type declarations, and symbolic constant declarations for each QuickWin routine.

Because **INTERFACE** statements must appear before the body of a program, the **USE DFLIB** statement must appear before the body of a program unit. This usually means putting **USE DFLIB** before any other statement (such as **IMPLICIT NONE** or **INTEGER**).

Depending on the type of routines used by your application, other **USE** statements that include other Visual Fortran modules may be needed in addition to **USE DFLIB**. The description of each Visual Fortran routine in the *Language Reference* (see A to Z Reference) indicates the module that needs to be included for external routines (such as **USE DFLIB**, **USE DFPORT**).

Creating QuickWin Windows

The QuickWin library contains many routines to create and control your QuickWin windows. These routines are discussed in the following topics:

- Accessing Window Properties
- Creating Child Windows

Accessing Window Properties

SETWINDOWCONFIG and GETWINDOWCONFIG set and get the current *virtual window* properties. Virtual window properties set by SETWINDOWCONFIG contain the maximum amount of text and graphics for that unit. The SETWSIZEQQ routine sets the properties of the *visible window*, which is generally smaller than a virtual window.

If the size of the virtual window (**SETWINDOWCONFIG**) is larger than the size of the visible window (**SETWSIZEQQ**), scroll bars are automatically provided to allow all the text and graphics in a virtual window to be displayed.

These virtual window properties are stored in the `windowconfig` derived type defined in DFLIB.MOD, which contains the following parameters:

```
TYPE windowconfig
   INTEGER(2) numxpixels           ! Number of pixels on x-axis.
   INTEGER(2) numypixels           ! Number of pixels on y-axis.
   INTEGER(2) numtextcols          ! Number of text columns available.
   INTEGER(2) numtextrows          ! Number of scrollable text lines available.
   INTEGER(2) numcolors            ! Number of color indexes.
   INTEGER(4) fontsize             ! Size of default font. Set to
                                   ! QWIN$EXTENDFONT when using multibyte
                                   ! characters, in which case
                                   ! extendfontsize sets the font size.
   CHARACTER(80) title             ! Window title, where title is a C string.
   INTEGER(2) bitsperpixel         ! Number of bits per pixel. This value
                                   ! is calculated by the system and is an
                                   ! output-only parameter.
                                   ! The next three parameters support multibyte
                                   ! character sets (such as Japanese)
   CHARACTER(32) extendfontname    ! Any non-proportionally spaced font
                                   ! available on the system.
   INTEGER(4) extendfontsize       ! Takes same values as fontsize, but
                                   ! used for multiple-byte character sets
                                   ! when fontsize set to QWIN$EXTENDFONT.
   INTEGER(4) extendfontattributes ! Font attributes such as bold and
                                   ! italic for multibyte character sets.
END TYPE windowconfig
```

If you use **SETWINDOWCONFIG** to set the variables in `windowconfig` to -1, the highest resolution will be set for your system, given the other fields you specify, if any. You can set the actual size of the window by specifying parameters that influence the window size -- the number of *x* and *y* pixels, the number of rows and columns, and the font size. If you do not call **SETWINDOWCONFIG**, the window defaults to the best possible resolution and a font size of 8 by 16. The number of colors depends on the video driver used.

The font size, x pixels, y pixels, and columns and rows are related and cannot all be set arbitrarily. The following example specifies the number of *x* and *y* pixels and the font size and accepts the system calculation for the best number of rows and columns for the window:

```
     USE DFLIB
     TYPE (windowconfig) wc
     LOGICAL status
  ! Set the x & y pixels to 800X600 and font size to 8x12.
     wc%numxpixels  = 800               ! pixels on x-axis, window width
     wc%numypixels  = 600               ! pixels on y-axis, window height
     wc%numtextcols = -1                ! -1 requests system default/calculation
     wc%numtextrows = -1
     wc%numcolors   = -1
     wc%title       = " "C
     wc%fontsize    = #0008000C         ! Request 8x12 pixel fonts
     status         = SETWINDOWCONFIG(wc)
```

In this example:

- The variables wc%numxpixels and wc%numypixels specify the size of the window, in this case 800 by 600 pixels. Within this window size, you can choose to specify either the font size (wc%fontsize) or the number of text columns (wc%numtextcols) and rows (wc%numtextrows).

  This example specifies the window size and font size, and lets the system calculate the number of text columns and rows.

  If you choose to specify the number of text columns and rows, you can let the system calculate (specify -1) either the font size or the window size.

- The variable wc%fontsize is given as hexadecimal constant of #0008000C, which is interpreted in two parts:
  - The left side of 0008 (8) specifies the width of the font, in pixels.
  - The right side of 000C (12 in decimal) specifies the height of the font, in pixels.

- The variable wc%numtextrows is -1 and wc%numtextcols is -1, which allows the system to calculate the best available number of text columns and text rows to be used, as follows:
  - The number of text columns is calculated as wc%numypixels (800) divided by the width of the font 8 (decimal) or 100.
  - The number of text rows is calculated as wc%numxpixels (600) divided by the width of the font, 12 (decimal) or 50.

The requested font size is matched to the nearest available font size. If the matched size differs from the requested size, the matched size is used to determine the number of columns and rows.

If scroll bars are needed (virtual window size exceeds the visible window size), because of the size required by horizontal and vertical scroll bars for a window, you may need to set the number of lines and columns to a value 1 or 2 greater than the number of rows and columns needed to display the application's information.

If the requested configuration cannot be set, **SETWINDOWCONFIG** returns .FALSE. and calculates parameter values that will work and best fit the requested configuration. Another call to **SETWINDOWCONFIG** establishes these values:

```
IF(.NOT.status) status = SETWINDOWCONFIG(wc)
```

For an example, see the QuickWin Sample Cleanwin.

For information on setting the graphics mode with SETWINDOWCONFIG, see Setting the Graphics Mode.

Routines such as **SETWINDOWCONFIG** work on the window that is currently in focus. You can have multiple windows open as your application requires, but you need to decide which one gains focus. There is a single frame window and one or more child windows. A window is in focus right after it is opened, after I/O to it, and when **FOCUSQQ** is used. Clicking the mouse when the cursor is in a window will also bring the window into focus.

For example, to set the characteristics for the window associated with unit 10, either gain focus with either an **OPEN**, a subsequent **READ** or **WRITE** statement to unit 10, or **FOCUSQQ**. For example, use **OPEN**:

```
open(unit=10, file='user')
result = setwindowconfig(wc)
```

After you open unit 10, focus can be regained by a **READ** or **WRITE** statement to that unit. For example:

```
write(10,*) "Hello, this is unit 10"
```

Or you can use **FOCUSQQ**:

```
result = focusqq(10)
result = setwindowconfig(wc)
```

For more information about when a window gains focus, see Giving a Window Focus and Setting the Active Window.

Creating Child Windows

The FILE='USER' option in the OPEN statement opens a child window. The child window defaults to a scrollable text window, 30 rows by 80 columns. You can open up to 40 child windows.

Running a QuickWin application displays the frame window, but not the child window. You must call SETWINDOWCONFIG or execute an I/O statement or a graphics statement to display the child window. The window receives output by its unit number, as in:

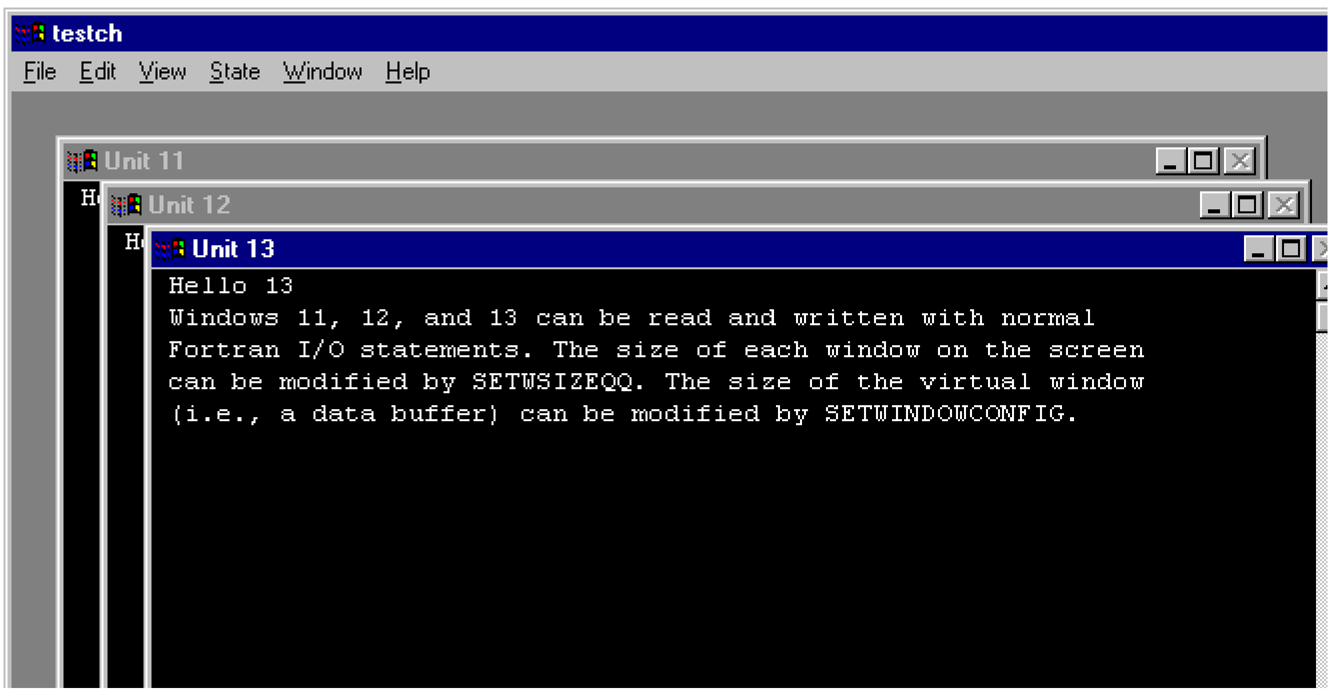
```
OPEN (UNIT= 12, FILE= 'USER', TITLE= 'Product Matrix')
WRITE (12, *) 'Enter matrix type: '
```

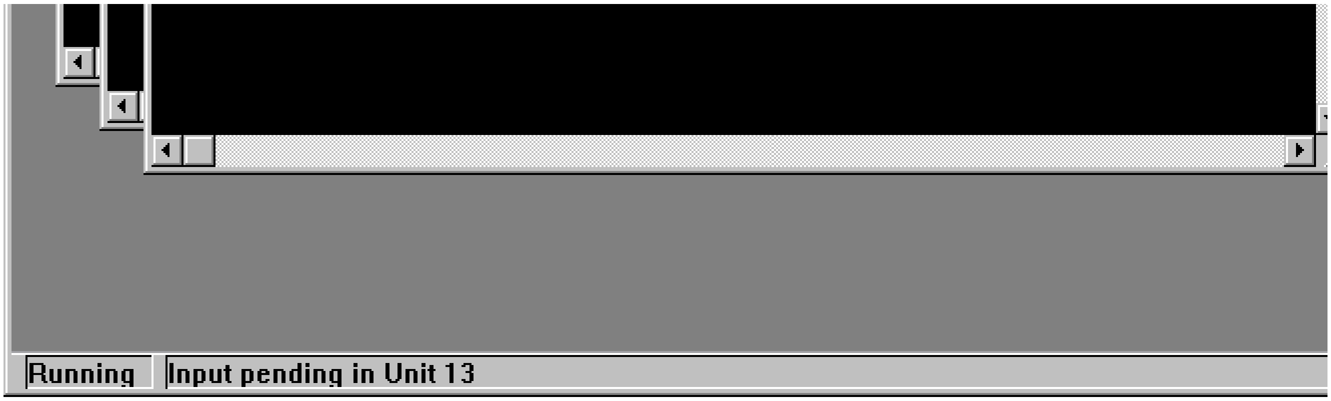
Child windows opened with FILE='USER' must be opened as sequential-access formatted files (the default). Other file specifications (direct-access, binary, or unformatted) result in run-time errors.

The following example creates three child windows. A frame window is automatically created. Text is written to each so the child windows are visible:

```
program testch
 use dflib
 open(11,file="user")
 write(11,*) "Hello 11"
 open(12,file="user")
 write(12,*) "Hello 12"
 open(13,file="user")
 write(13,*) "Hello 13"
 write(13,*) "Windows 11, 12, and 13 can be read and written with normal"
 write(13,*) "Fortran I/O statements. The size of each window on the screen"
 write(13,*) "can be modified by SETWSIZEQQ. The size of the virtual window"
 write(13,*) "(i.e., a data buffer) can be modified by SETWINDOWCONFIG."
 read(13,*)
end
```

When this program is run, the output appears as follows:





Giving a Window Focus and Setting the Active Window

When a window is made *active*, it receives graphics output (from **ARC**, **LINETO**, and **OUTGTEXT**, for example) but is not brought to the foreground and thus does *not* have the *focus*. When a window acquires focus, either by a mouse click, I/O to it, or by a **FOCUSQQ** call, it also becomes the *active* window. When a window gains focus, the window that previously had focus will lose focus.

If a window needs to be brought to the foreground, it must be given *focus*. The window that has the focus is always on top, and all other windows have their title bars grayed out. A window can have the focus and yet not be active and not have graphics output directed to it. Graphical output is independent of focus.

Under most circumstances, *focus* and *active* should apply to the same window. This is the default behavior of QuickWin and a programmer must consciously override this default.

Certain QuickWin routines (such as GETCHARQQ, PASSDIRKEYSQQ, and SETWINDOWCONFIG) that do not take a unit number as an input argument usually effect the *active* window whether or not it is in *focus*.

If another window is made *active* but is not in *focus*, these routines effect the window *active* at the time of the routine call. This may appear unusual to the user since a **GETCHARQQ** under these circumstances will expect input from a grayed, background window. The user would then have to click on that window before input could be typed to it.

To use these routines (that effect the *active* window), either do I/O to the unit number of the window you wish to put in *focus* (and also make *active*), or call FOCUSQQ (with a unit number specified). If only one window is open then that window is the one effected. If several windows are opened, then the last one opened is the one effected since that window will get *focus* and *active* as a side effect of being opened.

The **OPEN** (IOFOCUS) parameter also can determine whether a window receives the focus when a I/O statement is executed on that unit. For example:

```
OPEN (UNIT = 10, FILE = 'USER', IOFOCUS = .TRUE.)
```

With an explicit **OPEN** with FILE='USER', IOFOCUS defaults to .TRUE. For child windows opened implicitly (no **OPEN** statement before the **READ WRITE**, or PRINT) as unit 0, 5, or 6, IOFOCUS defaults to .FALSE..

If IOFOCUS=.TRUE., the child window receives focus prior to each **READ**, **WRITE**, or **PRINT**. Calls to **OUTTEXT** or graphics functions (for example, **OUTGTEXT**, **LINETO**, and **ELLIPSE**) do not cause the focus to shift. If you use IOFOCUS with any unit other than a QuickWin child window, a run-time error occurs.

The focus shifts to a window when it is given the focus with **FOCUSQQ**, when it is selected by a mouse click, or when an I/O operation other than a graphics operation is performed on it, unless the window was opened with IOFOCUS=.FALSE.. INQFOCUSQQ determines which unit has the focus. For example:

```
   USE DFLIB
   INTEGER(4) status, focusunit
   OPEN(UNIT = 10, FILE = 'USER', TITLE = 'Child Window 1')
   OPEN(UNIT = 11, FILE = 'USER', TITLE = 'Child Window 2')
! Give focus to Child Window 2 by writing to it:
   WRITE (11, *) 'Giving focus to Child 2.'
! Give focus to Child Window 1 with the FOCUSQQ function:
   status = FOCUSQQ(10)
    ...
! Find out the unit number of the child window that currently has focus:
   status = INQFOCUSQQ(focusunit)
```

SETACTIVEQQ makes a child window active without bringing it to the foreground. GETACTIVEQQ returns the unit number of the currently active child window. GETHWNDQQ converts the unit number into a Windows handle for functions that require it.

Keeping Child Windows Open

A child window remains open as long as its unit is open. The STATUS parameter in the **CLOSE** statement determines whether the child window remains open after the unit has been closed. If you set STATUS='KEEP', the associated window remains open but no further input or output is permitted. Also, the Close command is added to the child window's menu and the word Closed is appended to the window title. The default is STATUS='DELETE', which closes the window.

A window that remains open when you use STATUS='KEEP' counts as one of the 40 child windows available for the QuickWin application.

Controlling Size and Position of Windows

SETWSIZEQQ and **GETWSIZEQQ** set and get the size and position of the visible representation of a window. The positions and dimensions of visible child windows are expressed in units of character height and width. The position and dimensions of the frame window are expressed in screen pixels. The position and dimensions are returned in the derived type `qwinfo` defined in DFLIB.MOD as follows:

```
TYPE QWINFO
   INTEGER(2) TYPE     ! Type of action performed by SETWSIZEQQ.
   INTEGER(2) X        ! x-coordinate for upper left corner.
   INTEGER(2) Y        ! y-coordinate for upper left corner.
   INTEGER(2) H        ! Window height.
   INTEGER(2) W        ! Window width.
END TYPE QWINFO
```

The options for the `qwinfo` type are listed under SETWSIZEQQ in the *Language Reference*.

GETWSIZEQQ returns the position and the current or maximum window size of the current frame or child window. To access information about a child window, specify the unit number associated with it. Unit numbers 0, 5, and 6 refer to the default startup window if you have not explicitly opened them with the OPEN statement. To access information about the frame window, specify the unit number as the symbolic constant QWIN$FRAMEWINDOW. For example:

```
   USE DFLIB
   INTEGER(4) status
   TYPE (QWINFO) winfo
   OPEN (4, FILE='USER')
    ...
 ! Get current size of child window associated with unit 4.
   status = GETWSIZEQQ(4, QWIN$SIZECURR, winfo)
   WRITE (*,*) "Child window size is ", winfo.H, " by ", winfo.W
 ! Get maximum size of frame window.
   status = GETWSIZEQQ(QWIN$FRAMEWINDOW, QWIN$SIZEMAX, winfo)
   WRITE (*,*) "Max frame window size is ", winfo.H, " by ", winfo.W
```

SETWSIZEQQ is used to set the visible window position and size. For example:

```
   USE DFLIB
   INTEGER(4) status
   TYPE (QWINFO) winfo
   OPEN (4, FILE='USER')
   winfo.H    = 30
   winfo.W    = 80
   winfo.TYPE = QWIN$SET
   status     = SETWSIZEQQ(4, winfo)
```

Using Graphics and Character-Font Routines

Graphics routines are functions and subroutines that draw lines, rectangles, ellipses, and similar elements on the screen. Font routines create text in a variety of sizes and styles. The QuickWin graphics library provides routines that:

- Change the window's dimensions.
- Set coordinates.
- Set color palettes.
- Set line styles, fill masks, and other figure attributes.
- Draw graphics elements.
- Display text in several character styles.
- Display text in fonts compatible with Microsoft Windows.
- Store and retrieve screen images.

Defining Graphics Characteristics

The following topics discuss groups of routines that define the way text and graphics are displayed:

- Selecting Display Options
- Setting Graphics Coordinates
- Using Color
- Setting Figure Properties

Selecting Display Options

The QuickWin run-time library provides a number of routines that you can use to define text and graphics displays. These routines determine the graphics environment characteristics and control the cursor.

SETWINDOWCONFIG is the routine you use to configure window properties. You can use DISPLAYCURSOR to control whether the cursor will be displayed. The cursor becomes invisible after a call to **SETWINDOWCONFIG**. To display the cursor you must explicitly turn on cursor visibility with **DISPLAYCURSOR** ($GCURSORON).

SETGTEXTROTATION sets the current orientation for font text output, and GETGTEXTROTATION returns the current setting. The current orientation is used in calls to OUTGTEXT.

For more information on these routines, see the *Language Reference*.

Setting Graphics Coordinates

The coordinate-setting routines control where graphics can appear on the screen. Visual Fortran graphics routines recognize the following sets of coordinates:

- Fixed *physical coordinates*, which are determined by the hardware and the video mode used
- *Viewport coordinates*, which you can define in the application
- *Window coordinates*, which you can define to simplify scaling of floating-point data values

Unless you change it, the viewport-coordinate system is identical to the physical-coordinate system. The physical origin (0, 0) is always in the upper-left corner of the *display*.

For QuickWin, *display* means a child window's client area, not the actual monitor screen (unless you go to Full Screen mode). The x-axis extends in the positive direction left to right, while the y-axis extends in the positive direction top to bottom. The default viewport has the dimensions of the selected mode. In a QuickWin application, you can draw outside of the child window's current client area. If you then make the child window bigger, you will see what was previously outside the frame.

You can also use coordinate routines to convert between physical-, viewport-, and window-coordinate systems. (For more detailed information on coordinate systems, see Drawing Graphics Elements.)

You can set the pixel dimensions of the x- and y-axes with SETWINDOWCONFIG. You can access these values through the *wc%numxpixels* and *wc%numypixels* values returned by GETWINDOWCONFIG. Similarly, **GETWINDOWCONFIG** also returns the range of colors available in the current mode through the *wc%numcolors* value.

You can also define the graphics area with SETCLIPRGN and SETVIEWPORT. Both of these functions define a subset of the available window area for graphics output. **SETCLIPRGN** does not change the viewport coordinates, but merely masks part of the screen. **SETVIEWPORT** resets the viewport bounds to the limits you give it and sets the origin to the upper-left corner of this region.

The origin of the viewport-coordinate system can be moved to a new position relative to the physical origin with SETVIEWORG. Regardless of the viewport coordinates, however, you can always locate the current graphics output position with GETCURRENTPOSITION and GETCURRENTPOSITION_W. (For more detailed information on viewports and clipping regions, see Drawing Graphics Elements.)

Using the window-coordinate system, you can easily scale any set of data to fit on the screen. You define any range of coordinates (such as 0 to 5000) that works well for your data as the range for the window-coordinate axes. By telling the program that you want the window-coordinate system to fit in a particular area on the screen (map to a particular set of viewport coordinates), you can scale a chart or drawing to any size you want. SETWINDOW defines a window-coordinate system bounded by the specified values. See the Visual Fortran Sample SINE.F90 in the `...\DF98\SAMPLES\TUTORIAL` folder for an example of this technique.

GETPHYSCOORD converts viewport coordinates to physical coordinates, and GETVIEWCOORD translates from physical coordinates to viewport coordinates. Similarly, GETVIEWCOORD_W converts window coordinates to viewport coordinates, and GETWINDOWCOORD converts viewport coordinates to window coordinates.

For more information:

- On these routines, see their descriptions in the *Language Reference*.

Using Color

If you have a VGA machine, you are restricted to displaying at most 256 colors at a time. These 256 colors are held in a palette. You can choose the palette colors from a range of 262,144 colors (256K), but only 256 at a time. The palette routines REMAPPALETTERGB and REMAPALLPALETTERGB assign Red-Green-Blue (RGB) colors to palette indexes.

Functions and subroutines that use color indexes create graphic outputs that depend on the mapping between palette indexes and RGB colors. **REMAPPALETTERGB** remaps one color index to an RGB color, and **REMAPALLPALETTERGB** remaps the entire palette, up to 236 colors, (20 colors are reserved by the system). You cannot remap the palette on machines capable of displaying 20 colors or fewer.

SVGA and true color video adapters are capable of displaying 262,144 (256K) colors and 16.7 million colors respectively. If you use a palette, you are restricted to the colors available in the palette.

To access the entire set of available colors, not just the 256 or fewer colors in the palette, you should use functions that specify a color value directly. These functions end in RGB and use Red-Green-Blue color values, not indexes to a palette. For example, SETCOLORRGB, SETTEXTCOLORRGB, and SETPIXELRGB specify a direct color value, while SETCOLOR, SETTEXTCOLOR, and SETPIXEL each specify a palette color index. If you are displaying more than 256 colors simultaneously, you need to use the RGB direct color value functions exclusively.

To set the physical display properties of your monitor, open the Control Panel and click the Display icon.

QuickWin only supports a 256-color pallette, regardless of the number of colors set for the monitor.

For more information on setting colors, see Adding Color in Drawing Graphics Elements.

Setting Figure Properties

The output routines that draw arcs, ellipses, and other primitive figures do not specify color or line-style information. Instead, they rely on properties set independently by other routines.

GETCOLORRGB (or GETCOLOR) and SETCOLORRGB (or SETCOLOR) obtain or set the current color value (or color index), which FLOODFILLRGB (or FLOODFILL), OUTGTEXT, and the shape-drawing routines all use. Similarly, GETBKCOLORRGB (or GETBKCOLOR) and SETBKCOLORRGB (or SETBKCOLOR) retrieve or set the current background color.

GETFILLMASK and SETFILLMASK return or set the current fill mask. The mask is an 8-by-8-bit array with each bit representing a pixel. If a bit is 0, the pixel in memory is left untouched: the mask is transparent to that pixel. If a bit is 1, the pixel is assigned the current color value. The array acts as a template that repeats over the entire fill area. It "masks" the background with a pattern of pixels drawn in the current color, creating a large number of fill patterns. These routines are particularly useful for shading.

GETWRITEMODE and SETWRITEMODE return or set the current *logical write mode* used when drawing lines. The logical write mode, which can be set to $GAND, $GOR, $GPRESET, $GPSET, or $GXOR, determines the interaction between the new drawing and the existing screen and current graphics color. The logical write mode affects the **LINETO**, **RECTANGLE**, and **POLYGON** routines.

GETLINESTYLE and SETLINESTYLE retrieve and set the current line style. The line style is determined by a 16-bit-long mask that determines which of the five available styles is chosen. You can use these two routines to create a wide variety of dashed lines that affect the **LINETO**, **RECTANGLE**, and **POLYGON** routines.

For more information:

- On these routines, see their description in the *Language Reference*.

Displaying Graphics Output

The run-time graphics library routines can draw geometric features, display text, display font-based characters, and transfer images between memory and the screen. These capabilities are discussed in the following topics:

- Drawing Graphics
- Displaying Character-Based Text
- Displaying Font-Based Characters

Drawing Graphics

If you want anything other than the default line style (solid), mask (no mask), background color (black), or foreground color (white), you must call the appropriate routine before calling the drawing routine. Subsequent output routines employ the same attributes until you change them or open a new child window.

The following is a list of routines that ask about the current graphics settings, set new graphics settings, and draw graphics:

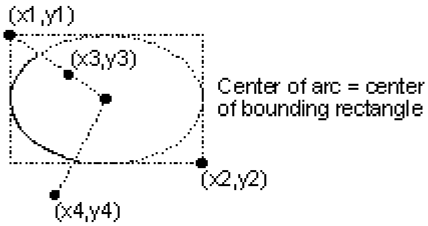
Routine	Description
ARC, ARC_W	Draws an arc
CLEARSCREEN	Clears the screen, viewport, or text window
ELLIPSE, ELLIPSE_W	Draws an ellipse or circle
FLOODFILL, FLOODFILL_W	Fills an enclosed area of the screen with the current color index using the current fill mask
FLOODFILLRGB, FLOODFILLRGB_W	Fills an enclosed area of the screen with the current RGB color using the current fill mask
GETARCINFO	Determines the endpoints of the most recently drawn arc or pie
GETCURRENTPOSITION, GETCURRENTPOSITION_W	Returns the coordinates of the current graphics-output position
GETPIXEL, GETPIXEL_W	Returns a pixel's color index
GETPIXELRGB, GETPIXELRGB_W	Returns a pixel's Red-Green-Blue color value

GETPIXELS	Gets the color indices of multiple pixels
GETPIXELSRGB	Gets the Red-Green-Blue color values of multiple pixels
GRSTATUS	Returns the status (success or failure) of the most recently called graphics routine
INTEGERTORGB	Convert a true color value into its red, green, and blue components
LINETO, LINETO_W	Draws a line from the current graphics-output position to a specified point
LINETOAR, LINETOAREX	Draws lines from arrays at x,y coordinate points
MOVETO, MOVETO_W	Moves the current graphics-output position to a specified point
PIE, PIE_W	Draws a pie-slice-shaped figure
POLYGON, POLYGON_W	Draws a polygon
RECTANGLE, RECTANGLE_W	Draws a rectangle
RGBTOINTEGER	Convert a trio of red, green, and blue values to a true color value for use with RGB functions and subroutines
SETPIXEL, SETPIXEL_W	Sets a pixel at a specified location to a color index
SETPIXELRGB, SETPIXELRGB_W	Sets a pixel at a specified location to a Red-Green-Blue color value
SETPIXELS	Set the color indices of multiple pixels
SETPIXELSRGB	Set the Red-Green-Blue color value of multiple pixels

Most of these routines have multiple forms. Routine names that end with _W use the window-coordinate system and REAL(8) argument values. Routines without this suffix use the viewport-coordinate system and INTEGER(2) argument values.

Curved figures, such as arcs and ellipses, are centered within a *bounding rectangle*, which is specified by the upper-left and lower-right corners of the rectangle. The center of the rectangle becomes the center for the figure, and the rectangle's borders determine the size of the figure. In the following figure, the points (*x1*, *y1*) and (*x2*, *y2*) define the bounding rectangle.

Bounding Rectangle



For more information:

- On these routines, see their descriptions in the *Language Reference*.

Displaying Character-Based Text

The routines in the following table ask about screen attributes that affect text display, prepare the screen for text and send text to the screen. To print text in specialized fonts, see Displaying Font-Based Characters and Using Fonts from the Graphics Library.

In addition to these general text routines, you can customize the text in your menus with MODIFYMENUSTRINGQQ. You can also customize any other string that QuickWin produces, including status bar messages, the state message (for example, "Paused" or "Running"), and dialog box messages, with SETMESSAGEQQ. Use of these customization routines is described in Customizing QuickWin Applications.

The following routines recognize text-window boundaries:

Routine	Description
CLEARSCREEN	Clears the screen, viewport, or text window
DISPLAYCURSOR	Sets the cursor on or off
GETBKCOLOR	Returns the current background color index
GETBKCOLORRGB	Returns the current background Red-Green-Blue color value
GETTEXTCOLOR	Returns the current text color index
GETTEXTCOLORRGB	Returns the current text Red-Green-Blue color value

GETTEXTPOSITION	Returns the current text-output position
GETTEXTWINDOW	Returns the boundaries of the current text window
OUTTEXT	Sends text to the screen at the current position
SCROLLTEXTWINDOW	Scrolls the contents of a text window
SETBKCOLOR	Sets the current background color index
SETBKCOLORRGB	Sets the current background Red-Green-Blue color value
SETTEXTCOLOR	Sets the current text color to a new color index
SETTEXTCOLORRGB	Sets the current text color to a new Red-Green-Blue color value
SETTEXTPOSITION	Changes the current text position
SETTEXTWINDOW	Sets the current text-display window
WRAPON	Turns line wrapping on or off

These routines do not provide text-formatting capabilities. If you want to print integer or floating-point values, you must convert the values into a string (using an internal WRITE statement) before calling these routines. The text routines specify all screen positions in character-row and column coordinates.

SETTEXTWINDOW is the text equivalent of the SETVIEWPORT graphics routine, except that it restricts only the display area for text printed with **OUTTEXT**, PRINT, and **WRITE**. **GETTEXTWINDOW** returns the boundaries of the current text window set by **SETTEXTWINDOW**. **SCROLLTEXTWINDOW** scrolls the contents of a text window. **OUTTEXT**, **PRINT**, and **WRITE** display text strings written to the current text window.

> **Warning:** The **WRITE** statement sends its carriage return (CR) and line feed (LF) to the screen at the beginning of the first I/O statement following the **WRITE** statement. This can cause unpredictable text positioning if you mix the graphics routines **SETTEXTPOSITION** and **OUTTEXT** with the **WRITE** statement. To minimize this effect, use the backslash (\ ) or dollar sign ($) format descriptor (to suppress CR-LF) in the associated FORMAT statement.

For more information:

- On these routines, see their descriptions in the *Language Reference*.

- On allocating a console to display text in a QuickWin application, see Using the Console.

Displaying Font-Based Characters

Because the Visual Fortran Graphics Library provides a variety of fonts, you must indicate which font to use when displaying font-based characters. After you select a font, you can make inquiries about the width of a string printed in that font or about font characteristics.

The following functions control the display of font-based characters:

Routine	Description
GETFONTINFO	Returns the current font characteristics
GETGTEXTEXTENT	Determines the width of specified text in the current font
GETGTEXTROTATION	Gets the current orientation for font text output in 0.1º increments
INITIALIZEFONTS	Initializes the font library
OUTGTEXT	Sends text in the current font to the screen at the current graphics output position
SETFONT	Finds a single font that matches a specified set of characteristics and makes it the current font used by **OUTGTEXT**
SETGTEXTROTATION	Sets the current orientation for font text output in 0.1º increments

Characters may be drawn ("mapped") in one of two ways: as bitmapped letters (a "picture" of the letter) or as TrueType characters. See Using Fonts from the Graphics Library, for detailed explanations and examples of how to use the font routines from the QuickWin Library.

For more information on these routines, see the *Language Reference*.

Working With Screen Images

The routines described in the following sections offer the following ways to store and retrieve images:

- Transfer images between memory buffers and the screen

  Transferring images from buffers is a quick and flexible way to move things around the screen. Memory images can interact with the current screen image; for example, you can perform a logical AND of a memory image and the current screen or superimpose a negative of the memory image on the screen.

- Transfer images between the screen and Windows bitmap files

  Transferring images from files gives access to images created by other programs, and saves graphs and images for later use. However, images loaded from bitmap files overwrite the portion of the screen they are pasted into and retain the attributes they were created with, such as the color palette, rather than accepting current attributes.

- Transfer images between the screen and the Clipboard from the QuickWin Edit menu

  Editing screen images from the QuickWin Edit menu is a quick and easy way to move and modify images interactively on the screen, retaining the current screen attributes, and also provides temporary storage (the Clipboard) for transferring images among applications.

These routines allow you to cut, paste, and move images around the screen.

Transferring Images in Memory

The **GETIMAGE** and **PUTIMAGE** routines transfer images between memory and the screen and give you options that control the way the image and screen interact. When you hold an image in memory, the application allocates a memory buffer for the image. The **IMAGESIZE** routines calculate the size of the buffer needed to store a given image.

Routines that end with _W use window coordinates; the other functions use viewport coordinates.

Routine	**Description**
GETIMAGE, GETIMAGE_W	Stores a screen image in memory
IMAGESIZE, IMAGESIZE_W	Returns image size in bytes
PUTIMAGE, PUTIMAGE_W	Retrieves an image from memory and displays it

For more information:

- On these routines, see their descriptions in the *Language Reference*.

Loading and Saving Images to Files

The **LOADIMAGE** and **SAVEIMAGE** routines transfer images between the screen and Windows bitmap files:

Routine	Description
LOADIMAGE, LOADIMAGE_W	Reads a Windows bitmap file (.BMP) from disk and displays it as specified coordinates
SAVEIMAGE, SAVEIMAGE_W	Captures a screen image from the specified portion of the screen and saves it as a Windows bitmap file

You can use a Windows format bitmap file created with a graphics program as a backdrop for graphics that you draw with the Visual Fortran graphics functions and subroutines.

For more information:

- On these routines, see their descriptions in the *Language Reference*.

Editing Text and Graphics from the QuickWin Edit Menu

From the QuickWin Edit menu you can choose the Select Text, Select Graphics, or Select All options. You can then outline your selection with the mouse or the keyboard arrow keys. When you use the Select Text option, your selection is highlighted. When you use the Select Graphics or Select All option, your selection is marked with a box whose dimensions you control.

Once you have selected a portion of the screen, you can copy it onto the Clipboard by using the Edit/Copy option or by using the Ctrl+INS key combination. If the screen area you have selected contains only text, it is copied onto the Clipboard as text. If the selected screen area contains graphics, or a mix of text and graphics, it is copied onto the Clipboard as a bitmap.

The Edit menu's Paste option will only paste text. Bitmaps can be pasted into other Windows applications from the Clipboard (with the Ctrl+V or Shift+INS key combinations).

Remember the following when selecting portions of the screen:

- If you have chosen the Select All option from the Edit menu, the whole screen is selected and you cannot then select a portion of the screen.
- Text selections are not bounded by the current text window set with **SETTEXTWINDOW**.
- When text is copied to the Clipboard, trailing blanks in a line are removed.
- Text that is written to a window can be overdrawn by graphics. In this case, the text is still present in the screen text buffer, though not visible on the screen. When you select a portion of the screen to copy, you can select text that is actually present but not visible, and that text will be copied onto the Clipboard.
- When you chose Select Text or Select Graphics from the Edit menu, the application is paused, a caret (^) appears at the top left corner of the currently active window, all user-defined callbacks are disabled, and the window title changes to "Mark Text - *windownam* "or "Mark Graphics - *windowname*", where *windowname* is the name of the currently active window.

  As soon as you begin selection (by pressing an arrow key or a mouse button), the Window title changes to "Select Text - *windowname*" or "Select Graphics - *windowname*" and selection begins at that point. If you do not want selection to begin in the upper-left corner, your first action when "Mark Text" or "Mark Graphics" appears in the title is to use the mouse to place the cursor at the position where selection is to be begin.

Enhancing QuickWin Applications

In addition to the basic QuickWin features, you can optionally customize and enhance your QuickWin applications with the features described in the following table. The use of these features to create customized menus, respond to mouse events, and add custom icons is described in the section Customizing QuickWin Applications.

Category	**QuickWin Function**	**Description**
Initial settings	INITIALSETTINGS	Controls initial menu settings and/or initial frame window
Display/add box	MESSAGEBOXQQ	Displays a message box
	ABOUTBOXQQ	Adds an About Box with customized text

Menu items	CLICKMENUQQ	Simulates the effect of clicking or selecting a menu item
	APPENDMENUQQ	Appends a menu item
	DELETEMENUQQ	Deletes a menu item
	INSERTMENUQQ	Inserts a menu item
	MODIFYMENUFLAGSQQ	Modifies a menu item's state
	MODIFYMENUROUTINEQQ	Modifies a menu item's callback routine
	MODIFYMENUSTRINGQQ	Changes a menu item's text string
	SETWINDOWMENUQQ	Sets the menu to which a list of current child window names are appended
Directional keys	PASSDIRKEYSQQ	Enables (or disables) use of the arrow directional keys and page keys as input (see the Sample DIRKEYS.F90 in the ...`\DF98\SAMPLES\ADVANCED\DIRKEYS` folder)
QuickWin messages	SETMESSAGEQQ	Changes any QuickWin message, including status bar messages, state messages and dialog box messages
Mouse actions	REGISTERMOUSEEVENT	Registers the application defined routines to be called on mouse events
	UNREGISTERMOUSEEVENT	Removes the routine registered by **REGISTERMOUSEEVENT**
	WAITONMOUSEEVENT	Blocks return until a mouse event occurs

Customizing QuickWin Applications

The QuickWin library is a set of routines you can use to create graphics programs or simple applications for Windows. For a general overview of QuickWin and a description of how to create and size child windows, see the beginning of this section. For information on how to compile and link QuickWin applications, see Building Programs and Libraries.

The following topics describe how to customize and fine-tune your QuickWin applications:

- Program Control of Menus
- Changing Status Bar and State Messages
- Displaying Message Boxes
- Defining an About Box
- Using Custom Icons
- Using a Mouse

Program Control of Menus

You do not have to use the default QuickWin menus. You can eliminate and alter menus, menu item lists, menu titles or item titles. The QuickWin functions that control menus are described in the following sections:

- Controlling the Initial Menu and Frame Window
- Deleting, Inserting, and Appending Menu Items
- Modifying Menu Items
- Creating a Menu List of Available Child Windows
- Simulating Menu Selections

Controlling the Initial Menu and Frame Window

You can change the initial appearance of an application's default frame window and menus by defining an **INITIALSETTINGS** function. If no user-defined **INITIALSETTINGS** function is supplied, QuickWin calls a predefined (default) **INITIALSETTINGS** routine that provides a default frame window and menu.

Your application does not call **INITIALSETTINGS**. If you supply the function in your project, QuickWin calls it automatically.

If you supply it, **INITIALSETTINGS** can call QuickWin functions that set the initial menus and the size and position of the frame window. Besides the menu functions, **SETWSIZEQQ** can be called from your **INITIALSETTINGS** function to adjust the frame window size and position before the window is first drawn.

The following is a sample of **INITIALSETTINGS**:

```
   LOGICAL(4) FUNCTION INITIALSETTINGS( )
     USE DFLIB
     LOGICAL(4) result
     TYPE (qwinfo) qwi
 ! Set window frame size.
     qwi%x = 0
     qwi%y = 0
     qwi%w = 400
```

```
      qwi%h = 400
      qwi%type = QWIN$SET
      i = SetWSizeQQ( QWIN$FRAMEWINDOW, qwi )
  ! Create first menu called Games.
      result = APPENDMENUQQ(1, $MENUENABLED, '&Games'C, NUL )
  ! Add item called TicTacToe.
      result = APPENDMENUQQ(1, $MENUENABLED, '&TicTacToe'C, WINPRINT)
  ! Draw a separator bar.
      result = APPENDMENUQQ(1, $MENUSEPARATOR, ''C, NUL )
  ! Add item called Exit.
      result = APPENDMENUQQ(1, $MENUENABLED, 'E&xit'C, WINEXIT )
  ! Add second menu called Help.
      result = APPENDMENUQQ(2, $MENUENABLED, '&Help'C, NUL )
      result = APPENDMENUQQ(2, $MENUENABLED, '&QuickWin Help'C, WININDEX)
      INITIALSETTINGS= .true.
   END FUNCTION INITIALSETTINGS
```

QuickWin executes your INITIALSETTINGS function during initialization, before creating the frame window. When your function is done, control returns to QuickWin and it does the remaining initialization. The control then passes to the Visual Fortran application.

You only need to include the code for an **INITIALSETTINGS** function in your project. If it is part of your project, you do not need to call your **INITIALSETTINGS** function.

The **INITIALSETTINGS** function can specify the position and size of the frame window and the contents of the menus. Because the **INITIALSETTINGS** function is executed before creating the frame window, it must not call any routines that require that frame window initialization be complete. For example, routines that refer to the child window in focus (such as **SETWINDOWCINFIG**) or a specific child window unit number (such as **OPEN**) should not be called from the **INITIALSETTINGS** function.

Your **INITIALSETTINGS** function should return .TRUE. if it succeeds, and .FALSE. otherwise. The QuickWin default function returns a value of .TRUE. only.

Note that default menus are created after **INITIALSETTINGS** has been called, and only if you do not create your own menus. Therefore, using DELETEMENUQQ, INSERTMENUQQ, APPENDMENUQQ, and the other menu configuration QuickWin functions while in **INITIALSETTINGS** affects your custom menus, not the default QuickWin menus.

Deleting, Inserting, and Appending Menu Items

Menus are defined from left to right, starting with 1 at the far left. Menu items are defined from top to bottom, starting with 0 at the top (the menu title itself). Within INITIALSETTINGS, if you supply it, you can delete, insert, and append menu items in custom menus. Outside **INITIALSETTINGS**, you can alter the default QuickWin menus as well as custom menus at any point in your application. (Default QuickWin menus are not created until after **INITIALSETTINGS** has run and only if you do not create custom menus.)

To delete a menu item, specify the menu number and item number in DELETEMENUQQ. To delete an entire menu, delete item 0 of that menu. For example:

```
USE DFLIB
LOGICAL status
status = DELETEMENUQQ(1, 2) ! Delete the second menu item from
                            ! menu 1 (the default FILE menu).
status = DELETEMENUQQ(5, 0) ! Delete menu 5 (the default Windows
                            ! menu).
```

INSERTMENUQQ inserts a menu item or menu and registers its callback routine. QuickWin supplies several standard callback routines such as WINEXIT to terminate a program, WININDEX to list QuickWin Help, and WINCOPY which copies the contents of the current window to the Clipboard. A list of available callbacks is given in the *Language Reference* for INSERTMENUQQ and APPENDMENUQQ.

Often, you will supply your own callback routines to perform a particular action when a user selects something from one of your menus.

In general, you should not assign the same callback routine to more than one menu item because a menu item's state might not be properly updated when you change it (put a check mark next to it, gray it out, or disable, or enable it). You cannot insert a menu item or menu beyond the existing number; for example, inserting item 7 when 5 and 6 have not been defined yet. To insert an entire menu, specify menu item 0. The new menu can take any position among or immediately after existing menus.

If you specify a menu position occupied by an existing menu, the existing menu and any menus to the right of the one you add are shifted right and their menu numbers are incremented.

For example, the following code inserts a fifth menu item called `Position` into menu 5 (the default Windows menu):

```
USE DFLIB
LOGICAL(4) status
status = INSERTMENUQQ (5, 5, $MENUCHECKED, 'Position'C, WINPRINT)
```

The next code example inserts a new menu called `My List` into menu position 3. The menu currently in position 3 and any menus to the right (the default menus View, State, Windows, and Help) are shifted right one position:

```
USE DFLIB
LOGICAL(4) status
status = INSERTMENUQQ(3,0, $MENUENABLED, 'My List'C, WINSTATE)
```

You can append a menu item with APPENDMENUQQ. The item is added to the bottom of the menu list. If there is no item yet for the menu, your appended item is treated as the top-level menu item, and the string you assign to it appears on the menu bar.

The QuickWin menu routines like **INSERTMENUQQ** and **APPENDMENUQQ** let you to create a single level of menu items beneath a menu name. You cannot create submenus with the QuickWin project type.

The following code uses **APPENDMENUQQ** to append the menu item called `Cascade Windows` to the first menu (the default File menu):

```
   USE DFLIB
   LOGICAL(4) status
   status = APPENDMENUQQ(1, $MENUCHECKED, 'Cascade Windows'C,   &
  & WINCASCADE)
```

The $MENUCHECKED flag in the example puts a check mark next to the menu item. To remove the check mark, you can set the flag to $MENUUNCHECKED in the **MODIFYMENUFLAGSQQ** function. Some predefined routines (such as WINSTATUS) take care of updating their own check marks. However, if the routine is registered to more than one menu item, the check marks might not be properly updated. See APPENDMENUQQ or INSERTMENUQQ in the *Language Reference* for the list of callback routines and other flags.

Modifying Menu Items

MODIFYMENUSTRINGQQ can modify the string identifier of a menu item, MODIFYMENUROUTINEQQ can modify the callback routine called when the item is selected, and MODIFYMENUFLAGSQQ can modify a menu item's state (such as enabled, grayed out, checked, and so on).

The following example code uses **MODIFYMENUSTRINGQQ** to modify the menu string for the fourth item in the first menu (the File menu by default) to `Tile Windows`, it uses **MODIFYMENUROUTINEQQ** to change the callback routine called if the item is selected to `WINTILE`, and uses **MODIFYMENUFLAGSQQ** to put a check mark next to the menu item:

```
  status = MODIFYMENUSTRINGQQ( 1, 4, 'Tile Windows'C)
  status = MODIFYMENUROUTINEQQ( 1, 4, WINTILE)
  status = MODIFYMENUFLAGSQQ( 1, 4, $MENUCHECKED)
```

Creating a Menu List of Available Child Windows

By default, the Windows menu contains a list of all open child windows in your QuickWin applications. SETWINDOWMENUQQ changes the menu which lists the currently open child windows to the menu you specify. The list of child window names is appended to the end of the menu you choose and deleted from any other menu that previously contained it. For example:

```
   USE DFLIB
   LOGICAL(4) status
   ...
 ! Append list of open child windows to menu 1 (the default File menu)
   status = SETWINDOWMENUQQ(1)
```

Simulating Menu Selections

CLICKMENUQQ simulates the effect of clicking or selecting a menu command from the Window menu. The QuickWin application behaves as though the user had clicked or selected the command. The following code fragment simulates the effect of selecting the Tile item from the Window menu:

```
  USE DFLIB
  INTEGER(4) status
  status = CLICKMENUQQ(QWIN$TILE)
```

Items from the Window menu can be specified in **CLICKMENUQQ**. Other predefined routines such as WINFULLSCREEN and WINSIZETOFIT (see the callback subroutine names listed in APPENDMENUQQ) can be invoked by calling **CLICKMENUQQ** with an argument containing the **LOC** intrinsic function before the callback routine name. For example, the following program calls WINSIZETOFIT:

```
! Some of the callback subroutine names listed in APPENDMENUQQ may not
! work or be useful in this context, but they will be "called".
! Run the program and note how the scroll bars disappear
      use dflib
      integer*4 result
      character*1 ch
      print *,'type a character'
      read(*,*) ch
      result = clickmenuqq(loc(WINSIZETOFIT))
      print *,'type a character'
      read(*,*) ch
      end
```

Changing Status Bar and State Messages

Any string QuickWin produces can be changed by calling **SETMESSAGEQQ** with the appropriate message ID. Unlike other QuickWin message functions, **SETMESSAGEQQ** uses regular Fortran strings, not null-terminated C strings. For example, to change the PAUSED state message to `I am waiting`:

```
  USE DFLIB
  CALL SETMESSAGEQQ('I am waiting', QWIN$MSG_PAUSED)
```

This function is useful for localizing your QuickWin applications for countries with different native languages. A list of message IDs is given in SETMESSAGEQQ in the *Language Reference*.

Displaying Message Boxes

MESSAGEBOXQQ causes your program to display a message box. You can specify the message the box displays and the caption that appears in the title bar. Both strings must be null-terminated C strings. You can also specify the type of message box. Box types are symbolic constants defined in DFLIB.MOD, and can be combined by means of the IOR intrinsic function or the .OR. operator. The available box types are listed under MESSAGEBOXQQ in the *Language Reference*. For example:

```
 USE DFLIB
 INTEGER(4) response
 response = MESSAGEBOXQQ('Retry or Cancel?'C, 'Smith Chart   &
& Simulator'C, MB$RETRYCANCELQWIN .OR. MB$DEFBUTTON2)
```

Defining an About Box

The ABOUTBOXQQ function specifies the message displayed in the message box that appears when the user selects the About command from a QuickWin application's Help menu. (If your program does not call **ABOUTBOXQQ**, the QuickWin run-time library supplies a default string.) The message string must be a null-terminated C string. For example:

```
USE DFLIB
INTEGER(4) status
status = ABOUTBOXQQ ('Sound Speed Profile Tables Version 1.0'C)
```

Using Custom Icons

The QuickWin run-time library provides default icons that appear when the user minimizes the application's frame window or its child windows. You can add custom-made icons to your executable files, and Windows will display them instead of the default icons.

To add a custom child window icon to your QuickWin program:

1. Select Resource from the Insert menu in the visual development environment. Select Icon from the list that appears. The screen will become an icon drawing tool.

2. Draw the icon. (For more information about using the Graphics Editor in the visual development environment, see "Resource Editors, Graphics Editor" in the *Visual C++ User's Guide*.)

   – or –

   If your icon already exists (for example, as a bitmap) and you want to import it, not draw it, select Resource from the Insert menu, then select Import from the buttons in the Resource dialog. You will be prompted for the file containing your icon.

3. Name the icon. The frame window's icon must have the name "frameicon," and the child window's icon must have the name "childicon." These names must be entered as strings into the Icon Properties dialog box.

   To display the Icon Properties dialog box, double-click in the icon editor area outside the icon's grid or press ALT+ENTER.

   In the ID field on the General tab of Icon Properties dialog box, type over the default icon name with "frameicon" or "childicon." You must add the quotation marks to the text you type in order to make the name be interpreted as a string.

   Your icon will be saved in a file with the extension .ICO.

4. Create a script file to hold your icons. Select File/Save As. You will be prompted for the name of the script file that will contain your icons. Name the script file. It must end with the extension .RC; for example, myicons.rc. Using this method, the icons and their string values will be automatically saved in the script file. (Alternatively, you can create a script file with any editor and add the icon names and their string values by hand.)

5. Add the script file to the project that contains your QuickWin application. Select Build and the script file will be built into the application's executable. (The compiled script file will have the extension .RES.)

When you run your application, the icon you created will take the place of the default child or frame icon. Your custom icon appears in the upper-left corner of the window frame. When you minimize the window, the icon appears on the left of the minimized window bar.

Using a Mouse

Your applications can detect and respond to mouse events, such as left mouse button down, right mouse button down, or double-click. Mouse events can be used as an alternative to keyboard input or for manipulating what is shown on the screen.

QuickWin provides two types of mouse functions:

1. *Event-based functions*, which call an application-defined callback routine when a mouse click occurs
2. *Blocking (sequential) functions*, which provide blocking functions that halt an application until mouse input is made

The mouse is an asynchronous device, so the user can click the mouse anytime while the application is running (mouse input does not have to be synchronized to anything). When a mouse-click occurs, Windows sends a message to the application, which takes the appropriate action. Mouse support in applications is most often event-based, that is, a mouse-click occurs and the application does something.

However, an application can use blocking functions to wait for a mouse-click. This allows an application to execute in a particular sequential order and yet provide mouse support. QuickWin performs default processing based on mouse events.

To change the shape of the mouse cursor, use the SETMOUSECURSOR routine.

Event-Based Functions

The QuickWin function REGISTERMOUSEEVENT registers the routine to be called when a particular mouse event occurs (left mouse button, right mouse button, double-click, and so on). You define what events you want it to handle and the routines to be called if those events occur. UNREGISTERMOUSEEVENT unregisters the routines so that QuickWin doesn't call them but uses default handling for the particular event.

By default, QuickWin typically ignores events except when mouse-clicks occur on menus or dialog controls. Note that no events are received on a minimized window. A window must be restored or maximized in order for mouse events to happen within it.

For example:

```
USE DFLIB
INTEGER(4) result
OPEN (4, FILE= 'USER')
...
result = REGISTERMOUSEEVENT (4, MOUSE$LBUTTONDBLCLK, CALCULATE)
```

This registers the routine CALCULATE, to be called when the user double-clicks the left mouse button while the mouse cursor is in the child window opened as unit 4. The symbolic constants available to identify mouse events are:

Mouse Event [1]	**Description**
MOUSE$LBUTTONDOWN	Left mouse button down
MOUSE$LBUTTONUP	Left mouse button up
MOUSE$LBUTTONDBLCLK	Left mouse button double-click

MOUSE$RBUTTONDOWN	Right mouse button down
MOUSE$RBUTTONUP	Right mouse button up
MOUSE$RBUTTONDBLCLK	Right mouse button double-click
MOUSE$MOVE	Mouse moved

[1] For every BUTTONDOWN and BUTTONDBLCLK event there is an associated BUTTONUP event. When the user double-clicks, four events happen: BUTTONDOWN and BUTTONUP for the first click, and BUTTONDBLCLK and BUTTONUP for the second click. The difference between getting BUTTONDBLCLK and BUTTONDOWN for the second click depends on whether the second click occurs in the double-click interval, set in the system's CONTROL PANEL/MOUSE.

To unregister the routine in the preceding example, use the following code:

```
result = UNREGISTERMOUSEEVENT (4, MOUSE$LBUTTONDBLCLK)
```

If **REGISTERMOUSEEVENT** is called again without unregistering a previous call, it overrides the first call. A new callback routine is then called on the specified event.

The callback routine you create to be called when a mouse event occurs should have the following prototype:

```
INTERFACE
  SUBROUTINE MouseCallBackRoutine (unit, mouseevent, keystate, &
   & MouseXpos,MouseYpos)
     INTEGER unit
     INTEGER mouseevent
     INTEGER keystate
     INTEGER MouseXpos
     INTEGER MouseYpos
  END SUBROUTINE
END INTERFACE
```

The `unit` parameter is the unit number associated with the child window where events are to be detected, and the `mouseevent` parameter is one of those listed in the preceding table. The `MouseXpos` and the `MouseYpos` parameters specify the x and y positions of the mouse during the event. The `keystate` parameter indicates the state of the shift and control keys at the time of the mouse event, and can be any ORed combination of the following constants:

Keystate Parameter	Description
MOUSE$KS_LBUTTON	Left mouse button down during event
MOUSE$KS_RBUTTON	Right mouse button down during event
MOUSE$KS_SHIFT	Shift key held down during event
MOUSE$KS_CONTROL	Control key held down during event

QuickWin callback routines for mouse events should do a minimum of processing and then return. While processing a callback, the program will appear to be non-responsive because messages are not being serviced, so it is important to return quickly. If more processing time is needed in a callback, another thread should be started to perform this work; threads can be created by calling the Win32 API CreateThread. (For more information on creating and using threads, see Creating Multithread Applications.) If a callback routine does not start a new thread, the callback will not be re-entered until it is done processing.

Note: In event-based functions, there is no buffering of events. Therefore, issues such as multithreading and synchronizing access to shared resources must be addressed. To avoid multithreading problems, use blocking functions rather than event-based functions. Blocking functions work well in applications that proceed sequentially. Applications where there is little sequential flow and the user jumps around the application are probably better implemented as event-based functions.

Blocking (Sequential) Functions

The QuickWin blocking function WAITONMOUSEEVENT blocks execution until a specific mouse input is received. This function is similar to INCHARQQ, except that it waits for a mouse event instead of a keystroke.

For example:

```
   USE DFLIB
   INTEGER(4) mouseevent, keystate, x, y, result
   ...
   mouseevent = MOUSE$RBUTTONDOWN .OR. MOUSE$LBUTTONDOWN
   result = WAITONMOUSEEVENT (mouseevent, keystate, x , y) ! Wait
 ! until right or left mouse button clicked, then check the keystate
 ! with the following:
   if ((MOUSE$KS_SHIFT .AND. keystate) == MOUSE$KS_SHIFT) then      &
  & write (*,*) 'Shift key was down'
   if ((MOUSE$KS_CONTROL .AND. keystate) == MOUSE$KS_CONTROL) then  &
  & write (*,*) 'Ctrl key was down'
```

Your application passes a mouse event parameter, which can be any ORed combination of mouse events, to **WAITONMOUSEEVENT**. The function then waits and blocks execution until one of the specified events occurs. It returns the state of the Shift and Ctrl keys at the time of the event in the parameter keystate, and returns the position of the mouse when the event occurred in the parameters x and y.

A mouse event must happen in the window that had focus when **WAITONMOUSEEVENT** was initially called. Mouse events in other windows will not end the wait. Mouse events in other windows cause callbacks to be called for the other windows, if callbacks were previously registered for those windows.

Default QuickWin Processing

QuickWin performs some actions based on mouse events. It uses mouse events to return from the FullScreen mode and to select text and/or graphics to copy to the Clipboard. Servicing the mouse event functions takes precedence over return from FullScreen mode. Servicing mouse event functions does not take precedence over Cut/Paste selection modes. Once selection mode is over, processing of mouse event functions resumes.

QuickWin Programming Precautions

Two features of QuickWin programming need to applied thoughtfully to avoid non-responsive programs that halt an application while waiting for a process to execute or input to be entered in a child window. The two features are described in the topics:

- Blocking Procedures
- Callback Routines

Blocking Procedures

Procedures that wait for an event before allowing the program to proceed, such as READ or WAITONMOUSEEVENT, both of which wait for user input, are called *blocking procedures* because they block execution of the program until the awaited event occurs. QuickWin child processes can contain multiple callback routines; for example, a different routine to be called for each menu selection and each kind of mouse-click (left button, right button, double-click, and so on).

Problems can arise when a process and its callback routine, or two callback routines within the same process, both contain blocking procedures. This is because each QuickWin child process supports a primary and secondary thread.

As a result of selecting a menu item, a menu procedure may call a blocking procedure, while the main thread of the process has also called a blocking procedure. For example, say you have created a file menu, which contains an option to LOAD a file. Selecting the LOAD menu option calls a blocking function that prompts for a filename and waits for the user to enter the name. However, a blocking call such as **WAITONMOUSEEVENT** can be pending in the main process thread when the user selects the LOAD menu option, so two blocking functions are initiated.

When QuickWin has two blocking calls pending, it displays a message in the status bar that corresponds to the blocking call first encountered. If there are further callbacks with other blocking procedures in the two threads, the status bar may not correspond to the actual input pending, execution can appear to be taking place in one thread when it is really blocked in another, and the application can be confusing and misleading to the user.

To avoid this confusion, you should try not to use blocking procedures in your callback routines. QuickWin will not accept more than one **READ** or INCHARQQ request through user callbacks from the same child window at one time. If one **READ** or **INCHARQQ** request is pending, subsequent **READ** or **INCHARQQ** requests will be ignored and -1 will be returned to the caller.

If you have a child window that in some user scenario might call multiple callback routines containing **READ** or **INCHARQQ** requests, you need to check the return value to make sure the request has been successful, and if not, take appropriate action, for example, request again.

This protective QuickWin behavior does not guard against multiple blocking calls through mouse selection of menu input options. As a general rule, using blocking procedures in callback routines is not advised, since the results can lead to program flow that is unexpected and difficult to interpret.

Callback Routines

All callback routines run in a separate thread from the main program. So, all multithread issues are in full force. In particular, sharing data, drawing to windows, and doing I/O must be properly coordinated and controlled. The Visual Fortran Sample POKER.F90 (in the `...\DF98\SAMPLES\QUICKWIN\POKER` folder) is a good example of how to control access to shared resources.

QuickWin callback routines, both for menu callbacks and mouse callbacks, should do a minimum of processing and then return. While processing a callback, the program will appear to be non-responsive because messages are not being serviced. This is why it is important to return quickly.

If more processing time is needed in a callback, another thread should be started to perform this work; threads can be created by calling the Win32 API CreateThread. (For more information on creating and using threads, see

Creating Multithread Applications.) If a callback routine does not start a new thread, the callback will not be reentered until it is done processing.

Simulating Nonblocking I/O

QuickWin does not accept unsolicited input. You get beeps if you type into an active window if no READ or GETCHARQQ has been done. Because of this, it is necessary to do a **READ** or **GETCHARQQ** in order for a character to be accepted. But this type of blocking I/O puts the program to sleep until a character has been typed.

In Fortran Console applications, PEEKCHARQQ can be used to see if a character has already been typed. However, **PEEKCHARQQ** does not work under Fortran QuickWin applications, since QuickWin has no console buffer to accept unsolicited input. Because of this limitation, **PEEKCHARQQ** cannot be used as it is with Fortran Console applications to see whether a character has already been typed.

One way to simulate **PEEKCHARQQ** with QuickWin applications is to add an additional thread:

- One thread does a **READ** or **GETCHARQQ** and is blocked until a character typed.
- The other thread (the main program) is in a loop doing useful work and checking in the loop to see if the other thread has received input.

For more information, see the Visual Fortran Samples PEEKAPP and PEEKAPP3 in the `...\DF98\SAMPLES\QUICKWIN` folder.

Creating Fortran DLLs

A dynamic-link library (DLL) contains one or more subprogram procedures (functions or subroutines) that are compiled, linked, and stored separately from the applications using them. Because the functions or subroutines are separate from the applications using them, they can be shared or replaced easily.

Like a static library, a DLL is an executable file. Unlike a static library where routines are included in the base executable image during linking, the routines in a DLL are loaded when an application that references that DLL is loaded (run time). A DLL can also be used as a place to share data across processes.

The advantages of DLLs include:

- You can change the functions in a DLL without recompiling or relinking the applications that use them, as long as the functions' arguments and return types do not change.

  This allows you to upgrade your applications easily. For example, a display driver DLL can be modified to support a display that was not available when your application was created.

- When general functions are placed in DLLs, the applications that share the DLLs can have very small executables.
- Multiple applications can access the same DLL.

  This reduces the overall amount of memory needed in the system, which results in fewer memory swaps to disk and improves performance.

- Common blocks or module data placed in a DLL can be shared across multiple processes.

To build a DLL in the visual development environment, specify the Fortran Dynamic-Link Library project type. On the command line, specify the /dll option.

You cannot make a QuickWin application into a DLL (see Using QuickWin) and QuickWin applications cannot be used with Fortran run-time routines in a DLL.

This section describes the following aspects of creating Fortran DLLs:

- Coding Requirements for Sharing Procedures in DLLs
- Coding Requirements for Sharing Data in DLLs
- Building and Using Dynamic-Link Libraries

Coding Requirements for Sharing Procedures in

DLLs

A dynamic-link library (DLL) contains one or more subprograms that are compiled, linked and stored separately from the applications using them.

Coding requirements include using the *c*DEC$ ATTRIBUTES DLLIMPORT and DLLEXPORT compiler directives. Variables and routines declared in the main program and in the DLL are not visible to each other unless you use DLLIMPORT and DLLEXPORT.

This section discusses aspects of sharing subprogram procedures (functions and subroutines) in a Fortran DLL.

To export and import each DLL subprogram:

1. Within your Fortran DLL, export each subprogram that will be used outside the DLL. Add a *c***DEC$ ATTRIBUTES** DLLEXPORT directive to declare that a function, subroutine, or data is being exported outside the DLL. For example:

```
SUBROUTINE ARRAYTEST(arr)
!DEC$ ATTRIBUTES DLLEXPORT :: ARRAYTEST
   REAL(4) arr(3, 7)
   INTEGER i, j
   DO i = 1, 3
      DO j = 1, 7
         arr (i, j) = 11.0 * i + j
      END DO
   END DO
END SUBROUTINE
```

2. Within your Fortran application, import each DLL subprogram. Add a *c***DEC$ ATTRIBUTES** DLLIMPORT directive to declare that a function, subroutine, or data is being imported from outside the current image. For example:

```
INTERFACE
   SUBROUTINE ARRAYTEST (rarray)
   !DEC$ ATTRIBUTES DLLIMPORT :: ARRAYTEST
      REAL rarray(3, 7)
   END SUBROUTINE ARRAYTEST
END INTERFACE
```

   The DLLEXPORT and DLLIMPORT options (for the *c*DEC$ ATTRIBUTES directive) define a DLL's interface.

   The DLLEXPORT property declares that functions or data are being exported to other images or DLLs, usually eliminating the need for a Linker module definition (.DEF) file to export symbols for the functions or subroutines declared with DLLEXPORT. When you declare a function, subroutine, or data with the DLLEXPORT property, it must be defined in the same module of the same program.

A program that uses symbols defined in another image (such as a DLL) must import them. The DLL user needs to link with the import LIB file from the other image and use the DLLIMPORT property inside the application that imports the symbol. The DLLIMPORT option is used in a declaration, not a definition, because you do not define the symbol you are importing.

3. Build the DLL and then build the main program, as described in Building and Using Dynamic-Link Libraries.

Fortran and C applications can call Fortran and C DLLs provided the calling conventions are consistent (see Programming with Mixed Languages, especially Visual Fortran/Visual C++ Mixed-Language Programs).

Visual Basic applications can also call Fortran functions and subroutines in the form of DLLs (see Programming with Mixed Languages, especially Calling Visual Fortran from Visual Basic).

For more information:

- About building DLLs, see Building and Using Dynamic-Link Libraries.
- On sharing either common block or module data in a DLL, see Coding Requirements for Sharing Data in DLLs.
- About importing and exporting subprograms using a Sample program, see the Visual Fortran Sample TLS in folder `...\Df98\Samples\Advanced\Win32`.

Coding Requirements for Sharing Data in DLLs

A dynamic-link library (DLL) is an executable file that can be used as a place to share data across processes.

Coding requirements include using the *c*DEC$ ATTRIBUTES DLLIMPORT and DLLEXPORT compiler directives. Variables and routines declared in the program and in the DLL are not visible to each another unless you use DLLIMPORT and DLLEXPORT.

When sharing data among multiple threads or processes, do the following:

- Declare the order, size, and data types of shared data consistently in the DLL and in all procedures importing the DLL exported data.
- If more than one thread or process can write to the common block simultaneously, use the appropriate features of the Windows operating system to control access to the shared data. Such features on Windows NT 4 and Windows 2000 systems include critical sections (for single process, multiple thread synchronization) and mutex objects (for multi-process

synchronization).

This section discusses:

- Exporting and Importing Common Block Data
- Exporting and Importing Data Objects in Modules

Exporting and Importing Common Block Data

Data and code in a dynamic-link library is loaded into the same address space as the data and code of the program that calls it. However, variables and routines declared in the program and in the DLL are not visible to one another unless you use the *c***DEC$ ATTRIBUTES** DLLIMPORT and DLLEXPORT compiler directives. These directives enable the compiler and linker to map to the correct portions of the address space so that the data and routines can be shared, allowing use of common block data across multiple images.

You can use DLLEXPORT to declare that a common block in a DLL is being exported to a program or another DLL. Similarly, you can use DLLIMPORT within a calling routine to tell the compiler that a common block is being imported from the DLL that defines it.

To export and import common block data:

1. Create a common block in the subprogram that will be built into a Fortran DLL. Export that common block with a *c***DEC$ ATTRIBUTES** DLLEXPORT directive, followed by the **COMMON** statement, associated data declarations, and any procedure declarations to be exported. For example:

```
!DEC$ ATTRIBUTES DLLEXPORT :: /X/
    COMMON /X/ C, B, A
    REAL C, B, A
    END
    ...
```

   If the Fortran DLL procedure contains only a common block declaration, you can use the **BLOCK DATA** statement:

```
    BLOCK DATA T
!DEC$ ATTRIBUTES DLLEXPORT :: /X/
    COMMON /X/ C, B, A
    REAL C, B, A
    END
```

   The Fortran procedure to be linked into a DLL can contain a procedure, such as the following:

```
   SUBROUTINE SETA(I)
!DEC$ ATTRIBUTES DLLEXPORT :: SETA, /X/
     COMMON /X/ C, B, A
     REAL C, B, A
```

```
     INTEGER I
     A = A + 1.
     I = I + 1
     WRITE (6,*) 'In SETA subroutine, values of A and I:' , A, I
     RETURN
   END SUBROUTINE
```

2. Refer to the common block in the main image with a *c***DEC$ ATTRIBUTES** DLLIMPORT directive, followed by the local data declarations and any procedure declarations defined in the exported DLL. For example:

```
   PROGRAM COMMONX
!DEC$ ATTRIBUTES DLLIMPORT:: SETA,  /X/
      COMMON /X/ C, B, A
      REAL C, B, A, Q
      EQUIVALENCE (A,Q)

    A = 0.
    I = 0
    WRITE (6,*) 'In Main program before calling SETA...'
    WRITE (6,*) 'values of A and I:' , A, I

    CALL SETA(I)
    WRITE (6,*) 'In Main program after calling SETA...'
    WRITE (6,*) 'values of A and I:' , Q, I

    A = A + 1.
    I = I + 1
    WRITE (6,*) 'In Main program after incrementing values'
 END PROGRAM COMMONX
```

3. Build the DLL and then build the main program, as described in Building and Using Dynamic-Link Libraries.

Exporting and Importing Data Objects in Modules

You can give data objects in a module the DLLEXPORT property, in which case the object is exported from a DLL.

When a module is used in other program units, through the USE statement, any objects in the module with the DLLEXPORT property are treated in the program using the module as if they were declared with the DLLIMPORT property. So, a main program that uses a module contained in a DLL has the correct import attributes for all objects exported from the DLL.

You can also give some objects in a module the DLLIMPORT property. Only procedure declarations in **INTERFACE** blocks and objects declared EXTERNAL or with *c*DEC$ ATTRIBUTES EXTERN can have the DLLIMPORT property. In this case, the objects are imported by any program unit using the module.

If you use a module that is part of a DLL and you use an object from that module that does not have the DLLEXPORT or DLLIMPORT property, the results are undefined.

For more information:

- On building a DLL, see Building and Using Dynamic-Link Libraries.
- On multithread programming, see Creating Multithread Applications.

Building and Using Dynamic-Link Libraries

A dynamic-link library is a collection of source and object code in the same manner as a static library. The differences between the two libraries are:

- The DLL requires an interface specification.
- The DLL is associated with a main project during execution, not during linking.

For more information, see:

Building Dynamic-Link Libraries

When you first create a DLL, you follow the general steps described in Defining Your Project. Select Fortran Dynamic-Link Library as the project type when you create a new project in the Microsoft visual development environment.

To debug a DLL, you must use a main program that calls the library routines (or references the data). From the Project Settings menu, choose the Debug tab. A dialog box is available for you to specify the executable for a debug session.

To build the DLL from the Microsoft visual development environment:

1. A Fortran DLL project is created like any other project, but you must specify Fortran Dynamic-Link Library as the project type (see Defining Your Project).
2. Add files to your Fortran DLL project (see Defining Your Project). Include the DLL Fortran source that exports procedures or data as a file in your project.
3. If your DLL exports data, for both the DLL and any image that references the DLL's exported data, consistently specify the project settings options in the Fortran Data category. In the Fortran Data compiler option category, specify the appropriate values for Common Element Alignment (common block data) and Structure Element Alignment (structures in a module). This

sets the /alignment option, which specifies whether padding is needed to ensure that exported data items are naturally aligned.

For example, in the case of a common block containing four-byte variables, in the Project Setting dialog box you might specify:

- Open the appropriate workspace
- From the Project menu, click Settings
- Click the Fortran tab
- Select the Fortran Data category
- In the Common Element Alignment box, specify 4.

4. If you need to specify linker options, use the Linker tab of the Project Settings dialog box.
5. Build your Fortran DLL project.

   The Microsoft visual development environment automatically selects the correct linker instructions for loading the proper run-time library routines (located in a DLL themselves). Your DLL is created as a multithread-enabled library. An import library (.LIB) is created for use when you link images that reference the DLL.

To build the DLL from the command line:

1. If you build a DLL from the command line or use an exported makefile, you must specify the /dll option. For example, if the Fortran DLL source code is in the file `f90arr.f90`, use the following command line:

   ```
   DF /dll f90arr.f90
   ```

   This command creates:

   - A DLL named `f90arr.dll`.
   - An import library, `f90arr.lib`, that you must link with applications that call your DLL.

   If you also specify /exe:*file* or /link /out:*file*, you name a .DLL rather than an .EXE file (the default file extension becomes *projectname*.DLL instead of *projectname*.EXE)

   The /dll option selects as the default the DLL run-time libraries to support multithreaded operation.

2. If your DLL will export data, the procedures must be compiled and linked consistently. Consistently use the same /alignment option for the DLL export procedure and the application that references (imports) it. The goal is to specify padding to ensure that exported data items are naturally

aligned, including common block data items and structure element alignment (structures in a module).
3. If you need to specify linker options, place them after the /link option on the DF command line.
4. Build the application.

   For example, if your DLL exports a common block containing four-byte variables, you might use the following command line (specify the /dll option):

   ```
   DF /align:commons /dll dllfile.for
   ```

   The /dll option automatically selects the correct linker instructions for loading the proper run-time library routines (located in a DLL themselves). Your DLL is created as a multithread-enabled library.

For more information, see:

- The DLL Build Output
- Checking the DLL Symbol Export Table
- Building Executables that Use DLLs
- DLL Sample Programs

The DLL Build Output

When a DLL is built, two library files are created:

- An import library (.LIB), which the linker uses to associate a main program with the DLL.
- The .DLL file containing the library's executable code.

Both files have the same basename as the library project by default.

Your library routines are contained in the file *projectname*.DLL located in the default directory for your project, unless you specified another name and location. Your import library file is *projectname*.LIB, located in the default directory for your project.

Checking the DLL Symbol Export Table

To make sure that everything that you want to be visible shows up in the export table, look at the export information of an existing DLL *file* by using QuickView in the Windows Explorer File menu or the following DUMPBIN command:

```
DUMPBIN /exports file.dll
```

Building Executables that Use DLLs

When you build the executable that imports the procedures or data defined in the DLL, you must link using the import library, check certain project settings or command-line options, copy the import library so the Linker can locate it, and then build the executable.

To use the DLL from another image:

1. Add the import .LIB file with its path and library name to the other image.

   In the visual development environment, add the .LIB import library file to your project. In the Project menu, click Add to project, then Files.

   On the command line, specify the .LIB file on the command line.

   The import .LIB file contains information that your program needs to work with the DLL.

2. If your DLL exports data, consistently use the same project settings options in the Fortran Data category /alignment option as was used to create the DLL. In the Fortran Data compiler option category, specify the appropriate values for Common Element Alignment (common block data) and Structure Element Alignment (structures in a module). This sets the /alignment option, which specifies whether padding is needed to ensure that imported data items are naturally aligned.
3. In the Project Settings dialog box (Fortran tab), make sure the type of libraries specified is consistent with that specified for the Fortran DLL.
4. If you need to specify linker options:
   - In the visual development environment, specify linker options in the Linker tab of the Project Settings dialog box.
   - On the DF command line, place linker options after the /link option.
5. Copy the DLL into your path.

   For an application to access your DLL, it must be located in a directory on the search path or in the same directory as the main project. If you have more than one program accessing your DLL, you can keep it in a convenient directory identified in the environment path. If you have several DLLs, you can place them all in the same directory to avoid adding numerous directories to the path specification.

   When changing your path specification on a Windows Me, Windows 98, or Windows 95 system, you must restart the operating system for the change to take effect. On a Windows NT 4 or Windows 2000 system, you should log out and back in after modifying the system path.

6. Build the image that references the DLL.

When using the visual development environment:

- Make sure you have added the import library (created when you built the DLL file) to the project by (click the FileView tab).
- Like building other projects in the visual development environment, use the Build menu items to create the executable (see Defining Your Project).

When using the command line:

- Specify the import library at the end of the command line.
- If your DLL exports data that will be used by the application being built, specify the same /alignment options that were used to build the DLL.
- If you are building a main application, omit the /dll option.
- When building a Fortran DLL that references another DLL, specify the /dll option.

For example, to build the main application from the command line that references 4-byte items in a common block defined in dllfile.dll:

```
DF /align:commons mainapp.f90 dllfile.lib
```

DLL Sample Programs

Visual Fortran provides Sample programs are installed in `...\Df98\SAMPLES\` when you request the Samples with a custom installation. You can copy the Samples folders from the `...\DF\SAMPLES\` folder on the Visual Fortran CD-ROM to your hard disk.

For an example of a DLL, see the Samples folder `...\DF98\SAMPLES\ADVANCED\WIN32\TLS`, which creates a DLL as a subproject. The subproject DLL is used in a second project.

Other Samples that use DLLs are folders in `...\DF98\SAMPLES\DLL\`. For example:

- The files associated with Sample DLLEXP2 are in the folder `...\DF98\SAMPLES\DLL\DLLEXP2\`. DLLEXP2 demonstrates how COMMON variables defined in a DLL can be shared between multiple programs. To build DLLEXP2, use the makefile.
- The Sample Loadexp1 shows how to dynamically load a DLL by using the LoadLibrary and GetProcAddress Win32 routines. The folder `...\DF98\SAMPLES\DLL\Loadexp1\` contains the source files and a project workspace file.

For a description of the Samples, see Visual Fortran Samples.

Creating Windows Applications

With Visual Fortran, you can build Fortran applications that are also fully-featured Windows applications. You can create full Windows applications that use the familiar Windows interface, complete with tool bars, pull-down menus, dialog boxes, and other features. You can include data entry and mouse control, and interaction with programs written in other languages or commercial programs such as Microsoft Excel.

With full Windows programming you can:

- Deliver Fortran applications with a Windows Graphical User Interface (GUI). GUI applications typically use at least the Graphic Device Interface (GDI) and USER32 Win32 routines.
- Access all available Windows GDI calls with your Fortran applications. GDI functions use a 32-bit coordinate system, allowing coordinates in the +/-2 GB range, and performs skewing, reflection, rotation and shearing.

Only the Fortran Windows project type provides access to the full set of Win32 routines needed to create GUI applications. Windows projects are much more complex than other kinds of Visual Fortran projects. Before attempting to use the full capabilities of Windows programming, you should be comfortable with writing C applications and should familiarize yourself with the Win32 Software Development Kit (SDK).

To build your application as a Fortran Windows application in the visual development environment, choose Fortran Windows Application from the list of Project types when you open a new project.

When using the command line, specify the /winapp option to search the commonly used link libraries.

Fortran Windows applications must use the DFWIN module or subset of DFWIN (see Calling Win32 Routines).

The following Fortran Windows application topics are discussed:

- Calling Win32 Routines
- Coding Requirements for Fortran Windows Applications
- Using Menus and Dialogs in SDI and MDI Fortran Windows Applications
- Sample Fortran Windows Applications
- Getting Help with Windows Programming

Calling Win32 Routines

This section describes general information about calling Win32 routines from Visual Fortran applications. It describes the following topics:

- A Comparison of Visual Fortran and Win32 Routines
- Including the Visual Fortran Interface Definitions for Win32 Routines
- Calling Win32 Routines Using the Visual Fortran Interface Definitions
- Special Naming Convention for Certain QuickWin and Win32 Graphics Routines
- Understanding Data Types Differences
- Examples Programs and Samples
- Additional Resources

A Comparison of Visual Fortran and Win32 Routines

Visual Fortran provides Fortran 95/90 language elements (such as intrinsic procedures and statements) that conform to the Fortran 95 standard. Visual Fortran also provides language elements that are language extensions, including library routines.

The library routines provided by Visual Fortran:

- Are intended to be called from the Fortran language. For example, character arguments are assumed to be Fortran character variables, not null-terminated C strings.
- May have QQ appended at the end of their names to differentiate them from equivalent Win32 operating system routines.
- Are described in the Visual Fortran *Language Reference* online documentation, in the A to Z Reference. The routine description lists the appropriate **USE** statement needed to include the interface definitions, such as **USE DFLIB**.
- Call appropriate Windows system (Win32) routines provided with the operating system.
- Are specific to Windows systems (one exception: most of the Visual Fortran Portability Library routines exist on most U*X systems).

In contrast, the Win32 Application Programming Interface (API) routines provided by the Windows operating system:

- Are intended to be called from the C language. For example, character arguments are assumed to be null-terminated C strings.

  However, Visual Fortran provides interface block definitions that simplify calling Win32 routines from Visual Fortran (such as allowing you to specify Fortran data arguments as being passed by reference). To obtain these interface definitions, add the **USE DFWIN** line to your program (explained below).

- Often have multiple words appended together in their names, such as GetSystemTime.
- Are described in the Platform SDK online documentation. To look up a specific routine, use the Index or Search tabs in HTML Help viewer. The calling format is listed near the top of the page, followed by a description of the routine's arguments. The QuickInfo at the bottom of the Win32 routine documentation page lists the import library needed.
- Are also specific to Windows operating systems.

There are many groups of Win32 routines (see the Platform SDK and other resources). Win32 routines provide sophisticated window management, memory management, graphics support, threading, security, and networking.

You can access many Win32 routines from any Fortran application, including Fortran Console and Fortran QuickWin applications. Only the Fortran Windows application project type provides access to the full set of Win32 routines needed to create GUI applications.

Fortran Console applications are text-only applications. Fortran QuickWin applications allow you to build Windows style applications easily, but access only a small subset of the available Win32 API features. (Fortran QuickWin applications also allow you to use graphics.) For differences between Fortran QuickWin and Fortran Windows applications, see Comparing QuickWin with Windows-Based Applications.

Including the Visual Fortran Interface Definitions for Win32 Routines

Visual Fortran provides interface definitions for both the Visual Fortran library routines and nearly all of the Win32 API routines in the standard include directory:

```
...\DF98\INCLUDE\
```

To include the Win32 interface definitions, do one of the following:

1. Add the statement **USE DFWIN** to include all Win32 API routine definitions.

   The **USE DFWIN** statement makes all parameters and interfaces for most Windows routines available to your Visual Fortran program. Any program or subprogram that uses the Windows features can include the statement **USE DFWIN**, which is needed in each subprogram that makes graphics calls.

   Add the **USE** statement before any declaration statements (such as **IMPLICIT NONE** or **INTEGER**) or any other modules containing declaration statements.

2. You can limit the type of parameters and interfaces for Windows applications to make compilation times faster. To do this, include only the subsets of the Win32 API needed in multiple USE statements (see the file `...\DF98\INCLUDE\DFWIN.F90`).

   To locate the specific libraries for the routines being called, view the QuickInfo at the bottom of the routine page in the Platform SDK documentation, which lists the import library name. For example, to call only GetSystemTime, you need the interface definitions provided in kernel32.mod (binary form). To do this, add the following USE statement:

   ```
   USE KERNEL32
   ```

   If you want to further minimize compile time, add the ONLY keyword to the USE statement. For example:

   ```
   USE KERNEL32, only: GetSystemTime, GetLastError
   ```

Calling Win32 Routines Using the Visual Fortran Interface Definitions

To call the appropriate Win32 routine after including the Visual Fortran interface definitions, follow these guidelines:

1. Examine the documentation for the appropriate routine in the Platform SDK (for example GetSystemTime) to obtain the following information:
   - The number and order of arguments. You will need to declare and initialize each argument variable using the correct data type. In the case of the GetSystemTime routine, a structure (derived type) is passed by reference.

     If character arguments are present, add a null character as a terminator to the character variable before calling the Win32 routine.

   - Whether the routine returns a result (a function) or not (subroutine). For example, the GetSystemTime routine calling format starts with VOID, so this routine should be called as a subroutine with a **CALL** statement.

2. If you are not sure about the data type of arguments or its function return value, you can examine the interface definitions in the appropriate .F90 file in `...\DF98\INCLUDE\`. For example, to view the interface definition for GetSystemTime:
   1. In a text editor (such as Notepad), open the file kernel32.f90 from `...\DF98\INCLUDE\`.

2. Search (or Find) the routine name (such as GetSystemTime)
3. View the interface definition and copy-and-paste parts of it into your source file text editor window.

3. If one of the arguments is a structure, you should look up the definition in DFWINTY.F90 in `...\DF98\INCLUDE\`. For example, to view the data type definition for the T_SYSTEMTIME type used in GetSystemTime:
   1. In a text editor (such as Notepad), open the file DFWINTY.F90 from `...\DF98\INCLUDE\`.
   2. Search (or Find) the data type name (such as T_SYSTEMTIME).
   3. View the data type definition and copy-and-paste parts of it into your source file text editor window. Note the defined field names for later use.
   4. Define a variable name to use the derived-type definition in your program, such as:

      ```
      TYPE (T_SYSTEMTIME) MYTIME
      ```

   5. Use the variable definition to call the Win32 routine. For example, the completed program follows:

      ```
       !  Getsystime.f90 file, shows how to call a Win32 routine
       !
       ! Since the only routine called is GetSystemTime, only include
       ! interface definitions from kernel32.mod instead of all modules
       ! included by dfwin.f90. Type definitions are defined in DFWINTY,
       ! which is used within KERNEL32.

        PROGRAM Getsystime

         USE KERNEL32

         TYPE (T_SYSTEMTIME) MYTIME

         CALL GetSystemTime(MYTIME)

         WRITE (*,*) 'Current UTC time hour and minute:', Mytime.wHour, Mytime.

        END PROGRAM
      ```

      You might create a new Fortran Console (or QuickWin) application project, add the code shown above as a source file, build it, and view the result.

Special Naming Convention for Certain QuickWin and Win32 Graphics Routines

Most QuickWin routines have a QQ appended to their name ito differentiate them from equivalent Win32 operating system routines. However, a small group of QuickWin graphics routines have the same name as the Win32 routines, causing a potential naming conflict if your program unit includes both **USE DFLIBS** (which includes QuickWin routine interface definitions) and **USE DFWIN** (which includes Win32 API routine interface definitions).

The QuickWin routines perform the same functions as the SDK routines but take a unit number, or use the unit in focus at the time of call, instead of taking a device context (DC) as one of their arguments.

To handle this situation, a special MSFWIN$ prefix is used for the Win32 routines. These prefixed names must be used even if you only specify **USE DFWIN**.

For example, Rectangle is a QuickWin routine, not a Win32 SDK routine, and you must use the name MSFWIN$Rectangle to refer to the SDK routine:

QuickWin Routine	**Win32 API Routine**
ARC	MSFWIN$Arc
ELLIPSE	MSFWIN$Ellipse
FLOODFILL	MSFWIN$FloodFill
GETBKCOLOR	MSFWIN$GetBkColor
GETPIXEL	MSFWIN$GetPixel
GETTEXTCOLOR	MSFWIN$GetTextColor
LINETO	MSFWIN$LineTo
PIE	MSFWIN$Pie
POLYGON	MSFWIN$Polygon
RECTANGLE	MSFWIN$Rectangle
[1]	MSFWIN$SelectPalette
SETBKCOLOR	MSFWIN$SetBkColor
SETPIXEL	MSFWIN$SetPixel
SETTEXTCOLOR	MSFWIN$SetTextColor

[1] There is no longer a QuickWin routine named SELECTPALLETE.

Understanding Data Type Differences

The files referenced by the DFWIN module are a Fortran version (a subset) of the Win32 WINDOWS.H header file. The correspondence of data types is given in the following table:

Win32 Data Type	Equivalent Fortran Data Type
BOOL, BOOLEAN	LOGICAL(4)
BYTE	BYTE
CHAR, CCHAR, UCHAR	CHARACTER
COLORREF	INTEGER(4)
DWORD, INT, LONG, ULONG	INTEGER(4)
SHORT, USHORT, WORD	INTEGER(2)
FLOAT	REAL(4)
All Handles	INTEGER(4)
All Pointers (LP*, P*)	INTEGER(4) (Integer Pointers)

Other notes about equivalent data types for arguments:

- If an argument is described in the Platform SDK documentation as a pointer, then the corresponding Fortran interface definition of that argument would have the REFERENCE property (see the *c*DEC$ ATTRIBUTES directive). Older interface definitions use the Compaq Fortran pointer data type and pass the address of the argument.
- Pointer arguments are currently 32-bit (4 bytes) in length. A future version of the Windows operating system will support 64-bit (8-byte) pointer arguments.
- Be aware that Fortran character variables need to be null-terminated. This code shows the extension of using the null-terminator for the string in the Fortran **DATA** statement (see C Strings):

  ```
  DATA forstring /'This is a null-terminated string.'C/
  ```

  You can also use the CHAR intrinsic:

  ```
  character(LEN=32) forstring
  forstring= "Courier New" // CHAR(0)
  ```

The structures in WINDOWS.H have been converted to derived types in DFWINTY. Unions in structures are converted to union/maps within the derived type. Names of components are unchanged. Bit fields are converted to Fortran's INTEGER(4). Functions accessing bit fields are contained in the DFWIN.F90 module with names of the form:

StructureName$BitfieldName

These bit field functions take an integer argument and return an integer. All bit fields are unsigned integers. The following shows the WINDOWS.H definition. It is followed by an example program where Win32 structures are represented as Fortran derived types.

WINDOWS.H Definition

```
typedef struct _LDT_ENTRY {
  WORD LimitLow;
  WORD BaseLow;
  union {
     struct {
        BYTE BaseMid;
        BYTE Flags1;
        BYTE Flags2;
        BYTE BaseHi;
     } Bytes;

     struct {
        DWORD BaseMid : 8;
        DWORD Type : 5;
        DWORD Opl : 2;
        DWORD Pres : 1;
        DWORD LimitHi : 4;
        DWORD Sys : 1;
        DWORD Reserved_0 : 1;
        DWORD Default_Big : 1;
        DWORD Granularity : 1;
        DWORD BaseHi : 8;
     } Bits;
  } HighWord;
 } LDT_ENTRY, *PLDT_ENTRY;
```

Note that `_LDT_ENTRY` and `PLDT_ENTRY` do not exist in the Fortran definition. Also note that `Bits.xxx` is not the same as the C version. In the Fortran case, the bit field functions must be used. For example, the C variable `yyy.HighWord.Bits.BaseHi` is represented in Fortran by LDT_ENTRY$BaseHi (ldtentry%HighWord%bits).

The following Fortran example shows the use of the corresponding Fortran data definitions and the use of a bit extraction utility routine:

```
Program Test
    type T_LDT_ENTRY$HIGHWORD_BYTES
       sequence
       BYTE  BaseMid
       BYTE  Flags1
```

```
      BYTE  Flags2
      BYTE  BaseHi
   end type T_LDT_ENTRY$HIGHWORD_BYTES

   type  T_LDT_ENTRY$HIGHWORD
      sequence
      union
         map
            type (T_LDT_ENTRY$HIGHWORD_BYTES)  Bytes
         end map
         map
            integer(4)  Bits
         end map
      end union
   end type T_LDT_ENTRY$HIGHWORD

   type T_LDT_ENTRY
      sequence
      integer(2) LimitLow
      integer(2) BaseLow
      type (T_LDT_ENTRY$HIGHWORD)  HighWord
   end type T_LDT_ENTRY

type(T_LDT_ENTRY) ldtentry

integer(4) thebits

external LDT_ENTRY$BaseHi
integer(4) LDT_ENTRY$BaseHi

ldtentry%HighWord%bits = #ABFFFFFF

thebits = LDT_ENTRY$BaseHi(ldtentry%HighWord%bits)
write(*,'(Z)') thebits
end program Test

integer(4) function LDT_ENTRY$BaseHi (Bits)
integer(4)   Bits
   LDT_ENTRY$BaseHi = IAND(ISHFT(bits,-24),#FF)
end function LDT_ENTRY$BaseHi
```

In addition to using the **TYPE** statement, you can use the **STRUCTURE** statement as shown by the following example. If you have embedded data types, the data type definitions are easier to read. Also, selecting the components is more natural. For example:

```
  program struct
 STRUCTURE /T_LDT_ENTRY/
    integer(2) LimitLow
    integer(2) BaseLow
    UNION
       MAP
         STRUCTURE /f_Bytes/ Bytes
            BYTE  BaseMid
            BYTE  Flags1
            BYTE  Flags2
            BYTE  BaseHi
         END STRUCTURE
       END MAP

       MAP
         STRUCTURE /f_Bits/ Bits
```

```
            INTEGER(4) Bits
        END STRUCTURE
      END MAP
   END UNION
END STRUCTURE

type(T_LDT_ENTRY) ldtentry

ldtentry%Bits%Bits = #7f6f5f4f
write(*,'(8Z)') ldtentry%Bits%Bits
write(*,'(8Z)') ldtentry%Bytes%BaseMid

end program
```

The expected program output follows:

```
7F6F5F4F
 4F
```

You can create a data object defined by a STRUCTURE statement in two ways, by using one of the following:

- `type(T_LDT_ENTRY) ldtentry`
- `RECORD /T_LDT_ENTRY/ ldtentry`

The example program shows how to access a field in a structured data object, for example:

```
I4=ldtentry%Bits%Bits
```

Examples Programs and Samples

Visual Fortran provides many Sample programs that show Fortran Windows applications that call Win32 routines, such as the following:

- Fortran Console applications in the folder `...\Df98\Misc`, such as Console and Forprint.
- Fortran QuickWin applications in the folder `...\Df98\QuickWin`, such as Conapp, Cleanwin, and Testscrl.
- Fortran Windows applications the folder `...\Df98\Advanced\Win32`, such as Generic and Bounce.

Additional Resources

For more information about Win32 API routines and Windows programming, see the following:

- *Platform SDK* online HTML Help title
- *Microsoft Win32 Developer's Reference Library* by David Iseminger (Microsoft Press)
- *Programming Windows* by Charles Petzold (Microsoft Press)

- *Windows NT Win32 API SuperBible* by Richard Simon (Waite Group Press)
- *Win32 Programming* by Brent Rector and Joseph Newcomer (Addison-Wesley)
- *Win32 System Programming* by Johnson Hart (Addison-Wesley)

Visual Fortran provides an online bookstore that lists suggested titles:

1. Open the Visual Fortran home page (http://www.compaq.com/fortran)
2. Click Bookstore in the left margin
3. Click the link to the Compaq Fortran Online Bookstore
4. Click the link for the appropriate area of interest, such as Win32
5. View the descriptions of the appropriate books

Coding Requirements for Fortran Windows Applications

This section contains the following topics:

- General Coding Requirements: WinMain Function and USE Statements
- Code Generation Options Using the Fortran Windows Application Wizard
- Single Document Interface (SDI) or Multiple Document Interface (MDI) Applications
- Dialog-Based Applications

General Coding Requirements: WinMain Function and USE Statements

Coding requirements for Fortran Windows applications include (in the following order):

1. WinMain function declaration and interface

   The WinMain function declaration and interface are required for Windows Graphical User Interface (GUI) applications (typically use at least the GDI and USER32 Win32 routines). An interface block for the function declaration can be provided. On ia32 systems, the following function must be defined by the user:

```
      INTEGER(4) function WinMain ( hInstance, hPrevInstance, &
     &          lpszCmdLine, nCmdShow )
!DEC$ ATTRIBUTES STDCALL, ALIAS:'_WinMain@16' :: WinMain
           INTEGER(4), INTENT(IN) :: hInstance, hPrevInstance
           INTEGER(4), INTENT(IN) :: lpszCmdLine
           INTEGER(4), INTENT(IN) :: nCmdShow
```

   In a program that includes a WinMain function, no program unit can be identified as the main program with the **PROGRAM** statement.

2. The statement **USE DFWIN** or other appropriate **USE** statements

   The **USE DFWIN** statement makes all parameters and interfaces for nearly all Windows public routines available to your Visual Fortran program. Any program or subprogram that uses the Windows features must include the statement **USE DFWIN**, which must appear in each subprogram that makes graphics calls, before any declaration statements (such as **IMPLICIT NONE** or **INTEGER**) or any other modules containing declaration statements.

   If you want to limit the type of parameters and interfaces for Windows applications or if unresolved references occur when linking your Fortran Windows application, see Calling Win32 Routines.

3. Data declarations for the WinMain function arguments.

4. Application-dependent code (other **USE** statements, variable declarations, and then executable code).

For example, the first lines of the Visual Fortran Sample named Generic uses the following free-form source code and conditional ia32 and ia64 code:

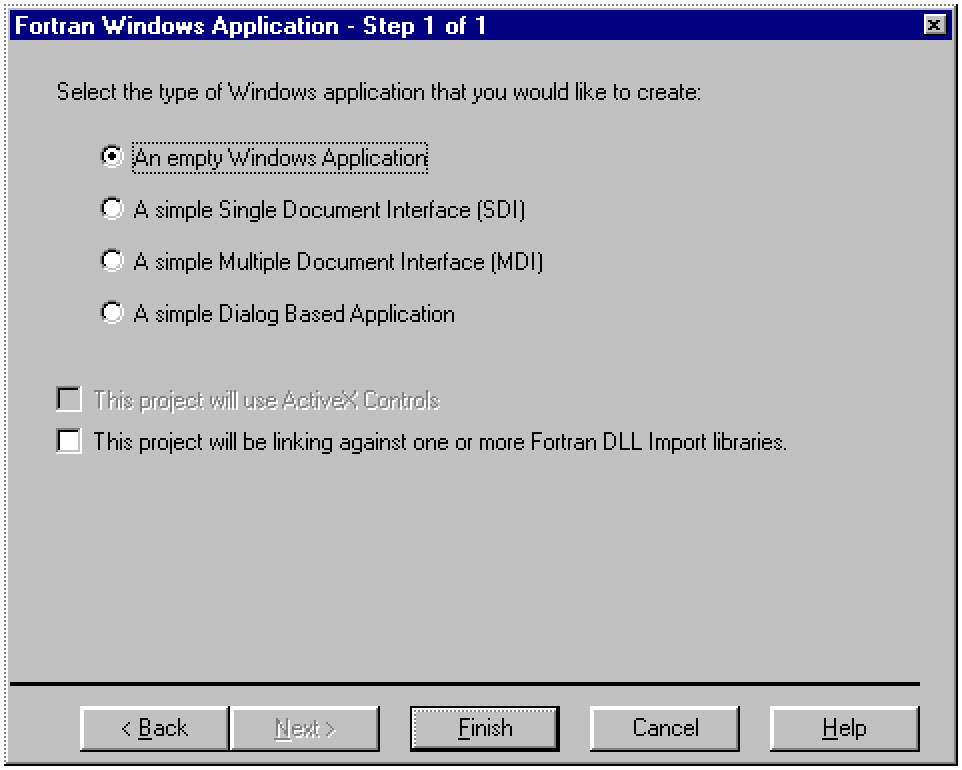
```
integer function WinMain( hInstance, hPrevInstance, lpszCmdLine, nCmdShow )
!DEC$ IF DEFINED(_M_IX86)
!DEC$ ATTRIBUTES STDCALL, ALIAS : '_WinMain@16' :: WinMain
!DEC$ ELSE
!DEC$ ATTRIBUTES STDCALL, ALIAS : 'WinMain' :: WinMain
!DEC$ ENDIF
use dfwin

integer hInstance
integer hPrevInstance
integer nCmdShow
integer lpszCmdLine
.
.
.
```

This Sample uses the IF Directive Construct and a predefined preprocessor symbol _M_IX86 to generate portable conditional code. For a description of predefined preprocessor symbols (such as _M_IX86 and _M_IA64), see the /define compiler option.

DFWIN.F90 includes a Fortran version (a subset) of the Win32 WINDOWS.H header file (see Calling Win32 Routines).

Code Generation Options Using the Fortran Windows Application Wizard

When you create a project with the Fortran Windows Application project type, the Fortran Windows Application Wizard (AppWizard) appears, allowing you to select whether the new project being created will have source code, type of tutorial source code, and specify other options:



If selected, you can specify whether the source file will contain template-like source statements typically used by one of the Fortran Windows applications subtypes:

- Single document interface (SDI) or multiple document interface (MDI) applications
- Dialog-based applications

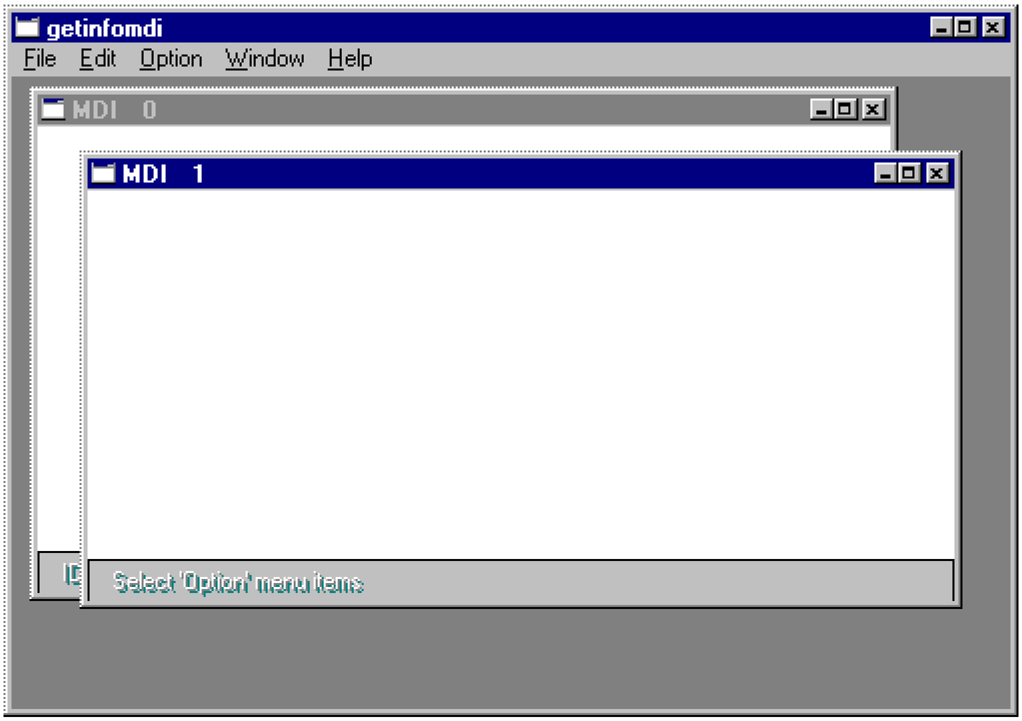
If your application (SDI, MDI, or dialog-based) will use ActiveX controls in a dialog box, if you check the box labeled "This project will use ActiveX controls," the Fortran Windows AppWizard will add additional template code for supporting ActiveX controls in your dialog boxes.

To select project options that request that the project be linked against dynamic-link libraries (instead of static libraries), click the check box labeled "This project will be linking against one or more Fortran DLL Import libraries."

Single Document Interface (SDI) or Multiple Document Interface (MDI) Applications

Creating these applications requires advanced programming expertise and knowledge of the Win32 routines API. Such applications call certain library routines and requires the statement USE DFWIN and usually USE DFLIB. SDI applications display a single window, whereas MDI application can display multiple windows (a main frame window with one or more child windows that appear within the frame window).

For example, select the MDI option from the Fortran AppWizard screen. After you build and run the application (without changing the source files), the following screen might appear after you create two child window by clicking New from the File menu twice:



If you selected the SDI option from the Fortran AppWizard screen and built and ran the application, you could not create child windows within the main window.

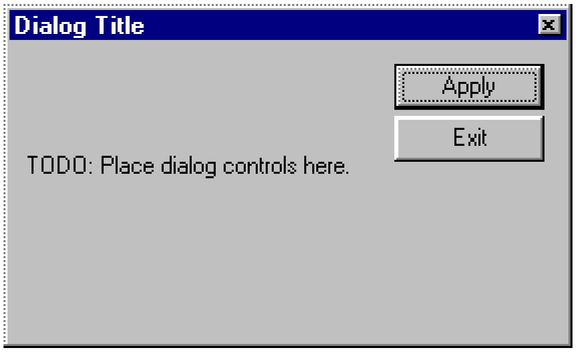
For more information:

- On using menus and dialogs from SDI and MDI Fortran Windows applications, see Using Menus and Dialogs in SDI and MDI Fortran Windows Applications
- About SDI and MDI Samples that use the Fortran Windows project type, see Sample Fortran Windows Applications.

Dialog-Based Applications

Dialog applications use a dialog box for the application's main window. Creating these applications requires some knowledge of the Win32 routines API, but considerably less than for a SDI or MDI application. These applications call certain Visual Fortran library routines and requires the statements **USE DFWIN** and **USE DFLOGM**. Dialog-based applications usually do not have menus.

For example, select the Dialog-based applications from the Fortran AppWizard screen. After you build and run the application (without changing the source files), the following dialog box appears:



For more information:

- On using dialogs, see Using Dialogs.
- About dialog Samples that use the Fortran Windows project type, see Sample Fortran Windows Applications.

Using Menus and Dialogs in SDI and MDI Fortran Windows Applications

This section describes the following topics:

- Creating the Menu
- Using the Menu
- Handling Menu Messages
- Using Dialogs in an SDI or MDI Application

Creating the Menu

When you create a new SDI or MDI application using the Fortran Windows AppWizard, a default menu bar is created for you. The default menu bar contains many of the menu entries that are common to Windows applications. You can modify the default menu, or create a new menu, by using the Menu Editor, which is one of the Developer Studio Resource Editors.

To create a new menu resource (menu bar):

1. Click Resource from the Insert menu
2. Select Menu as the resource type

The menu bar consists of multiple menu names, where each menu name contains one or more items. You can use the Menu Editor to create submenus (select the pop-up property).

To edit an existing menu:

1. Select the ResourceView
2. Expand the Menu item in the list of resource types
3. Double click on the menu mame

For more information about the menu resource editor, see the Visual C++ User's Guide section on Resource Editors.

Using the Menu

To use a menu bar in your Fortran application, you must load the menu resource and use it when creating the main window of the application. Code to do this is created automatically by the Fortran Windows AppWizard. The code that loads the menu resource is:

```
ghMenu = LoadMenu(hInstance, LOC(lpszMenuName))
```

The returned menu handle is then used in the call to CreatWindowEx:

```
ghwndMain = CreateWindowEx( 0, lpszClassName,         &
                               lpszAppName,               &
                               INT(WS_OVERLAPPEDWINDOW),  &
                               CW_USEDEFAULT,             &
                               0,                         &
                               CW_USEDEFAULT,             &
                               0,                         &
                               NULL,                      &
                               ghMenu,                    &
                               hInstance,                 &
                               NULL                       &
                             )
```

Handling Menu Messages

Windows sends a WM_COMMAND message to the main window when the user selects an item from the menu. The wParam parameter to the WM_COMMAND message contains:

- The low-order word specifies the identifier of the menu item
- The high-order word specifies either 0 if the message is from a menu item, or 1 if the message is the result of an accelerator key. It is usually not important to distinguish between these two cases, but you must be careful to compare against only the low-order word as in the example below.

For example, the following code from the main window procedure generated by the Fortran Windows AppWizard handles the WM_COMMAND messages from the File menu Exit item and the Help menu About item:

```
 ! WM_COMMAND: user command
    case (WM_COMMAND)
     select case ( IAND(wParam, 16#ffff ) )

        case (IDM_EXIT)
            ret = SendMessage( hWnd, WM_CLOSE, 0, 0 )
             MainWndProc = 0
             return

         case (IDM_ABOUT)
             lpszName = "AboutDlg"C
             ret = DialogBoxParam(ghInstance,LOC(lpszName),hWnd,&
               LOC(AboutDlgProc), 0)
             MainWndProc = 0
             return

         ...
```

For advanced techniques with using menus, refer to the online Platform SDK section on User Interface Services, for subsections: Windows User Interface, Resources, Menus.

Using Dialogs in an SDI or MDI Application

An Fortran Windows SDI or MDI application that uses dialogs has the choice of using:

- The Visual Fortran Dialog routines
- The native Win32 APIs for creating dialog boxes

For any particular dialog box, you should use either the Visual Fortran Dialog routines or the native Win32 dialog box APIs. For example, if you create a dialog box using Win32 APIs, you cannot use the Visual Fortran dialog routines to work with that dialog box.

You should Note, for example, that the code generated by the Fortran Windows AppWizard uses the native Win32 APIs to display the About dialog box.

For more information:

- On using the Visual Fortran Dialog routines, see Using Dialogs
- On using the Win32 APIs, see the online Platform SDK section on User Interface Services, for subsections: Windows User Interface, Windowing, Dialog Boxes.

Sample Fortran Windows Applications

The Visual Fortran Samples ...\DF98\SAMPLES\ADVANCED folder contains many Fortran Windows applications that demonstrate Windows functionality or a particular Win32 function. Each sample application is in separate folder.

Users unfamiliar with full Windows applications should start by looking at:

- Sample SDI and MDI Fortran Windows Samples in ...\DF98\SAMPLES\ADVANCED\WIN32, such as Generic, Platform, or Polydraw.
- Sample dialog Fortran Windows Samples in ...\DF98\SAMPLES\DIALOG, such as THERM or MMPLAYER. For more information about coding reqirements for dialog boxes and using the Dialog Resource editor, see Using Dialogs.

Getting Help with Windows Programming

In HTML Help Viewer, you can access the title "Platform SDK Documentation."

The full Win32 API set is documented in the *Win32 Application Programming Interface for Windows NT Programmer's Reference*, available from Microsoft Press® and also distributed as part of the online Platform Software Development Kit (sdk).

Other titles related to Windows programming and calling Win32 APIs are listed in Additional Resources (in Calling Win32 Routines), which describes the Visual Fortran Online Bookstore.

Portability and Design Considerations

Before you can start to write new programs or port existing ones to Visual Fortran, you must decide what to build and how to build it. This section covers the following topics:

- Portability considerations
- Choosing Your Development Environment with Visual Fortran
- Selecting a Program Type that you can build
- Structuring Your Program
- Special Design Considerations
- Using the Special Features of Microsoft Windows with your programs

Portability

This section presents topics to help you understand how language standards, operating system differences, and computing hardware influence your use of Visual Fortran and the portability of your programs.

Your program is portable if you can implement it on one hardware-software platform and then move it to additional systems with a minimum of changes to the source code. Correct results on the first system should be correct on the additional systems. The number of changes you might have to make when moving your program varies significantly. You might have no changes at all (strictly portable), or so many (non-portable customization) that it is more efficient to design or implement a new program. Most programs in their lifetime will need to be ported from one system to another, and this section can help you write code that makes this easy.

For information on special library routines to help port your program from one system to another, see Portability Library.

For more information:

- Standard Fortran Language
- Operating System
- Storage and Representation of Data

Standard Fortran Language

A language standard specifies the form and establishes the interpretation of programs expressed in the language. Its primary purpose is to promote, among vendors and users, portability of programs across a variety of systems.

The vendor-user community has adopted four major Fortran language standards. ANSI (American National Standards Institute) and ISO (International Standards Organization) are the primary organizations that develop and publish the standards.

The major Fortran language standards are:

- FORTRAN IV

  American National Standard Programming Language FORTRAN, ANSI X3.9-1966. This was the first attempt to standardize the languages called FORTRAN by many vendors.

- FORTRAN 77

  American National Standard Programming Language FORTRAN, ANSI X3.9-1978. This standard added new features based on vendor extensions to FORTRAN IV and addressed problems associated with large-scale projects, such as improved control structures.

- Fortran 90

  American National Standard Programming Language Fortran, ANSI X3.198-1992 and International Standards Organization, ISO/IEC 1539: 1991, Information technology -- Programming languages -- Fortran. This standard emphasizes modernization of the language by introducing new developments. For information about differences between Fortran 90 and FORTRAN 77, see Features of Fortran 90 or the printed *Compaq Fortran Language Reference Manual*.

- Fortran 95

  American National Standard Programming Language Fortran and International Standards Organization, ISO/IEC 1539-1: 1997(E), Information technology -- Programming languages -- Fortran. This recent standard introduces certain language elements and corrections into Fortran 90. Fortran 95 includes Fortran 90 and most features of FORTRAN 77. For information about differences between Fortran 95 and Fortran 90, see Features of Fortran 95 or the printed *Compaq Fortran Language Reference Manual*.

Although a language standard seeks to define the form and the interpretation uniquely, a standard might not cover all areas of interpretation. It might also include some ambiguities. You need to carefully craft your program in these cases so that you get the answers that you want when producing a portable program.

For more information:

Standard vs. Extensions

Use standard features to achieve the greatest degree of portability for your Visual Fortran programs. You can design a robust implementation to improve the portability of your program, or you can choose to use extensions to the standard to increase the readability, functionality, and efficiency of your programs. You can ensure your program enforces the Fortran standard by using the /stand:f90 or /stand:f95 compiler option to flag extensions.

Not all extensions will cause problems in porting to other platforms. Many extensions are supported on a wide range of platforms, and if a system you are porting a program to supports an extension, there is no reason to avoid using it. There is no guarantee, however, that the same feature on another system will be implemented in the same way as it is in Visual Fortran. Only the Fortran standard is guaranteed to coexist uniformly on all platforms.

Compaq Fortran supports many language extensions on multiple platforms, including Compaq Alpha systems. For information on compatibility with Compaq Fortran on Alpha systems, see Compatibility with Compaq Fortran on Other Platforms. Also, the printed *Compaq Fortran Language Reference Manual* identifies whether each language element is supported on other Compaq Fortran platforms.

It is a good programming practice to declare any external procedures either in an EXTERNAL statement or in a procedure interface block, for the following reasons:

- The Fortran 90 standard added many new intrinsic procedures to the language. Programs that conformed to the FORTRAN 77 standard may include nonintrinsic functions or subroutines having the same name as new Fortran 90 procedures.
- Some processors include nonstandard intrinsic procedures that might conflict with procedure names in your program.

If you do not explicitly declare the external procedures and the name duplicates an intrinsic procedure, the processor calls the intrinsic procedure, not your external routine. For more information on how the Fortran compiler resolves name definitions, see Resolving Procedure References.

Compiler Optimizations

Many Fortran compilers perform code-generation optimizations to increase the speed of execution or to decrease the required amount of memory for the generated code. Although the behaviors of both the optimized and nonoptimized programs fall within the language standard specification, different behaviors can occur in areas not covered by the language standard. Compiler optimization especially can influence floating-point numeric results.

The Visual Fortran compiler can perform optimizations to increase execution speed and to improve floating-point numerical consistency. For a summary of optimization levels, see Optimization Levels and Other Options Related to Optimization.

Floating-point consistency refers to obtaining results consistent with the IEEE binary floating-point standards (see the /fltconsistency option).

Unless you properly design your code, you might encounter numerical difficulties when you optimize for fastest execution. The /nofltconsistency option uses the floating-point registers, which have a higher precision than stored variables, whenever possible. This tends to produce results that are inconsistent with the precision of stored variables. The /fltconsistency option (also set by /Oxp) can improve the consistency of generated code by rounding results of statement evaluations to the precision of the standard data types, but it does produce slower execution times.

Operating System

The operating system envelops your program and influences it both externally and internally. To achieve portability, you need to minimize the amount of operating-system-specific information required by your program. The Fortran language standards do not specify this information.

Operating-system-specific information consists of nonintrinsic extensions to the language, compiler and linker options, and possibly the graphical user interface of Windows. Input and output operations use devices that may be system-specific, and may involve a file system with system-specific record and file structures.

The operating system also governs resource management and error handling. You can depend on default resource management and error handling mechanisms or provide mechanisms of your own. For information on special library routines to help port your program from one system to another, see Portability Library.

The minimal interaction with the operating system is for input/output operations and usually consists of knowing the standard units preconnected for input and output. You can use default file units with the asterisk (*) unit specifier.

To increase the portability of your programs across operating systems, consider the following:

- Do not assume the use of a particular type of file system.
- Do not embed filenames or paths in the body of your program. Define them as constants at the beginning of the program or read them from input data.
- Do not assume a particular type of standard I/O device or the "size" of that device (number of rows and columns).
- Do not assume display attributes for the standard I/O device. Some environments do not support attributes such as color, underlined text, blinking text, highlighted text, inverse text, protected text, or dim text.

Storage and Representation of Data

The Fortran language standard specifies little about the storage of data types. This loose specification of storage for data types results from a great diversity of computing hardware. This diversity poses problems in representing data and especially in transporting stored data among a multitude of systems. The size (as measured by the number of bits) of a storage unit (a word, usually several bytes) varies from machine to machine. In addition, the ordering of bits within bytes and bytes within words varies from one machine to another. Furthermore, binary representations of negative integers and floating-point representations of real and complex numbers take several different forms.

If you are careful, you can avoid most of the problems involving data storage. The simplest and most reliable means of transferring data between dissimilar systems is in *character* and not binary form. Simple programming practices ensure that your data as well as your program is portable.

For more information:

- Size of Basic Types
- Bit, Byte, and Word Characteristics
- Transportability of Data

Size of Basic Types

The intrinsic data types are INTEGER, REAL, LOGICAL, COMPLEX, and CHARACTER, whose sizes are shown in the following table.

Data Types and Storage Sizes

Types	Number of Bytes
INTEGER(1), LOGICAL(1), CHARACTER	1
INTEGER(2), LOGICAL(2)	2
INTEGER, LOGICAL, REAL	Depending on default integer size (set by the /integer_size compiler option or equivalent directive) , INTEGER and LOGICAL can have 2, 4, or 8 bytes; default allocation is 4 bytes. Depending on default real size (set by the /real_size compiler option or equivalent directive), REAL can have 4 or 8 bytes; default allocation is 4 bytes.
INTEGER(4), REAL (4), LOGICAL(4)	4
INTEGER(8), LOGICAL(8)	8
COMPLEX	Depending on default real, COMPLEX can have 8 or 16 bytes; default allocation is 8 bytes.
DOUBLE PRECISION, REAL (8), COMPLEX(4)	8
DOUBLE COMPLEX, COMPLEX(8)	16
CHARACTER(n)	n
Structures	Size of derived type (can be affected by the **PACK** directive)
RECORD	Size of record structure (can be affected by the **PACK** directive)

Bit, Byte, and Word Characteristics

In a 32-bit word environment such as that of Visual Fortran, it might seem as though there should be no problems with data storage, since all data types are consecutive subcomponents (bytes) of a word or are consecutive, multiple words. However, when transporting binary data among disparate systems -- either by intermediate storage medium (disk, tape) or by direct connection (serial port, network) -- problems arise from different definitions of serial bit and serial byte order. For simplicity, the following discussion considers only byte order within a word, since that is the usual case of difficulty. (For more information, refer to "On Holy Wars and a Plea for Peace" by Danny Cohen, *IEEE Computer*, vol. 14, pp. 48-54, 1981.)

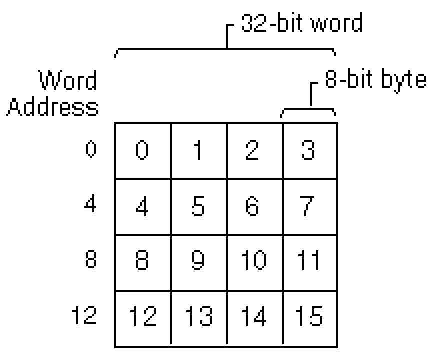
For more information:

- Big End or Little End Ordering
- Binary Representations
- Declaring Data Types

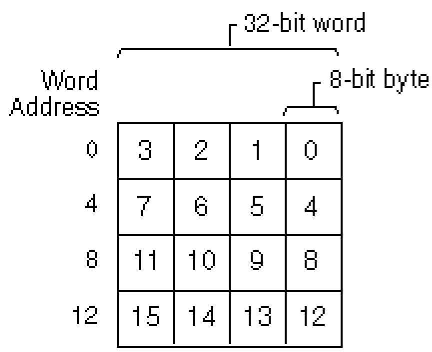
Big End or Little End Ordering

Computer memory is a linear sequence of bits organized into a hierarchical structure of bytes and words. One system is the "Big End," where bits and bytes are numbered starting at the most significant bit (MSB, "left," or high end). Another system is the "Little End," where bits and bytes start at the least significant bit (LSB, "right, " or low end). The following figure illustrates the difference between the two conventions for the case of addressing bytes within words.

Byte Order Within Words: (a) Big End, (b) Little End



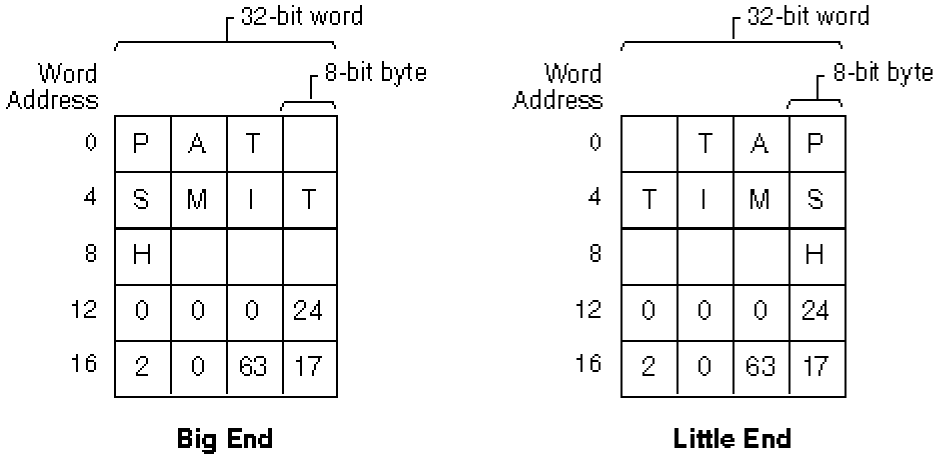
Big End



Little End

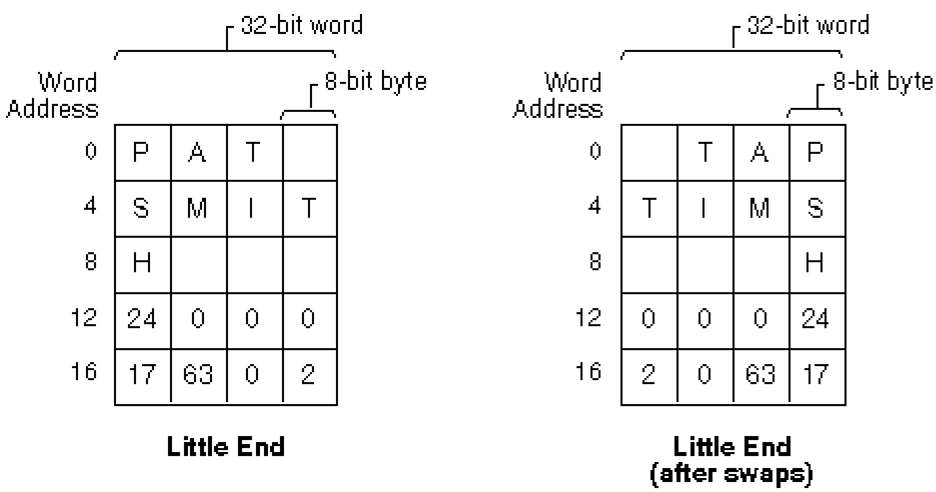
Data types stored as subcomponents (bytes stored in words) end up in different locations within corresponding words of the two conventions. The following figure illustrates the difference between the representation of several data types in the two conventions. Letters represent 8-bit character data, while numbers represent the 8-bit partial contribution to 32-bit integer data.

Character and Integer Data in Words: (a) Big End, (b) Little End



If you serially transfer bytes now from the Big End words to the Little End words (BE byte 0 to LE byte 0, BE byte 1 to LE byte 1, ...), the left half of the figure shows how the data ends up in the Little End words. Note that data of size one byte (characters in this case) is ordered correctly, but that integer data no longer correctly represents the original binary values. The right half of the figure shows that you need to swap bytes around the middle of the word to reconstitute the correct 32-bit integer values. After swapping bytes, the two preceding figures are identical.

Data Sent from Big to Little: (a) After Transfer, (b) After Byte Swaps



You can generalize the previous example to include floating-point data types and to include multiple-word data types. The following table summarizes the ordering nature of several common processors.

Ordering Nature of Processors

Processor	Byte Order	Bit Order
Intel 80486, Pentium Series	Little	Little
Compaq Alpha and VAX	Little	Little
Motorola® 680XX	Big	Little
IBM Mainframes	Big	Big

The important result is that portable, serial transport of 8-bit character data between most systems is possible with little or no knowledge about the ordering nature of each system.

For more information on big and little endian data and Visual Fortran unformatted data conversion capabilities, see Converting Unformatted Numeric Data.

Binary Representations

The discussion in Big End or Little End Ordering stresses 8-bit character data because you might encounter hardware that uses a different representation of binary data. The Visual Fortran system uses the two's-complement representation of negative binary integers. You might encounter a system that uses a signed magnitude representation, a one's complement representation, or a biased (excess) representation. Additionally, the bit representation of binary floating-point numbers is not unique.

If you transport binary data to or from a different system, you need to know the respective representations to convert the binary data appropriately.

Declaring Data Types

Use default data types unless you anticipate memory problems, or if your data is sensitive to overflow limits. If data precision errors or numeric overflow could affect your program, specify type and kind parameters for the intrinsic types as well as for declared data objects. Default data types are portable and are usually aligned by the compiler to achieve good memory access speed. Using some of the nondefault data types on certain machines may slow down memory access.

Transportability of Data

You can achieve the highest transportability of your data by formatting it as 8-bit character data. Use a standard character set such as the ASCII standard for encoding your character data. Although this practice is less efficient than using binary data, it will save you from shuffling and converting your data.

If you are transporting your data by means of a record-structured medium, it is best to use the Fortran sequential formatted (as character data) form. You can also use the direct formatted form, but you need to know the record length of your data. Remember also that some systems use a carriage return-linefeed pair as an end-of-record indicator, while other systems use linefeed only. If you use either the direct unformatted or the sequential unformatted form, there might be system-dependent values embedded within your data that complicate its transport.

Implementing a strictly portable solution requires a careful effort. Maximizing portability may also mean making compromises to the efficiency and functionality of your solution. If portability is not your highest priority, you can use some of the techniques that appear in later sections to ease your task of customizing a solution.

For more information on big and little endian data and unformatted data conversion, see Converting Unformatted Numeric Data.

Choosing Your Development Environment

With Visual Fortran, you can build programs either from a command-line window (which allows you to enter text commands directly into a command prompt) or from the Microsoft visual development environment.

For information on using the Microsoft visual development environment, see Building Programs and Libraries. For information on using the command-line environment, see Using the Compiler and Linker from the Command Line.

The visual development environment offers a number of ways to simplify the task of compiling and linking programs. For example, a dialog box presents compiler and linker options in logical groupings, with descriptive names and simple mouse or keyboard selection methods. (If you need assistance using this or any other dialog box, choose the Help button in the dialog box.)

The visual development environment also provides a default text editor, which is integrated with Help, the debugger, and error tracking features. The default visual development environment text editor can be customized for keyboard compatibility with certain editors (in the Tools menu, select Customize and click the Compatibility tab) and you can customize keyboard bindings (in the Tools menu, select Customize and click the Keyboard tab). You can also use your favorite ASCII text editor outside the visual development environment. If you do, however, you may not be able to use the integrated Help, debugger, and error tracking features.

Because software development is an iterative process, it is important to be able to move quickly and efficiently to various locations in your source code. If you use the visual development environment to compile and link your programs, you can call up both the description of the error message and the relevant source code directly from the error messages in the output window.

You also use the visual development environment text editor to view and control execution of your program with the integrated source level debugger. Finally, when you use the project browser to locate routines, data elements, and references to them, the visual development environment uses its editor to go directly to the source code.

When you build programs from the console, you are in complete control of the build tools. If you choose to, you can customize how your program is built by your selection of compiler and linker options. Compiler and linker options are described in Compiler and Linker Options.

Even if you choose to edit and build your program from the command line, you can still use the visual development environment debugger and browser after your program has compiled and linked cleanly (see Preparing Your Program for Debugging). Finally, you can run the profiler to produce a text report of your program's execution statistics either from the command-line console or from the visual development environment.

Selecting a Program Type

When you create a new project, you need to select the appropriate Fortran project type. You can build four basic kinds of executable programs:

- Fortran Console applications
- Fortran Standard graphics applications
- Fortran QuickWin graphics applications
- Fortran Windows applications

You can also create a Fortran COM server project or a library project that contains subprograms (functions or subroutines) called from your main application:

- Static libraries
- Dynamic-Link Libraries (DLLs)

Code that works in one application may not work in others. For example, graphics calls are not appropriate in a Fortran console application.

Fortran console applications are the most portable to other systems because they are text-only and do not support graphics.

With Fortran standard graphics (QuickWin single document) applications, you can add graphics to your text without the additional overhead of menus and other interface features of typical programs for Windows. Fortran QuickWin (QuickWin multiple document) graphics applications provide a simple way to use some features of Windows in a Visual Fortran program with graphics.

Fortran Windows applications give users full access to the Win32 Application Programming Interface (API), giving you a larger set of functions than QuickWin offers. With Windows applications, you can access low-level system services directly, or access higher level system services such as OpenGL.

None of the graphics functions in Visual Fortran, except for those in the OpenGL library, are directly portable to operating systems offered by other vendors. A graphical interface does, however, offer certain advantages to the application designer and to the person who will use the program. The choice of what kind of program to build is a trade-off between performance, portability, ease of coding, and ease of use. The advantages and disadvantages of each type of application are summarized in the following sections.

All four kinds of main applications can be maximized, minimized, resized, and moved around the screen when displayed in a window. If the drawing area of a window in your application is larger than the window in which it is displayed, scroll bars are automatically added to the bottom and right edges of the window.

You can write any of the applications with one section of the program beginning execution before another has completed. These threads of execution run either concurrently on a computer with one processor or simultaneously on a computer with multiple processors. (See Creating Multithread Applications.)

For more information on the Visual Fortran application project types, see Types of Projects.

Structuring Your Program

There are several ways to organize your projects and the applications that you build with Visual Fortran. This section introduces several of these options and offers suggestions for when you might want to use them.

For more information:

- Creating Fortran Executables
- Advantages of Modules
- Advantages of Internal Procedures

- Storing Object Code in Static Libraries
- Storing Routines in Dynamic-Link Libraries

Creating Fortran Executables

The simplest way to build an application is to compile all of your Visual Fortran source files (.FOR) and then link the resulting object files (.OBJ) into a single executable file (.EXE). You can build single-file executables either with the visual development environment or by using the DF (or FL32) command from the console command line.

The executable file you build with this method contains all of the code needed to execute the program, including the run-time library. Because the program resides in a single file, it is easy to copy or install. However, the project contains all of the source and object files for the routines that you used to build the application. If you need to use some of these routines in other projects, you must link all of them again.

Advantages of Modules

One way to reduce potential confusion when you use the same source code in several projects is to organize the routines into modules. There are two main uses for modules in Visual Fortran:

- Internal encapsulation – A single complex program can be made up of many modules. Each module can be a self-contained entity, incorporating all the procedures and data required for one of your program's tasks. When a task is encapsulated, it is easy to share the code between two different projects.

  In this case, all the modules should be included in the main project directory. If many projects all share the same module, the module should reside in only one directory. All projects that use it should specify the /I compiler option to indicate the location of the module.

- External modules – If you use a module provided from an outside source, you need only the .MOD file at compile time, and the .OBJ file at link time. Use the /[no]include[*path*] (or /I*path*) command line option (or the INCLUDE environment variable) to specify the location of these files, which will probably not be the same as your project directory.

During the building of a project, the compiler scans the project files for dependencies. If you specify the /[no]include[*path*] (or /I*path*) command line option or the INCLUDE environment variable, the compiler is able to find the external modules.

Store precompiled module files, with the extension .MOD, in a directory included in the path. When the compiler sees the **USE** statement in a program, it finds the module based on the name given in the **USE** statement, so there is no need to maintain several copies of the same source or object code.

Modules are excellent ways to organize programs. You can set up separate modules for:

- Commonly used routines
- Data definitions specific to certain operating systems
- System-dependent language extensions

Advantages of Internal Procedures

Functions or subroutines that are used in only one program can be organized as internal procedures, following the **CONTAINS** statement of a program or module.

Internal procedures have the advantage of host association, that is, variables declared and used in the main program are also available to any internal procedure it may contain. For more information on procedures and host association, see Program Units and Procedures.

Internal procedures, like modules, provide a means of encapsulation. Where modules can be used to store routines commonly used by many programs, internal procedures separate functions and subroutines whose use is limited or temporary.

Storing Object Code in Static Libraries

Another way to organize source code used by several projects is to build a static library (.LIB) containing the object files for the reused procedures. You can create a static library:

- From the visual development environment, build a Fortran Static Library project type.
- From the command line, use the LIB command.

After you have created a static library, you can use it to build any of the other types of Visual Fortran projects.

For more information:

- About static libraries, see Fortran Static Library Projects

Storing Routines in Dynamic-Link Libraries

Another method of organizing the code in your application involves storing the executable code for certain routines in a separate file called a Dynamic-Link Library (DLL) and building your applications so that they call these routines from the DLL.

When routines in a DLL are called, the routines are loaded into memory at run-time as they are needed. This is most useful when several applications use a common group of routines. By storing these common routines in a DLL, you reduce the size of each application that calls the DLL. In addition, you can update the routines in the DLL without having to rebuild any of the applications that call the DLL.

For more information on compiler and linker options and how to build a project, see Fortran Dynamic-Link Library Projects.

Special Design Considerations

You can write your code any way you want if you plan to run it on a single computer, use only one variation of one programming language, and never hand your code to anyone else. If any of these assumptions changes, there are several other issues to consider when you design your program.

For more information:

- Porting Fortran Source Between Systems
- Mixed-Language Issues
- Porting Data Between Systems

Porting Fortran Source Code Between Systems

In general, Visual Fortran is a portable language. One of the main advantages of the language is the availability of large and well-tested libraries of Fortran code. You also might have existing code addressing your problem that you want to reuse. Math and scientific code libraries from most vendors should port to Visual Fortran with virtually no problems.

You might also want to use Visual Fortran as a development platform for code that can later be ported to another Compaq Fortran system, such as mainframe-class Alpha systems running the Compaq Tru64 UNIX, Linux, or Compaq OpenVMS operating system.

Whether you are bringing code from another system or planning to export it to another system, you will need to do the following:

- Isolate system-dependent code into separate modules. Maintain distinct modules with similar functionality for each separate platform.
- In your main program, use only language extensions that will compile on both platforms, putting system-dependent code into modules.
- Place language extension subsets into modules.
- If you use Microsoft compiler directives, replace the older $*directive* format with the **!DEC$** *directive* format, because this will be ignored by other systems.
- Specify data precision, for integers and logicals as well as for floating-point numbers when the size matters. If you do not explicitly specify KIND for variables, this could be the source of problems if one system uses a default of (KIND=2) for integers, while your program assumes (KIND=4).
- Conversely, if the size of a variable is not significant, avoid specifying data precision. Code that does specify precision will run slower on systems that do not use the same default integer and real sizes.
- Avoid using algorithms that exhibit floating-point instability. For information on handling floating-point numbers, see The Floating-Point Environment.
- Specify equivalent floating-point precision on each platform.
- Specify the appropriate attributes when defining routines and data that will be interacting with code written in Microsoft Visual C/C++ or assembly language.

For more information:

- On porting code between systems, see Portability.
- On compatibility with Compaq Fortran on Alpha platforms, see Compatibility with Compaq Fortran on Other Platforms

Choosing a Language Extension Subset

The Visual Fortran compiler supports extensions used on a variety of platforms, plus some that are specific to Visual Fortran. Because there are Fortran compilers for many different computers, you might need to move your source code from one to another. If the trip is one-way and it is permanent, you can simply change the code to work on the second platform. But if you need to make sure you can move the code where ever it is needed, you must be aware of the extensions to Fortran that are supported on each platform.

You can use some of the Visual Fortran compiler options to help you write portable code. For example, by specifying ANSI/ISO syntax adherence (/stand option) in the Project Settings (Fortran tab) dialog box or on the command line, you can have the compiler enforce Fortran 90 or 95 syntax. Code that compiles cleanly with this option set is very likely to compile cleanly on any other computer with a Fortran compiler that obeys strict Fortran syntax.

If you choose to use platform-specific extensions, you need to note whether there are any differences in how those extensions are implemented on each computer, and use only those features that are identical on both. (For more information, see Portability.) The default is to compile with the full set of extensions available.

Because Visual Fortran compiler directives look like standard Fortran comments (such as **!DEC$** *directive*), programs that use directives can compile on other systems. They will, however, lose their function as compiler directives.

Floating-Point Issues

Floating-point answers can differ from system to system, because different systems have different precisions and treat rounding errors in different ways.

One programming practice that can be a serious source of floating-point instability is performing an **IF** test (either obvious or implied) that takes some action if and only if a floating-point number exactly equals a particular value. If your program contains code like this, rewrite the code to a version that is stable in the presence of rounding error. For more details, see The Floating-Point Environment.

Another source of floating-point instability is the use of mathematical algorithms that tend to diminish precision. Incorrect answers can result when the code is moved to a system with less precision. For more information, see The Floating-Point Environment.

One way of making all REAL variables on one system DOUBLE PRECISION on another is to use modules to declare explicit data types for each system. Specify a different KIND parameter in each module. Another way is to add an include file that declares explicit data types on each system in all source files.

Mixed-Language Issues

You can combine object modules generated by Visual Fortran with object files from compilers for 32-bit Windows that compile other languages (such as Microsoft Visual C++, or Microsoft MASM), so long as the compilers use the COFF object module format used by Microsoft.

You need to respect certain calling, naming, and argument-passing conventions when combining object modules from different languages. These conventions are discussed in Programming with Mixed Languages.

Porting Data Between Systems

The easiest way to port data to or from the Visual Fortran environment is as a formatted, sequential, 8-bit ASCII character file that can be read using Fortran formatted input statements; if you do this, you should have no trouble.

If you try to transfer unformatted binary data between systems, you need to be aware of the different orders (low-order byte first or high-order byte first) in which different systems store bytes within words. If you need to transfer unformatted binary data, review:

- Portability
- Compatibility with Compaq Fortran on Other Platforms
- Converting Unformatted Numeric Data

You can avoid these problems by using a formatted ASCII file.

Using the Special Features of Microsoft Windows

One of the greatest advantages to building applications for Windows is the power and security provided by the operating system. By simply recompiling your old source code and building a (text-only) Fortran Console application, you can run your program in a protected address space where it cannot damage other applications, hang the processor, or cause the computer to crash.

If you choose to take advantage of the power of Windows operating systems, your programs can run more efficiently on single-processor computers. Window NT 4 and Windows 2000 also support multi-processor computers.

For more information:

- Built-in Benefits of Windows
- Single or Multithread Program Execution
- Dialog Boxes
- QuickWin and Windows Programs

Built-in Benefits of Windows

Windows executes your application in a secure environment that includes the support services your application needs to execute efficiently and with a minimum of problems. This environment is a flat virtual address space that can be as large as 2 gigabytes, providing you have enough available disk space. While executing, your program is protected by Windows from damaging other applications and from being damaged by other applications.

The operating system uses *preemptive multitasking* to control how much processor time each application uses. Instead of waiting for an application to voluntarily yield control of the computer back to the operating system, Windows allocates a period of processor time to the application and regains control when that period has expired. This prevents a program with an infinite loop from hanging the computer. If your program hangs, you can easily and safely stop it by using the Windows task manager. (For information about using this or any other feature of Windows, see the manuals that came with the operating system.)

Because you can use one application while another continues to execute, you can make better use of your own time. For example, you can use the visual development environment to edit the source for one project while another project is building, or use Microsoft Excel to prepare a graph for data that your program is busy producing. And if your computer has multiple processors and you are using Windows NT 4 or Windows 2000, the computation-intensive program producing your data might be executing on an otherwise idle processor, making it less likely that your other work will slow it down.

Single or Multithread Program Execution

You can take further advantage of preemptive multitasking by designing your program so that portions of it, called *threads*, can be executed in parallel. For example, one thread can perform a lengthy input/output operation while another thread processes data. All of the threads in your application share the same virtual address space.

Windows 9*x*, Windows 2000, and Windows NT 4 operating systems support multithreading. On a Windows NT 4 or Windows 2000 system with multiple processors sharing memory, threads can execute in parallel (symmetric multiprocessing).

Multithreaded code must be written so that the threads do not interfere with each other and overwrite each other's data, as described in Creating Multithread Applications.

Dialog Boxes

Visual Fortran gives you an easy way to create simple dialog boxes that can be used for data entry and application control. Dialogs are a user-friendly way to get and process input. As your application executes, you can make a dialog box appear on the screen and the user can click on a button or scroll bar to enter data or choose what happens next. You can add dialog boxes to any Fortran application, including Fortran Windows, Fortran QuickWin, and Fortran Console applications.

You design your dialog with the Resource Editor, and drive them with a combination of the dialog routines, such as **DLGSET**, and your own subroutines. A complete discussion of how to design and use dialog boxes is given in Using Dialogs.

QuickWin and Windows Programs

One decision you must make when designing a program is how it will be used. If the person using your program must interact with it, the method of interaction can be important. For example, anytime the user must supply data, that data must be validated or it could cause errors. One way to minimize data errors is to change how the data is provided. In this example, if the data is one of several values that are known when the program is executed, the user can select a menu item instead of typing on the keyboard.

When you design programs to be interactive, you use a different structure than if you design them to be run in unattended batches. Interactive applications behave more like state machines than numerical algorithms, because they perform the actions you request when you request them. You may also find that once you can change what your program is doing while it runs, you will be more likely to experiment with it.

The QuickWin library lets you build simple Windows applications. Because QuickWin is a wrapper around a subset of the Windows API, there are limitations to what you can do, but it can fulfill the requirement of most users. If you need additional capabilities, you can call the Windows API directly rather than using QuickWin to build your program. (For more information, see Using QuickWin). You can also build a graphic user interface in either Microsoft Visual C++ or Visual Basic® that calls your Fortran code.

Using Dialogs

Dialogs are a user-friendly way to solicit application control. As your application executes, you can make a dialog box appear on the screen and the user can click on a dialog box control to enter data or choose what happens next.

With the dialog routines provided with Visual Fortran, you can add dialog boxes to your application. These routines define dialog boxes and their controls (scroll bars, buttons, and so on), and call your subroutines to respond to user selections.

There are two types of dialog boxes:

- *Modal* dialog boxes, which you can use with any Fortran project type, including Fortran Windows, Fortran QuickWin (multiple doc.), Fortran Standard Graphics (QuickWin single doc.), Fortran Console, Fortran DLL, and Fortran Static library project types.
- *Modeless* dialog boxes, which are typically used with the Fortran Windows project type.

When your program displays a modal dialog box (any project type), the user must explicitly enter data and close the dialog box before your application resumes execution.

When your program displays a modeless dialog box, your application continues executing. Unlike a modal dialog box, the user can switch between the modeless dialog box and the other windows in the application.

There are two steps to make a dialog:

1. Specify the appearance of the dialog box and the names and properties of the controls it contains.
2. Write an application that activates those controls by recognizing and responding to user selections.

This section covers the following topics:

- Using the Resource Editor to Design a Dialog
- Writing a Dialog Application
- Dialog Routines
- Dialog Controls
- Using Dialog Controls
- Using ActiveX Controls

Using the Resource Editor to Design a Dialog

You design the appearance of the dialog box, choose and name the dialog controls within it, and set other control properties with the Dialog Editor.

The Dialog Editor is one of the Resource Editors provided by the visual development environment (Developer Studio). Developer Studio contains other resource editors for editing icons, bitmaps, menus, and so on. For information on the other resource editors, see "Resource Editors" section in the Visual C++ User's Guide .

A program's resources are defined in a resource file (typically with a .rc extension). A Developer Studio project typically contains a single resource file. The contents of the resource file are displayed in the ResourceView. The resource file can be created by one of the following:

- When you create a project and use one of the Fortran AppWizards (for example, when using the Fortran Windows Application AppWizard).
- When you save the resources that you define using one of the Resource Editors.

If you create the resource file from the resource editors, be sure to add the resource file to your project. After you do this, the resources will be displayed in the ResourceView. It is possible to include additional resource files in a project (see Including Resources Using Multiple Resource Files).

This section describes the steps needed to design a dialog box, and uses as an example a dialog box that converts temperatures between Celsius and Fahrenheit. The code in the example is explained as you read through this chapter.

In this section, we include the dialog box in a Fortran Console project. You can use the completed Visual Fortran sample in the `...\Samples\Dialog\Temp` directory or you can create your own application.

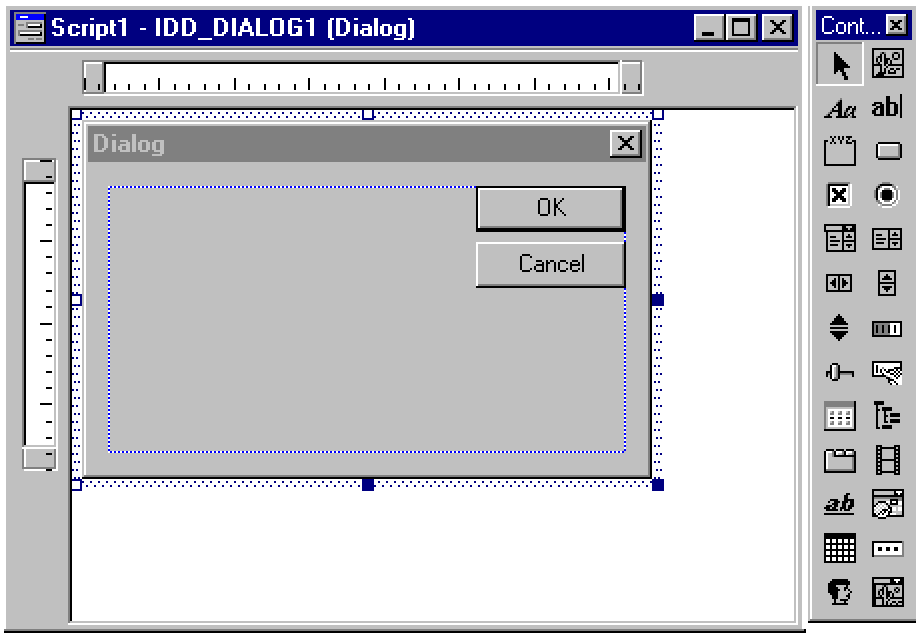
To create a Fortran Console application:

- From the File menu, click New...
- Click the Project tab
- From the list of project types, select Fortran Console Application
- Enter TEMP as the name for the project, verify where the project will be created, and click OK
- In the Fortran Console Application - Step 1 of 1 dialog box, choose `A simple project` and click Finish
- Click OK after reading the displayed summary information. The project workspace is opened, displaying the FileView pane.
- In the FileView pane, click the plus sign (+) next to the project name to display the categories of source files.

► To open the dialog resource editor:

1. From the Insert menu, choose Resource.
2. From the list of possible resources, choose Dialog.
3. Click the New button. The dialog editor (one of the resource editors) appears on the screen as shown below.

Dialog Editor Sample 1



A blank dialog box appears at the left and a toolbar of available controls appears on the right. If the Controls toolbar does not appear:

1. Click Customize in the Tools menu
2. Click the Toolbars tab
3. Select (check) Controls

If you place the cursor over a control on the toolbar, the name of the control appears. The Controls toolbar items that are supported by Visual Fortran follow:

Button	Check box
Combo box (such as a drop-down list box)	Group box
Edit box	List box
Picture	Progress bar

Radio button	Scroll bar, horizontal
Scroll bar, vertical	Slider
Spin control	Static text
Tab control	

You can also add ActiveX controls to your dialog box (see Using ActiveX Controls).

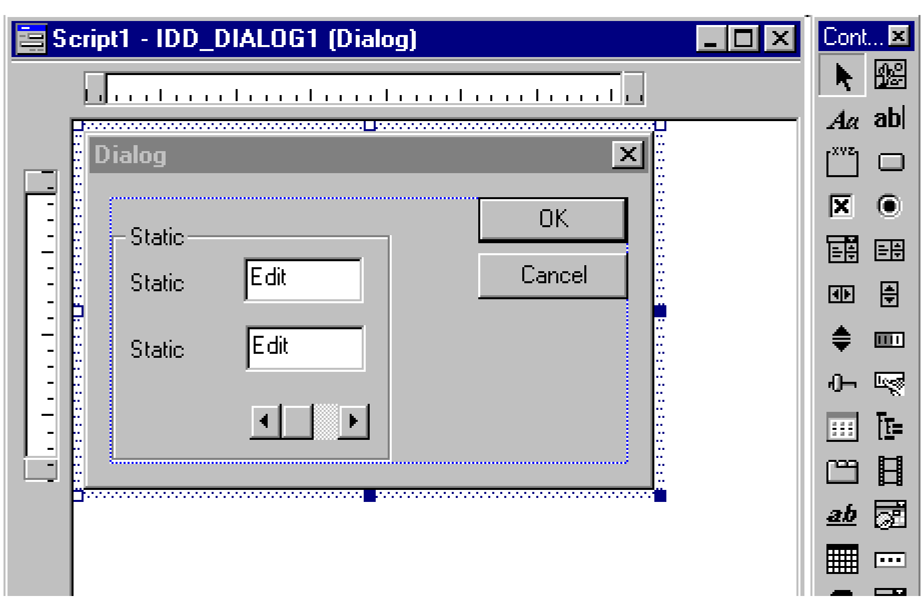
To add controls to the dialog box:

1. Point at one of the available controls on the Control toolbar, hold down the left mouse button and drag the control to the dialog box.
2. Place the dialog control where you want it to be on the dialog box and release the mouse button. You can delete controls by selecting them with the mouse, then pressing the Delete (or DEL) key.

The following figure shows the dialog box after adding two Static text lines (currently say Static), two Edit boxes (currently say Edit), a Horizontal Scroll bar, and a Group box. The Group box is the outlined rectangular area in the dialog box that encloses the other related controls.

The OK and CANCEL buttons were added for you by the Resource Editor. You can delete (select the control and press DEL key), move (drag the control), resize (drag one of the anchor points), rename the OK and CANCEL buttons or any of the controls that you add.

Dialog Editor Sample 2

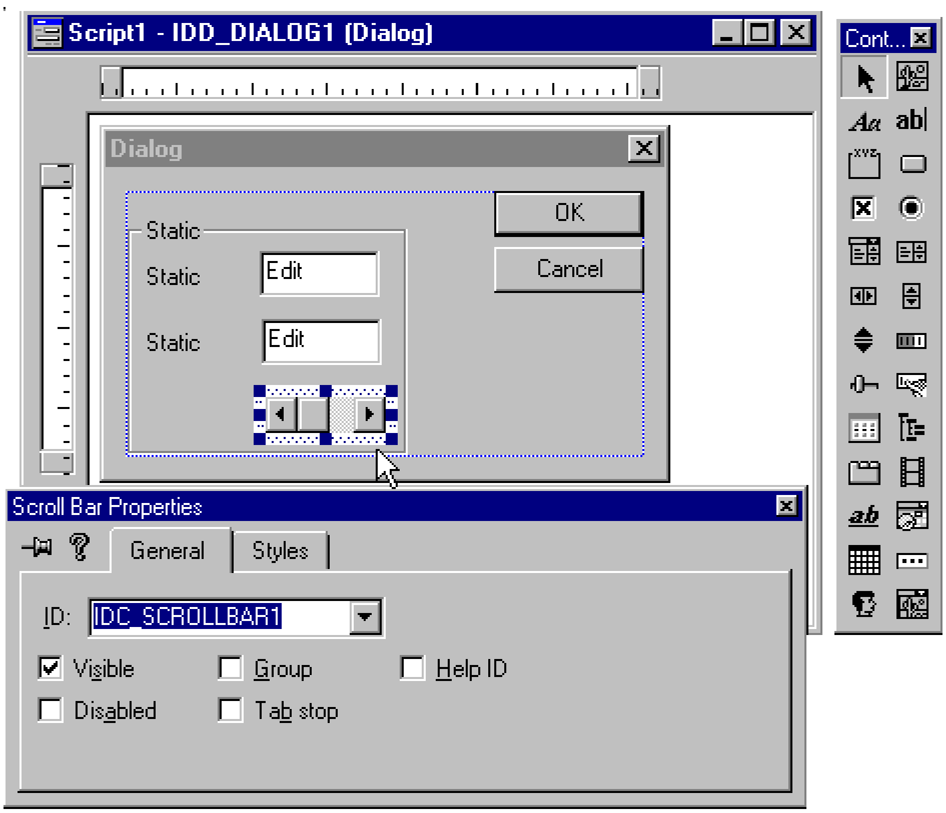


To specify the names and properties of the added controls:

1. Double-click one of the controls in your dialog box with the left mouse button. A Properties box appears showing the default name and properties for that control.

   The following figure shows the Properties box for the Horizontal Scroll bar with the default values.

   Dialog Editor Sample 3



2. Change the control name by typing over the default name (`IDC_SCROLLBAR1` in the following figure).
3. Check or uncheck the available options to change the control's properties. (The Visible option in the following figure is checked by default.)
4. Click the left mouse button in the upper-right corner of the window Properties box to save the control's properties and to close the box.

   Repeat the same process for each control and for the dialog box itself.

To use the controls from within a program, you need symbolic names for each of them. In this example, the Horizontal Scroll bar symbolic name is changed in the Properties box to `IDC_SCROLLBAR_TEMPERATURE`. This is how the control will be referred to in your program; for example, when you get the slide position:

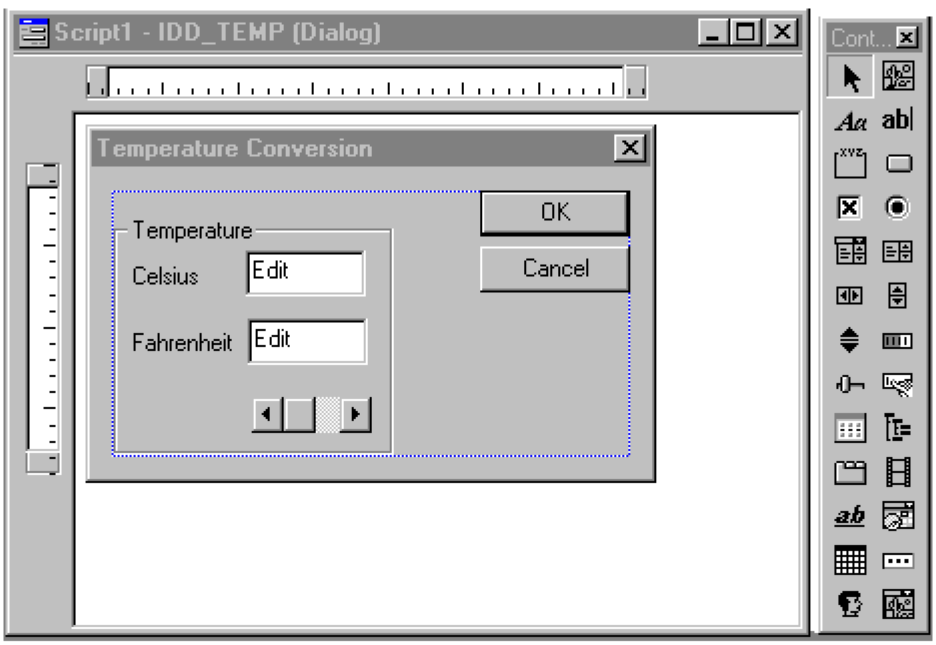
```
INTEGER slide_position
retlog = DLGGET (dlg, IDC_SCROLLBAR_TEMPERATURE,            &
                 slide_position, DLG_POSITION)
```

The controls are renamed as follows:

- The top Edit box is named `IDC_EDIT_CELSIUS`. The Static text next to it is named `IDC_TEXT_CELSIUS` and set to the left-aligned text "Celsius".
- The lower Edit box is named `IDC_EDIT_FAHRENHEIT`, and the Static text next to it is named `IDC_TEXT_FAHRENHEIT` and set to the left-aligned text "Fahrenheit".
- The Group box is named `IDC_BOX_TEMPERATURE`, and its caption is set to Temperature.
- The dialog itself is named `IDD_TEMP` and its caption is set to Temperature Conversion.
- All other control properties are left at the default values.

The resulting dialog box is shown in the following figure:

Dialog Editor Sample 4



To save the dialog box as a resource file:

1. From the File menu, choose Save As.

2. Enter a resource filename for your file.

   In this example, the resource file is given the name `TEMP.RC`. The visual development environment saves the resource file and creates an include file with the name RESOURCE.FD. Typically, only one resource file is used with each Visual Fortran project (see Including Resources Using Multiple Resource Files).

3. Add the TEMP.RC file to your project:
    1. In the Project menu, select Add to Project and click Files... from the submenu.
    2. The Insert Files into Project dialog box appears. Use this dialog box to select the TEMP.RC file to be added to the project.

To open an existing dialog box in the resource editor:

1. From the File menu, open the project workspace.
2. Click the ResourceView tab.
3. Click the plus sign (+) next to *project-name* Resources.
4. Click the plus sign (+) next to Dialog.
5. Double-click the appropriate dialog name, such as IDD_DIALOG1.
6. Use the Resource Editor to add a new control or modify an existing control. To modify an existing control, use the Tab key to select the appropriate control. Double-click the selected control to view or modify its properties.

At this point the appearance of the dialog box is finished and the controls are named, but the box cannot function on its own. An application must be created to run it.

Not all the controls on the Resource Editor Controls toolbar are supported by Visual Fortran dialog routines. The supported dialog controls are:

- Button
- Check box
- Combo box (such as a drop-down list box)
- Edit box
- Group box
- List box
- Picture
- Progress bar
- Radio button
- Scroll bar (Horizontal and Vertical)
- Slider
- Spin control
- Static text
- Tab control

You can also add ActiveX controls to your dialog box. For information, see Using ActiveX Controls.

For further information on resources and control properties, see:

For information on creating an application for your dialog box, see Writing a Dialog Application.

For more information about using the Resource Dialog editor, see Using Resource Editors in the *Visual C++ User's Guide (for Visual Fortran)*, located in the HTML Help folder Developer Studio 98.

Setting Control Properties

Help is available within the Resource Editor to explain the options for each of the dialog controls. Click the question mark in the upper-left area of the Dialog Properties box to display Resource Editor help.

Some of the controls have multiple Properties sets. Click the mouse on the name of the Properties set you want to view or modify.

In addition to changing the properties of its individual controls, you can change the properties of the dialog box itself. To change the dialog box properties, double-click the left mouse button (or right-click and select Properties from the pop-up menu) in any clear area in the box. The Properties box opens for the dialog.

To specify where your dialog appears on the screen do one of the following:

- In General tab of the Properties box, you can change the x and y values. These specify the pixel position of the dialog box's upper-left corner, relative to its parent window. For a modal or a popup modeless dialog box, the parent window is the screen. For example, specifying the X position as 40 and Y position as 40 would place a modal dialog box in the upper-left corner of the screen.

- In the More Styles tab, you can specify the Center checkbox to display the dialog box in the center of its parent window or specify the Center Mouse checkbox to place the dialog centered at the current mouse pointer position.

You can change the size of the dialog box by holding down the left mouse button as you drag the right or lower perimeter of the box. If you have sized your dialog window to be larger than the edit window, use the scroll bars to move the view region.

You can edit the appearance of the dialog box later. To start the Resource Editor and display the selected dialog box:

1. From the File menu, open the project workspace.
2. Click the ResourceView tab.
3. Click the plus sign (+) next to *project-name* Resources.
4. Click the plus sign (+) next to Dialog.
5. Double-click the appropriate dialog name, such as IDD_DIALOG1.
6. Use the Resource Editor to modify an existing control or add a new one.

Including Resources Using Multiple Resource Files

Normally it is easy and convenient to work with the default arrangement of all resources in one resource script (.rc) file. However, you can add resources in other files to your current project at compile time by listing them in the compile-time directives box in the Resource Includes dialog box.

There are several reasons to place resources in a file other than the main .rc file:

- To include resources that have already been developed and tested and do not need further modification.
- To include resources that are being used by several different projects, or that are part of a source code version-control system, and thus must exist in a central location where modifications will affect all projects.
- To include resources that are in a custom format.
- To include statements in your resource file that execute conditionally at compile time using compiler directives, such as #ifdef and #else. For example, your project may have a group of resources that are bracketed by #ifdef _DEBUG ... #endif and are thus included only if the constant _DEBUG is defined at compile time.
- To include statements in your resource file that modify resource-file syntax by using the #define directive to implement simple macros.

If you have sections in your existing .rc files that meet any of these conditions, you should place the sections in one or more separate .rc files and include them in your project using the Resource Includes dialog box.

To include resource files that will be added to your project at compile time:

1. Place the resources in a resource script file with a unique filename. (Do not use *projectname*.rc, since this is the default filename used for the main resource script file.)
2. From the View menu, choose Resource Includes.
3. In the Compile-time directives box, use the #include compiler directive to include the new resource file in the main resource file in the development environment. The resources in files included in this way are made a part of your executable file at compile time. They are not directly available for

editing or modification when you are working on your project's main .rc file. You need to open included .rc files separately.
4. Click OK.

The Include (.FD) File

Each control in a dialog box has a unique integer identifier. When the Resource Editor creates the include file (.FD), it assigns the **PARAMETER** attribute to each control and to the dialog box itself, so they become named constants. It also assigns each control and the dialog box an integer value. You can read the list of names and values in your dialog boxes include file (for example, `RESOURCE.FD`). To view and modify the named constants, click Resource Symbols in the View menu.

When your application uses a control, it can refer to the control or dialog box by its name (for example, `IDC_SCROLLBAR_TEMPERATURE` or `IDD_TEMP`), or by its integer value. If you want to rename a control or make some other change to your dialog box, you should make the change through the Resource Editor in the visual development environment. Do not use a text editor to alter your .FD include file because the dialog resource will not be able to access the changes.

Writing a Dialog Application

When creating a dialog box with the Resource Editor, you specify the types of controls that are to be included in the box. You then must provide procedures to make the dialog box active. These procedures use both dialog routines and your subroutines to control your program's response to the user's dialog box input.

You give your application access to your dialog resource by adding the .RC file to your project, giving your application access to the dialog include file, and associating the dialog properties in these files with the `dialog` type (see Initializing and Activating the Dialog Box).

Your application must include the statement **USE DFLOGM** to access the dialog routines, and it must include the .FD file the Resource Editor created for your dialog. For example:

```
PROGRAM TEMPERATURE
USE DFLOGM
IMPLICIT NONE
INCLUDE 'RESOURCE.FD'
  .
  . ! Call dialog routines, such as DlgInit, DlgModal, and DlgUninit
  .
END PROGRAM TEMPERATURE
```

The following sections describe how to code a dialog application:

Initializing and Activating the Dialog Box

Each dialog box has an associated variable of the derived type `dialog`. The `dialog` derived type is defined in the DFLOGM.F90 module; you access it with **USE DFLOGM**. When you write your dialog application, refer to your dialog box as a variable of type `dialog`. For example:

```
USE DFLOGM
INCLUDE 'RESOURCE.FD'
TYPE (dialog) dlg
LOGICAL return
return = DLGINIT( IDD_TEMP, dlg )
```

This code associates the `dialog` type with the dialog (`IDD_TEMP` in this example) defined in your resource and include files (`TEMP.RC` and `RESOURCE.FD` in this example).

You give your application access to your dialog resource by adding the .RC file to your project. You give your application access to the dialog include file by including the .FD file in each subprogram. You associate the dialog properties in these files with the `dialog` type by calling **DLGINIT** with your dialog name.

An application that controls a dialog box should perform the following actions:

1. Call DLGINIT or DLGINITWITHRESOURCEHANDLE to initialize the `dialog` type and associate your dialog and its properties with the type.
2. Initialize the controls with the dialog set routines, such as DLGSET.
3. Set the callback routines to be executed when a user manipulates a control in the dialog box with DLGSETSUB.
4. Depending on whether you want a modal or modeless dialog type:
   - To use a modal dialog, run the dialog with DLGMODAL.
   - To use a modeless dialog, call DLGMODELESS and use DLGISDLGMESSAGE in your message loop.
5. Retrieve control information with the dialog get functions, such as DLGGET.
6. Free resources from the dialog with DLGUNINIT.

As an example of activating a dialog box and controls, the following code initializes the temperature dialog box and controls created in the TEMP project example. It also sets the callback routine as `UpdateTemp`, displays the dialog box, and releases the dialog resources when done:

```
  SUBROUTINE DoDialog( )
  USE DFLOGM
  IMPLICIT NONE
  INCLUDE 'RESOURCE.FD'

  INTEGER retint
  LOGICAL retlog
  TYPE (dialog) dlg
  EXTERNAL UpdateTemp
! Initialize.
  IF ( .not. DlgInit( idd_temp, dlg ) ) THEN
    WRITE (*,*) "Error: dialog not found"
  ELSE
! Set up temperature controls.
    retlog = DlgSet( dlg, IDC_SCROLLBAR_TEMPERATURE, 200, DLG_RANGEMAX)
    retlog = DlgSet( dlg, IDC_EDIT_CELSIUS, "100" )
    CALL UpdateTemp( dlg, IDC_EDIT_CELSIUS, DLG_CHANGE)
    retlog = DlgSetSub( dlg, IDC_EDIT_CELSIUS, UpdateTemp )
    retlog = DlgSetSub( dlg, IDC_EDIT_FAHRENHEIT, UpdateTemp )
    retlog = DlgSetSub( dlg, IDC_SCROLLBAR_TEMPERATURE, UpdateTemp )
! Activate the modal dialog.
    retint = DlgModal( dlg )
! Release dialog resources.
    CALL DlgUninit( dlg )
  END IF
  END SUBROUTINE DoDialog
```

The dialog routines, such as **DLGSET** and **DLGSETSUB**, refer to the dialog controls by the names you assigned to them in the Properties box while creating the dialog box in the Resource Editor. For example:

```
retlog = DlgSet( dlg, IDC_SCROLLBAR_TEMPERATURE, 200, DLG_RANGEMAX)
```

In this statement, the dialog function **DLGSET** assigns the control named `IDC_SCROLLBAR_TEMPERATURE` a value of 200. The index `DLG_RANGEMAX` specifies that this value is a scroll bar maximum range. Consider the following:

```
retlog = DlgSet( dlg, IDC_EDIT_CELSIUS, "100" )
CALL UpdateTemp( dlg, IDC_EDIT_CELSIUS, DLG_CHANGE)
```

The preceding statements set the dialog's top Edit box, named `IDC_EDIT_CELSIUS` in the Resource Editor, to an initial value of 100, and calls the routine `UpdateTemp` to inform the application that the value has changed. Consider the following:

```
retlog = DlgSetSub( dlg, IDC_EDIT_CELSIUS, UpdateTemp )
retlog = DlgSetSub( dlg, IDC_EDIT_FAHRENHEIT, UpdateTemp )
retlog = DlgSetSub( dlg, IDC_SCROLLBAR_TEMPERATURE,UpdateTemp )
```

The preceding statements associate the callback routine `UpdateTemp` with the three controls. This results in the `UpdateTemp` routine being called whenever the value of any of the three controls changes.

Routines are assigned to the controls with the function **DLGSETSUB**. Its first argument is the dialog variable, the second is the control name, the third is the name of the routine you have written for the control, and the optional fourth argument is an index to select between multiple routines. You can set the callback routines for your dialog controls anywhere in your application: before opening your dialog with either **DLGMODAL** or **DLGMODELESS**, or from within another callback routine.

In the TEMP example, the main program calls the DoDialog subroutine to display the Temperature Conversion dialog box.

Dialog Callback Routines

All callback routines should have the following interface:

SUBROUTINE callback (*dlg*, *control_name*, *callbacktype*)

Where:

dlg
Refers to the dialog box and allows the callback to change values of the dialog controls.

control_name
Is the name of the control that caused the callback.

callbacktype
Indicates what callback is occurring (for example, `DLG_CLICKED`, `DLG_CHANGE`, `DLG_DBLCLICK`).

The last two arguments let you write a single subroutine that can be used with multiple callbacks from more than one control. Typically, you do this for controls comprising a logical group. For example, all the controls in the temperature dialog in the TEMP example are associated with the same callback routine, `UpdateTemp`. You can also associate more than one callback routine with the same control, but you must then provide an index parameter to indicate which callback is to be used.

The following is an example of a callback routine:

```
  SUBROUTINE UpdateTemp( dlg, control_name, callbacktype )
  USE DFLOGM
  IMPLICIT NONE
  TYPE (dialog) dlg
  INTEGER control_name
  INTEGER callbacktype
  INCLUDE 'RESOURCE.FD'
  CHARACTER(256) text
  INTEGER cel, far, retint
  LOGICAL retlog
! Suppress compiler warnings for unreferenced arguments.
  INTEGER local_callbacktype
```

```
  local_callbacktype = callbacktype

  SELECT CASE (control_name)
    CASE (IDC_EDIT_CELSIUS)
    ! Celsius value was modified by the user so
    ! update both Fahrenheit and Scroll bar values.
      retlog = DlgGet( dlg, IDC_EDIT_CELSIUS, text )
      READ (text, *, iostat=retint) cel
      IF ( retint .eq. 0 ) THEN
        far = (cel-0.0)*((212.0-32.0)/100.0)+32.0
        WRITE (text,*) far
        retlog = DlgSet( dlg, IDC_EDIT_FAHRENHEIT,                     &
    &                    TRIM(ADJUSTL(text)) )
        retlog = DlgSet( dlg, IDC_SCROLLBAR_TEMPERATURE, cel,          &
    &                    DLG_POSITION )
      END IF
    CASE (IDC_EDIT_FAHRENHEIT)
    ! Fahrenheit value was modified by the user so
    ! update both celsius and Scroll bar values.
       retlog = DlgGet( dlg, IDC_EDIT_FAHRENHEIT, text )
       READ (text, *, iostat=retint) far
       IF ( retint .eq. 0 ) THEN
         cel = (far-32.0)*(100.0/(212.0-32.0))+0.0
         WRITE (text,*) cel
         retlog = DlgSet( dlg, IDC_EDIT_CELSIUS, TRIM(ADJUSTL(text)) )
         retlog = DlgSet( dlg, IDC_SCROLLBAR_TEMPERATURE, cel,         &
    &                     DLG_POSITION )
       END IF
    CASE (IDC_SCROLLBAR_TEMPERATURE)
    ! Scroll bar value was modified by the user so
    ! update both Celsius and Fahrenheit values.
       retlog = DlgGet( dlg, IDC_SCROLLBAR_TEMPERATURE, cel,           &
    &                   DLG_POSITION  )
       far = (cel-0.0)*((212.0-32.0)/100.0)+32.0
       WRITE (text,*) far
       retlog = DlgSet( dlg, IDC_EDIT_FAHRENHEIT, TRIM(ADJUSTL(text)) )
       WRITE (text,*) cel
       retlog = DlgSet( dlg, IDC_EDIT_CELSIUS, TRIM(ADJUSTL(text)) )
    END SELECT
  END SUBROUTINE UpdateTemp
```

Each control in a dialog box, except a pushbutton, has a default callback that performs no action. The default callback for a pushbutton's click event sets the return value of the dialog to the pushbutton's name and then exits the dialog. This makes all pushbuttons exit the dialog by default, and gives the OK and CANCEL buttons good default behavior. A routine that calls **DLGMODAL** can then test to see which pushbutton caused the modal dialog to exit.

Callbacks for a particular control are called after the value of the control has been changed by the user's action. Calling **DLGSET** does not cause a callback to be called for the changing value of a control. In particular, when inside a callback, performing a **DLGSET** on a control will not cause the associated callback for that control to be called.

Calling **DLGSET** before or after **DLGMODAL** or **DLGMODELESS** has been called also does not cause the callback to be called. If the callback needs to be called, it can be called manually using **CALL** after the **DLGSET** is performed.

Using a Modeless Dialog Box

To display a modeless dialog box, call the DLGMODELESS function. A modeless dialog box remains displayed until the **DLGEXIT** routine is called, either explicitly or by a default button callback. The application must provide a message loop to process Windows messages and must call the DLGISDLGMESSAGE function at the beginning of the message loop.

The variable of type **DIALOG** passed to **DLGMODELESS** must remain in memory for the duration of the dialog box (from the **DLGINIT** call through the **DLGUNINIT** call). The variable can be declared as global data in a Fortran module, as a variable with the STATIC attribute (or statement), or in a calling procedure that is active for the duration on the dialog box. For more information, see the Syntax for DLGMODELESS.

Modeless dialog boxes are typically used in a Fortran Windows project. A modeless dialog box can be used in a Fortran Console, Fortran DLL, or Fortran Static Library application as long as the requirements for using a modeless dialog box (discussed in the previous paragraphs) are met. For example, see the Visual Fortran sample `...\Df98\Samples\Dialog\Dllprgrs`.

As an example of using a modeless dialog box, the following code is the WinMain function of an application that displays a modeless dialog box as its main window:

```
integer*4 function WinMain(hInstance, hPrevInstance, lpszCmdLine, nCmdShow)
!DEC$ IF DEFINED(_X86_)
!DEC$ ATTRIBUTES STDCALL, ALIAS : '_WinMain@16' :: WinMain
!DEC$ ELSE
!DEC$ ATTRIBUTES STDCALL, ALIAS : 'WinMain' :: WinMain
!DEC$ ENDIF

   use dfwin
   use dflogm

   integer(4) hInstance
   integer(4) hPrevInstance
   integer(4) lpszCmdLine
   integer(4) nCmdShow

   ! Include the constants provided by the Resource Editor
   include 'resource.fd'

   ! A dialog box callback
   external ThermometerSub

   ! Variables
   type (dialog) dlg
   type (T_MSG)  mesg
   integer(4)  ret
   logical(4)  lret

   ! Create the thermometer dialog box and set up the controls and callbacks
```

```
    lret = DlgInit(IDD_THERMOMETER, dlg_thermometer)
    lret = DlgSetSub(dlg_thermometer, IDD_THERMOMETER, ThermometerSub)
    lret = DlgSet(dlg_thermometer, IDC_PROGRESS1, 32, DLG_RANGEMIN)
    lret = DlgSet(dlg_thermometer, IDC_PROGRESS1, 212, DLG_RANGEMAX)
    lret = DlgSet(dlg_thermometer, IDC_PROGRESS1, 32)
    lret = DlgModeless(dlg_thermometer, nCmdShow)

    ! Read and process messages until GetMessage returns 0 because
    ! PostQuitMessage has been called
    do while( GetMessage (mesg, NULL, 0, 0) )
       ! Note that DlgIsDlgMessage must be called in order to give
       ! the dialog box first chance at the message.
       if ( DlgIsDlgMessage(mesg) .EQV. .FALSE. ) then
           lret = TranslateMessage( mesg )
           ret  = DispatchMessage( mesg )
       end if
    end do

    ! Cleanup dialog box memory
    call DlgUninit(dlg)

    ! The return value is the wParam of the Quit message
    WinMain = mesg.wParam
    return
 end function
```

Using Fortran AppWizards to Help Add Modal Dialog Box Coding

Any Fortran project type can use a modal dialog box. Thus, when you create a project, you can use any of the Fortran Project AppWizards to help you create a project that uses a modal dialog box.

To create a "Hello World" Fortran Console application that uses a modal dialog box to display "Hello World!":

1. Create a new project with the Fortran Console project type named HelloDlg. After you create the project, the Fortran Console AppWizard appears. Select the "A Hello World sample project" option. Your workspace and source file (HelloDlg.f90) will be created for you.

2. In the Insert menu, select Resource... and select Dialog. Create the box using the dialog resource editor, as follows:
   1. Delete the Cancel button (click the Cancel button and press the Delete key).
   2. Add a new static text control to the dialog box.
   3. You can enlarge or resize the static text control if needed.
   4. Double click on the static text control to edit its properties. Change the Caption to "Hello World!." Under the Styles tab, you might change the Align text option to Center.
   5. Dismiss the dialog box by clicking the x in the upper-right corner of the window.

3. In the File menu, select Save As... and save the resources to a file named

`HelloDlg.rc` in the project directory.

4. In the Project menu, select Add To Project -> Files. Select `HelloDlg.rc` and click OK.

5. Edit (double-click its name in the FileView) the file `HelloDlg.f90`:
   - After the `program HELLODLG` line, add the following line:

     ```
     USE DFLOGM
     ```

   - Replace the line:

     ```
     print *, 'Hello World'
     ```

     With the following lines:

     ```
     include 'resource.fd'
     type (DIALOG) dlg
     logical lret
     integer iret
     lret = DlgInit(IDD_DIALOG1, dlg)
     iret = DlgModal(dlg)
     call DlgUninit(dlg)
     ```

   In the code above:

   - The `USE DFLOGM` line includes the DFLOGM module interfaces to the Dialog routines.
   - The line `include 'resource.fd'` includes the .fd file.
   - The function reference to DLGINIT initializes the dialog box.
   - The function reference to DLGMODAL displays the dialog box.
   - The call to DLGUNINIT frees the dialog box resources.

6. Build the Hellodlg Fortran Console project application. When you execute the application, the dialog box you created appears in front of the Console window:

7. Click OK to dismiss the dialog box.

For Visual Fortran applications using the Fortran Windows project type, you can use the Fortran Windows Project AppWizard to help you add dialog coding for a modeless dialog box.

For information about coding requirements for modal and modeless dialog boxes, see Initializing and Activating the Dialog Box.

Using Fortran AppWizards to Help Add Modeless Dialog Box Coding

To use a modeless dialog box, you typically use a Fortran Windows project type. The Fortran Windows Project AppWizard helps you add coding for using a modeless dialog box.

When you create a project and specify the Fortran Windows project, the Fortran Windows Project AppWizard displays four options (press the F1 key to view an explanation of these options).

Select one of the following to help learn about dialog coding where a dialog box is the primary window of the application:

- A simple Dialog Based Application

  To create an application where a dialog box is the main window of the application, *without* a menu bar, choose the A simple Dialog Based Application option.

  This creates the skeleton of an entire application that you can immediately build and run to display a sample dialog box. You can add controls to the dialog box and add dialog procedure calls to manipulate the controls and handle dialog callbacks. A number of the sample projects in the `...\SAMPLES\DIALOG\` directory were started using the A simple Dialog Based Application option.

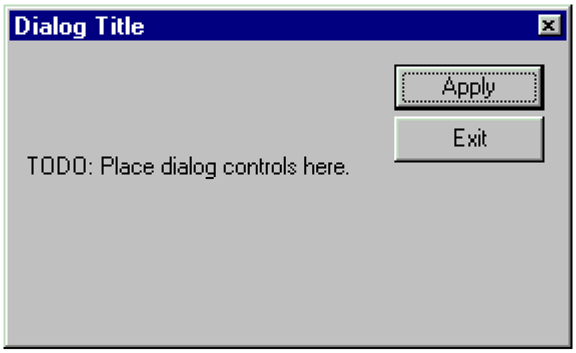
- A simple Single Document Interface (SDI)

  To create an application where a dialog box is the main window of the application *with* a menu bar, choose the A simple Single Document Interface (SDI) option.

This also creates the skeleton of an entire application that you can immediately build and run. You can add a dialog box to the client area of the main window (as explained later).

In the template-like code generated when you select A simple Dialog Based Application option:

- After you create a project with the A simple Dialog Based Application option, build it, and execute it, the following dialog box is displayed:



- Some of the code specific to the dialog routine interfaces and data declarations follows. For this example, the project name is FWin. The project name is used in some of the data declarations:

```
  use dflogm
  use FWin_dialogGlobals
  .
  .
  .
  include 'resource.fd'

  external FWin_dialogSub
  external FWin_dialogApply

! Variables
  type (T_MSG)            mesg
  integer*4               ret
  logical*4               lret
```

The FWin_dialogGlobals module is defined in a separate source file in that project. The FWin_dialogSub and FWin_dialogApply are subroutines defined later in the main source file that are callback routines for different controls for the dialog box.

- The code specific to creating the dialog follows:

```
  lret = DlgInit(IDD_FWIN_DIALOG_DIALOG, gdlg)              1
  if (lret == .FALSE.) goto 99999
  lret = DlgSetSub(gdlg, IDD_FWIN_DIALOG_DIALOG, FWin_dialogSub) 2
  lret = DlgSetSub(gdlg, IDM_APPLY, FWin_dialogApply)       3
  lret = DlgModeless(gdlg, nCmdShow)                        4
```

```
if (lret == .FALSE.) goto 99999
```

Notes for this example:

1 DlgInit initializes the dialog box.

2 The first call to DlgSetSub assigns a callback subroutine to the Exit button. It associates the FWin_dialogSub subroutine with the dialog box identifier IDD_FWIN_DIALOG_DIALOG (project name is FWin_Dialog). The FWin_dialogSub routine contains code to terminate the program.

3 The second call to DlgSetSub associates FWin_dialogApply with the Apply button identifier IDM_APPLY. The user should add code in the FWin_dialogApply subroutine to take appropriate action.

4 DlgModeless displays the initialized modeless dialog box, which is ready for user input.

- The code specific to processing messages (message loop) to react to user input follows:

```
! Read and process messages
do while( GetMessage (mesg, NULL, 0, 0) )              1
   if ( DlgIsDlgMessage(mesg) .EQV. .FALSE. ) then     2
       lret = TranslateMessage( mesg )                 3
       ret  = DispatchMessage( mesg )                  4
   end if
end do
```

Notes for this example:

1 The GetMessage Win32 call inside a DO WHILE loop returns a message from the calling thread's message queue.

2 DlgIsDlgMessage determines whether the specified message is intended for one of the currently displayed modeless dialog boxes, or a specific dialog box.

3 The TranslateMessage Win32 call translates virtual-key messages into character messages.

4 The DispatchMessage Win32 call dispatches a message to a window procedure.

- The dialog box is terminated and its resources are released by calling DlgUninit:

```
call DlgUninit(gdlg)
```

In the template-like code generated when you select A simple Single Document Interface (SDI) AppWizard option, to add the dialog box to the client area of the main window:

1. In the Insert menu, select Resource... and create a new Dialog box. Edit the Dialog Properties. Select the Styles tab and set Styles to Child and Border to Thin.

2. In the main source file, add the following USE statement:

```
USE dflogm
```

3. In the main source file, in the function MainWndProc, add a case to handle the WM_CREATE message. In this case, initialize the dialog box in the normal manner. To display the dialog box, call:

```
lret = DlgModeless(dlg, SW_SHOWNA, hwndParent)
```

   In this call, hwndParent is the window handle of the application's main window.

4. In the main source file, add a call to DlgIsDlgMessage to the message loop, before the call to the Win32 routine TranslateAccelerator. It should look like:

```
! Read and process messages
do while( GetMessage (mesg, NULL, 0, 0) )
  if ( DlgIsDlgMessage(mesg, dlg) .EQV. .FALSE. ) then
    if ( TranslateAccelerator (mesg%hwnd, haccel, mesg) == 0) then
       lret = TranslateMessage( mesg )
       ret  = DispatchMessage( mesg )
    end if
  end if
end do
```

5. Optionally, if you want to allow the user to resize the main window, add a case to handle the WM_RESIZE message and change the layout of the dialog box based upon its size.

See the FXPLORER Visual Fortran Sample in `...\SAMPLES\DIALOG` for an example of this type of application.

Using Dialog Controls in a DLL

You can use a dialog box that is defined in a DLL. To do so, you must inform the dialog routines that the dialog resource is located in the DLL, rather than in the main application. The dialog routines will look for the dialog resource in the main application by default.

To do this, initialize your dialog box using **DlgInitWithResourceHandle** rather than **DlgInit**. As compared to **DlgInit**, DlgInitWithResourceHandle takes an additional argument named "hinst". The "hinst" argument is the module instance handle in which the dialog resource can be found. For a DLL, this handle is passed into the DLL entry point, DllMain.

An example of a DllMain function follows:

```
module dll_globals
   integer(4) ghInst    ! DLL instance handle
end module dll_globals

!********************************************************************
!*   FUNCTION: DllMain(HANDLE, DWORD, LPVOID)
!*
!*   PURPOSE:  DllMain is called by Windows when
!*     the DLL is initialized, Thread Attached, and other times.
!*     Refer to SDK documentation, as to the different ways this
!*     may be called.
!*
!*     The DllMain function should perform additional initialization
!*     tasks required by the DLL.  DllMain should return a value of 1
!*     if the initialization is successful.
!*
!*********************************************************************

integer(4) function DllMain (hInst, ul_reason_being_called, lpReserved)
!DEC$ IF DEFINED(_X86_)
!DEC$ ATTRIBUTES STDCALL, ALIAS : '_DllMain@12' :: DllMain
!DEC$ ELSE
!DEC$ ATTRIBUTES STDCALL, ALIAS : 'DllMain' :: DllMain
!DEC$ ENDIF

   use dll_globals

   integer(4) hInst
   integer(4) ul_reason_being_called
   integer(4) lpReserved

   !  Save the module instance handle in a global variable
   !  This would typically be in a Module or a COMMON block.
   ghInst =  hInst

   DllMain = 1
   return
end
```

One way to use **DlgInitWithResourceHandle** is to build a *resource-only DLL*. A resource-only DLL contains an .RC file, but no code. It is useful for building an application that supports multiple languages. You can create a main application and several resource-only DLLs (one for each language) and call the Win32 LoadLibrary routine at the beginning of your application to load the appropriate resource-only DLL. To use a dialog box from the resource-only DLL, first call LoadLibrary (see the Platform SDK online documentation) to return the instance handle that you can use when you call **DlgInitWithResourceHandle**.

When you create a Fortran DLL project, you can create a resource-only DLL using the Fortran Dynamic Link Library AppWizard:

1. In the Fortran Dynamic Link Library AppWizard, select "An empty DLL application."
2. Complete creating the project.
3. In the Project menu, select Add to Project...Files to add your .RC file and the RESOURCE.H file that defines the identifiers of the controls.
4. In the Project menu:
   - Click Settings
   - Click Link tab
   - Add the /noentry switch to the end of the options in the Project Options edit box

Dialog Routines

You can use dialog routines as you would any intrinsic procedure or run-time routine.

As described in Using Dialogs, Visual Fortran supports two types of dialog boxes: modal and modeless. You can use a modal dialog box with any Fortran project type. You can use a modeless dialog box only with the Fortran Windows project types.

The dialog routines can:

- Initialize and close the dialog box
- Retrieve user input from a dialog box
- Display data in the dialog box
- Modify the dialog box controls

The include file (.FD) of the dialog box contains the names of the dialog controls that you specified in the Properties box of the Resource Editor when you created the dialog box. The module DFLOGM.MOD contains predefined variable names and type definitions. These control names, variables, and type definitions are used in the dialog routine argument lists to manage your dialog box.

The dialog routines are listed in the following table:

Dialog Routine	**Description**
DLGEXIT	Closes an open dialog
DLGFLUSH	Updates the dialog display

DLGGET	Gets the value of a control variable
DLGGETCHAR	Gets the value of a character control variable
DLGGETINT	Gets the value of an integer control variable
DLGGETLOG	Gets the value of a logical control variable
DLGINIT	Initializes the dialog
DLGINITWITHRESOURCEHANDLE	Initializes the dialog (alternative to **DLGINIT**)
DLGISDLGMESSAGE	Determines whether a message is intended for a modeless dialog box
DLGISDLGMESSAGEWITHDLG	Determines whether a message is intended for a modeless dialog box (alternative to **DLGISDLGMESSAGE**)
DLGMODAL	Displays a modal dialog box
DLGMODALWITHPARENT	Displays a modal dialog box (alternative to **DLGMODAL**)
DLGMODELESS	Displays a modeless dialog box
DLGSENDCTRLMESSAGE	Sends a message to a control
DLGSET	Assigns a value to a control variable
DLGSETCHAR	Assigns a value to a character control variable
DLGSETCTRLEVENTHANDLER	Assigns a routine to handle an ActiveX control event.
DLGSETINT	Assigns a value to an integer control variable
DLGSETLOG	Assigns a value to a logical control variable
DLGSETRETURN	Sets the return value for **DLGMODAL**
DLGSETSUB	Assigns a defined callback routine to a control

DLGSETTITLE	Sets the dialog title
DLGUNINIT	Deallocates memory for an initialized dialog

These routines are described in the *Language Reference* (see also Dialog Procedures: table).

Dialog Controls

Each dialog control in a dialog box has a unique integer identifier and name. You specify the name in the Properties box for each control within the Resource Editor, and the Resource Editor assigns the PARAMETER attribute and an integer value to each control name. You can refer to a control by its name, for example `IDC_SCROLLBAR_TEMPERATURE`, or by its integer value, which you can read from the include (.FD) file.

Each dialog control has one or more variables associated with it, called *control indexes*. These indexes can be integer, logical, character, or external. For example, a plain Button has three associated variables: one is a logical value associated with its current enabled state, one is a character variable that determines its title, and the third is an external variable that indicates the subroutine to be called if a mouse click occurs.

Dialog controls can have multiple variables of the same type. For example, the scroll bar control has four integer variables associated with it:

- Scroll bar position
- Scroll bar minimum range
- Scroll bar maximum range
- Position change if the user clicks on the scroll bar space next to the slide (big step)

Dialog controls and their indexes are discussed in:

- Control Indexes
- Available Indexes for Each Dialog Control
- Specifying Control Indexes

Control Indexes

The value of a dialog control's index is set with the DLGSET functions: **DLGSET**, **DLGSETINT**, **DLGSETLOG**, **DLGSETCHAR**, and **DLGSETSUB**. The control name and control index name are arguments to the **DLGSET** functions and specify the particular control index being set. For example:

```
retlog = DlgSet( dlg, IDC_SCROLLBAR_TEMPERATURE, 45, DLG_POSITION )
```

The index `DLG_POSITION` specifies the scroll bar position is set to 45. Consider the following:

```
retlog = DlgSet( dlg, IDC_SCROLLBAR_TEMPERATURE, 200, DLG_RANGEMAX)
```

In this statement, the index `DLG_RANGEMAX` specifies the scroll bar maximum range is set to 200. The **DLGSET** functions have the following syntax:

result **= DLGSET** (*dlg*, *control_name*, *value*, *control_index_name*)

The *control_index_name* determines what the *value* in the **DLGSET** function means.

The control index names are declared in the module DFLOGM.MOD and should not be declared in your routines. Available control indexes and how they specify the interpretation of the *value* argument are listed in the following Control Indexes table.

Control Index	How the Value is Interpreted
DLG_ADDSTRING	Used with **DLGSETCHAR** to add an entry to a List box or Combo box
DLG_BIGSTEP	The amount of change that occurs in a Scroll bar's or Slider's position when the user clicks beside the Scroll bar's or slider's slide (default = 10)
DLG_CHANGE	A subroutine called after the user has modified a control and the control has been updated on the screen
DLG_CLICKED	A subroutine called when the control receives a mouse-click
DLG_DBLCLICK	A subroutine called when a control is double-clicked
DLG_DEFAULT	Same as not specifying a control index
DLG_ENABLE	The enable state of the control (*value* = .TRUE. means enabled, *value* = .FALSE. means disabled)
DLG_GAINFOCUS	A subroutine called when an Edit Box receives input focus.
DLG_IDISPATCH	The object pointer of an ActiveX control.

DLG_LOSEFOCUS	A subroutine called when an Edit Box loses input focus.
DLG_NUMITEMS	The total number of items in a List box, Combo box, or Tab control
DLG_POSITION	The current position of the Scroll bar, Spin, Slider, or Progress bar. Also, the current cursor position in the edit box.
DLG_RANGEMIN	The minimum value of a Scroll bar's, Spin's, Slider's, or Progress' position (default = 1 for scroll bar, 0 for other controls)
DLG_RANGEMAX	The maximum value of a Scroll bar's, Spin's, Slider's, or Progress' position (default = 100)
DLG_SELCHANGE	A subroutine called when the selection in a List Box or Combo Box changes
DLG_SELCHANGING	A subroutine called when the selected Tab control is about to be changed. In this subroutine, calling **DLGGETINT** with the index DLG_STATE refers to the Tab that was active before the change.
DLG_SMALLSTEP	The amount of change that occurs in a Slider's position when the user presses the keyboard arrow keys (default = 1)
DLG_STATE	The user changeable state of a control
DLG_TEXTLENGTH	The length of text in an edit box.
DLG_TICKFREQ	The interval frequency for tick marks in a Slider (default = 1)
DLG_TITLE	The title text associated with a control
DLG_UPDATE	A subroutine called after the user has modified the control state but before the control has been updated on the screen

The index names associated with dialog controls do not need to be used unless there is more than one variable of the same type for the control and you do not want the default variable. For example:

```
retlog = DlgSet(dlg, IDC_SCROLLBAR_TEMPERATURE, 45, DLG_POSITION)
retlog = DlgSet(dlg, IDC_SCROLLBAR_TEMPERATURE, 45)
```

These statements both set the Scroll bar position to 45, because `DLG_POSITION` is the default control index for the scroll bar.

Dialog Indexes

The control identifier specified in **DLGSETSUB** can also be the identifier of the dialog box. In this case, the index must be one of the values listed in the Dialog Indexes table:

Dialog Index	How the Value is Interpreted
DLG_INIT	A subroutine called after the dialog box is created but before it is displayed (with callbacktype=DLG_INIT) and immediately before the dialog box is destroyed (with callbacktype=DLG_DESTROY).
DLG_SIZECHANGE	A subroutine called after the dialog box is resized.

For more information on dialog controls, see Available Indexes for Each Dialog Control.

Available Indexes for Each Dialog Control

The available indexes and defaults for each of the controls are listed in the following table:

Dialog Controls and Their Indexes

Control Type	Integer Index Name	Logical Index Name	Character Index Name	Subroutine I Name
ActiveX control	DLG_IDISPATCH	DLG_ENABLE		
Button		DLG_ENABLE	DLG_TITLE	DLG_CLICKED
Check box		DLG_STATE (default) DLG_ENABLE	DLG_TITLE	DLG_CLICKED

Combo box	DLG_NUMITEMS Sets or returns the total number of items in a list	DLG_ENABLE	Use DLG_STATE, DLG_ADDSTRING, or an index: DLG_STATE By default, sets or returns the text of the selected item or first item in the list DLG_ADDSTRING Used with **DLGSETCHAR** to add a new item. It automatically increments DLG_NUMITEMS. An index, 1 to *n* Sets or returns the text of a particular item	DLG_SELCHANGE (default) DLG_DBLCLICK DLG_CHANGE DLG_UPDATE
Drop-down list box	Use DLG_NUMITEMS or DLG_STATE: DLG_NUMITEMS (default) Sets or returns the total number of items in a list DLG_STATE Sets or returns the index of the selected item	DLG_ENABLE	Use DLG_STATE, DLG_ADDSTRING, or an index: DLG_STATE By default, sets or returns the text of the selected item or first item in the list, or you can include an index, 1 to *n*, to set or return indicates the text of a particular item DLG_ADDSTRING Used with **DLGSETCHAR** to add a new item. It automatically increments	DLG_SELCHANGE (default) DLG_DBLCLICK

			DLG_NUMITEMS.	
Edit box	DLG_TEXTLENGTH (default) Sets or returns the length of the text in the edit box. DLG_POSITION Sets or returns the cursor position	DLG_ENABLE	DLG_STATE	DLG_CHANGE (default) DLG_UPDATE DLG_GAINFOCUS DLG_LOSEFOCUS
Group box		DLG_ENABLE	DLG_TITLE	
List box	Use DLG_NUMITEMS or an index: DLG_NUMITEMS Sets or returns the total number of items in a list An index, 1 to *n* Determines which list items have been selected and their order	DLG_ENABLE	Use DLG_STATE, DLG_ADDSTRING, or an index: DLG_STATE By default, returns the text of the first selected item DLG_ADDSTRING Used with **DLGSETCHAR** to add a new item. It automatically increments DLG_NUMITEMS. An index, 1 to *n* Sets or returns the text of a particular item	DLG_SELCHANGE (default) DLG_DBLCLICK
Picture		DLG_ENABLE		
Progress bar	DLG_POSITION (default) DLG_RANGEMIN DLG_RANGEMAX	DLG_ENABLE		

Radio button		DLG_STATE (default) DLG_ENABLE	DLG_TITLE	DLG_CLICKED
Scroll bar	DLG_POSITION (default) DLG_RANGEMIN DLG_RANGEMAX DLG_BIGSTEP	DLG_ENABLE		DLG_CHANGE
Slider	DLG_POSITION (default) DLG_RANGEMIN DLG_RANGEMAX DLG_SMALLSTEP DLG_BIGSTEP DLG_TICKFREQ	DLG_ENABLE		DLG_CHANGE
Spin controls	DLG_POSITION (default) DLG_RANGEMIN DLG_RANGEMAX	DLG_ENABLE		DLG_CHANGE
Static text		DLG_ENABLE	DLG_TITLE	
Tab control	Use DLG_NUMITEMS (default), DLG_STATE, or an index: DLG_NUMITEMS Sets or returns the total number of tabs DLG_STATE Sets or returns the currently selected tab An index, 1 to *n* Sets or returns the dialog name of the dialog box associated with a	DLG_ENABLE	Use DLG_STATE or an index: DLG_STATE By default, sets or returns the currently selected tab An index, 1 to *n* Sets or returns the text of a particular Tab	DLG_SELCHANGE (default) DLG_SELCHANGING

	particular tab			

For an overview on control indexes, see Control Indexes.

Specifying Control Indexes

Where there is only one possibility for a particular dialog control's index type (integer, logical, character, or subroutine), you do not need to specify the control index name in an argument list. For example, you can set the Static text control `IDC_TEXT_CELSIUS` to a new value with either of the following statements:

```
  retlog = DLGSETCHAR (dlg, IDC_TEXT_CELSIUS, "New Celsius Title",  &
 &                    DLG_TITLE)
  retlog = DLGSET (dlg, IDC_TEXT_CELSIUS, "New Celsius Title")
```

You do not need the control index `DLG_TITLE` because there is only one character index for a Static text control. The generic function DLGSET chooses the control index to change based on the argument type, in this case CHARACTER.

For each type of index, you can use the generic **DLGSET** function or the specific **DLGSET** function for that type: DLGSETINT, DLGSETLOG, or DLGSETCHAR.

For example, you can disable the Static text control `IDC_TEXT_CELSIUS` by setting its logical value to .FALSE. with either **DLGSET** or **DLGSETLOG**:

```
  retlog = DLGSETLOG (dlg, IDC_TEXT_CELSIUS, .FALSE., DLG_ENABLE)
  retlog = DLGSET (dlg, IDC_TEXT_CELSIUS, .FALSE., DLG_ENABLE)
```

In both these cases, the control index `DLG_ENABLE` can be omitted because there is only one logical control index for Static text controls.

You can query the value of a particular control index with the DLGGET functions, DLGGET, DLGGETINT, DLGGETLOG, and DLGGETCHAR. For example:

```
  INTEGER current_val
  LOGICAL are_you_enabled
     retlog = DLGGET (dlg, IDC_SCROLLBAR_TEMPERATURE, current_val,      &
    &                 DLG_RANGEMAX)
     retlog = DLGGET (dlg, IDC_SCROLLBAR_TEMPERATURE, are_you_enabled,  &
    &                 DLG_ENABLE)
```

This code returns the maximum range and the enable state of the scroll bar. The arguments you declare (`current_val` and `are_you_enabled` in the preceding example) to hold the queried values must be of the same type as the values retrieved. If you use specific **DLGGET** functions such as **DLGGETINT** or **DLGGETCHAR**, the control index value retrieved must be the appropriate type. For example, you cannot use **DLGGETCHAR** to retrieve an integer or logical value. The **DLGGET** functions return .FALSE. for illegal type combinations. You cannot query for the name of an external callback routine.

In general, it is better to use the generic functions **DLGSET** and **DLGGET** rather than their type-specific variations because then you do not have to worry about matching the function to type of value set or retrieved. **DLGSET** and **DLGGET** perform the correct operation automatically, based on the type of argument you pass to them.

More information on these routines is available in the *Language Reference*.

Using Dialog Controls

The dialog controls provided in the Resource Editor are versatile and flexible and when used together can provide a sophisticated user-friendly interface for your application. This section discusses the available dialog controls.

Any control can be disabled by your application at any time, so that it no longer changes or responds to the user. This is done by setting the control index DLG_ENABLE to .FALSE. DLGSET or DLGSETLOG. For example:

```
LOGICAL retlog
retlog = DLGSET (dlg, IDC_CHECKBOX1, .FALSE., DLG_ENABLE)
```

This example disables the control named `IDC_CHECKBOX1`.

When you create your dialog box in the Resource Editor, the dialog controls are given a tab order. When the user hits the `Tab` key, the dialog box focus shifts to the next control in the tab order. By default, the tab order of the controls follows the order in which they were created. This may not be the order you want.

You can change the order by opening the Layout menu and choosing Tab Order (or by pressing the key combination `Ctrl+D`) in the Resource Editor. A tab number will appear next to each control. Click the mouse on the control you want to be first, then on the control you want to be second in the tab order and so on. Tab order also determines which control gets the focus if the user presses the Group box hotkey. (See Using Group Boxes.)

For information on Visual Fortran Samples that use the Dialog functions, see the `...\DF98\SAMPLES\DIALOG` folder.

The following sections describe the function and use of the dialog controls:

- Using Static Text
- Using Edit Boxes
- Using Group Boxes
- Using Check Boxes and Radio Buttons
- Using Buttons

- Using List Boxes and Combo Boxes
- Using Scroll Bars
- Using Pictures
- Using Progress Bars
- Using Spin Controls
- Using Sliders
- Using Tab Controls
- Setting Return Values and Exiting

For information on using ActiveX controls in a dialog, see Using ActiveX Controls.

Using Static Text

Static text is an area in the dialog that your application writes text to. The user cannot change it. Your application can modify the Static text at any time, for instance to display a current user selection, but the user cannot modify the text. Static text is typically used to label other controls or display messages to the user.

Using Edit Boxes

An Edit box is an area that your application can write text to at anytime. However, unlike Static Text, the user can write to an Edit box by clicking the mouse in the box and typing. The following statements write to an Edit box:

```
CHARACTER(20) text /"Send text"/
retlog = DLGSET (dlg, IDC_EDITBOX1, text)
```

The next statement reads the character string in an Edit box:

```
retlog = DLGGET (dlg, IDC_EDITBOX1, text)
```

The values a user enters into the Edit box are always retrieved as character strings, and your application needs to interpret these strings as the data they represent. For example, numbers entered by the user are interpreted by your application as character strings. Likewise, numbers you write to the Edit box are sent as character strings. You can convert between numbers and strings by using internal read and write statements to make type conversions.

To read a number in the Edit box, retrieve it as a character string with DLGGET or DLGGETCHAR, and then execute an internal read using a variable of the numeric type you want (such as integer or real). For example:

```
REAL    x
LOGICAL retlog
CHARACTER(256) text
retlog = DLGGET (dlg, IDC_EDITBOX1, text)
READ (text, *) x
```

In this example, the real variable x is assigned the value that was entered into the Edit box, including any decimal fraction.

Complex and double complex values are read the same way, except that your application must separate the Edit box character string into the real part and imaginary part. You can do this with two separate Edit boxes, one for the real and one for the imaginary part, or by requiring the user to enter a separator between the two parts and parsing the string for the separator before converting. If the separator is a comma (,) you can read the string with two real edit descriptors without having to parse the string.

To write numbers to an Edit box, do an internal write to a string, then send the string to the Edit box with DLGSET. For example:

```
INTEGER  j
LOGICAL  retlog
CHARACTER(256) text
WRITE (text,'(I4)') j
retlog = DLGSET (dlg, IDC_EDITBOX1, text)
```

Use the DLG_TEXTLENGTH control index to get or set the length of the characters in the edit box. The length is automatically updated when:

- Your program calls **DLGSET** to set the text in the edit box (trailing blanks are stripped before setting the edit box).
- The user modifies the text in the edit box.

If you want to set the text with significant trailing blanks, call **DLGSET** to set the text followed by DLGSET with the DLG_TEXTLENGTH index to set the length that you want.

Use the DLG_POSITION index to get or set the current cursor position in the edit box. Note that setting the cursor position cancels any current selection in the edit box.

Using Group Boxes

A Group box visually organizes a collection of controls as a group. When you select Group box in Resource Editor, you create an expanding (or shrinking) box around the controls you want to group and give the group a title. You can add a hotkey to your group title with an ampersand (&). For example, consider the following group title:

```
&Temperature
```

This causes the "T" to be underlined in the title and makes it a hotkey. When the user presses the key combination ALT+T, the focus of the dialog box shifts to the next control after the Group box in the tab order. This control should be a control in the group. (You can view and change the tab order from the Layout/Tab Order menu option in the Resource Editor.)

Disabling the Group box disables the hotkey, but does not disable any of the controls within the group. As a matter of style, you should generally disable the controls in a group when you disable the Group box.

Using Check Boxes and Radio Buttons

Check boxes and Radio buttons present the user with an either-or choice. A Radio button is pushed or not, and a Check box is checked or not. You use DLGGET or DLGGETLOG to check the state of these controls. Their state is a logical value that is .TRUE. if they are pushed or checked, and .FALSE. if they are not. For example:

```
LOGICAL pushed_state, checked_state, retlog
retlog = DLGGET (dlg, IDC_RADIOBUTTON1, pushed_state)
retlog = DLGGET (dlg, IDC_CHECKBOX1, checked_state)
```

If you need to change the state of the button, for initialization or in response to other user input, you use DLGSET or DLGSETLOG. For example:

```
LOGICAL retlog
retlog = DLGSET (dlg, IDC_RADIOBUTTON1, .TRUE.)
retlog = DLGSET (dlg, IDC_CHECKBOX1, .TRUE.)
```

Radio buttons are typically used in a group where the user can select only one of a set of radio buttons. When using Radio buttons with the Dialog routines, use the following guidelines:

- Each Radio button should have the "Auto" style set. This is the default for a new Radio button.
- The first Radio button in a group should have the "Group" style set. This is not the default for a new Radio button.
- The remaining Radio buttons in the group should not have the "Group" style set, and should immediately follow the first button in the dialog box "Tab order". The default tab order is the order in which you create the controls. You can view and change the tab order from the Layout/Tab Order menu option in the Resource Editor.
- When the user selects a Radio button in a group, its state is set to .TRUE. and the state of the other Radio buttons in the group is set to .FALSE..
- To set the currently selected Radio button from your code, call DLGSETLOG to set the selected Radio button to .TRUE.. Do not set the other Radio buttons to .FALSE.. This is handled automatically.

Using Buttons

Unlike Check Boxes and Radio Buttons, Buttons do not have a state. They do not hold the value of being pushed or not pushed. When the user clicks on a Button with the mouse, the Button's callback routine is called. Thus,the purpose of a Button is to initiate an action. The external procedure you assign as a callback determines the action initiated. For example:

```
LOGICAL retlog
EXTERNAL DisplayTime
retlog = DlgSetSub( dlg, IDC_BUTTON_TIME, DisplayTime)
```

Visual Fortran dialog routines do not support user-drawn Buttons.

Using List Boxes and Combo Boxes

List boxes and Combo boxes are used when the user needs to select a value from a set of many values. They are similar to a set of Radio buttons except that List boxes and Combo boxes are scrollable and can contain more items than a set of Radio buttons which are limited by the screen display area. Also, unlike Radio buttons, the number of entries in a List box or Combo box can change at run-time.

The difference between a List box and a Combo box is that a List box is simply a list of items, while a Combo box is a combination of a List box and an Edit box. A List box allows the user to choose multiple selections from the list at one time, while a Combo box allows only a single selection, but a Combo box allows the user to edit the selected value while a List box only allows the user to choose from the given list.

A Drop-down list box looks like a Combo box since it has a drop-down arrow to display the list. Like a Combo box, only one selection can be made at a time in a Drop-down list box, but, like a List box, the selected value cannot be edited. A Drop-down list box serves the same function as a List box except for the disadvantage that the user can choose only a single selection, and the advantage that it takes up less dialog screen space.

Visual Fortran dialog routines do not support user-drawn List boxes or user-drawn Combo boxes. You must create List boxes and Combo boxes with the Resource Editor.

The following sections describe how to use List boxes and Combo boxes:

- Using List boxes
- Using Combo boxes
- Using Drop-down List boxes

Using List Boxes

For both List boxes and Combo boxes, the control index DLG_NUMITEMS determines how many items are in the box. Once this value is set, you set the text of List box items by specifying a character string for each item index. Indexes run from 1 to the total number of list items set with DLG_NUMITEMS. For example:

```
LOGICAL retlog
retlog = DlgSet ( dlg, IDC_LISTBOX1, 3, DLG_NUMITEMS )
retlog = DlgSet ( dlg, IDC_LISTBOX1, "Moe", 1 )
retlog = DlgSet ( dlg, IDC_LISTBOX1, "Larry", 2 )
retlog = DlgSet ( dlg, IDC_LISTBOX1, "Curly", 3 )
```

These function calls to DLGSET put three items in the List box. The initial value of each List box entry is a blank string and the value becomes nonblank after it has been set.

You can change the list length and item values at any time, including from within callback routines. If the list is shortened, the set of entries is truncated. If the list is lengthened, blank entries are added. In the preceding example, you could extend the list length and define the new item with the following:

```
retlog = DLGSET ( dlg, IDC_LISTBOX1, 4)
retlog = DLGSET ( dlg, IDC_LISTBOX1, "Shemp", 4)
```

Since List boxes allow selection of multiple entries, you need a way to determine which entries are selected. When the user selects a List box item, it is assigned an integer index. You can test which list items are selected by reading the selection indexes in order until a zero value is read. For example, if in the previous List box the user selected Moe and Curly, the List box selection indexes would have the following values:

Selection Index	Value
1	1 (for Moe)
2	3 (for Curly)
3	0 (no more selections)

If Larry alone had been selected, the List box selection index values would be:

Selection Index	Value
1	2 (for Larry)
2	0 (no more selections)

To determine the items selected, the List box values can be read with DLGGET until a zero is encountered. For example:

```
INTEGER j, num, test
INTEGER, ALLOCATABLE :: values(:)
LOGICAL retlog

retlog = DLGGET (dlg, IDC_LISTBOX1, num, DLG_NUMITEMS)
ALLOCATE (values(num))
j = 1
test = -1
DO WHILE (test .NE. 0)
   retlog = DLGGET (dlg, IDC_LISTBOX1, values(j), j)
   test = values(j)
   j = j + 1
END DO
```

In this example, j is the selection index and values(j) holds the list numbers, of the items selected by the user, if any.

To read a single selection, or the first selected item in a set, you can use DLG_STATE, since for a List Box DLG_STATE holds the character string of the first selected item (if any). For example:

```
! Get the string for the first selected item.
retlog = DLGGET (dlg, IDC_LISTBOX1, str, DLG_STATE)
```

Alternatively, you can first retrieve the list number of the selected item, and then get the string associated with that item:

```
INTEGER value
CHARACTER(256) str
  ! Get the list number of the first selected item.
  retlog = DLGGET (dlg, IDC_LISTBOX1, value, 1)
  ! Get the string for that item.
  retlog = DLGGET (dlg, IDC_LISTBOX1, str, value)
```

In these examples, if no selection has been made by the user, str will be a blank string.

In the Properties/Styles box in the Resource Editor, List boxes can be specified as sorted or unsorted. The default is sorted, which causes List box items to be sorted alphabetically starting with A. If a List box is specified as sorted, the items in the list are sorted whenever they are updated on the screen. This occurs when the dialog box is first displayed and when the items are changed in a callback.

The alphabetical sorting follows the ASCII collating sequence, and uppercase letters come before lowercase letters. For example, if the List box in the example above with the list "Moe," "Larry," "Curly," and "Shemp" were sorted, before a callback or after **DLGMODAL** returned, index 1 would refer to "Curly," index 2 to "Larry," index 3 to "Moe," and index 4 to "Shemp." For this reason, when using sorted List boxes, indexes should not be counted on to be the same once the dialog is displayed and any change is made to the list items.

You can also call DLGSETCHAR with the DLG_ADDSTRING index to add items to a List box or Combo box. For example:

```
retlog = DlgSet(dlgtab, IDC_LIST, "Item 1", DLG_ADDSTRING)
```

When you use DLG_ADDSTRING, the DLG_NUMITEMS control index of the List or Combo box is automatically incremented.

When adding items to a sorted list or Combo box, using DLG_ADDSTRING can be much easier than the alternative (setting DLG_NUMITEMS and then setting items using an index value), because you need not worry about the list being sorted and the index values changing between calls.

Using Combo Boxes

A Combo box is a combination of a List box and an Edit box. The user can make a selection from the list that is then displayed in the Edit box part of the control, or enter text directly into the Edit box.

All dialog values a user enters are character strings, and your application must interpret these strings as the data they represent. For example, numbers entered by the user are returned to your application as character strings.

Because user input can be given in two ways, selection from the List box portion or typing into the Edit box portion directly, you need to register two callback types with DLGSETSUB for a Combo box. These callback types are `dlg_selchange` to handle a new list selection by the user, and `dlg_update` to handle text entered by the user directly into the Edit box portion. For example:

```
retlog = DlgSetSub( dlg, IDC_COMBO1, UpdateCombo, dlg_selchange )
retlog = DlgSetSub( dlg, IDC_COMBO1, UpdateCombo, dlg_update )
```

A Combo box list is created the same way a List box list is created, as described in the previous section, but the user can select only one item from a Combo box at a time. When the user selects an item from the list, Windows automatically puts the item into the Edit box portion of the Combo box. Thus, there is no need, and no mechanism, to retrieve the item list number of a selected item.

If the user is typing an entry directly into the Edit box part of the Combo box, again Windows automatically displays it and you do not need to. You can retrieve the character string of the selected item or Edit box entry with the following statement:

```
! Returns the character string of the selected item or Edit box entry as str.
```

```
retlog = DLGGET (dlg, IDC_COMBO1, str)
```

Like List boxes, Combo boxes can be specified as sorted or unsorted. The notes about sorted List boxes also apply to sorted Combo boxes.

You have three choices for Combo box Type in the Styles tab of Combo box Properties:

- Simple
- Drop list
- Drop-down

Simple and Drop-down are the same, except that a simple Combo box always displays the Combo box choices in a list, while a Drop-down list Combo box has a Drop-down button and displays the choices in a Drop-down list, conserving screen space. The Drop list type is halfway between a Combo box and a List box and is described below.

Using Drop-Down List Boxes

To create a Drop-down list box, choose a Combo box from the control toolbar and place it in your dialog. Double-click the left mouse button on the Combo box to open the Properties box. On the Styles Tab, choose Drop List as the control type.

A Drop-down list box has a drop-down arrow to display the list. Like a Combo box, only one selection can be made at a time in the list, but like a List Box, the selected value cannot be edited. A Drop-down list box serves the same function as a List box except for the disadvantage that the user can choose only a single selection, and the advantage that it takes up less dialog screen space.

A Drop-down list box has the same control indexes as a Combo box with the addition of another INTEGER index to set or return the list number of the item selected in the list. For example:

```
INTEGER num
  ! Returns index of the selected item.
  retlog = DLGGET (dlg, IDC_DROPDOWN1, num, DLG_STATE)
```

Using Scroll Bars

With a Scroll bar, the user determines input by manipulating the slide up and down or right and left. Your application sets the range for the Scroll bar, and thus can interpret a position of the slide as a number. If you want to display this number to the user, you need to send the number (as a character string) to a Static text or Edit Box control.

You set the lower and upper limits of the Scroll bar range by setting the control index DLG_RANGEMIN and DLG_RANGEMAX with DLGSET or DLGSETINT. The default values are 1 and 100. For example:

```
LOGICAL retlog
retlog = DLGSET (dlg, IDC_SCROLLBAR1, 212, DLG_RANGEMAX)
```

You get the slide position by retrieving the control index DLG_POSITION with DLGGET or DLGGETINT. For example:

```
INTEGER slide_position
retlog = DLGGET (dlg, IDC_SCROLLBAR1, slide_position, DLG_POSITION)
```

You can also set the increment taken when the user clicks in the blank area above or below the slide in a vertical Scroll bar, or to the left or right of the slide in a horizontal Scroll bar, by setting the control index DLG_BIGSTEP. For example:

```
retlog = DLGSET (dlg, IDC_SCROLLBAR1, 20, DLG_BIGSTEP)
```

When the user clicks on the arrow buttons of the Scroll bar, the position is always incremented or decremented by 1.

The maximum value (DLG_POSITION) that a scroll bar can report (that is, the maximum scrolling position) depends on the page size (DLG_BIGSTEP). If the scroll bar has a page size greater than one, the maximum scrolling position is less than the maximum range value (DLG_RANGEMAX or DLG_RANGE). You can use the following formula to calculate the maximum scrolling position:

```
MaxScrollPos = MaxRangeValue - (PageSize - 1)
```

For example, if a scroll bar has DLG_RANGEMAX = 100 (100 is the default value of DLG_RANGEMAX) and DLG_BIGSTEP = 10 (10 is the default value of DLG_BIGSTEP), then the maximum DLG_POSITION is 91 (100 - (10 - 1)).

The maximum DLG_POSITION of scroll bars in the Visual Fortran V5 (and Microsoft Fortran PowerStation V4) Dialog Procedures is the same value as the maximum range value (DLG_RANGE).

This allows your application to implement a "proportional" scroll bar. The size of the scroll box (or thumb) is determined by the value of DLG_BIGSTEP and should represent a "page" of data (that is, the amount of data visible in the window).

When the user clicks in the "shaft" of the scroll bar, the next (or previous) page is displayed. The top of the thumb (for a vertical scroll bar) or the left edge of the thumb (for a horizontal scroll bar) represents the position of the scroll bar (DLG_POSITION).

The size of the thumb represents the amount of data currently visible. There is a minimum thumb size so as not to affect usability. When the scroll bar is at its maximum position, the position will represent the position in the data such that the last "page" of data is visible in the window. When the top (or left edge) of the scroll bar is at the mid-point of the shaft, DLG_POSITION will be the mid-point of the range and the mid-point of the data should be displayed at the top of the window.

Using Pictures

The Picture control is an area of your dialog box in which your application displays a picture.

The user cannot change it, since it is an output-only window. It does not respond to user input and therefore does not support any callbacks.

The picture displayed can be set using the Properties dialog box in the Resource Editor. The options that can be fully defined using the Resource Editor include a:

- Icon
- Bitmap
- Frame
- Rectangle

When using the Resource editor, you need to double-click on the border of the picture to display the Picture Properties box. If the Properties box displayed has a title of Dialog Properties instead of Picture Properties, dismiss the Dialog Properties box and try to select the border before you perform the double-click. The Picture Properties box allows you to select the Type of picture as well as specify the Image for certain picture types.

For example, to add an existing BMP (Bitmap) file to a dialog:

1. After you open your project workspace, from the Insert menu, click Resource.
2. Select the Resource type (such as Icon or Bitmap) and then select whether it is a new resource, an Import (existing) resource, or Custom resource. In our example, we will specify an existing Bitmap file we have previously copied into our project directory (click Import).
3. After we specify the resource, its name appears in the ResourceView under the appropriate resource type (such as bitmap).
4. Add a picture to the dialog box, by dragging the picture icon from the Control toolbar to the appropriate place in the dialog box. You can resize the picture as needed. The default picture type is frame.
5. Carefully double-click on the border of the picture area to display the Picture Properties box. If the Dialog Properties box appears instead of Picture Properties, dismiss the Dialog Properties box and try again.
6. In the Picture Properties box, select the Type of picture. If you select a

type of Bitmap or Icon, for example, you can select the Image from the list of available project resources.
7. You can move the picture as needed.
8. Dismiss the Picture Properties box.

Using Progress Bars

The Progress bar is a window that can be used to indicate the progress of a lengthy operation. It consists of a rectangle that is gradually filled as an operation progresses.

Your application sets the range of the Progress bar, using `DLG_RANGEMIN` and `DLG_RANGEMAX`, and the current position, using `DLG_POSITION`. Both the minimum and maximum range values must be between 0 and 65535.

A Progress bar is an output-only window. It does not respond to user input and therefore does not support any callbacks.

Using Spin Controls

The Spin control contains up and down arrows that allow the user to step through values. Your application sets or gets the range of the Spin control's values, using `DLG_RANGEMIN` and `DLG_RANGEMAX`, and the current value, using `DLG_POSITION`.

The Spin control is usually associated with a companion control that is called a "buddy window." To the user, the Spin control and its buddy window often look like a single control. You can specify that the Spin control automatically position itself next to its buddy window and that it automatically set the title of its buddy window to its current value. This is accomplished by setting the "Auto buddy" and "Set buddy integer" styles on the Spin control.

The buddy window is usually an Edit Box or Static Text control. When the "Auto buddy" style is set, the Spin control automatically uses the previous control in the dialog box tab order as its buddy window.

The Spin Control calls the `DLG_CHANGE` callback whenever the user changes the current value of the control.

The Spin control is named the "Up-down" control in Windows programming documentation.

Using Sliders

The Slider Control is a window that contains a slider and optional tick marks. Your application sets or gets the range of the Slider control's values, using

DLG_RANGEMIN and DLG_RANGEMAX, and the current value, using DLG_POSITION. Your application can also set:

- The number of logical positions the slider moves in response to keyboard input from the arrow keys using DLG_SMALLSTEP.
- The number of logical positions the slider moves in response to keyboard input, such as the PAGE UP or PAGE DOWN keys, or mouse input, such as clicks in the slider's channel, using DLG_BIGSTEP.
- The interval frequency for tick marks on the slider using DLG_TICKFREQ.

The Slider Control calls the DLG_CHANGE callback whenever the user changes the current value of the control.

The Slider control is named the "Trackbar" control in Windows programming documentation.

Using Tab Controls

The Tab control is like the dividers in a notebook or the labels on a file cabinet. By using a Tab control, an application can define multiple pages for the same area of a dialog box. Each page is associated with a particular Tab and only one page is displayed at a time.

The control index DLG_NUMITEMS determines how many Tabs are contained in the Tab control. For each Tab, you specify the label of the Tab using DLGSETCHAR and an index value from 1 to the number of Tabs set with DLG_NUMITEMS. Each Tab has an associated dialog box that is displayed when the Tab is selected. You specify the dialog box using DLGSETINT with the dialog name and an index value corresponding to the the Tab. For example, the code below defines three Tabs in a Tab control. The Tab with the label "Family" is associated with the dialog box named IDD_TAB_DIALOG1, and so on.

```
!  Set initial Tabs
lret = DlgSet(gdlg, IDC_TAB, 3)
lret = DlgSet(gdlg, IDC_TAB, "Family", 1)
lret = DlgSet(gdlg, IDC_TAB, "Style", 2)
lret = DlgSet(gdlg, IDC_TAB, "Size", 3)
lret = DlgSet(gdlg, IDC_TAB, IDD_TAB_DIALOG1, 1)
lret = DlgSet(gdlg, IDC_TAB, IDD_TAB_DIALOG2, 2)
lret = DlgSet(gdlg, IDC_TAB, IDD_TAB_DIALOG3, 3)
```

You define each of the Tab dialogs using the resource editor as you do for the dialog box that contains the Tab control. In the Dialog Properties, you must make the following style settings for each Tab dialog:

1. Set the "Style" to "Child"
2. Set "Border" to "None"

3. Uncheck "Title Bar"

Before displaying the dialog box that contains the Tab control (using DLGMODAL or DLGMODELESS):

1. Call DLGSETSUB to define a DLG_INIT callback for the dialog box
2. Call DLGINIT for each Tab dialog

In the DLG_INIT callback of the dialog box that contains the Tab control, if the callbacktype is DLG_INIT, call DLGMODELESS for each of the Tab dialog boxes. Specify `SW_HIDE` as the second parameter, and the window handle of the Tab control as the third parameter. After calling **DLGMODELESS**, call DLGSET with the `DLG_STATE` index to set the initial Tab. For example:

```
 ! When the Main dialog box is first displayed, call DlgModeless to
! display the Tab dialog boxes.  Note the use of SW_HIDE.  The
! Dialog Functions will "show" the proper Tab dialog box.
if (callbacktype == dlg_init) then
      hwnd = GetDlgItem(dlg % hwnd, IDC_TAB)
      lret = DlgModeless(gdlg_tab1, SW_HIDE, hwnd)
      lret = DlgModeless(gdlg_tab2, SW_HIDE, hwnd)
      lret = DlgModeless(gdlg_tab3, SW_HIDE, hwnd)

      ! Note that we must set the default Tab after the calls to
      ! DlgModeless.  Otherwise, no Tab dialog box will be displayed
      ! initially.
      lret = DlgSet(dlg, IDC_TAB, 1, dlg_state)
```

Call DLGUNINIT for each Tab dialog when you are done with it.

For a complete example of using a Tab control, see the Visual Fortran Sample ShowFont in the `...\DF98\SAMPLES\DIALOG` folder.

Setting Return Values and Exiting

When the user selects the dialog's OK or CANCEL button, your dialog procedure is exited and the dialog box is closed. DLGMODAL returns the control name (associated with an integer identifier in your include (.FD) file) of the control that caused it to exit; for example, `IDOK` or `IDCANCEL`.

If you want to exit your dialog box on a condition other than the user selecting the OK or CANCEL button, you need to include a call to the dialog subroutine DLGEXIT from within your callback routine. For example:

```
SUBROUTINE EXITSUB (dlg, exit_button_id, callbacktype)
USE DFLOGM
TYPE (DIALOG) dlg
INTEGER exit_button_id, callbacktype
...
  CALL DLGEXIT (dlg)
```

The only argument for **DLGEXIT** is the **dialog** derived type. The dialog box is exited after **DLGEXIT** returns control back to the dialog manager, not immediately after calling **DLGEXIT**. That is, if there are other statements following **DLGEXIT** within the callback routine that contains it, those statements are executed and the callback routine returns before the dialog box is exited.

If you want **DLGMODAL** to return with a value other than the control name of the control that caused the exit, (or -1 if **DLGMODAL** fails to open the dialog box), you can specify your own return value with the subroutine DLGSETRETURN. For example:

```
TYPE (DIALOG) dlg
INTEGER altreturn
...
altreturn = 485
CALL DLGSETRETURN (dlg, altreturn)
CALL DLGEXIT(dlg)
```

To avoid confusion with the default failure condition, use return values other than -1.

It is not possible to return a value when a modeless dialog box exits. However, you can call DLGSETSUB to set the DLG_INIT callback routine to have a procedure called immediately before the dialog box is destroyed.

If you want the user to be able to close the dialog from the system menu or by pressing the ESC key, you need a control that has the ID of IDCANCEL. When a system escape or close is performed, it simulates pressing the dialog button with the ID IDCANCEL. If no control in the dialog has the ID IDCANCEL, then the close command will be ignored (and the dialog can not be closed in this way).

If you want to enable system close or ESC to close a dialog, but do not want a cancel button, you can add a button with the ID IDCANCEL to your dialog and then remove the visible property in the button's Properties box. Pressing ESC will then activate the default click callback of the cancel button and close the dialog.

Using ActiveX Controls

The dialog routines support the use of ActiveX controls. That is, the dialog routines can act as an ActiveX control container. The FXPLORER and MMPLAYER samples in the ...\SAMPLES\DIALOG folder are examples of using an ActiveX control in a Visual Fortran application.

Using an ActiveX control in a dialog box requires four steps discussed in the following sections:

1. Using the Resource Editor to Insert an ActiveX Control discusses using the resource editor to insert the ActiveX control into the dialog box.
2. Using the Fortran Module Wizard to Generate Code discusses using the

Fortran Module Wizard to generate a module that allows you to use the methods, properties, and events of the ActiveX control from Fortran.
3. Adding Code to Your Application discusses adding code to your application to manipulate the ActiveX control and respond to control events.
4. Target System Requirements describes how to ensure that the ActiveX control and the dialog procedure ActiveX container DLL are present and registered on the target system.

Using the Resource Editor to Insert an ActiveX Control

To add ActiveX controls to a dialog box:

1. In the Resource dialog editor window, right click and hold to display the pop-up (shortcut) menu.
2. Click the Insert ActiveX Control item in the shortcut menu.
3. Click the right mouse button in any clear area in the dialog box.
4. Select the Insert ActiveX Control item from the menu. A dialog box appears displaying the list of ActiveX controls that are registered on your system.
5. Select one of the listed controls and press OK to add it to your dialog box.

Once you insert the ActiveX control, you can modify it using the resource editor like other controls. You can move, resize, and delete the ActiveX control. You can also modify its properties. ActiveX controls often have a large set of properties that you can modify.

Using the Fortran Module Wizard to Generate Code

An ActiveX control is an Automation object. ActiveX controls typically support methods, properties, and events. ActiveX controls use events to notify an application that something has happened to the control. Common examples of events include clicks on the control, data entered using the keyboard, and changes in the control's state. When these actions occur, the control issues an event to alert the application.

The application, in return, uses methods and properties to communicate with the control. Methods are functions that perform an action on the ActiveX control. For example, you would use a method to tell an Internet Explorer ActiveX control to load a particular URL. Properties hold information about the state of an object, for example, the font being used by a control to draw text.

The Fortran Module Wizard generates Fortran 90 modules that simplify calling COM and Automation objects from Fortran programs. To run the Fortran Module Wizard, in the Tools menu, click Fortran Module Wizard.

The module wizard asks a series of questions. For an ActiveX control, choose the Type Library Containing Automation Information option in the initial Module

Wizard screen. In the Type Library screen, choose the ActiveX control that you want to use. Typically, this is a file with a .OCX extension. See the documentation on the ActiveX control to determine its filename. You may select individual components of the ActiveX control to process using the Module Wizard, but typically you can let the wizard default to processing all of the components.

After entering the information and pressing the Generate button, the Fortran Module Wizard asks you for the name of the source file to be generated. It then asks COM to open the type library and generates a file containing Fortran modules. To add the newly created file to your project, in the Project menu, click Add To Project -> Files.

For more information:

- About using the Fortran Module Wizard, see Using COM and Automation Objects.

Adding Code to Your Application

The structure of your application remains the same as when using a dialog box that does not contain an ActiveX control. See Writing a Dialog Application for details. This section discusses programming specific to ActiveX controls.

Your application must call COMINITIALIZE before calling DLGINIT with a dialog box that contains an ActiveX control. Your application must include the statement `USE DFCOM` to access **COMINITIALIZE**. Your application must call COMUNINITIALIZE when you are done using ActiveX controls, but not before calling DLGUNINIT for the dialog box that contains the ActiveX control.

You can call the methods of an ActiveX control and set and retrieve its property values using the interfaces generated by the Fortran Module Wizard or by using the DFAUTO routines. To do this, you must have the object's IDispatch interface pointer. Use the DLGGET function with the ActiveX control's name, the DLG_IDISPATCH control index, and an integer variable to receive the IDispatch pointer. For example:

```
retlog = DlgGet( dlg, IDC_ACTIVEX, idispatch, DLG_IDISPATCH )
```

You do not need to specify the index DLG_IDISPATCH because it is the default integer index for an ActiveX control.

Note however, that the control's IDispatch pointer is not available until after the control has been created and is only valid until the dialog box is closed. The control is created during the call to **DLGMODAL** or **DLGMODELESS**. If you call **DLGGET** to retrieve the IDispatch pointer before calling **DLGMODAL** or **DLGMODELESS**, the value returned will be 0.

Do not call COMRELEASEOBJECT with the iDispatch pointer returned by DLGGET. The dialog procedures use a reference counting optimization since the lifetime of the control is guaranteed to be less than the lifetime of the dialog box.

If you want to use a method or property of a control before the dialog box is displayed to your application's user, you can use a DLG_INIT callback. Call DLGSETSUB using the dialog box name and the DLG_INIT index to define the callback. For example:

```
retlog = DlgSetSub( dlg, IDD_DIALOG, DlgSub, DLG_INIT )
```

The **DLG_INIT** callback is called after the dialog box is created but before it is displayed (with callbacktype=DLG_INIT) and immediately before the dialog box is destroyed (with callbacktype=DLG_DESTROY). The **DLG_INIT** callback is the soonest that the control's IDispatch pointer is available. The **DLG_DESTROY** callback is the latest that this pointer is valid. After the **DLG_DESTROY** callback, the ActiveX control is destroyed.

The following example shows using a DLG_INIT callback to reset the state of a control property before it is destroyed:

```
SUBROUTINE mmplayerSub( dlg, id, callbacktype )
  !DEC$ ATTRIBUTES DEFAULT :: mmplayerSub
  use dflogm
  use dfcom
  use dfauto
  implicit none
  type (dialog) dlg
  integer id, callbacktype
  include 'resource.fd'
  integer obj, iret
  logical lret
  if (callbacktype == dlg_init) then
      lret = DlgGet(dlg, IDC_ACTIVEMOVIECONTROL1, obj)
      !  Add any method or property calls here before the
      !  dialog box is displayed
  else if (callbacktype == dlg_destroy) then
      !  Reset the filename to "" to "close" the current file
      lret = DlgGet(dlg, IDC_ACTIVEMOVIECONTROL1, obj)
      iret = AUTOSETPROPERTY(obj, "FileName", "")
  endif
END SUBROUTINE mmplayerSub
```

The module generated by the Fortran Module Wizard for an ActiveX control contains a number of sections:

- `! CLSIDs`
  Parameters of derived type GUID which identify the ActiveX control class. Your application typically doesn't need to use this parameter.
- `! IIDs`
  Parameters of derived type GUID which identify source (event) interfaces

of the ActiveX control. Your application can use these values in calls to DLGSETCTRLEVENTHANDLER (see below).

- `! Enums`
  Parameters of type integer that identify constants used in the ActiveX control's interfaces.
- `! Interfaces`
  Interfaces for the source (event) interfaces that are defined by the ActiveX control. There may be 0, 1, or more source interfaces implemented by the control. A control does not have to support events.
- `! Module Procedures`
  Wrapper routines that make it easy to call the control's methods and get or retrieve the control's properties.

See Calling the Routines Generated by the Module Wizard for more information on using the method and property interfaces generated by the Fortran Module Wizard.

In addition to methods and properties, ActiveX controls also define events to notify your application that something has happened to the control. The dialog procedures provide a routine, **DLGSETCTRLEVENTHANDLER**, that allows you to define a routine to be executed when an event occurs.

The DLGSETCTRLEVENTHANDLER function has the following interface:

```
integer DlgSetCtrlEventHandler( dlg, controlid, handler, dispid, iid )
```

The arguments are as follows:

`dlg`	(Input) Derived type DIALOG. Contains dialog box parameters.
`controlid`	(Input) Integer. Specifies the identifier of a control within the dialog box (from the .FD file).
`handler`	(Input) EXTERNAL. Name of the routine to be called when the event occurs.
`dispid`	(Input) Integer. Specifies the member id of the method in the event interface that identifies the event
`iid`	(Input, Optional) Derived type(GUID). Specifies the Interface identifier of the source (event) interface. If not supplied, the default source interface of the ActiveX control is used.

Consider the following function call:

```
ret = DlgSetCtrlEventHandler( dlg, IDC_ACTIVEMOVIECONTROL1, &
      ActiveMovie_ReadyStateChange, -609, IID_DActiveMovieEvents2 )
```

In this function call:

- `IDC_ACTIVEMOVIECONTROL1` identifies an ActiveMovie control in the dialog box.
- `ActiveMovie_ReadyStateChange` is the name of the event handling routine.
- `-609` is the member id of the ActiveMovie's control ReadyStateChange event. You can get this number from:
  - The module that the Fortran Module Wizard generated. There is a "MEMBERID = nn" comment generated for each method in a source interface (see the example below).
  - The documentation of the ActiveX control.
  - A tool that allows you to examine the type information of the ActiveX control, for example, the OLE-COM Object Viewer in the Visual Fortran folder.
- `IID_DActiveMovieEvents2` is the identifier of the source (event) interface.

The interface generated by the Fortran Module Wizard for the ReadyStateChange event follows:

```
INTERFACE
   !Reports that the ReadyState property of the ActiveMovie Control has changed
   ! MEMBERID = -609
   SUBROUTINE DActiveMovieEvents2_ReadyStateChange($OBJECT, ReadyState)
       INTEGER(4), INTENT(IN)  :: $OBJECT       ! Object Pointer
       !DEC$ ATTRIBUTES VALUE  :: $OBJECT
       INTEGER(4)      :: ReadyState
       !DEC$ ATTRIBUTES VALUE  :: ReadyState
       !DEC$ ATTRIBUTES STDCALL :: DActiveMovieEvents2_ReadyStateChange
    END SUBROUTINE DActiveMovieEvents2_ReadyStateChange
 END INTERFACE
```

The handler that you define in your application must have the same interface. Otherwise, your application will likely crash in unexpected ways because of the application's stack getting corrupted.

Note that an object is always the first parameter in an event handler. This object value is a pointer to the control's source (event) interface, not the IDispatch pointer of the control. You can use **DLGGET** as described above to retrieve the control's IDispatch pointer.

Target System Requirements

Any ActiveX control that you use must be properly installed and registered on your machine and any machine that you distribute your application to. See the documentation for the ActiveX control for information on how to redistribute it.

The dialog routine ActiveX control container support is implemented in the files `DFDLG`*`nnn`*`.DLL` that can be found in the `...\DF\REDIST` folder on the Visual Fortran CD-ROM. This DLL must be present and registered on any machine that you distribute your application to.

To register a DLL, use REGSVR32.EXE, located in the Windows system directory. REGSVR32 takes a single argument: the path of the DLL. You can alternatively use VFRUN*xxx* to install the complete set of Visual Fortran run-time files. You can download Visual Fortran redistributable files (VFRUN*xxx*) from the download/update area of Compaq Fortran Web site:

http://www.compaq.com/fortran

Drawing Graphics Elements

The graphics routines provided with Visual Fortran set points, draw lines, draw text, change colors, and draw shapes such as circles, rectangles, and arcs. This section assumes you have read the overview in Using QuickWin.

This section uses the following terms:

- The *origin* (point 0, 0) is the upper-left corner of the screen or the client area (defined user area) of the child window being written to. The x-axis and y-axis start at the origin. You can change the origin in some coordinate systems.
- The horizontal direction is represented by the *x-axis*, increasing to the right.
- The vertical direction is represented by the *y-axis*, increasing down.
- Some graphics adapters offer a *color palette* that can be changed.
- Some graphics adapters (VGA and SVGA) allow you to change the color that a color index refers to by providing a *color value* that describes a new color. The color value indicates the mix of red, green, and blue in a screen color. A color value is always an INTEGER(4) number.

The sections on drawing graphics are organized as follows:

- Working with Graphics Modes
- Adding Color
- Understanding Coordinate Systems
- Advanced Graphics Using OpenGL

Working with Graphics Modes

To display graphics, you need to set the desired graphics mode using SETWINDOWCONFIG, and then call the routines needed to create the graphics.

These sections explain each step:

- Checking the Current Graphics Mode
- Setting the Graphics Mode
- Writing a Graphics Program

Checking the Current Graphics Mode

Call GETWINDOWCONFIG to get the child window settings. The DFLIB.F90 module in the `\DF98\INCLUDE` subdirectory defines a derived type, `windowconfig`, that **GETWINDOWCONFIG** uses as a parameter:

```
TYPE windowconfig
  INTEGER(2) numxpixels      ! Number of pixels on x-axis
  INTEGER(2) numypixels      ! Number of pixels on y-axis
  INTEGER(2) numtextcols     ! Number of text columns available
  INTEGER(2) numtextrows     ! Number of text rows available
  INTEGER(2) numcolors       ! Number of color indexes
  INTEGER(4) fontsize        ! Size of default font
  CHARACTER(80) title        ! window title
  INTEGER(2) bitsperpixel    ! Number of bits per pixel
END TYPE windowconfig
```

By default, a QuickWin child window is a scrollable text window 640x480 pixels, has 30 lines and 80 columns, and a font size of 8x16. Also by default, a Standard Graphics window is Full Screen. You can change the values of window properties at any time with SETWINDOWCONFIG, and retrieve the current values at any time with **GETWINDOWCONFIG**.

Setting the Graphics Mode

Use SETWINDOWCONFIG to configure the window for the properties you want. To set the highest possible resolution available with your graphics driver, assign a -1 value for *numxpixels*, *numypixels*, *numtextcols*, and *numtextrows* in the `windowconfig` derived type. This causes Fortran Standard Graphics applications to start in Full Screen mode.

If you specify less than the largest graphics area, the application starts in a window. You can use ALT+ENTER to toggle between Full Screen and windowed views. If your application is a QuickWin application and you do not call **SETWINDOWCONFIG**, the child window defaults to a scrollable text window with the dimensions of 640x480 pixels, 30 lines, 80 columns, and a font size of 8x16. The number of colors depends on the video driver used.

If **SETWINDOWCONFIG** returns .FALSE., the video driver does not support the options specified. The function then adjusts the values in the `windowconfig` derived type to ones that will work and are as close as possible to the requested configuration. You can then call **SETWINDOWCONFIG** again with the adjusted values, which will succeed. For example:

```
LOGICAL statusmode
TYPE (windowconfig) wc
wc%numxpixels  = 1000
wc%numypixels  = 300
wc%numtextcols = -1
wc%numtextrows = -1
wc%numcolors   = -1
wc%title = "Opening Title"C
wc%fontsize = #000A000C ! 10 X 12
statusmode = SETWINDOWCONFIG(wc)
IF (.NOT. statusmode) THEN statusmode = SETWINDOWCONFIG(wc)
```

If you use **SETWINDOWCONFIG**, you should specify a value for each field (–1 or your own number for numeric fields, and a C string for the title). Calling **SETWINDOWCONFIG** with only some of the fields specified can result in useless values for the other fields.

Writing a Graphics Program

Like many programs, graphics programs work well when written in small units. Using discrete routines aids debugging by isolating the functional components of the program. The following example program and its associated subroutines show the steps involved in initializing, drawing, and closing a graphics program.

The SINE program draws a sine wave. Its procedures call many of the common graphics routines. The main program calls five subroutines that carry out the actual graphics commands (also located in the SINE.F90 file):

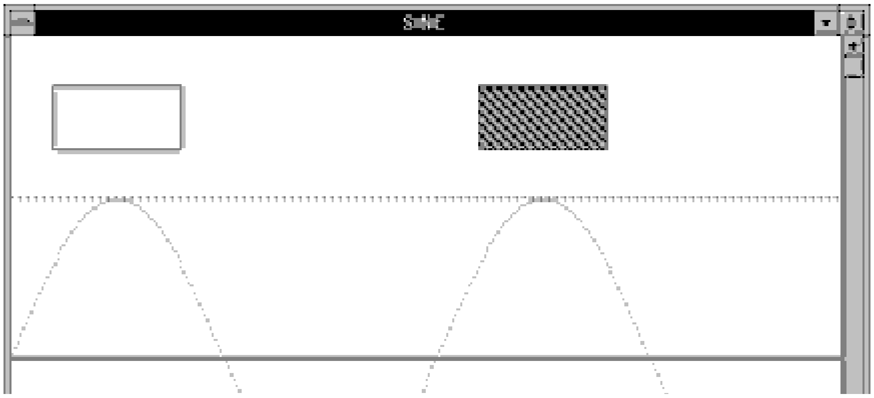
```
! SINE.F90 - Illustrates basic graphics commands.
!
  USE DFLIB
  CALL graphicsmode( )
  CALL drawlines( )
  CALL sinewave( )
  CALL drawshapes( )
  END
   .
   .
   .
```

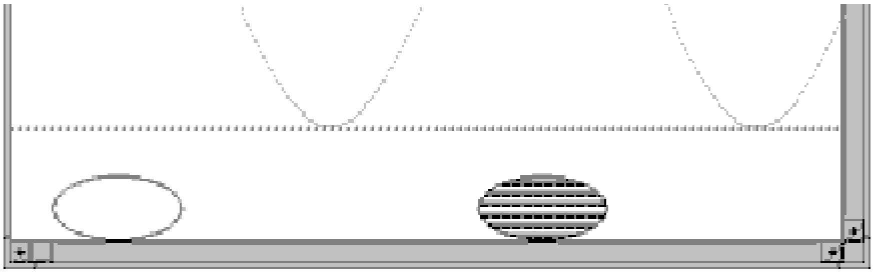
For information on the subroutines used in the SINE program, see:

- graphicsmode in section Activating a Graphics Mode
- drawlines in section Drawing Lines on the Screen
- sinewave in section Drawing a Sine Curve
- drawshapes in section Adding Shapes

The SINE program's output appears in the following figure. The SINE routines are in the Visual Fortran Sample TUTORIAL folder. The project is built as a Fortran Standard Graphics application.

Sine Program Output





Activating a Graphics Mode

If you call a graphics routine without setting a graphics mode with SETWINDOWCONFIG, QuickWin automatically sets the graphics mode with default values.

SINE selects and sets the graphics mode in the subroutine `graphicsmode`, which selects the highest possible resolution for the current video driver:

```
  SUBROUTINE graphicsmode( )
    USE DFLIB
    LOGICAL              modestatus
    INTEGER(2)           maxx, maxy
    TYPE (windowconfig) myscreen
    COMMON               maxx, maxy

 !  Set highest resolution graphics mode.

    myscreen.numxpixels=-1
    myscreen.numypixels=-1
    myscreen.numtextcols=-1
    myscreen.numtextrows=-1
    myscreen.numcolors=-1
    myscreen.fontsize=-1
    myscreen.title = " "C ! blank

    modestatus=SETWINDOWCONFIG(myscreen)

 !  Determine the maximum dimensions.

    modestatus=GETWINDOWCONFIG(myscreen)
    maxx=myscreen.numxpixels - 1
    maxy=myscreen.numypixels - 1
  END SUBROUTINE
```

Pixel coordinates start at zero, so, for example, a screen with a resolution of 640 horizontal pixels has a maximum x-coordinate of 639. Thus, maxx (the highest available x-pixel coordinate) must be 1 less than the total number of pixels. The same applies to maxy.

To remain independent of the video mode set by `graphicsmode`, two short functions convert an arbitrary screen size of 1000x1000 pixels to whatever video mode is in effect. From now on, the program assumes it has 1000 pixels in each direction. To draw the points on the screen, `newx` and `newy` map each point to their physical (pixel) coordinates:

```
  ! NEWX - This function finds new x-coordinates.

    INTEGER(2) FUNCTION newx( xcoord )

    INTEGER(2) xcoord, maxx, maxy
    REAL(4) tempx
    COMMON maxx, maxy

    tempx = maxx / 1000.0
    tempx = xcoord * tempx + 0.5
    newx = tempx
    END FUNCTION

  ! NEWY - This function finds new y-coordinates.
  !
    INTEGER(2) FUNCTION newy( ycoord )
    INTEGER(2) ycoord, maxx, maxy
    REAL(4) tempy
    COMMON maxx, maxy

    tempy = maxy / 1000.0
    tempy = ycoord * tempy + 0.5
    newy = tempy
    END FUNCTION
```

You can set up a similar independent coordinate system with *window coordinates*, described in Understanding Coordinate Systems.

Drawing Lines on the Screen

SINE next calls the subroutine `drawlines`, which draws a rectangle around the outer edges of the screen and three horizontal lines that divide the screen into quarters. (See Sine Program Output.)

```
 !  DRAWLINES - This subroutine draws a box and
 !  several lines.

 SUBROUTINE drawlines( )
    USE DFLIB

    EXTERNAL         newx, newy
    INTEGER(2)       status, newx, newy, maxx, maxy
    TYPE (xycoord)   xy
    COMMON           maxx, maxy
 !
 !  Draw the box.

    status = RECTANGLE( $GBORDER, INT2(0), INT2(0), maxx, maxy )
    CALL SETVIEWORG( INT2(0), newy( INT2( 500 ) ), xy )     ! This sets
 !           the new origin to 0 for x and 500 for y. See comment after subroutine.

 !  Draw the lines.

    CALL MOVETO( INT2(0), INT2(0), xy )
    status = LINETO( newx( INT2( 1000 )), INT2(0))
    CALL SETLINESTYLE( INT2( #AA3C ))
    CALL MOVETO( INT2(0), newy( INT2( -250 )), xy )
    status = LINETO(newx( INT2( 1000 )),newy( INT2( -250 )))
    CALL SETLINESTYLE( INT2( #8888 ))
```

```
   CALL MOVETO(INT2(0), newy( INT2( 250 )), xy )
   status = LINETO( newx( INT2( 1000 )),newy( INT2( 250 ) ) )
END SUBROUTINE
```

The first argument to RECTANGLE is the *fill flag*, which can be either $GBORDER or $GFILLINTERIOR. Choose $GBORDER if you want a rectangle of four lines (a border only, in the current line style), or $GFILLINTERIOR if you want a solid rectangle (filled in with the current color and fill pattern). Choosing the color and fill pattern is discussed in Adding Color and Adding Shapes.

The second and third **RECTANGLE** arguments are the x- and y-coordinates of the upper-left corner of the rectangle. The fourth and fifth arguments are the coordinates for the lower-right corner. Because the coordinates for the two corners are (0, 0) and (maxx, maxy), the call to **RECTANGLE** frames the entire screen.

The program calls SETVIEWORG to change the location of the viewport origin. By resetting the origin to (0, 500) in a 1000x1000 viewport, you effectively make the viewport run from (0, -500) at the top left of the screen to (1000, 500) at the bottom right of the screen:

```
CALL SETVIEWORG( INT2(0), newy( INT2( 500 ) ), xy )
```

Changing the coordinates illustrates the ability to alter the viewport coordinates to whatever dimensions you prefer. (Viewports and the **SETVIEWORG** routine are explained in more detail in Understanding Coordinate Systems.)

The call to SETLINESTYLE changes the line style from a solid line to a dashed line. A series of 16 bits tells the routine which pattern to follow. A "1" indicates a solid pixel and "0" an empty pixel. Therefore, 1111 1111 1111 1111 represents a solid line. A dashed line might look like 1111 1111 0000 0000 (long dashes) or 1111 0000 1111 0000 (short dashes). You can choose any combination of ones and zeros. Any INTEGER(2) number in any base is an acceptable input, but binary and hexadecimal numbers are easier to envision as line-style patterns.

In the example, the hexadecimal constant #AA3C equals the binary value 1010 1010 0011 1100. You can use the decimal value 43580 just as effectively.

When drawing lines, first set an appropriate line style. Then, move to where you want the line to begin and call LINETO, passing to it the point where you want the line to end. The `drawlines` subroutine uses the following code:

```
CALL SETLINESTYLE(INT2( #AA3C ) )
CALL MOVETO( INT2(0), newy( INT2( -250 ) ), xy )
dummy = LINETO( newx( INT2( 1000 )), newy( INT2( -250 )))
```

MOVETO positions an imaginary pixel cursor at a point on the screen (nothing appears on the screen), and **LINETO** draws a line. When the program called **SETVIEWORG**, it changed the viewport origin, and the initial y-axis range of 0 to 1000 now corresponds to a range of –500 to +500. Therefore, the negative value –250 is used as the y-coordinate of **LINETO** to draw a horizontal line across the center of the top half of the screen, and the value of 250 is used as the y-coordinate to draw a horizontal line across the center of the bottom half of the screen.

Drawing a Sine Curve

With the axes and frame in place, SINE is ready to draw the sine curve. The `sinewave` routine calculates the x and y positions for two cycles and plots them on the screen:

```
! SINEWAVE - This subroutine calculates and plots a sine wave.

SUBROUTINE sinewave( )

   USE DFLIB

   INTEGER(2)    dummy, newx, newy, locx, locy, i
   INTEGER(4)    color
   REAL          rad
   EXTERNAL      newx, newy

   PARAMETER    ( PI = 3.14159 )
!
!  Calculate each position and display it on the screen.
   color = #0000FF ! red
!
   DO i = 0, 999, 3
      rad   = -SIN( PI * i / 250.0 )
      locx  = newx( i )
      locy  = newy( INT2( rad * 250.0 ) )
      dummy = SETPIXELRGB( locx, locy, color )
   END DO
END SUBROUTINE
```

SETPIXELRGB takes the two location parameters, locx and locy, and sets the pixel at that position with the specified color value (red).

Adding Shapes

After drawing the sine curve, SINE calls `drawshapes` to put two rectangles and two ellipses on the screen. The fill flag alternates between $GBORDER and $GFILLINTERIOR:

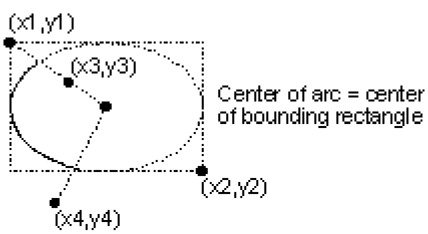
```
! DRAWSHAPES - Draws two boxes and two ellipses.
!
 SUBROUTINE drawshapes( )

    USE DFLIB

    EXTERNAL    newx, newy
    INTEGER(2)  dummy, newx, newy
  !
  !  Create a masking (fill) pattern.
  !
```

```
      INTEGER(1) diagmask(8), horzmask(8)
      DATA diagmask / #93, #C9, #64, #B2, #59, #2C, #96, #4B /
      DATA horzmask / #FF, #00, #7F, #FE, #00, #00, #00, #CC /
   !
   !  Draw the rectangles.
   !
      CALL SETLINESTYLE( INT2(#FFFF ))
      CALL SETFILLMASK( diagmask )
      dummy = RECTANGLE( $GBORDER,newx(INT2(50)),newy(INT2(-325)), &
      & newx(INT2(200)),newy(INT2(-425)))
      dummy = RECTANGLE( $GFILLINTERIOR,newx(INT2(550)), &
      & newy(INT2(-325)),newx(INT2(700)),newy(INT2(-425)))
   !
   !  Draw the ellipses.
   !
      CALL SETFILLMASK( horzmask )
      dummy = ELLIPSE( $GBORDER,newx(INT2(50)),newy(INT2(325)), &
      & newx(INT2(200)),newy(INT2(425)))
      dummy = ELLIPSE( $GFILLINTERIOR,newx(INT2(550)), &
      & znewy(INT2(325)),newx(INT2(700)),newy(INT2(425)))
    END SUBROUTINE
```

The call to **SETLINESTYLE** resets the line pattern to a solid line. Omitting this routine causes the first rectangle to appear with a dashed border, because the `drawlines` subroutine called earlier changed the line style to a dashed line.

ELLIPSE draws an ellipse using parameters similar to those for **RECTANGLE**. It, too, requires a fill flag and two corners of a bounding rectangle. The following figure shows how an ellipse uses a bounding rectangle:

Bounding Rectangle



The $GFILLINTERIOR constant fills the shape with the current fill pattern. To create a pattern, pass the address of an 8-byte array to **SETFILLMASK**. In `drawshapes`, the `diagmask` array is initialized with the pattern shown in the following table:

Fill Patterns

```
Bit pattern                  Value in diagmask
Bit No.7 6 5 4 3 2 1 0
       x o o x o o x x       diagmask(1) = #93
       x x o o x o o x       diagmask(2) = #C9
       o x x o o x o o       diagmask(3) = #64
       x o x x o o x o       diagmask(4) = #B2
       o x o x x o o x       diagmask(5) = #59
       o o x o x x o o       diagmask(6) = #2C
       x o o x o x x o       diagmask(7) = #96
```

```
o x o o x o x x      diagmask(8) = #4B
```

Adding Color

The Visual Fortran QuickWin Library supports color graphics. The number of total available colors depends on the current video driver and video adapter you are using. The number of available colors you use depends on the graphics functions you choose. The different color modes and color functions are discussed and demonstrated in the following sections:

- Color Mixing
- VGA Color Palette
- Using Text Colors

Color Mixing

If you have a VGA machine, you are restricted to displaying at most 256 colors at a time. These 256 colors are held in a palette. You can choose the palette colors from a range of 262,144 colors (256K), but only 256 at a time. Some display adapters (most SVGAs) are capable of displaying all of the 256K colors and some (true color display adapters) are capable of displaying 256 * 256 * 256 = 16.7 million colors.

If you use a palette, you are restricted to the colors available in the palette. In order to access all colors available on your system, you need to specify an explicit Red-Green-Blue (RGB) value, not a palette index.

When you select a color index, you specify one of the colors in the system's predefined palette. SETCOLOR, SETBKCOLOR, and SETTEXTCOLOR set the current color, background color, and text color to a palette index.

SETCOLORRGB, SETBKCOLORRGB, and SETTEXTCOLORRGB set the colors to a color value chosen from the entire available range. When you select a color value, you specify a level of intensity with a range of 0 - 255 for each of the red, green, and blue color values. The long integer that defines a color value consists of 3 bytes (24 bits) as follows:

```
MSB                     LSB
BBBBBBBB GGGGGGGG RRRRRRRR
```

where R, G, and B represent the bit values for red, green, and blue intensities. To mix a light red (pink), turn red all the way up and mix in some green and blue:

```
10000000 10000000 11111111
```

In hexadecimal notation, this number equals #8080FF. To set the current color to this value, you can use the function:

```
i = SETCOLORRGB (#8080FF)
```

You can also pass decimal values to this function. Keep in mind that 1 (binary 00000001, hex 01) represents a low color intensity and that 255 (binary 11111111, hex FF) equals full color intensity. To create pure yellow (100-percent red plus 100-percent green) use this line:

```
i = SETCOLORRGB( #00FFFF )
```

For white, turn all of the colors on:

```
i = SETCOLORRGB( #FFFFFF)
```

For black, set all of the colors to 0:

```
i = SETCOLORRGB( #000000)
```

RGB values for example colors are in the following table.

RGB Color Values			
Color	**RGB Value**	**Color**	**RGB Value**
Black	#000000	Bright White	#FFFFFF
Dull Red	#000080	Bright Red	#0000FF
Dull Green	#008000	Bright Green	#00FF00
Dull Yellow	#008080	Bright Yellow	#00FFFF
Dull Blue	#800000	Bright Blue	#FF0000
Dull Magenta	#800080	Bright Magenta	#FF00FF
Dull Turquoise	#808000	Bright Turquoise	#FFFF00
Dark Gray	#808080	Light Gray	#C0C0C0

If you have a 64K-color machine and you set an RGB color value that is not equal to one of the 64K preset RGB color values, the system approximates the requested RGB color to the closest available RGB value. The same thing happens on a VGA machine when you set an RGB color that is not in the palette. (You can remap your VGA color palette to different RGB values; see VGA Color Palette.)

However, although your graphics are drawn with an approximated color, if you retrieve the color with GETCOLORRGB, GETBKCOLORRGB, or GETTEXTCOLORRGB, the color you specified is returned, not the actual color used. This is because the **SETCOLORRGB** functions do not execute any graphics, they simply set the color and the approximation is made when the drawing is made (by **ELLIPSE** or **ARC**, for example).

GETPIXELRGB and GETPIXELSRGB do return the approximated color actually used, because SETPIXELRGB and SETPIXELSRGB actually set a pixel to a color on the screen and the approximation, if any, is made at the time they are called.

VGA Color Palette

A VGA machine is capable of displaying at most 256 colors at a time. QuickWin provides support for VGA monitors and more advanced monitors that are set at 256 colors. Only a 256-color palette (or less) is supported internally regardless of the current number of colors set for the display (in the Control Panel). The number of colors you select for your VGA palette depends on your application, and is set by setting the *wc%numcolors* variable in the `windowconfig` derived type to 2, 16, or 256 with SETWINDOWCONFIG.

An RGB color value must be in the palette to be accessible to your VGA graphic displays. You can change the default colors and customize your color palette by using REMAPPALETTERGB to change a palette color index to any RGB color value. The following example remaps the color index 1 (default blue color) to the pure red color value given by the RGB value #0000FF. After this is executed, whatever was displayed as blue will appear as red:

```
USE DFLIB
INTEGER(4) status
status = REMAPPALETTERGB( 1, #0000FF )  ! Reassign color index 1
                                        ! to RGB red
```

REMAPALLPALETTERGB remaps one or more color indexes simultaneously. Its argument is an array of RGB color values that are mapped into the palette. The first color number in the array becomes the new color associated with color index 0, the second with color index 1, and so on. At most 236 indexes can be mapped, because 20 indexes are reserved for system use.

If you request an RGB color that is not in the palette, the color selected from the palette is the closest approximation to the RGB color requested. If the RGB color was previously placed in the palette with REMAPPALETTERGB or **REMAPALLPALETTERGB**, then that exact RGB color is available.

Remapping the palette has no effect on 64K-color machines, SVGA, or true-color machines, unless you limit yourself to a palette by using color index functions such as SETCOLOR. On a VGA machine, if you remap all the colors in your palette and display that palette in graphics, you cannot then remap and simultaneously display a second palette.

For instance, in VGA 256-color mode, if you remap all 256 palette colors and display graphics in one child window, then open another child window, remap the palette and display graphics in the second child window, you are attempting to display more than 256 colors at one time. The machine cannot do this, so whichever child window has the focus will appear correct, while the one without the focus will change color.

> **Note:** Machines that support more than 256 colors will not be able to do animation by remapping the palette. Windows operating systems create a logical palette that maps to the video hardware palette. On video hardware that supports a palette of 256 colors or less, remapping the palette maps over the current palette and redraws the screen in the new colors.
>
> On large hardware palettes that support more than 256 colors, remapping is done into the unused portion of the palette. It does not map over the current colors nor redraw the screen. So, on machines with large palettes (more than 256 colors), the technique of changing the screen through remapping, called palette animation, cannot be used. See the *Platform SDK Manual* for more information.

Symbolic constants (names) for the default color numbers are supplied in the graphics modules. The names are self-descriptive; for example, the color numbers for black, yellow, and red are represented by the symbolic constants $BLACK, $YELLOW, and $RED.

Using Text Colors

SETTEXTCOLORRGB (or SETTEXTCOLOR) and SETBKCOLORRGB (or SETBKCOLOR) set the foreground and background colors for text output. All use a single argument specifying the color value (or color index) for text displayed with OUTTEXT and WRITE. For the color index functions, colors are represented by the range 0-31. Index values in the range of 16-31 access the same colors as those in the range of 0-15.

You can retrieve the current foreground and background color values with GETTEXTCOLORRGB and GETBKCOLORRGB or the color indexes with GETTEXTCOLOR and GETBKCOLOR. Use SETTEXTPOSITION to move the cursor to a particular row and column. **OUTTEXT** and **WRITE** print the text at the current cursor location.

For more information on these routines, see the appropriate routines in the

Language Reference.

Understanding Coordinate Systems

Several different coordinate systems are supported by the Visual Fortran QuickWin Library. Text coordinates work in rows and columns; physical coordinates serve as an absolute reference and as a starting place for creating custom window and viewport coordinates. Conversion routines make it simple to convert between different coordinate systems.

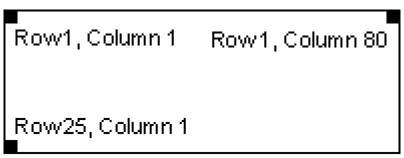
The coordinate systems are demonstrated and discussed in the following sections:

- Text Coordinates
- Graphics Coordinates
- Real Coordinates Sample Program

Text Coordinates

The text modes use a coordinate system that divides the screen into rows and columns as shown in the following figure:

Text Screen Coordinates



Text coordinates use the following conventions:

- Numbering starts at 1. An 80-column screen contains columns 1-80.
- The row is always listed before the column.

If the screen displays 25 rows and 80 columns (as shown in the above Figure), the rows are numbered 1-25 and the columns are numbered 1-80. The text-positioning routines, such as SETTEXTPOSITION and SCROLLTEXTWINDOW, use row and column coordinates.

Graphics Coordinates

Three coordinate systems describe the location of pixels on the screen:

- Physical coordinates
- Viewport coordinates
- Window coordinates

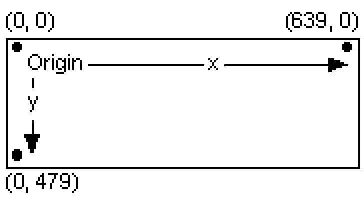
In all three coordinate systems, the x-coordinate is listed before the y-coordinate.

Physical Coordinates

Physical coordinates are integers that refer to pixels in a window's client area. By default, numbering starts at 0, not 1. If there are 640 pixels, they are numbered 0-639.

Suppose your program calls SETWINDOWCONFIG to set up a client area containing 640 horizontal pixels and 480 vertical pixels. Each individual pixel is referred to by its location relative to the x-axis and y-axis, as shown in the following figure:

Physical Coordinates



The upper-left corner is the *origin*. The x- and y-coordinates for the origin are always (0, 0).

Physical coordinates refer to each pixel directly and are therefore integers (that is, the window's client area cannot display a fractional pixel). If you use variables to refer to pixel locations, declare them as integers or use type-conversion routines when passing them to graphics functions. For example:

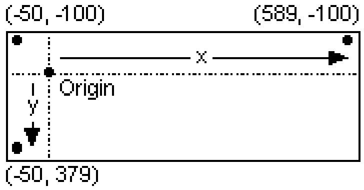
```
ISTATUS = LINETO( INT2(REAL_x), INT2(REAL_y))
```

If a program uses the default dimension of a window, the *viewport* (drawing area) is equal to 640x480. SETVIEWORG changes the location of the viewport's origin. You pass it two integers, which represent the x and y physical screen coordinates for the new origin. You also pass it an `xycoord` type that the routine fills with the physical coordinates of the previous origin. For example, the following line moves the viewport origin to the physical screen location (50, 100):

```
  TYPE (xycoord) origin
  CALL SETVIEWORG(INT2(50), INT2(100), origin)
```

The effect on the screen is illustrated in the following figure:

Origin Coordinates Changed by SETVIEWORG



The number of pixels hasn't changed, but the coordinates used to refer to the points have changed. The x-axis now ranges from -50 to +589 instead of 0 to 639. The y-axis now covers the values -100 to +379.

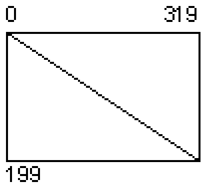
All graphics routines that use viewport coordinates are affected by the new origin, including **MOVETO**, **LINETO**, **RECTANGLE**, **ELLIPSE**, **POLYGON**, **ARC**, and **PIE**. For example, if you call **RECTANGLE** after relocating the viewport origin and pass it the values (0, 0) and (40, 40), the upper-left corner of the rectangle would appear 50 pixels from the left edge of the screen and 100 pixels from the top. It would not appear in the upper-left corner of the screen.

SETCLIPRGN creates an invisible rectangular area on the screen called a *clipping region*. You can draw inside the clipping region, but attempts to draw outside the region fail (nothing appears outside the clipping region).

The default clipping region occupies the entire screen. The QuickWin Library ignores any attempts to draw outside the screen.

You can change the clipping region by calling **SETCLIPRGN**. For example, suppose you entered a screen resolution of 320x200 pixels. If you draw a diagonal line from (0, 0) to (319, 199), the upper-left to the lower-right corner, the screen looks like the following figure:

Line Drawn on a Full Screen

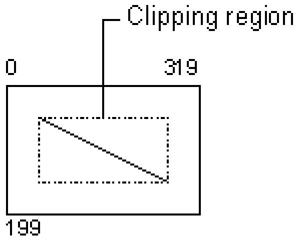


You could create a clipping region by entering:

```
CALL SETCLIPRGN(INT2(10), INT2(10), INT2(309), INT2(189))
```

With the clipping region in effect, the same LINETO command would put the line shown in the following figure on the screen:

Line Drawn Within a Clipping Region



The dashed lines indicate the outer bounds of the clipping region and do not actually print on the screen.

Viewport Coordinates

The viewport is the area of the screen displayed, which may be only a portion of the window's client area. Viewport coordinates represent the pixels within the current viewport. SETVIEWPORT establishes a new viewport within the boundaries of the physical client area. A standard viewport has two distinguishing features:

- The origin of a viewport is in the upper-left corner.
- The default clipping region matches the outer boundaries of the viewport.

SETVIEWPORT has the same effect as **SETVIEWORG** and **SETCLIPRGN** combined. It specifies a limited area of the screen in the same manner as **SETCLIPRGN**, then sets the viewport origin to the upper-left corner of the area.

Window Coordinates

Functions that refer to coordinates on the client-area screen and within the viewport require integer values. However, many applications need floating-point values—for frequency, viscosity, mass, and so on. SETWINDOW lets you scale the screen to almost any size. In addition, window-related functions accept double-precision values.

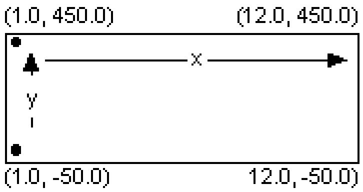
Window coordinates use the current viewport as their boundaries. A window overlays the current viewport. Graphics drawn at window coordinates beyond the boundaries of the window—the same as being outside the viewport—are clipped.

For example, to graph 12 months of average temperatures on the planet Venus that range from –50 to +450, add the following line to your program:

```
status = SETWINDOW(.TRUE., 1.0D0, -50.0D0, 12.0D0, 450.0D0)
```

The first argument is the invert flag, which puts the lowest y value in the lower-left corner. The minimum and maximum x- and y-coordinates follow; the decimal point marks them as floating-point values. The new organization of the screen is shown in the following figure:

Window Coordinates



January and December plot on the left and right edges of the screen. In an application like this, numbering the x-axis from 0.0 to 13.0 provides some padding space on the sides and would improve appearance.

If you next plot a point with **SETPIXEL_W** or draw a line with **LINETO_W**, the values are automatically scaled to the established window.

To use window coordinates with floating-point values:

1. Set a graphics mode with **SETWINDOWCONFIG**.
2. Use **SETVIEWPORT** to create a viewport area. This step is not necessary if you plan to use the entire screen.
3. Create a real-coordinate window with **SETWINDOW**, passing a **LOGICAL** invert flag and four **DOUBLE PRECISION** x- and y-coordinates for the minimum and maximum values.
4. Draw graphics shapes with RECTANGLE_W and similar routines. Do not confuse **RECTANGLE** (the viewport routine) with **RECTANGLE_W** (the window routine for drawing rectangles). All window function names end with an underscore and the letter **W** (**_W**).

Real-coordinate graphics give you flexibility and device independence. For example, you can fit an axis into a small range (such as 151.25 to 151.45) or into a large range (–50000.0 to +80000.0), depending on the type of data you graph. In addition, by changing the window coordinates, you can create the effects of zooming in or panning across a figure. The window coordinates also make your drawings independent of the computer's hardware. Output to the viewport is independent of the actual screen resolution.

Real Coordinates Sample Program

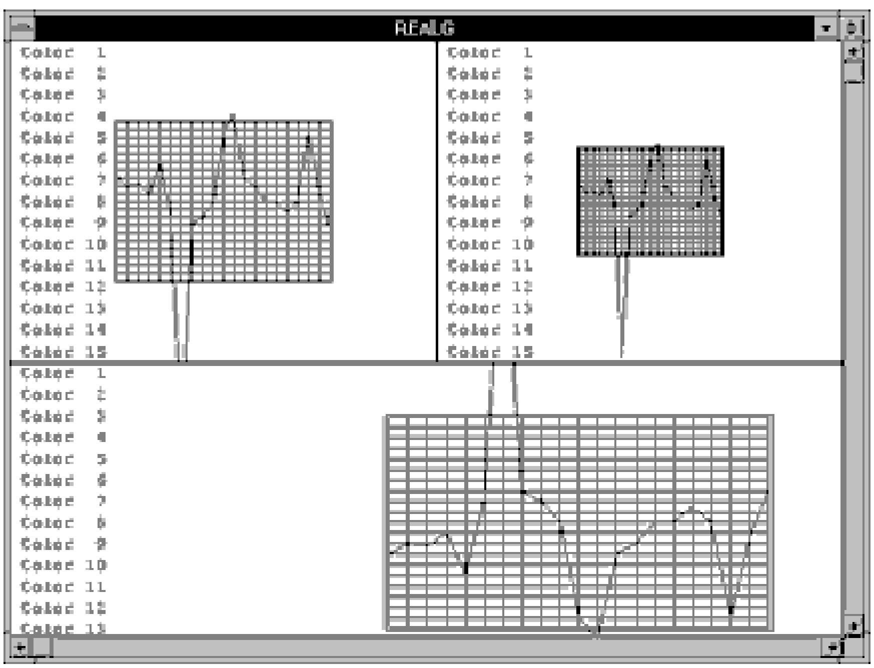
The program REALG.F90 shows how to create multiple window-coordinate sets, each in a separate viewport, on a single screen. REALG.F90 is a Visual Fortran Sample in the TUTORIAL folder.

```
! REALG.F90 (main program) - Illustrates coordinate graphics.
!
    USE DFLIB
    LOGICAL              statusmode
    TYPE (windowconfig)  myscreen
```

```
     COMMON              myscreen
   !
   !  Set the screen to the best resolution and maximum number of
   !  available colors.
     myscreen.numxpixels  = -1
     myscreen.numypixels  = -1
     myscreen.numtextcols = -1
     myscreen.numtextrows = -1
     myscreen.numcolors   = -1
     myscreen.fontsize    = -1
     myscreen.title       = " "C
     statusmode = SETWINDOWCONFIG(myscreen)
     IF(.NOT. statusmode) statusmode = SETWINDOWCONFIG(myscreen)

     statusmode = GETWINDOWCONFIG( myscreen )
     CALL threegraphs( )
     END
     .
     .
     .
```

The main body of the program is very short. It sets the window to the best resolution of the graphics driver (by setting the first four fields to -1) and the maximum number of colors (by setting `numcolors` to –1). The program then calls the threegraphs subroutine that draws three graphs. The program output is shown in the following figure:

REALG Program Output



The gridshape subroutine, which draws the graphs, uses the same data in each case. However, the program uses three different coordinate windows.

The two viewports in the top half are the same size in physical coordinates, but have different window sizes. Each window uses different maximum and minimum values. In all three cases, the graph area is two units wide. The window in the upper-left corner has a range in the x-axis of four units (4 units wide); the window in the upper-right corner has a range in the x-axis of six units, which makes the graph on the right appear smaller.

In two of the three graphs, one of the lines goes off the edge, outside the clipping region. The lines do not intrude into the other viewports, because defining a viewport creates a clipping region.

Finally, the graph on the bottom inverts the data with respect to the two graphs above it.

The next section describes and discusses the subroutine invoked by REALG.F90:

Drawing the Graphs

The main program calls `threegraphs`, which prints the three graphs:

```
  SUBROUTINE threegraphs()
    USE DFLIB
    INTEGER(2)           status, halfx, halfy
    INTEGER(2)           xwidth, yheight, cols, rows
    TYPE (windowconfig)  myscreen
    COMMON               myscreen

    CALL CLEARSCREEN( $GCLEARSCREEN )
    xwidth  = myscreen.numxpixels
    yheight = myscreen.numypixels
    cols    = myscreen.numtextcols
    rows    = myscreen.numtextrows
    halfx   = xwidth / 2
    halfy   = (yheight / rows) * ( rows / 2 )
 !
 !  First window
 !
    CALL SETVIEWPORT( INT2(0), INT2(0), halfx - 1, halfy - 1 )
    CALL SETTEXTWINDOW( INT2(1), INT2(1), rows / 2, cols / 2 )
    status = SETWINDOW( .FALSE., -2.0_8, -2.0_8, 2.0_8, 2.0_8)
 !  The 2.0_8 notation makes these constants REAL(8)

    CALL gridshape( rows / 2 )
    status = RECTANGLE( $GBORDER,INT2(0),INT2(0),halfx-1,halfy-1)
 !
 !  Second window
 !
    CALL SETVIEWPORT( halfx, INT2(0), xwidth - 1, halfy - 1 )
    CALL SETTEXTWINDOW( INT2(1), (cols/2) + 1, rows/2, cols)
    status = SETWINDOW( .FALSE., -3.0D0, -3.0D0, 3.0D0, 3.0D0)
 !  The 3.0D0 notation makes these constants REAL(8)

    CALL gridshape( rows / 2 )
    status = RECTANGLE_W( $GBORDER, -3.0_8,-3.0_8,3.0_8, 3.0_8)

 !
 !  Third window
 !
    CALL SETVIEWPORT( 0, halfy, xwidth - 1, yheight - 1 )
    CALL SETTEXTWINDOW( (rows / 2 ) + 1, 1_2, rows, cols )
```

```
    status = SETWINDOW( .TRUE., -3.0_8, -1.5_8, 1.5_8, 1.5_8)
    CALL gridshape( INT2( (rows / 2) + MOD( rows, INT2(2))))
    status = RECTANGLE_W( $GBORDER, -3.0_8, -1.5_8, 1.5_8, 1.5_8)
  END SUBROUTINE
```

Although the screen is initially clear, `threegraphs` makes sure by calling the CLEARSCREEN routine to clear the window:

```
  CALL CLEARSCREEN( $GCLEARSCREEN )
```

The $GCLEARSCREEN constant clears the entire window. Other options include $GVIEWPORT and $GWINDOW, which clear the current viewport and the current text window, respectively.

After assigning values to some variables, `threegraphs` creates the first window:

```
  CALL SETVIEWPORT( INT2(0), INT2(0), halfx - 1, halfy - 1)
  CALL SETTEXTWINDOW( INT2(1), INT2(1), rows / 2, cols / 2)
  status = SETWINDOW( .FALSE., -2.0_8, -2.0_8, 2.0_8, 2.0_8)
```

The first instruction defines a viewport that covers the upper-left quarter of the screen. The next instruction defines a text window within the boundaries of that border. Finally, the third instruction creates a window with both x and y values ranging from –2.0 to 2.0. The .FALSE. constant causes the y-axis to increase from top to bottom, which is the default. The _8 notation identifies the constants as REAL(8).

Next, the function `gridshape` inserts the grid and plots the data, and a border is added to the window:

```
  CALL gridshape( rows / 2 )
  status = RECTANGLE( $GBORDER,INT2(0),INT2(0),halfx-1,halfy-1)
```

This is the standard **RECTANGLE** routine, which takes coordinates relative to the viewport, not the window.

The `gridshape` subroutine plots the data on the screen.

```
 ! GRIDSHAPE - This subroutine plots data for REALG.F90
 !
  SUBROUTINE gridshape( numc )

    USE DFLIB
    INTEGER(2)           numc, i, status
    INTEGER(4)           rgbcolor, oldcolor
    CHARACTER(8)         str
    REAL(8)              bananas(21), x
    TYPE (windowconfig)  myscreen
    TYPE (wxycoord)      wxy
    TYPE (rccoord)       curpos
    COMMON               myscreen
  !
  !  Data for the graph:
```

```
  !
     DATA bananas / -0.3, -0.2, -0.224, -0.1, -0.5, 0.21, 2.9, &
     & 0.3, 0.2, 0.0, -0.885, -1.1, -0.3, -0.2, &
     & 0.001, 0.005, 0.14, 0.0, -0.9, -0.13, 0.31 /
  !
  !  Print colored words on the screen.
  !

     IF(myscreen.numcolors .LT. numc) numc = myscreen.numcolors-1
     DO i = 1, numc
         CALL SETTEXTPOSITION( i, INT2(2), curpos )
         rgbcolor = 12**i -1
         rgbcolor = MODULO(rgbcolor, #FFFFFF)
         oldcolor = SETTEXTCOLORRGB( rgbcolor )
         WRITE ( str, '(I8)' ) rgbcolor
         CALL OUTTEXT( 'Color ' // str )
     END DO
  !
  !  Draw a double rectangle around the graph.
  !
     oldcolor = SETCOLORRGB( #0000FF ) ! full red
     status = RECTANGLE_W( $GBORDER, -1.00_8, -1.00_8, 1.00_8,1.00_8)
  ! constants made REAL(8) by appending _8
     status = RECTANGLE_W( $GBORDER, -1.02_8, -1.02_8, 1.02_8, 1.02_8)
  !
  !  Plot the points.
  !
     x = -0.90
     DO i = 1, 19
         oldcolor = SETCOLORRGB( #00FF00 ) ! full green
         CALL MOVETO_W( x, -1.0_8, wxy )
         status = LINETO_W( x, 1.0_8 )
         CALL MOVETO_W( -1.0_8, x, wxy )
         status = LINETO_W( 1.0_8, x )
         oldcolor = SETCOLORRGB( #FF0000 ) ! full blue
         CALL MOVETO_W( x - 0.1_8, bananas( i ), wxy )
         status = LINETO_W( x, bananas( i + 1 ) )
         x = x + 0.1
     END DO

     CALL MOVETO_W( 0.9_8, bananas( i ), wxy )
     status = LINETO_W( 1.0_8, bananas( i + 1 ) )
     oldcolor = SETCOLORRGB( #00FFFF ) ! yellow
  END SUBROUTINE
```

The routine names that end with **_W** work in the same way as their viewport equivalents, except that you pass double-precision floating-point values instead of integers. For example, you pass INTEGER(2) to **LINETO**, but REAL(8) values to **LINETO_W**.

The two other windows are similar to the first. All three call the gridshape function, which draws a grid from location (–1.0, –1.0) to (1.0, 1.0). The grid appears in different sizes because the coordinates in the windows vary. The second window ranges from (–3.0, –3.0) to (3.0, 3.0), and the third from (–3.0, –1.5) to (1.5, 1.5), so the sizes change accordingly.

The third window also contains a .TRUE. inversion argument. This causes the y-axis to increase from bottom to top, instead of top to bottom. As a result, this graph appears upside down with respect to the other two.

After calling `gridshape`, the program frames each window, using a statement such as the following:

```
status = RECTANGLE_W( $GBORDER, -3.0_8, -1.5_8, 1.5_8, 1.5_8)
```

The first argument is a fill flag indicating whether to fill the rectangle's interior or just to draw its outline. The remaining arguments are the x and y coordinates for the upper-left corner followed by the x and y coordinates for the lower-right corner. **RECTANGLE** takes integer arguments that refer to the viewport coordinates. **RECTANGLE_W** takes four double-precision floating-point values referring to window coordinates.

After you create various graphics elements, you can use the font-oriented routines to polish the appearance of titles, headings, comments, or labels. Using Fonts from the Graphics Library describes in more detail how to print text in various fonts with font routines.

Advanced Graphics Using OpenGL

OpenGL is a library of graphic functions that create sophisticated graphic displays such as 3-D images and animation. OpenGL is commonly available on workstations. Writing to this standard allows your program to be ported easily to other platforms.

OpenGL windows are used independently of and in addition to any console, QuickWin and regular Windows windows your application uses. Every window in OpenGL uses a pixel format, and the pixels carry, among other things, RGB values, opacity values, and depth values so that pixels with a small depth (shallow) overwrite deeper pixels. The basic steps in creating OpenGL applications are:

- Specify the pixel format
- Specify how the pixels will be rendered on the video device
- Call OpenGL commands

OpenGL programming is straightforward, but requires a particular initialization and order, like other software tools. References to get you started are:

- *The OpenGL Reference Manual*, Addison-Wesley, ISBN 0-201-46140-4.
- *The OpenGL Programming Guide*, Addison-Wesley, ISBN 0-201-46138-2.
- *OpenGL SuperBible: The Complete Guide to OpenGL Programming on Windows NT and Windows 95*, Richard Wright and Michael Sweet, Waite Group Press (Division of Sams Publishing), 1996, ISBN 1-57169-073-5.
- OpenGL documentation in the Platform SDK title in HTML Help Viewer.
- The OpenGL description from the Microsoft Visual C++ manuals.

Visual Fortran provides an OpenGL module, DFOPNGL.MOD, invoked with the **USE** statement line:

```
USE DFOPNGL
```

When you use this module, all constants and interfaces that bind Fortran to the OpenGL routines become available. Any link libraries required to link with an OpenGL program are automatically searched if **USE DFOPNGL** is present in your Fortran program.

An OpenGL window can be opened from a console, Windows, or QuickWin application. The OpenGL window uses OpenGL calls exclusively, not normal Graphic Device Interface (GDI) calls. Likewise, OpenGL calls cannot be made within an ordinary Windows window or QuickWin child window, because special initialization is required for OpenGL calls.

The Fortran OpenGL identifiers are the same as the C identifiers (such as using a GL_ prefix for constants), except that the gl prefix is changed to fgl for routines. The data types in the OpenGL C binding are translated to Fortran types as shown in the following table:

OpenGL/C Type	**Fortran Data Type**
GLbyte	INTEGER(1)
GLshort	INTEGER(2)
GLint, GLsizei	INTEGER(4)
GLfloat, GLclampf	REAL(4)
GLdouble, GLclampd	REAL(8)
GLubyte	INTEGER(1)
GLboolean	LOGICAL
GLushort	INTEGER(2)
GLuint, GLenum, GLbitfield	INTEGER(4)
GLvoid	not needed
pointers	INTEGER

If you include (**USE**) the parameter constant definitions from `DFOPNGLT.F90` (such as by `USE DFOPNGL`), you can use the constants to specify the kind type, such as

`INTEGER(K_GLint)` instead of `INTEGER(4)`.

Visual Fortran Samples that use OpenGL are available in separate folders in `...\DF98\SAMPLES\ADVANCED\OPENGL`. For example, OLYMPIC is a Fortran QuickWin project and CUBE5 is a Fortran Windows project.

Using Fonts from the Graphics Library

The Visual Fortran Graphics Library includes routines that print text in various sizes and type styles. These routines provide control over the appearance of your text and add visual interest to your screen displays.

This section assumes you have read Drawing Graphics Elements and that you understand the general terminology it introduces. You should also be familiar with the basic properties of both the SETWINDOWCONFIG and MOVETO routines. Also, remember that graphics programs containing graphics routines must be built as Fortran QuickWin or Fortran Standard Graphics applications.

The project type is set in the visual development environment when you select New from the File menu, then click on the Projects tab, and select Fortran QuickWin or Fortran Standard Graphics Application from the application types listed. Graphics applications can also be built with the /libs:qwin or /libs:qwins compiler option.

Font types and the use of fonts are described in the following sections:

- Available Typefaces
- Using Fonts
- SHOWFONT.F90 Example

Available Typefaces

A *font* is a set of text characters of a particular size and style.

A *typeface* (or *type style*) refers to the style of the displayed text—Arial, for example, or Times New Roman.

Type size measures the screen area occupied by individual characters. The term comes from the printer's lexicon, but uses screen pixels as the unit of measure rather than the traditional points. For example, "Courier 12 9" denotes the Courier typeface, with each character occupying a screen area of 12 vertical pixels by 9 horizontal pixels. The word "font", therefore implies both a typeface and a type size.

The QuickWin Library's font routines use all Windows operating system installed fonts. The first type of font used is a *bitmap* (or *raster-map*) font. Bitmap fonts have each character in a binary data map. Each bit in the map corresponds to a screen pixel. If the bit equals 1, its associated pixel is set to the current screen color. Bit values of 0 appear in the current background color.

The second type of font is called a TrueType font. Some screen fonts look different on a printer, but TrueType fonts print exactly as they appear on the screen. TrueType fonts may be bitmaps or soft fonts (fonts that are downloaded to your printer before printing), depending on the capabilities of your printer. TrueType fonts are scalable and can be sized to any height. It is recommended that you use TrueType fonts in your graphics programs.

Each type of font has advantages and disadvantages. Bitmapped characters appear smoother on the screen because of the predetermined pixel mapping. However, they cannot be scaled. You can scale TrueType text to any size, but the characters sometimes do not look quite as solid as the bitmapped characters on the screen. Usually this screen effect is hardly noticeable, and when printed, TrueType fonts are as smooth or smoother than bitmapped fonts.

The bitmapped typefaces come in preset sizes measured in pixels. The exact size of any font depends on screen resolution and display type.

Using Fonts

QuickWin's font routines can use all the Windows operating system installed fonts. To use fonts in your program, you must:

1. Initialize the fonts.
2. Select a current font from the initialized fonts.
3. Display font text with **OUTGTEXT**.

Initializing Fonts

A program that uses fonts must first organize the fonts into a list in memory, a process called initializing. The list gives the computer information about the available fonts.

Initialize the fonts by calling the INITIALIZEFONTS routine:

```
USE DFLIB
INTEGER(2) numfonts
numfonts = INITIALIZEFONTS( )
```

If the computer successfully initializes one or more fonts, INITIALIZEFONTS returns the number of fonts initialized. If the function fails, it returns a negative error code.

Setting the Font and Displaying Text

Before a program can display text in a particular font, it must know which of the initialized fonts to use. SETFONT makes one of the initialized fonts the current (or "active") font. **SETFONT** has the following syntax:

SETFONT(*options*)

The function's argument consists of letter codes that describe the desired font: typeface, character height and width in pixels, fixed or proportional, and attributes such as bold or italic. These options are discussed in detail in the SETFONT entry in the *Language Reference*. For example:

```
USE DFLIB
INTEGER(2) index, numfonts
numfonts = INITIALIZEFONTS ( )
index = SETFONT('t''Cottage''h18w10')
```

This sets the typeface to Cottage, the character height to 18 pixels and the width to 10 pixels.

The following example sets the typeface to Arial, the character height to 14, with proportional spacing and italics (the pi codes):

```
index = SETFONT('t''Arial''h14pi')
```

If **SETFONT** successfully sets the font, it returns the font's index number. If the function fails, it returns a negative integer. Call GRSTATUS to find the source of the problem; its return value indicates why the function failed. If you call **SETFONT** before initializing fonts, a run-time error occurs.

SETFONT updates the font information when it is used to select a font. GETFONTINFO can be used to obtain information about the currently selected font. **SETFONT** sets the user fields in the `fontinfo` type (a derived type defined in DFLIB.MOD), and **GETFONTINFO** returns the user-selected values. The following user fields are contained in `fontinfo`:

```
TYPE fontinfo
  INTEGER(2) type ! 1 = truetype, 0 = bit map
  INTEGER(2) ascent ! Pixel distance from top to baseline
  INTEGER(2) pixwidth ! Character width in pixels, 0=prop
  INTEGER(2) pixheight ! Character height in pixels
  INTEGER(2) avgwidth ! Average character width in pixels
  CHARACTER(32) facename ! Font name
END TYPE fontinfo
```

To find the parameters of the current font, call **GETFONTINFO**. For example:

```
USE DFLIB
TYPE (fontinfo) font
INTEGER(2) i, numfonts
numfonts = INITIALIZEFONTS()
i = SETFONT ( ' t ' 'Arial ' )
i = GETFONTINFO(font)
WRITE (*,*) font.avgwidth, font.pixheight, font.pixwidth
```

After you initialize the fonts and make one the active font, you can display the text on the screen.

To display text on the screen after selecting a font:

1. Select a starting position for the text with MOVETO.
2. Optionally, set a text display angle with SETGTEXTROTATION.
3. Send the text to the screen (in the current font) with OUTGTEXT.

MOVETO moves the current graphics point to the pixel coordinates passed to it when it is invoked. This becomes the starting position of the upper-left corner of the first character in the text. **SETGTEXTROTATION** can set the text's orientation in increments of one-tenth of a degree.

SHOWFONT.F90 Example

The Visual Fortran Sample program SHOWFONT.F90 in the ...`\DF98\SAMPLES\TUTORIAL` folder displays text in the fonts available on your system. (Once the screen fills with text, press `Enter` to display the next screen.) An abbreviated version follows. SHOWFONT calls SETFONT to specify the typeface. MOVETO then establishes the starting point for each text string. The program sends a message of sample text to the screen for each font initialized:

```
! Abbreviated version of SHOWFONT.F90.
    USE DFLIB

    INTEGER(2) grstat, numfonts,indx, curr_height
    TYPE (xycoord) xyt
    TYPE (fontinfo) f
    CHARACTER(6) str     ! 5 chars for font num
                          ! (max. is 32767), 1 for 'n'

! Initialization.
    numfonts=INITIALIZEFONTS( )
    IF (numfonts.LE.0) PRINT *,"INITIALIZEFONTS error"
    IF (GRSTATUS().NE.$GROK) PRINT *,'INITIALIZEFONTS GRSTATUS error.'
    CALL MOVETO (0,0,xyt)
    grstat=SETCOLORRGB(#FF0000)
    grstat=FLOODFILLRGB(0, 0, #00FF00)
    grstat=SETCOLORRGB(0)
! Get default font height for comparison later.
    grstat = SETFONT('n1')
    grstat = GETFONTINFO(f)
    curr_height = f.pixheight
! Done initializing, start displaying fonts.
    DO indx=1,numfonts
       WRITE(str,10)indx
       grstat=SETFONT(str)
       IF (grstat.LT.1) THEN
          CALL OUTGTEXT('SetFont error.')
       ELSE
          grstat=GETFONTINFO(f)
          grstat=SETFONT('n1')
          CALL OUTGTEXT(f.facename(:len_trim(f.facename)))
          CALL OUTGTEXT(' ')
! Display font.
```

```
            grstat=SETFONT(str)
            CALL OUTGTEXT('ABCDEFGabcdefg12345!@#$%')
         END IF
! Go to next line.
         IF (f.pixheight .GT. curr_height) curr_height=f.pixheight
         CALL GETCURRENTPOSITION(xyt)
         CALL MOVETO(0,INT2(xyt.ycoord+curr_height),xyt)
      END DO
10    FORMAT ('n',I5.5)
      END
```

Using National Language Support Routines

Visual Fortran provides a complete National Language Support (NLS) library of language-localization routines and multibyte-character routines. You can use these routines to write applications in many different languages.

In many languages, the standard ASCII character set is not enough because it lacks common symbols and punctuation (such as the British pound sign), or because the language uses a non-ASCII script (such as Cyrillic for Russian) or because the language consists of too many characters for each to be represented by a single byte (such as Chinese).

In the case of many non-ASCII languages, such as Arabic and Russian, an extended single-byte character set is sufficient. You need only change the language locale and codepage, which can be done at a system level or within your program. However, Eastern languages such as Japanese and Chinese use thousands of separate characters that cannot be encoded as single-byte characters. Multibyte characters are needed to represent them.

Character sets are stored in tables called code sets. There are three components of a code set: the locale, which is a language and country (since, for instance, the language Spanish may vary among countries), the codepage, which is a table of characters to make up the computer's alphabet, and the font used to represent the characters on the screen. These three components can be set independently. Each computer running Windows operating systems comes with many code sets built into the system, such as English, Arabic, and Spanish. Multibyte code sets, such as Chinese and Japanese, are not standard but come with special versions of the operating system (for instance, Windows NT-J comes with the Japanese code set).

The default code set is obtained from the operating system when a program starts up. When you install your operating system, you should install the system supplied code sets. Thereafter, they are always available. You can switch among them by:

- Open the Control Panel (available from Settings)
- Click the Regional Settings icon
- Choose from the dropdown list of available locales (languages and countries).

When you select a new locale, it becomes the default system locale, and will remain the default locale until you change it. Each locale has a default codepage associated with it, and a default currency, number, and date format.

Note: The default codepage does not change when you select a new locale until you reboot your computer.

You can change the currency, number, and date format in the International dialog box or the Regional Setting dialog box independently of the locale.

The locale determines the character set available to the user. The locale you select becomes the default for the NLS routines described in this section, but the NLS routines allow you to change locales and their parameters from within your programs. These routines are useful for creating original foreign-language programs or different versions of the same program for various international markets. Changes you make to the locale from within a program affect only the program. They do not change the system default settings.

The codepage you select, which can be set independently, controls the multibyte (MB routines) character routines described in this section. Only users with special multibyte-character code sets installed on their computers need to use MB routines. The standard code sets all use single-byte character code sets.

Note that in Visual Fortran source code, multibyte characters can be used only in character strings and source comments. They cannot be used within variable names or statements. Like program changes to the locale, program changes to codepages affect only the program, not the system defaults.

The NLS and MB routines are contained in the library DFNLS.LIB, which consists of DFNLS.MOD and DFNLS.F90. To access the routines, the following statement should be present in any program unit that uses NLS or MB routines:

```
USE DFNLS
```

This section includes a discussion of character sets and the NLS library routines:

- Single and Multibyte Character Sets
- National Language Support Library Routines

Single and Multibyte Character Sets

The ASCII character set defines the characters from 0 to 127 and an extended set from 128 to 255. Several alternative single-byte character sets, primarily European, define the characters from 0 to 127 identically to ASCII, but define the characters from 128 to 255 differently. With this extension, 8-bit representation is sufficient for defining the needed characters in most European-derived languages. However, some languages, such as Japanese Kanji, include many more characters than can be represented with a single byte. These languages require multibyte coding.

A multibyte character set consists of both one-byte and two-byte characters. A multibyte-character string can contain a mix of single and double-byte characters. A two-byte character has a lead byte and a trail byte. In a particular multibyte character set, the lead and trail byte values can overlap, and it is then necessary to use the byte's context to determine whether it is a lead or trail byte.

National Language Support Library Routines

The library routines for handling extended and multibyte character sets are divided into three categories:

- Locale Setting and Inquiry Routines to set locales (local code sets) and inquire about their current settings
- NLS Formatting Routines to format dates, currency, and numbers
- Multibyte Character Routines for using multi-byte characters

All of these routines are described in detail in the *Language Reference*, A to Z Reference.

In the descriptions that follow, function and parameter names are given with a mixture of upper- and lowercase letters. This is to make the names easier to understand. You can use any case for these names when writing your applications.

Locale Setting and Inquiry Routines

At program startup, the current language and country setting is retrieved from the operating system. The user can change this setting through the Control Panel Regional Settings icon. The current codepage is also retrieved from the system.

There is a system default console codepage and a system default Windows codepage. Console programs retrieve the system console codepage, while Windows programs (including QuickWin applications) retrieve the system Windows codepage.

The NLS Library provides routines to determine the current locale (local code set), to return parameters of the current locale, to provide a list of all the system supported locales, and to set the locale to another language, country and/or codepage. These routines are summarized in the following table. Note that the locales and codepages set with these routines affect only the program or console that calls the routine. They do not change the system defaults or affect other programs or consoles.

Routines to Set and Inquire about the Locales

Name	Procedure Type	Description
NLSSetLocale	Function	Sets the language, country and codepage
NLSGetLocale	Subroutine	Retrieves the current language, country and codepage
NLSGetLocaleInfo	Function	Retrieves requested information about the current local code set
NLSEnumLocales	Function	Returns all the languages and country combinations supported by the system
NLSEnumCodepages	Function	Returns all the supported codepages on the system
NLSSetEnvironmentCodepage	Function	Changes the codepage for the current console
NLSGetEnvironmentCodepage	Function	Returns the codepage number for the system (Window) codepage or the console codepage

As an example:

```
      USE DFNLS
      INTEGER(4) strlen, status
      CHARACTER(40) str

      strlen = NLSGetLocaleInfo(NLS$LI_SDAYNAME1, str)
      print *, str    ! prints Monday
      strlen = NLSGetLocaleInfo(NLS$LI_SDAYNAME2, str)
      print *, str    ! prints Tuesday
      strlen = NLSGetLocaleInfo(NLS$LI_SDAYNAME3, str)
      print *, str    ! prints Wednesday
! Change locale to Spanish, Mexico
      status = NLSSetLocale("Spanish", "Mexico")
      strlen = NLSGetLocaleInfo(NLS$LI_SDAYNAME1, str)
      print *, str    ! prints lunes
      strlen = NLSGetLocaleInfo(NLS$LI_SDAYNAME2, str)
      print *, str    ! prints martes
      strlen = NLSGetLocaleInfo(NLS$LI_SDAYNAME3, str)
      print *, str    ! prints miércoles
      END
```

NLS Formatting Routines

You can set time, date, currency and number formats from the Control Panel, by clicking on the Regional Settings icon. The NLS Library also provides formatting routines for the current locale. These routines are summarized in the following table. These routines return strings in the current codepage, set by default at program start or by **NLSSetLocale**.

All the formatting routines return the number of bytes in the formatted string (not the number of characters, which can vary if multibyte characters are included). If the output string is longer than the formatted string, the output string is blank padded. If the output string is shorter than the formatted string, an error occurs, NLS$ErrorInsufficientBuffer is returned, and nothing is written to the output string.

Formatting Routines

Name	**Procedure Type**	**Description**
NLSFormatCurrency	Function	Formats a number string and returns the correct currency string for the current locale
NLSFormatDate	Function	Returns a correctly formatted string containing the date for the current locale
NLSFormatNumber	Function	Formats a number string and returns the correct number string for the current locale
NLSFormatTime	Function	Returns a correctly formatted string containing the time for the current locale

As an example:

```
USE DFNLS
INTEGER(4) strlen, status
CHARACTER(40) str
strlen = NLSFormatTime(str)
print *, str             ! prints               11:42:24 AM
strlen = NLSFormatDate(str, flags= NLS$LongDate)
print *, str             ! prints        Friday, July 14, 2000
status = NLSSetLocale ("Spanish", "Mexico")
strlen = NLSFormatTime(str)
print *, str             ! prints               11:42:24
```

```
    print *, str            ! prints viernes 14 de julio de 2000
```

Multibyte Character Routines

All of the routines in this section are intended for use with Multibyte Character Sets (MBCS). Examples of such characters sets are Japanese, Korean, and Chinese. The routines in this section work from the current codepage, set with NLSSetLocale and read back with NLSGetLocale. String comparison routines, such as MBLLT, are based on the current language and country settings.

Routines discussed in this section are:

- MBCS Inquiry Routines
- MBCS Conversion Routines
- MBCS Fortran Equivalent Routines
- Standard Fortran Routines That Handle MBCS Characters

MBCS Inquiry Routines

The MBCS inquiry routines provide information on the maximum length of multibyte characters, the length, number and position of multibyte characters in strings, and whether a multibyte character is a leading or trailing byte. These routines are summarized in the following table. The NLS library provides a parameter, MBLenMax, defined in the NLS module to be the longest length (in bytes) of any character, in any codepage. This parameter can be useful in comparisons and tests. To determine the maximum character length of the current codepage, use the **MBCurMax** function.

MBCS Inquiry Routines

Name	Procedure Type	Description
MBCharLen	Function	Returns the length of the first multibyte character in a string
MBCurMax	Function	Returns the longest possible multibyte character for the current codepage
MBLead	Function	Determines whether a given character is the first byte of a multibyte character
MBLen	Function	Returns the number of multibyte characters in a string, including trailing spaces
MBLen_Trim	Function	Returns the number of multibyte characters in a string, not including trailing spaces

MBNext	Function	Returns the string position of the first byte of the multibyte character immediately after the given string position
MBPrev	Function	Returns the string position of the first byte of the multibyte character immediately before the given string position
MBStrLead	Function	Performs a context sensitive test to determine whether a given byte in a character string is a lead byte

As an example:

```
USE DFNLS
CHARACTER(4) str
INTEGER status
status = NLSSetLocale ("Japan")
str = " ·, " ¿"
PRINT '(1X,''String by char = '',\)'
DO i = 1, len(str)
   PRINT '(A2,\)',str(i:i)
END DO
PRINT '(/,1X,''MBLead = '',\)'
DO i = 1, len(str)
   PRINT '(L2,\)',mblead(str(i:i))
END DO
PRINT '(/,1X,''String as whole = '',A,\)',str
PRINT '(/,1X,''MBStrLead = '',\)'
DO i = 1, len(str)
   PRINT '(L1,\)',MBStrLead(str,i)
END DO
END
```

This code produces the following output for *str* = · , " ¿

```
String by char  =  ・・・ｿ
MBLead          =  T T T F
String as whole = 高徳
MBStrLead       = TFTF
```

MBCS Conversion Routines

There are four MBCS conversion routines:

- Two convert Japan Industry Standard characters to Microsoft Kanji characters or vice versa.
- Two convert between a codepage multibyte character string and a Unicode string.

These routines are summarized in the following table.

MBCS Conversion Routines

Name	Procedure Type	Description
MBConvertMBToUnicode	Function	Converts a character string from a multibyte codepage to a Unicode string
MBConvertUnicodeToMB	Function	Converts a Unicode string to a multibyte character string of the current codepage
MBJISToJMS	Function	Converts a Japan Industry Standard (JIS) character to a Microsoft Kanji (Shift JIS or JMS) character
MBJMSToJIS	Function	Converts a Microsoft Kanji (Shift JIS or JMS) character to a Japan Industry Standard (JIS) character

MBCS Fortran Equivalent Routines

The NLS Library provides several functions that are the exact equivalents of Fortran 90 functions except that the MBCS equivalents allow character strings to contain multibyte characters. These routines are summarized in the following table.

MBCS Fortran Equivalent Routines

Name	Procedure Type	Description
MBINCHARQQ	Function	Same as **INCHARQQ** but can read a single multibyte character at once and returns the number of bytes read
MBINDEX	Function	Same as **INDEX** except that multibyte characters can be included in its arguments
MBLGE, MBLGT, MBLLE, MBLLT, MBLEQ, MBLNE	Functions	Same as **LGE**, **LGT**, **LLE**, **LLT** and the operators .EQ. and .NE. except that multibyte characters can be included in their arguments

MBSCAN	Function	Same as **SCAN** except that multibyte characters can be included in its arguments
MBVERIFY	Function	Same as **VERIFY** except that multibyte characters can be included in its arguments

The following example is included in Visual Fortran Samples in the `...\DF98\SAMPLES\TUTORIAL` folder as MBCOMP.FOR:

```
    USE DFNLS

    INTEGER(4) i, len(7), infotype(7)
    CHARACTER(10) str(7)
    LOGICAL(4) log4

    data infotype / NLS$LI_SDAYNAME1, NLS$LI_SDAYNAME2, &
   & NLS$LI_SDAYNAME3, NLS$LI_SDAYNAME4, &
   & NLS$LI_SDAYNAME5, NLS$LI_SDAYNAME6, &
   & NLS$LI_SDAYNAME7 /
    WRITE(*,*) 'NLSGetLocaleInfo'
    WRITE(*,*) '----------------'
    WRITE(*,*) ' '
    WRITE(*,*) 'Getting the names of the days of the week...'

    DO i = 1, 7
       len(i) = NLSGetLocaleInfo(infotype(i), str(i))
       WRITE(*, 11) 'len/str/hex = ', len(i), str(i), str(i)
    END DO
 11 FORMAT (1X, A, I2, 2X, A10, 2X, '[', Z20, ']')

    WRITE(*,*) ' '
    WRITE(*,*) 'Lexically comparing the names of the days...'

    DO i = 1, 6
       log4 = MBLGE(str(i), str(i+1), NLS$IgnoreCase)
       WRITE(*, 12) 'Is day ', i, ' GT day ', i+1, '? Answer = ', log4
    END DO
 12 FORMAT (1X, A, I1, A, I1, A, L1)

    WRITE(*,*) ' '
    WRITE(*,*) 'Done.'
    END
```

This code produces the following output when the locale is Japan:

```
NLSGetLocaleInfo
----------------

Getting the names of the days of the week...
len/str/hex =  6  月曜日      [8C8E976A93FA20202020]
len/str/hex =  6  火曜日      [89CE976A93FA20202020]
len/str/hex =  6  水曜日      [9085976A93FA20202020]
len/str/hex =  6  木曜日      [96D8976A93FA20202020]
len/str/hex =  6  金曜日      [8BE0976A93FA20202020]
```

```
len/str/hex =  6  土曜日     [9379976A93FA20202020]
len/str/hex =  6  日曜日     [93FA976A93FA20202020]

Lexically comparing the names of the days...
Is day 1 GT day 2?  Answer = T
Is day 2 GT day 3?  Answer = F
Is day 3 GT day 4?  Answer = F
Is day 4 GT day 5?  Answer = T
Is day 5 GT day 6?  Answer = F
Is day 6 GT day 7?  Answer = F

Done.
```

Standard Fortran Routines That Handle MBCS Characters

This section describes Fortran routines that work as usual even if MBCS characters are included in strings.

Because a space can never be a lead or tail byte, many routines that deal with spaces work as expected on strings containing MBCS characters. Such functions include:

- ADJUSTL(*string*)
- ADJUSTR(*string*)
- TRIM(*string*)

Some routines work with the computer collating sequence to return a character in a certain position in the sequence or the position in the sequence of a certain character. These functions are not dependent on a particular collating sequence. (You should note, however, that elsewhere in this manual the ASCII collating sequence is mentioned in reference to these functions.) Such functions use *position* and *c* values between 0 and 255 (inclusive) and include:

- ACHAR(*position*)
- CHAR(*position* [, *kind*])
- IACHAR(*c*)
- ICHAR(*c*)

Because Fortran uses character lengths instead of NULLs to indicate the length of a string, some functions work solely from the length of the string, and not with the contents of the string. This function works as usual on strings containing MBCS characters, and include:

REPEAT (*string*, *ncopies*)

Portability Library

Visual Fortran includes functions and subroutines that ease porting of code from a different platform to a PC, or allow you to write code on a PC that is compatible with other platforms. Frequently used functions are included in a module called DFPORT.

This chapter describes how to use the portability module, and describes routines available in the following categories:

When writing new code, use Fortran 95/90 contains intrinsic procedures whenever possible (for portability and performance reasons). Fortran 95/90 contains intrinsic procedures for many of the portability functions. The portability routines are extensions to the Fortran 95 standard.

Using the Portability Library

You can use the portability library (DFPORT) in one of two ways:

- Add the statement **USE DFPORT** to your program. This USE statement includes the DFPORT module.
- Call portability routines using the correct parameters and return value.

The portability library DFPORT.LIB library is passed to the linker by default during linking. To prevent DFPORT.LIB library from being passed to the linker, specify the /fpscomp:nolibs option.

Using the DFPORT module provides interface blocks and parameter definitions for the routines, as well as compiler verification of calls.

Some routines in this library can be called with different sets of arguments, and sometimes even as a function instead of a subroutine. In these cases, the arguments and calling mechanism determine the meaning of the routine. The DFPORT module contains generic interface blocks that give procedure definitions for these routines.

Routines for Information Retrieval

Routines classified as information retrieval routines return information about system commands, command-line arguments, environment variables, and process or user information.

All portability routines that take path names also accept long file names or UNC (Universal Naming Convention) file names. A forward slash in a path name is treated as a backslash. All path names can contain drive specifications as well as MBCS (multiple-byte character set) characters. For information on MBCS characters, see Using National Language Support Routines.

Portability Routine	Description
IARGC	Returns the index of the last command-line argument
GETENV	Searches the environment for a given string, and returns its value if found
GETGID	Returns the group ID of the user
GETLOG	Get user's login name
GETPID	Returns the process ID of the process
GETUID	Returns the user ID of the user of the process
HOSTNAM	Returns the name of the user's host

Group, user, and process ID are INTEGER(4) variables. Login name and host name are character variables. The functions **GETGID** and **GETUID** are provided for portability, but always return 1.

IARGC is best used with GETARG. **GETARG**, which returns command line arguments, is available in the standard Visual Fortran library; you do not have to specify USE DFPORT in your program unit.

For more information:

- See Device and Directory Information.

Device and Directory Information Routines

You can retrieve information about devices, directories, and files with the functions listed below. File names can be long file names or UNC file names. A forward slash in a path name is treated as a backslash. All path names can contain drive specifications.

Portability Routine	Description
CHDIR	Changes the current working directory
FSTAT	Returns information about a logical file unit
GETCWD	Returns the current working directory path name
RENAME	Renames a file
STAT, LSTAT	Returns information about a named file
UNLINK	Removes a directory entry from the path

Standard Fortran 90 provides the INQUIRE statement, which returns detailed file information either by file name or unit number. Use **INQUIRE** as an equivalent to **FSTAT**, **LSTAT** or **STAT**. **LSTAT** and **STAT** return the same information; **STAT** is the preferred function.

Process Control Routines

Process control routines control the operation of a process or subprocess. You can wait for a subprocess to complete with either **SLEEP** or **ALARM**, monitor its progress and send signals via **KILL**, and stop its execution with **ABORT**.

In spite of its name, **KILL** does not necessarily stop execution of a program. Rather, the routine signaled could include a handler routine that examines the signal and takes appropriate action depending on the code passed.

Portability Routine	Description
ABORT	Stops execution of the current process, clears I/O buffers, and writes a string to external unit 0
ALARM	Executes an external subroutine after waiting a specified number of seconds
KILL	Sends a signal code to a process ID

SIGNAL	Changes the action for a signal
SLEEP	Suspends program execution for a specified number of seconds
SYSTEM	Executes a command in a separate shell

Note that when you use **SYSTEM**, commands are run in a separate shell. Defaults set with the **SYSTEM** function, such as current working directory or environment variables, do not affect the environment the calling program runs in.

The portability library does not include the **FORK** routine. On U*X systems, **FORK** creates a duplicate image of the parent process. Child and parent processes each have their own copies of resources, and become independent from one another. With Windows operating systems, you can create a child process (called a thread), but both parent and child processes share the same address space and share system resources. If you need to create another process, use the CreateProcess Win32 API routine.

For information on how to implement threading, see Creating Multithread Applications.

Numeric Routines

Numeric routines are available for calculating Bessel functions, data type conversion, and generating random numbers:

Portability Routine	**Description**
BESJ0, BESJ1, BESJN, BESY0, BESY1, BESYN	Computes the single precision values of Bessel functions of the first and second kind of orders 1, 2, and *n*, respectively
DBESJ0, DBESJ1, DBESJN, DBESY0, DBESY1, DBESYN	Computes the double-precision values of Bessel functions of the first and second kind of orders 1, 2, and *n*, respectively
LONG	Converts an INTEGER(2) variable to an INTEGER (4) type
SHORT	Converts an INTEGER(4) variable to an INTEGER (2) type

IRAND, IRANDM	Returns a positive integer in the range 0 through (2**31)-1, or (2**15)-1 if called without an argument
RAN	Returns random values in the range 0 through 1.0
RAND, DRAND	Returns random values in the range 0 through 1.0
DRANDM, RANDOM	Returns random values in the range 0 through 1.0
SRAND	Seeds the random number generator used with **IRAND** and **RAND**.
BIC, BIS, BIT	Perform bit level clear, set, and test for integers

Some of these functions have equivalents in standard Fortran 95/90. Data object conversion can be accomplished by using the INT intrinsic function instead of **LONG** or **SHORT**. The intrinsic subroutines RANDOM_NUMBER and RANDOM_SEED perform the same functions as the random number functions listed in the previous table.

Other bit manipulation functions such as AND, XOR, OR, LSHIFT, and RSHIFT are intrinsic functions. You do not need the DFPORT module to access them. Standard Fortran 95/90 includes many bit operation procedures; these are listed in the Bit Operation Procedures table in the *Language Reference*.

Input and Output With Portability Routines

The portability library contains routines that change file properties, read and write characters and buffers, and change the offset position in a file. These input and output routines can be used with standard Fortran input or output statements such as **READ** or **WRITE** on the same files, provided that you take into account the following:

- When used with direct files, after an **FSEEK**, **GETC**, or **PUTC** operation, the record number is the number of the next whole record. Any subsequent normal Fortran I/O to that unit occurs at the next whole record. For example, if you seek to absolute location 1 of a file whose record length is 10, the NEXTREC returned by an inquire would be 2. If you seek to absolute location 10, NEXTREC would still return 2.
- On units with CARRIAGECONTROL='FORTRAN' (the default), **PUTC** and **FPUTC** characters are treated as carriage control characters if they appear in column 1.

- On sequentially formatted units, the C string "\n"c, which represents the carriage return/line feed escape sequence, is written as **CHAR**(13) (carriage return) and **CHAR**(10) (line feed), instead of just line feed, or **CHAR**(10). On input, the sequence 13 followed by 10 is returned as just 10. (The length of character string "\n"c is 1 character, whose ASCII value, indicated by **ICHAR**('\n'c), is 10.)
- Reading and writing is in a raw form for direct files. Separators between records can be read and overwritten. Therefore, be careful if you continue using the file as a direct file.

I/O errors arising from the use of these routines result in a Visual Fortran run-time error.

Portability Routine	Description
ACCESS	Checks a file for accessibility according to mode
CHMOD	Changes file attributes
FGETC	Reads a character from an external unit
FLUSH	Flushes the buffer for an external unit to its associated file
FPUTC	Writes a character to an external unit
FSEEK	Repositions a file on an external unit
FTELL	Returns the offset, in bytes, from the beginning of the file
GETC	Reads a character from unit 5
PUTC	Writes a character to unit 6

All path names can include drive specifications, forward slashes, or backslashes.

Some portability file I/O routines have equivalents in standard Fortran 95/90. For example, you could use the **ACCESS** function to check a file specified by name for accessibility according to mode. It tests a file for read, write, or execute permission, as well as checking to see if the file exists. It works on the file attributes as they exist on disk, not as a program's **OPEN** statement specifies them.

Instead of **ACCESS**, you can use the INQUIRE statement with the ACTION parameter to check for similar information. (The **ACCESS** function always returns 0 for read permission on FAT files, meaning that all files have read permission.)

Date and Time Routines

Various date and time routines are available to determine system time, or convert it to local time, Greenwich Mean Time, arrays of date and time elements, or an ASCII character string.

The sample output column of the following table assumes the current date to be 2/24/97 7:11 pm Pacific Daylight Time. The third column shows what each routine returns, either when reporting the current time or when that date and time is passed to it in an appropriate argument. Full details of parameters and output are given in the description of each routine (A to Z Reference) in the *Language Reference*.

Portability Routine	**Description**	**Sample output**
CLOCK	Current time in "hh:mm:ss" format using a 24-hour clock	19:11:00
CTIME	Converts a system time to a 24-character ASCII string	"Wed Feb 24 19:11:00 1999"
DATE	A string representation of the current date	As a subroutine: "24-Feb-99" As a function: "02/24/99"
DTIME	Elapsed CPU time since later of (1) start of program, or (2) most recent call to DTIME	(/0.0, 0.0/) (Actual results depend on the program and the system)
ETIME	Elapsed CPU time since the start of program execution	(/0.0, 0.0/) (Actual results depend on the program and the system)
FDATE	The current date and time as an ASCII string	"Wed Feb 24 19:11:00 1999"
GMTIME	Greenwich Mean Time as a 9-element integer array	(/0,12,03,24,2,97,3,55,0/)

IDATE	Current date either as one 3-element array or three scalar parameters (month, day, year)	(1) (/24,2,1999/) (2) month=2, day=24, year=99
ITIME	Current time as a 3-element array (hour, minute, second)	(/7,11,00/)
JDATE	Current date as an 8-character string with the Julian date	"99055 "
LTIME	Local time as a 9-element integer array	(/0,11,7,24,2,99,3,55,0/)
RTC	Number of seconds since 00:00:00 GMT, Jan 1, 1970	762145860
SECNDS	The number of seconds since midnight, less the value of its argument	0.00
TIME	As a subroutine, returns the time formatted as hh:mm:ss As a function, returns the time in seconds since midnight GMT Jan 1, 1970	Subroutine: "07:11:00" Function: 762145860
TIMEF	The number of seconds since the first time this function was called (or zero)	0.0

TIME and **DATE** are available as either a function or subroutine. Because of the name duplication, if your programs do not include the **USE DFPORT** statement, each separately compiled program unit can use only one of these versions. For example, if a program calls the subroutine **TIME** once, it cannot also use **TIME** as a function.

Standard Fortran 95/90 includes date and time intrinsic subroutines. For more information, see DATE_AND_TIME in the *Language Reference*.

Error Handling Routines

The following routines are available for detecting and reporting errors:

Portability Routine	Description
IERRNO	Returns the last error code
GERROR	Returns the **IERRNO** error code as a string variable
PERROR	Sends an error message, preceded by a string, for the last error detected

IERRNO error codes are analogous to *errno* on U*X systems. The DFPORT module provides parameter definitions for many of U*X's *errno* names, found typically in errno.h on U*X systems.

IERRNO is updated only when an error occurs. For example, if a call to the **GETC** function results in an error, but two subsequent calls to **PUTC** succeed, a call to **IERRNO** returns the error for the **GETC** call. Examine **IERRNO** immediately after returning from one of the portability library routines. Other standard Fortran 90 routines might also change the value to an undefined value.

If your application uses multithreading, remember that **IERRNO** is set on a per-thread basis.

Miscellaneous String and Sorting Routines

The following routines perform miscellaneous string and sorting operations:

Portability Routine	Description
LNBLNK	Returns the index of the last non-blank character in a string.
QSORT	Sorts a one-dimensional array of a specified number of elements of a named size.
RINDEX	Returns the index of the last occurrence of a substring in a string.

For information on equivalent standard Fortran 95/90 character procedures, see Character Procedures in the *Language Reference*.

Other Compatibility Routines

If you need to call a routine not listed in the portability library, you may find it in the standard Visual Fortran library. Routines implemented as intrinsic or in the DFLIB module are:

Procedure	Description
AND	Bitwise AND
OR	Bitwise OR
XOR	Bitwise XOR
FREE	Frees dynamic memory
GETARG	Returns command line arguments
MALLOC	Allocates dynamic memory
LSHIFT	Left bitwise shift
RSHIFT	Right bitwise shift
EXIT	Exits program with a return code

Visual Fortran does not support certain other functions, such as:

Routine	Description	Similar Visual Fortran Functionality
CMVGM, CMVGN, CMVGP, CMVGT, CMVGZ	Conditional merge	MERGE intrinsic function
FORK	Creates an identical process	CreateProcess, System
LINK	Creates a hard link between two files	none
SYMLNK	Creates a symbolic link between two files	none

Note: CreateProcess is a Win32 API routine described in Creating

Multithread Applications.

Replace conditional merge routines with the standard Fortran 95/90 intrinsic MERGE routine, using the following arguments:

Routine	**Fortran 95/90 Replacement**
CVMGP(*tsrc*, *fsrc*, *mask*)	MERGE(*tsrc*, *fsrc*, *mask* >= 0)
CVMGM(*tsrc*, *fsrc*, *mask*)	MERGE(*tsrc*, *fsrc*, *mask* < 0)
CVMGZ(*tsrc*, *fsrc*, *mask*)	MERGE(*tsrc*, *fsrc*, *mask* = 0)
CVMGN(*tsrc*, *fsrc*, *mask*)	MERGE(*tsrc*, *fsrc*, *mask* /= 0)
CVMGT(*tsrc*, *fsrc*, *mask*)	MERGE(*tsrc*, *fsrc*, *mask* = .TRUE.)

There is no analogy to U*X file system links or soft links under Windows.

There is also no analogy to the U*X FORK routine, since FORK creates a duplicate image of the parent process which is independent from the parent process. With Windows operating systems, both parent and child processes share the same address space and share system resources. For more information on creating child processes, see Creating Multithread Applications.

Files, Devices, and I/O Hardware

This chapter discusses Visual Fortran files and devices, and using your input/output (I/O) hardware. Together with the sections on I/O statements and I/O editing, these sections explain where and how Fortran data is input and output.

Files and devices are where data is stored and retrieved, I/O editing determines how the data is organized when it is read or written, and I/O statements determine what input/output operations are performed on the data.

The following topics are discussed:

- Devices and Files
- I/O Hardware
- Using the Console
- Using the Serial I/O Port Routines

Devices and Files

In Fortran's I/O system, data is stored and transferred among files. All I/O data sources and destinations are considered files. Devices such as the screen, keyboard and printer are external files, as are data files stored on a device such as a disk.

Variables in memory can also act as a file on a disk, and are typically used to convert ASCII representations of numbers to binary form. When variables are used in this way, they are called internal files.

The discussion of I/O files is divided into two sections:

- Logical Devices, which describes logical unit specifiers, external files, and internal files.
- Files, which describes the types of files, file access, record types, and Microsoft Fortran PowerStation compatible files.

Logical Devices

Every file, internal or external, is associated with a logical device. You identify the logical device associated with a file by a unit specifier (UNIT=). The unit specifier for an internal file is the name of the character variable associated with it. The unit specifier for an external file is either a number you assign with the **OPEN** statement, a number preconnected as a unit specifier to a device, or an asterisk (*).

External unit specifiers that are preconnected to certain devices do not have to be opened. External units that you connect are disconnected when program execution terminates or when the unit is closed by a **CLOSE** statement.

A unit must not be connected to more than one file at a time, and a file must not be connected to more than one unit at a time. You can **OPEN** an already opened file but only to change some of the I/O options for the connection, not to connect an already opened file or unit to a different unit or file.

You must use a unit specifier for all I/O statements, except in the following three cases:

- **ACCEPT**, which always reads from standard input, unless the FOR_ACCEPT environment variable is defined.
- **INQUIRE** by file, which specifies the filename, rather than the unit with which the file is associated
- **PRINT**, which always writes to standard output, unless the FOR_PRINT environment variable is defined.
- **READ** statements that contain only an I/O list and format specifier, which read from standard input (UNIT=5), unless the FOR_READ environment variable is defined.
- **WRITE** statements that contain only an I/O list and format specifier, which write to standard output, unless the FOR_PRINT environment variable is defined.
- **TYPE**, which always writes to standard output, unless the FOR_TYPE environment variable is defined.

External Files

A unit specifier associated with an external file must be either an integer expression or an asterisk (*). The integer expression must be in the range 0 (zero) to a maximum value of 2,147,483,640. The following example connects the external file UNDAMP.DAT to unit 10 and writes to it:

```
OPEN (UNIT = 10, FILE = 'undamp.dat')
WRITE (10, '(A18,\)') ' Undamped Motion:'
```

The asterisk (*) unit specifier specifies the keyboard when reading and the screen when writing. The following example uses the asterisk specifier to write to the screen:

```
WRITE (*, '(1X, A30,\)') ' Write this to the screen.'
```

Visual Fortran has four units preconnected to external files (devices), as shown in the following table.

External Unit Specifier	Description
Asterisk (*)	Always represents the keyboard and screen (unless the appropriate environment variable is defined, such as FOR_READ).
0	Initially represents the screen (unless FORT0 is defined)
5	Initially represents the keyboard (unless FORT5 is defined)
6	Initially represents the screen (unless FORT6 is defined)

The asterisk (*) specifier is the only unit specifier that cannot be reconnected to another file, and attempting to close this unit causes a compile-time error. Units 0, 5, and 6, however, can be connected to any file with the **OPEN** statement. If you close unit 0, 5, or 6, it is automatically reconnected to its respective device the next time an I/O statement attempts to use that unit.

When you omit the file name in the OPEN statement or use an implicit OPEN, you can define the environment variable FORT*n* to specify the file name for a particular unit number (*n*) (except when the compiler option /fpscomp:filesfromcmd is *not* specified). For example, if you want unit 6 to write to a file instead of standard output, set the environment variable FORT6 to the path and filename to be used before you run the program.

The following example writes to the preconnected unit 6 (the screen), then reconnects unit 6 to an external file and writes to it, and finally reconnects unit 6 to the screen and writes to it:

```
      REAL a, b
!  Write to the screen (preconnected unit 6).
     WRITE(6, '('' This is unit 6'')')
!  Use the OPEN statement to connect unit 6
!  to an external file named 'COSINES'.
     OPEN (UNIT = 6, FILE = 'COSINES', STATUS = 'NEW')
     DO a = 0.1, 6.3, 0.1
          b = COS (a)
!  Write to the file 'COSINES'.
           WRITE (6, 100) a, b
100        FORMAT (F3.1, F5.2)
     END DO
!  Close it.
     CLOSE (6)
!  Reconnect unit 6 to the screen, by writing to it.
     WRITE(6,' ('' Cosines completed'')')
     END
```

Internal Files

The unit specifier associated with an internal file is a character string or character array. There are two types of internal files:

- An internal file that is a character variable, character array element, or noncharacter array element that has exactly one record, which is the same length as the variable, array element, or noncharacter array element.
- An internal file that is a character array, a character derived type, or a noncharacter array that is a sequence of elements, each of which is a record. The order of records is the same as the order of array elements or type elements, and the record length is the length of one array element or the length of the derived-type element.

Follow these rules when using internal files:

- Use only formatted I/O, including I/O formatted with a format specification and list-directed I/O. (List-directed I/O is treated as sequential formatted I/O.) Namelist formatting is not allowed.
- If the character variable is an allocatable array or array part of an allocatable array, the array must be allocated before use as an internal file. If the character variable is a pointer, it must be associated with a target.
- Use only READ and WRITE statements. You cannot use file connection (**OPEN**, **CLOSE**), file positioning (**REWIND**, **BACKSPACE**) or file inquiry (**INQUIRE**) statements with internal files.

You can read and write internal files with **FORMAT** I/O statements or list-directed I/O statements exactly as you can external files. Before an I/O statement is executed, internal files are positioned at the beginning, before the first record.

With internal files, you can use the formatting capabilities of the I/O system to convert values between external character representations and Fortran internal memory representations. That is, reading from an internal file converts the ASCII representations into numeric, logical, or character representations, and writing to an internal file converts these representations into their ASCII representations.

This feature makes it possible to read a string of characters without knowing its exact format, examine the string, and interpret its contents. It also makes it possible, as in dialog boxes, for the user to enter a string and for your application to interpret it as a number.

If less than an entire record is written to an internal file, the rest of the record is filled with blanks.

In the following example, `str` and `fname` specify internal files:

```
    CHARACTER(10) str
    INTEGER n1, n2, n3
    CHARACTER(14) fname
    INTEGER   i

    str = " 1   2   3"
! List-directed READ sets n1 = 1, n2 = 2, n3 = 3.
    READ(str, *) n1, n2, n3
    i = 4
! Formatted WRITE sets fname = 'FM004.DAT'.
    WRITE (fname, 200) i
200 FORMAT ('FM', I3.3, '.DAT')
```

Files

File organization refers to the way records are physically arranged on a storage device.

Record type refers to whether records in a file are all the same length, are of varying length, or use other conventions to define where one record ends and another begins.

Record access refers to the method used to read records from or write records to a file, regardless of its organization. The way a file is organized does not necessarily imply the way in which the records within that file will be accessed.

Fortran supports two kinds of file organizations: sequential and relative. The organization of a file is specified by means of the ORGANIZATION keyword in the **OPEN** statement. Relative files must be stored on disk. However, sequential files can be stored on either magnetic tape or disk. Other peripheral devices, such as terminals, pipes, card readers, and line printers, are treated as sequential files.

A sequentially organized file consists of records arranged in the sequence in which they are written to the file (the first record written is the first record in the file, the second record written is the second record in the file, and so on). As a result, records can be added only at the end of the file. Attempting to add records at someplace other than the end of the file will result in the file begin truncated at the end of the record just written.

Within a relative file are numbered positions, called cells. These cells are of fixed equal length and are consecutively numbered from 1 to *n*, where 1 is the first cell, and *n* is the last available cell in the file. Each cell either contains a single record or is empty. Records in a relative file are accessed according to cell number. A cell number is a record's relative record number; its location relative to the beginning of the file. By specifying relative record numbers, you can directly retrieve, add, or delete records regardless of their locations. (Detecting deleted records is only available if you specified the /vms option when the program was compiled. For information, see the /vms option.)

Fortran supports two methods of file access (sequential and direct) and three kinds of file structure (formatted, unformatted, and binary). Sequential-access and direct-access files can have any of the three file structures. The following kinds of files are possible:

- Formatted Sequential
- Formatted Direct
- Unformatted Sequential
- Unformatted Direct
- Binary Sequential
- Binary Direct

Each kind of file has advantages and the best choice depends on the application you are developing:

- Formatted Files

  You create a formatted file by opening it with the FORM='FORMATTED' option, or by omitting the FORM parameter when creating a sequential file. The records of a formatted file are stored as ASCII characters; numbers that would otherwise be stored in binary form are converted to ASCII format. Each record ends with the ASCII carriage return (CR) and line feed (LF) characters.

  If you need to view a data file's contents, use a formatted file. You can load a formatted file into a text editor and read its contents directly, that is, the numbers would look like numbers and the strings like character strings, whereas an unformatted or binary file looks like a set of hexadecimal characters.

- Unformatted Files

  You create an unformatted file by opening it with the FORM='UNFORMATTED' option, or by omitting the FORM parameter when creating a direct-access file. An unformatted file is a series of records composed of physical blocks. Each record contains a sequence of values stored in a representation that is close to that used in program memory. Little conversion is required during input/output.

  The lack of formatting makes these files quicker to access and more compact than files that store the same information in a formatted form. However, if the files contain numbers, you will not be able to read them with a text editor.

- Binary Files

You create a binary file by specifying FORM='BINARY'. Binary files are the most compact, and good for storing large amounts of data.

- Sequential-Access Files

  Data in sequential files must be accessed in order, one record after the other (unless you change your position in the file with the **REWIND** or **BACKSPACE** statements). Some methods of I/O are possible only with sequential files, including nonadvancing I/O, list-directed I/O, and namelist I/O. Internal files also must be sequential files. You must use sequential access for files associated with sequential devices.

  A sequential device is a physical storage device that does not allow explicit motion (other than reading or writing). The keyboard, screen, and printer are all sequential devices.

- Direct-Access Files

  Data in direct-access files can be read or written to in any order. Records are numbered sequentially, starting with record number 1. All records have the length specified by the RECL option in the **OPEN** statement. Data in direct files is accessed by specifying the record you want within the file. If you need random access I/O, use direct-access files. A common example of a random-access application is a database.

All files are composed of records. Each record is one entry in the file. It can be a line from a terminal or a logical record on a magnetic tape or disk file. All records within one file are of the same type.

In Fortran, the number of bytes written to a record must be less than or equal to the record length. One record is written for each unformatted **READ** or **WRITE** statement. A formatted **READ** or **WRITE** statement can transfer more than one record using the slash (***/***) edit descriptor.

For binary files, a single **READ** or **WRITE** statement reads or writes as many records as needed to accommodate the number of bytes being transferred. On output, incomplete formatted records are padded with spaces. Incomplete unformatted and binary records are padded with undefined bytes (zeros).

The remainder of this section contains information about:

- Record Types
- Microsoft Fortran PowerStation Compatible Files (when /fpscomp was specified during compilation)

Record Types

An I/O record is a collection of data items, called fields, that are logically related and are processed as a unit. The record type refers to the convention for storing fields in records.

The record type of the data within a file is not maintained as an attribute of the file. The results of using a record type other than the one used to create the file are indeterminate.

If you omit /fpscomp:ioformat during compilation, the following six record types are available:

Record Type	Available File Organizations and Portability Considerations
Fixed-length	Relative or sequential file organizations.
Variable-length	Sequential file organization only. The variable-length record type is generally the most portable record type across multi-vendor platforms.
Segmented	Sequential file organization only and only for unformatted sequential access. The segmented record type is unique to Compaq Fortran and should not be used for portability with programs written in languages other than Fortran or for places where Compaq Fortran is not used. However, because the segmented record type is unique to Compaq Fortran products, formatted data in segmented files can be ported across Compaq Fortran platforms.
Stream (uses no record delimiter)	Sequential file organization only.
Stream_CR (uses CR as record delimiter)	Sequential file organization only.
Stream_LF (uses CR and LF as record delimiter)	Sequential file organization only.

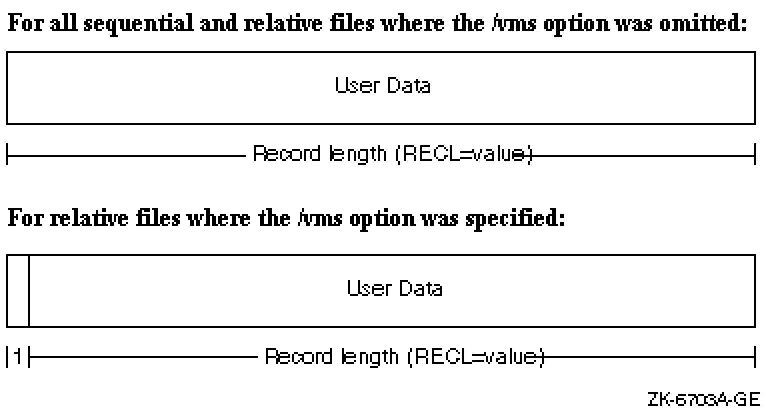
Fixed-Length Records

When you specify fixed-length records, you are specifying that all records in the file contain the same number of bytes. When you open a file that is to contain fixed-length records, you must specify the record size using the RECL keyword. A sequentially organized opened file for direct access must contain fixed-length records, to allow the record position in the file to be computed correctly.

For relative files, the layout and overhead of fixed-length records depends upon whether the program accessing the file was compiled using the /vms option or whether the /vms option was omitted:

- For relative files where the /vms option was omitted (the default), each record has no control information.
- For relative files where the /vms option was specified, each record has one byte of control information at the beginning of the record.

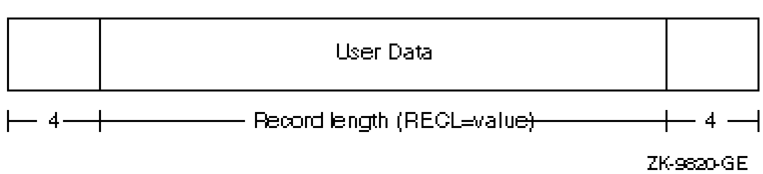
The following figure shows the record layout of fixed-length records.



Variable-Length Records

Variable-length records can contain any number of bytes, up to a specified maximum record length, and only apply to sequential files. These records are generally prefixed and suffixed by four bytes of control information containing count fields. The 4-byte integer value stored in each count field indicates the number of data bytes (excluding overhead bytes) in that particular variable-length record.

The record layout of variable-length records appears below.



The count field of a variable-length record is available when you read the record by issuing a **READ** statement with a **Q** format descriptor. You can then use the count field information to determine how many bytes should be in the associated I/O list.

Files written with variable-length records by Compaq Fortran programs usually cannot be accessed as text files. Instead, use the Stream_LF record format for text files with records of varying length.

Segmented Records

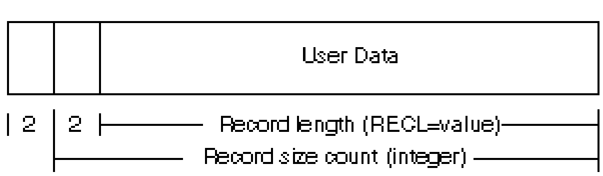
A segmented record is a single logical record consisting of one or more variable-length, unformatted records in a sequentially organized disk file. Unformatted data written to sequentially organized files using sequential access is stored as segmented records by default.

Segmented records are useful when you want to write exceptionally long records but cannot or do not wish to define one long variable-length record, perhaps because virtual memory limitations can prevent program execution. By using smaller, segmented records, you reduce the chance of problems caused by virtual memory limitations on systems on which the program may execute.

For disk files, the segmented record is a single logical record that consists of one or more segments. Each segment is a physical record. A segmented (logical) record can exceed the absolute maximum record length (2.14 billion bytes), but each segment (physical record) individually cannot exceed the maximum record length.

To access an unformatted sequential file that contains segmented records, specify FORM='UNFORMATTED' and RECORDTYPE='SEGMENTED' when you open the file. Otherwise, the file may be processed erroneously.

As shown below, the layout of segmented records consists of 4 bytes of control information followed by the user data.



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The control information consists of a 2-byte integer record length count (includes the 2 bytes used by the segment identifier), followed by a 2-byte integer segment identifier that identifies this segment as one of the following:

- The first segment (equals 1)
- The last segment (equals 2)
- The only segment (equals 3)

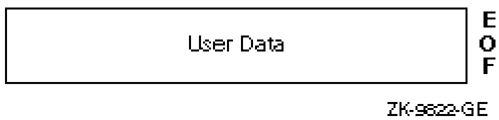
- One of the segments between the first and last segments (equals 0)

If the specified record length is an odd number, the user data will be padded with a single blank (1 byte), but this extra byte is not added to the 2-byte integer record length count.

Stream File Data

A stream file is not grouped into records and contains no control information. Stream files are used with CARRIAGECONTROL='NONE' and contain character or binary data that is read or written only to the extent of the variables specified on the input or output statement.

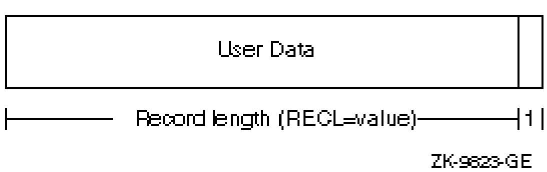
The layout of a stream file appears below.



Stream_CR Records

A stream_CR record is a variable-length record whose length is indicated by explicit record terminators embedded in the data, not by a count. These terminators are automatically added when you write records to a stream-type file, and they are removed when you read records. Stream_CR files use only a carriage-return as the terminator, so Stream_CR files must not contain embedded carriage-return characters.

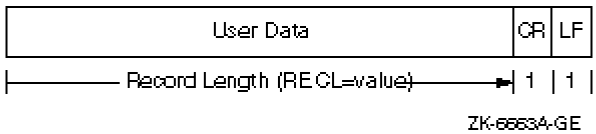
The layout of stream_CR records appears below.



Stream_LF Records

A stream_LF record is a variable-length record whose length is indicated by explicit record terminators embedded in the data, not by a count. These terminators are automatically added when you write records to a stream-type file, and they are removed when you read records. Stream_LF files use a carriage return followed by line-feed (new line) as the terminator, so Stream_LF files must not contain embedded line-feed (new line) characters. This is the usual operating system text file record type.

The layout of stream_LF records appears below.



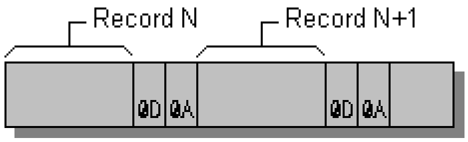
Microsoft Fortran PowerStation Compatible Files

When using the /fpscomp options for Microsoft Fortran PowerStation compatibility, the following types of files are possible:

- Formatted Sequential Files

  A formatted sequential file is a series of formatted records written sequentially and read in the order in which they appear in the file. Records can vary in length and can be empty. They are separated by carriage return (0D) and line feed (0A) characters as shown in the following figure.

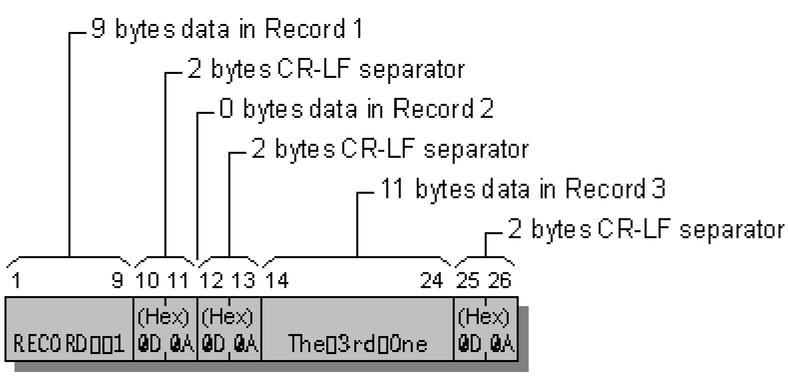
  ### Formatted Records in a Formatted Sequential File

  An example of a program writing three records to a formatted sequential file is given below. The resulting file is shown in the following figure.

```
   OPEN (3, FILE='FSEQ')
! FSEQ is a formatted sequential file by default.
   WRITE (3, '(A, I3)') 'RECORD', 1
   WRITE (3, '()')
   WRITE (3, '(A11)') 'The 3rd One'
   CLOSE (3)
   END
```

  ### Formatted Sequential File

- Formatted Direct Files

In a formatted direct file, all of the records are the same length and can be written or read in any order. The record size is specified with the RECL option in an **OPEN** statement and should be equal to or greater than the number of bytes in the longest record.

The carriage return (CR) and line feed (LF) characters are record separators and are not included in the RECL value. Once a direct-access record has been written, you cannot delete it, but you can rewrite it.

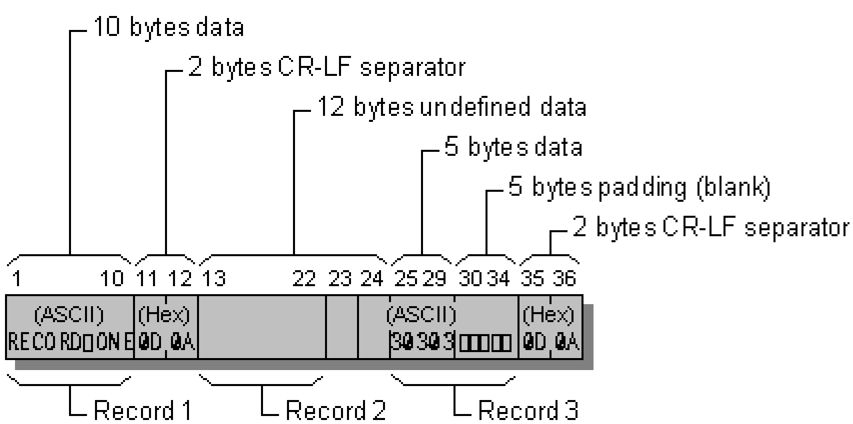
During output to a formatted direct file, if data does not completely fill a record, the compiler pads the remaining portion of the record with blank spaces. The blanks ensure that the file contains only completely filled records, all of the same length. During input, the compiler by default also pads the input if the input list and format require more data than the record contains.

You can override the default blank padding on input by setting PAD='NO' in the **OPEN** statement for the file. If PAD='NO', the input record must contain the amount of data indicated by the input list and format specification. Otherwise, an error occurs. PAD='NO' has no effect on output.

An example of a program writing two records, record one and record three, to a formatted direct file is given below. The result is shown in the following figure.

```
OPEN (3,FILE='FDIR', FORM='FORMATTED', ACCESS='DIRECT',RECL=10)
WRITE (3, '(A10)', REC=1) 'RECORD ONE'
WRITE (3, '(I5)', REC=3) 30303
CLOSE (3)
END
```

Formatted Direct File



- Unformatted Sequential Files

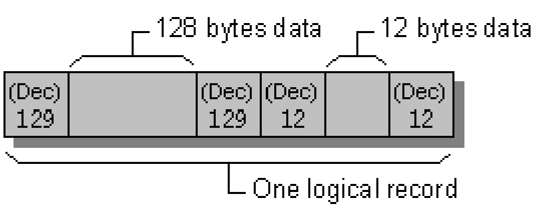
Unformatted sequential files are organized slightly differently on different platforms. This section describes unformatted sequential files created by Visual Fortran when the /fpscomp option (such as /fpscomp:(ioformat,general)) was specified. If you are accessing files from another platform that organizes them differently, see Converting Unformatted Numeric Data or you can use the conversion utility in the `...\DF98\SAMPLES\TUTORIAL` folder called UNFSEQ.F90.

The records in an unformatted sequential file can vary in length. Unformatted sequential files are organized in chunks of 130 bytes or less called *physical blocks*. Each physical block consists of the data you send to the file (up to 128 bytes) plus two 1-byte "length bytes" inserted by the compiler. The length bytes indicate where each record begins and ends.

A *logical record* refers to an unformatted record that contains one or more physical blocks. (See the following figure.) Logical records can be as big as you want; the compiler will use as many physical blocks as necessary.

When you create a logical record consisting of more than one physical block, the compiler sets the length byte to 129 to indicate that the data in the current physical block continues on into the next physical block. For example, if you write 140 bytes of data, the logical record has the structure shown in the following figure.

Logical Record in Unformatted Sequential File



The first and last bytes in an unformatted sequential file are reserved; the first contains a value of 75, and the last holds a value of 130. Fortran uses these bytes for error checking and end-of-file references.

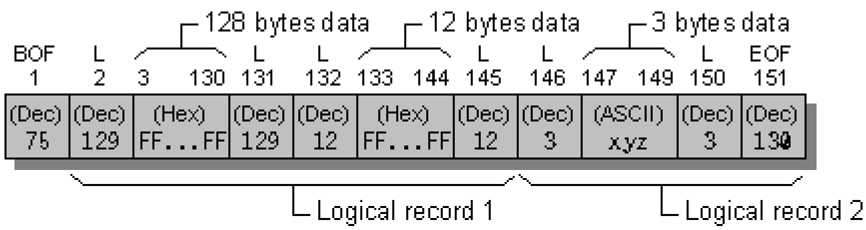
The following program creates the unformatted sequential file shown in the following figure:

```
!   Note: The file is sequential by default
!         -1 is FF FF FF FF hexadecimal.
!
   CHARACTER xyz(3)
   INTEGER(4) idata(35)
   DATA      idata /35 * -1/, xyz /'x', 'y', 'z'/

!
! Open the file and write out a 140-byte record:
! 128 bytes (block) + 12 bytes = 140 for IDATA, then 3 bytes for XYZ.
```

```
OPEN (3, FILE='UFSEQ',FORM='UNFORMATTED')
WRITE (3) idata
WRITE (3) xyz
CLOSE (3)
END
```

Unformatted Sequential File



BOF Beginning-of-file byte (75 decimal)
L Physical-block-length byte (0 <= L <= 129)
EOF End-of-file byte (130 decimal)

- Unformatted Direct Files

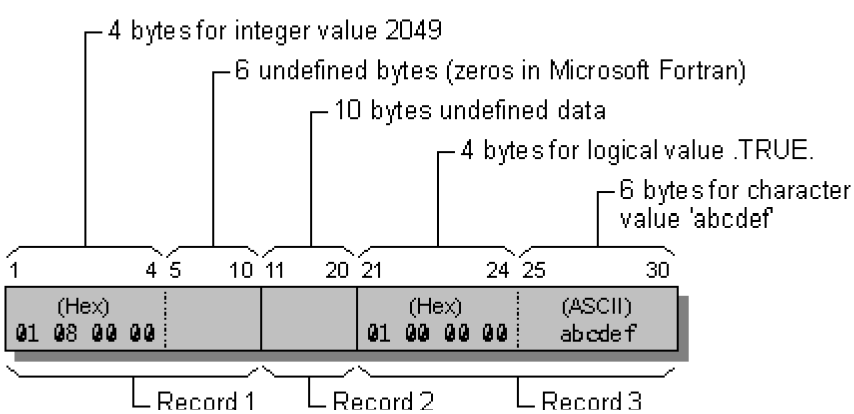
  An unformatted direct file is a series of unformatted records. You can write or read the records in any order you choose. All records have the same length, given by the RECL specifier in an **OPEN** statement. No delimiting bytes separate records or otherwise indicate record structure.

  You can write a partial record to an unformatted direct file. Visual Fortran pads these records to the fixed record length with ASCII NULL characters. Unwritten records in the file contain undefined data.

  The following program creates the sample unformatted direct file shown in the following figure:

```
OPEN (3, FILE='UFDIR', RECL=10,&
  & FORM = 'UNFORMATTED', ACCESS = 'DIRECT')
WRITE (3, REC=3) .TRUE., 'abcdef'
WRITE (3, REC=1) 2049
CLOSE (3)
END
```

Unformatted Direct File



- Binary Sequential Files

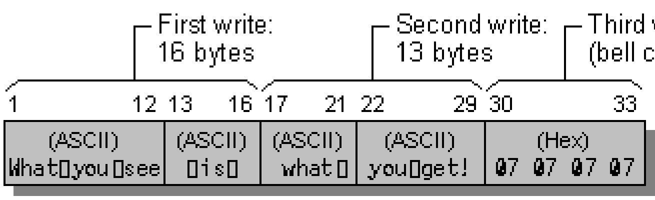
  A binary sequential file is a series of values written and read in the same order and stored as binary numbers. No record boundaries exist, and no special bytes indicate file structure. Data is read and written without changes in form or length. For any I/O data item, the sequence of bytes in memory is the sequence of bytes in the file.

  The next program creates the binary sequential file shown in the following figure:

```
!  NOTE: 07 is the bell character
!     Sequential is assumed by default.
!
   INTEGER(1) bells(4)
   CHARACTER(4) wys(3)
   CHARACTER(4) cvar
   DATA bells /4*7/
   DATA cvar /' is '/,wys /'What',' you',' see'/

   OPEN (3, FILE='BSEQ',FORM='BINARY')
   WRITE (3) wys, cvar
   WRITE (3) 'what ', 'you get!'
   WRITE (3) bells
   CLOSE (3)
   END
```

  Binary Sequential File



- Binary Direct Files

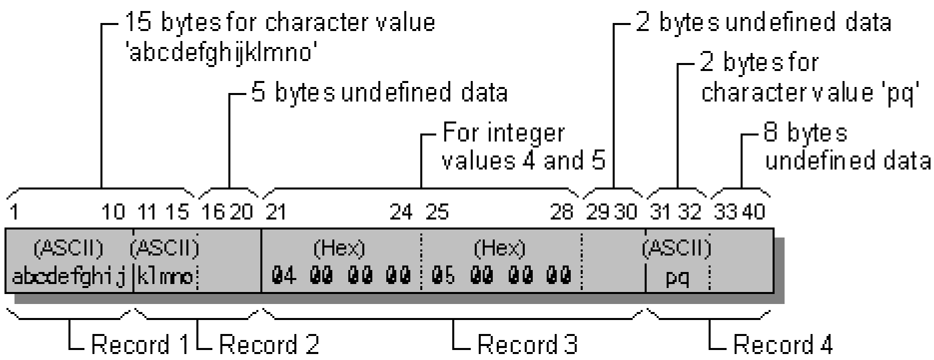
  A binary direct file stores records as a series of binary numbers, accessible in any order. Each record in the file has the same length, as specified by the RECL argument to the **OPEN** statement. You can write partial records to binary direct files; any unused portion of the record will contain undefined data.

  A single read or write operation can transfer more data than a record contains by continuing the operation into the next records of the file. Performing such an operation on an unformatted direct file would cause an error. Valid I/O operations for unformatted direct files produce identical results when they are performed on binary direct files, provided the operations do not depend on zero padding in partial records.

The following program creates the binary direct file shown in the following figure:

```
OPEN (3, FILE='BDIR',RECL=10,FORM='BINARY',ACCESS='DIRECT')
WRITE (3, REC=1) 'abcdefghijklmno'
WRITE (3) 4,5
WRITE (3, REC=4) 'pq'
CLOSE (3)
END
```

Binary Direct File



I/O Hardware

Most of your hardware configuration and setup is done through your computer's operating system. To connect and communicate with your printer, for example, you should read your system and printer manuals. This section describes how Visual Fortran refers to physical devices and shortcuts for printing text and graphics from the Microsoft visual development environment.

For more information:

- Printing
- Physical Devices

Printing

The simplest way to print a file while you are in the visual development environment is to choose File/Print from the file menu. You are prompted for the file name and the file is printed on the printer connected to your computer.

You can also print files with the extension .F90, .FOR, .FD, .FI, or .RC by dragging the file from Windows Explorer and dropping it on the Print Manager icon.

If you have drawn graphics on the screen and want to print the screen, the simplest way is to press the key combination ALT+PRINT SCREEN. This copies the active window (the one with graphical focus) onto the Clipboard. (If you only press PRINT SCREEN, it prints your entire screen including any background applications.)

Once you have copied your screen onto the Clipboard, open Paintbrush and select Edit/Paste to paste the image from the Clipboard into Paintbrush, then select File/Print to print it to the printer connected to your computer. You can also save the image as a bitmap (.BMP) file.

Physical Devices

I/O statements that do not refer to a specific file or I/O device read from standard input and write to standard output. Standard input is the keyboard, and standard output is the screen (console). To perform input and output on a physical device other than the keyboard or screen, you specify the device name as the filename to be read from or written to.

Some physical device names are determined by the host operating system; others are recognized by Visual Fortran. Extensions on most device names are ignored.

Filenames for Device I/O

Device	**Description**
CON	Console (standard output)
PRN	Printer
COM1	Serial port #1
COM2	Serial port #2
COM3	Serial port #3
COM4	Serial port #4
LPT1	Parallel Port #1
LPT2	Parallel Port #2
LPT3	Parallel Port #3
LPT4	Parallel Port #4
NUL	NULL device. Discards all output; contains no input
AUX	Serial port #1

LINE [1]	Serial port #1
USER [1]	Standard output
ERR [1]	Standard error
CONOUT$	Standard output
CONIN$	Standard input

[1] If you use one of these names with an extension—for example, LINE.TXT—Fortran will write to a file rather than to the device.

Examples of opening physical devices as units are:

```
OPEN (UNIT = 4, FILE = 'PRN')
OPEN (UNIT = 7, FILE = 'LPT2', ERR = 100)
```

Using the Console

On Windows systems, a console window typically allows input and output of characters (not graphics).

Certain console windows allow use of command-line interaction for programmers. For example, the Fortran Command Prompt available from the Compaq Visual Fortran program folder provides a command-line environment where Visual Fortran environment variables are already set. Similarly, the Command Prompt window provided by the operating system provides a general-purpose command-line console environment.

The primary purpose of an application's console window is to display and accept characters. For example, data written (explicitly or implicitly) by Fortran **WRITE** (or other) statements to Fortran logical unit 6 display characters on a console window. Similarly, data read by Fortran **READ** (or other) statements to unit 5 accept keyboard character input.

The console consists of two components:

- The actual console window that shows the characters on the screen.
- The console buffer that contains the characters to be displayed.

If the console screen buffer is bigger than the console window, scroll bars are provided automatically. The size of the console screen buffer must be larger (or equal to) the size of the console window (if not, an error occurs).

For applications that need to display more than a few hundred lines of text, the ability to scroll quickly through the text is important. Also, the maximum size of the console window buffer differs between Windows operating systems:

- On a Windows 98, Windows Me, or Windows 95 system, the number of character lines is limited to about 40-50 pages of output with 132-character lines.
- On a Windows NT or Windows 2000 system, the number of character lines is substantially larger than on Windows 98, Windows Me, and Windows 95 systems.

Fortran Console applications automatically provide a console. Fortran QuickWin (and Fortran Standard Graphics) applications do not provide a console, but display output and accept input from Fortran statements by using the program window.

Different Visual Fortran project types do or do not provide an application console window:

Project Type	**Description of Console Provided**
Fortran Console	Provides a console window since it is intended to be used for character-cell applications that use only text. When you run a Fortran Console application from a command prompt, the existing console environment is used. When you run the application from Windows or Developer Studio (by clicking on ! Execute *program-name* in the Build menu), a new console environment is created. The limits do not differ greatly whether the console is an existing command prompt or created by Windows or Developer Studio, but Windows NT and Windows 2000 systems have substantially greater capacity than Windows 98, Windows Me, and Windows 95 systems. Basic use of a console is described in Code Samples of Console Use.
Fortran QuickWin or Fortran Standard Graphics	Does not provide a console, but output to unit 6 and input to unit 5 are directed to the application program window, which can handle both text and graphics. However, because the program window must handle both text and graphics, it is not very efficient for just text-only use. A Fortran QuickWin or Fortran Standard Graphics program window (or child window) provides a console-like window. See Console Use for Fortran QuickWin and Fortran Standard Graphics Applications.

Fortran Windows	Does not provide a console window, but the user can create a console by using Win32 routines. See Console Use for Fortran Windows Applications and Fortran DLL Applications.
Fortran DLL	Does not provide a console window, but the user can create a console by using Win32 routines. See Console Use for Fortran Windows Applications and Fortran DLL Applications.
Fortran Static Library	Depends upon the project type of the main application that references the object code in the library (see above project types).

In addition to the Win32 routines mentioned below, there are other Win32 routines related to console use in the Platform SDK documentation, under Windows Base Services, File and I/O, Consoles and Character-Mode Support.

Console Use for Fortran QuickWin and Fortran Standard Graphics Applications

For a Fortran QuickWin or Fortran Standard Graphics application, because the default program window handles both graphics and text, the use of a QuickWin window may not be very efficient:

- QuickWin windows use lots of memory and thus cannot be larger than a certain size.
- They can be slow to scroll.

Although you can access the console window using **WRITE** and **READ** (or other) statements, applications that require display of substantial lines of text, consider creating a DLL that creates a separate console window for efficiency. The DLL application needs to call Win32 routines to allocate the console, display text, accept keyed input, and free the console resources.

For a Fortran QuickWin project that uses a DLL to create and use a console, see the CONAPP Visual Fortran sample in `...\Df98\Samples\QuickWin`.

Basic use of a console is described in Code Samples of Console Use.

Console Use for Fortran Windows Applications and Fortran DLL Applications

With a Fortran Windows or Fortran DLL application, attempting to write to the console using **WRITE** and **READ** (or other) statements before a console is created results in a run-time error (such as error performing WRITE).

A console created by a Fortran DLL is distinct from any application console window associated with the main application. A Fortran DLL application has neither a console nor an application window created for it, so it must create (allocate) its own console using Win32 routines. When used with a Fortran QuickWin or Fortran Standard Graphics application main program, the Fortran DLL can provide its main application with a very efficient console window for text-only use.

Like a Fortran DLL application, a Fortran Windows application has neither a console nor an application window created for it, so it must create its own console using Win32 routines. After allocating a console in a Fortran DLL, the handle identifier returned by the GetStdHandle Win32 routine refers to the actual console the DLL creates.

When the Fortran Windows application does create a console window, it is very efficient for text-only use. The handle identifier returned by the GetStdHandle Win32 routine refers to the actual console the Fortran Windows application creates.

For information about creating a console, see Allocating and Deallocating a Console below.

Code Samples for Console Use

The following sections shows sample code for using a console:

- Allocating and Deallocating a Console for Fortran Windows and DLL Applications
- Extending Size of the Console Window and Console Buffer for console use in any project type
- Writing and Reading Characters at a Cursor Position for console use in any project type

Allocating and Deallocating a Console

To create a console, you use the AllocConsole routine. When you are done with the console, free its resources with a FreeConsole routine. For example, the following code allocates the console, enlarges the buffer size, writes to the screen, waits for any key to be pressed, and deallocates the console:

```
! The following USE statement provides Fortran interfaces to Win32 routines
     USE DFWIN
! Begin data declarations
     integer lines,length
     logical status
     integer handle
     Type(T_COORD) wpos

! Set buffer size variables
     length = 80
         lines  = 90
```

```
! Begin executable code
!   Allocate a console
     status = AllocConsole() ! get a console window of the currently set size
     handle = GetStdHandle(STD_OUTPUT_HANDLE)
     wpos.x = length   ! must be >= currently set console window line length
     wpos.y = lines    ! must be >= currently set console window number of lines

     ! Set a console buffer bigger than the console window. This provides
     ! scroll bars on the console window to scroll through the console buffer

     status = SetConsoleScreenBufferSize(handle, wpos)

         ! Write to the screen as needed. Add a READ to pause before deallocation

         write (*,*) "This is the console output! It might display instructions or
         write (*,*) " "
         write (*,*) "Press any key when done viewing "
         read (*,*)

!   Deallocate the console to free its resources.

     status = FreeConsole()
```

Calling Win32 routines is described in Calling Win32 Routines and the Visual Fortran Windows Module.

If you are using a DLL, your DLL code will need to create subprograms and export their symbols to the main program (see Creating Fortran DLLs).

Basic use of a console is described in Extending Size of the Console Window and Console Buffer and Writing and Reading Characters at a Cursor Position.

Extending the Size of the Console Window and Console Buffer

When you execute a Fortran Console application, the console is already allocated. You can specify the size of the console window, size of the console buffer, and the location of the cursor.

If needed, you can extend the size of the console buffer and console window by using the following Win32 routines:

1. You first need to obtain the handle of the console window using the GetStdHandle routine. For example:

```
! USE statements to include routine interfaces
   use dflib
   use dfwin

! Data declarations
   integer fhandle
   logical lstat
! Executable code
   fhandle = GetStdHandle(STD_OUTPUT_HANDLE)
! ...
```

2. If needed, you can obtain the size of the:
    - Console window by using the GetConsoleWindowInfo routine
    - Console buffer by using the GetConsoleScreenBufferInfo routine

   For example:

```
! USE statements to include routine interfaces
   use dflib
   use dfwin
! Data declarations
   integer fhandle
   logical lstat
       Type(T_CONSOLE_SCREEN_BUFFER_INFO) conbuf
               type (T_COORD)        dwSize
       type (T_SMALL_RECT)   srWindow


   fhandle = GetStdHandle(STD_OUTPUT_HANDLE)

! Executable code to get console buffer size
    lstat = GetConsoleScreenBufferInfo(fhandle, conbuf)
        write (*,*) " "
        write (*,*) "Window coordinates= ", conbuf.srWindow
        write (*,*) "Buffer size= ", conbuf.dwSize

! ...
```

3. To set the size of the console window and buffer, use the SetConsoleWindowInfo and SetConsoleScreenBufferSize routines with the fhandle value returned previously:

```
! USE statements to include routine interfaces
   use dflib
   use dfwin
! Data declarations
   integer nlines, ncols
   logical lstat
   Type(T_COORD) wpos
       Type(T_SMALL_RECT) sr
   Type(T_CONSOLE_SCREEN_BUFFER_INFO) cinfo

! Executable code to set console window size
   sr.top    =   0
       sr.left   =   0
   sr.bottom =   40 ! <= console buffer height -1
   sr.right  =   60 ! <= console buffer width  -1
   lstat = SetConsoleWindowInfo(fhandle, .TRUE., sr)

! Executable code to set console buffer size
    nlines = 100
        ncols  =  80
    wpos.x = ncols  ! columns >= console window width
    wpos.y = nlines ! lines   >= console window height
    lstat = SetConsoleScreenBufferSize(fhandle, wpos)
! ...
```

Writing and Reading Characters at a Cursor Position

You can position the cursor as needed using the SetConsoleCursorPosition routine before you write characters to the screen:

```
! Use previous data declarations
! Position and write two lines
   wpos.x = 5 ! 6 characters from left
   wpos.y = 5 ! 6 lines down
   lstat = SetConsoleCursorPosition(fhandle, wpos)
   write(*,*) 'Six across Six down'
! ...
```

You read from the screen at an appropriate place, but usually you should set the cursor relative to the starting screen location:

```
  ! Use previous and the following data declaration
   CHARACTER(Len=50) charin
! Go back to beginning position of screen
   wpos.x = 0 ! 0 characters from left
   wpos.y = 0 ! 0 lines down
   lstat = SetConsoleCursorPosition(fhandle, wpos)
! Position character input at start of line 11
   wpos.x = 0 ! first character from left
   wpos.y = 10 ! 11 lines down
   lstat = SetConsoleCursorPosition(fhandle, wpos)
   read(*,*) charin
! ...
```

For console I/O, you can use Win32 routines WriteConsoleLine and ReadConsoleLine instead of Fortran **WRITE** and **READ** statements.

Using the Serial Port I/O Routines

The SPORT_*xxx* routines help the Fortran programmer perform basic input and output to serial ports. The programming model is much the same as a normal file except the user does a connect (SPORT_CONNECT) and release (SPORT_RELEASE) to the port instead of an open and close of a file.

Two types of read and write operations (as determined in a mode on the connect call) are provided:

- Read and write arbitrary data from/to the port using SPORT_READ_DATA and SPORT_WRITE_DATA.
- Read and writes line-terminated data using SPORT_READ_LINE and SPORT_WRITE_LINE.

Once any I/O operation has been requested on the port, an additional thread is started that keeps a read outstanding on the port so that data will not be missed.

The SPORT_SET_STATE and SPORT_SET_TIMEOUTS routines allow you to set basic port parameters such as baud rate, stop bits, timeouts, and so on. Additionally, you can call SPORT_GET_HANDLE to return the Win32 handle to the port so that you can call Win32 Communication Functions to implement additional needs.

Calling the Serial Port I/O Routines

The SPORT_*xxx* routines are functions that return an error status:

- An error status of 0 (zero) indicates success
- Other values are Win32 error values that indicate an error

As described in the calling syntax, these routines require the following **USE** statement:

```
USE DFLIB
```

The `USE DFLIB` statement includes the routine definitions in the compilation. You may also need to add a `USE DWINTY` statement to your program because some Win32 constants may be required that are typically defined in the DFWINTY module.

Many arguments are optional. If a constant is used where an argument is both input and output, a probe for writeability is done before the output. Thus, in many cases, a constant may be used without creating a temporary variable. It should be noted, however, that doing so may not be compatible with all Fortran implementations.

Run-Time Behavior of the Serial Port I/O Routines

To help ensure that data overruns do not occur, the SPORT_xxx run-time support creates a separate thread that maintains an outstanding read to the connected port. This thread is started when any read or write operation is performed to the port using the affiliated read/write routine. As such, port parameters must not be changed after you have started reading or writing to the port. Instead, you should set up the port parameters after connecting to the port and then leave them unchanged until after the port has been released.

If the parameters of the port must be changed more dynamically, use the SPORT_CANCEL_IO routine to ensure that no I/O is in progress. Additionally, that call will kill the helper thread so that it will automatically pick up the new, correct, parameters when it restarts during the next I/O operation.

Serial Port Usage

Depending upon the application, serial port programming can be very simple or very complex . The SPORT_xxx routines are intended to provide a level of support that will help the user implement simple applications as well as providing a foundation that can be used for more complex applications. Users needing to implement full serial port protocols (such as a PPP/SLIP implementation or some other complex protocol) should use the Win32 Communication Functions directly to achieve the detailed level of control needed in those cases. Simple tasks, such as communicating with a terminal or some other data collection device are well suited for implementations using the SPORT_xxx routines.

You should first familiarize yourself with the hardware connection to the serial device. Typical connections used today involve either a 9 pin/wire connector or a 25 pin/wire connector. Many cables do not implement all 9 or 25 connections in order to save on costs. For certain applications these subset cables may work just fine but others may require the full 9 or 25 connections. All cables will implement the Receive/SendData signals as well as the SignalGround. Without these signals, there can be no data transfer. There are two other categories of important signals:

- Signals used for *flow control*

  Flow control signals tell the device/computer on the other end of the cable that data may be sent or that they should wait. Typically, the RequestToSend/ClearToSend signals are used for this purpose. Other signals such as DataSetReady or DataTerminalReady may also be used. Make sure that the cable used implements all the signals required by your hardware/software solution. Special characters (normally as XON/XOFF) may also be used to control the flow of data instead of or in addition to the hardware signals. Check your specific application to see what cabling is needed.

- Signals that indicate status or state of a modem or phone connection.

  These signals may not be required if the connection between the computer and the device is direct and not through a modem. This signals typically convey information such as the state of the carrier (CarrierDetect) or if the phone line is ringing (Ring). Again, make sure the the cable used implements all the signals required for your application.

After the correct physical connection has been set up the programmer must become familiar with the data protocol used to communicate with the remote device/system.

Many simple devices terminate parcels of data with a "record terminator" (often a carriage return or line feed character). Other devices may simply send data in fixed length packets or packets containing some sort of count information. The two types of I/O routines provided by the SPORT_xxx support (line oriented using SPORT_READ_LINE and SPORT_WRITE_LINE or transfer raw data using

SPORT_READ_DATA and SPORT_WRITE_DATA) can handle these two types of data transfer. The programmer must become familiar with the particular application to determine which type of I/O is more appropriate to use.

List of Serial Port Routines

The SPORT routines are:

- SPORT_CANCEL_IO
- SPORT_CONNECT
- SPORT_GET_HANDLE
- SPORT_GET_TIMEOUTS
- SPORT_GET_STATE
- SPORT_PEEK_DATA
- SPORT_PEEK_LINE
- SPORT_PURGE
- SPORT_READ_DATA
- SPORT_READ_LINE
- SPORT_RELEASE
- SPORT_SET_STATE
- SPORT_SET_TIMEOUTS
- SPORT_SHOW_STATE
- SPORT_SPECIAL_FUNC
- SPORT_WRITE_DATA
- SPORT_WRITE_LINE

The SPORT_*xxx* routines call Win32 routines. For example, the SPORT_SET_STATE routine calls the Win32 routine SetCommState, which uses the DCB Communications Structure. The Win32 Communication Functions and Communication Structures are described in the Platform SDK section on Windows Base Services, subsection Files and I/O, under Communication Reference.

For more information:

- About calling Win32 routines from Fortran programs, see Calling Win32 Routines.
- About communications and using the Win32 Communications routines, see the Platform SDK descriptions below the following headings: Communications and Communications Functions

Using COM and Automation Objects

Visual Fortran provides a wizard to simplify the use of Component Object Model (COM) and Automation (formerly called OLE Automation) objects. The Visual Fortran Module Wizard generates Fortran 95/90 modules that simplify calling COM and Automation services from Fortran programs. This Fortran code lets you invoke routines in a dynamic link library, methods of an Automation object, and member functions of a Component Object Model (COM) object.

The following sections describe the use of COM and Automation objects as clients with Visual Fortran:

- Overview of COM and Automation Objects
- The Role of the Module Wizard
- Using the Module Wizard to Generate Code
- Calling the Routines Generated by the Module Wizard
- Getting a Pointer to an Object's Interface
- Additional Resources about COM and Automation

For information on creating a COM server with Visual Fortran, see Creating a COM Server.

Overview of COM and Automation Objects

This section provides a brief overview of:

- COM Objects
- Automation Objects
- Object Servers

COM Objects

The Component Object Model (COM) provides mechanisms for creating reusable software components. COM is an object-based programming model designed to promote software interoperability; that is, to allow two or more applications or *components* to easily cooperate with one another, even if they were written by different vendors at different times, in different programming languages, or if they are running on different machines running different operating systems.

With COM, components interact with each other and with the system through collections of function calls, also known as methods or member functions or requests, called *interfaces*. An interface is a semantically related set of member functions. The interface as a whole represents a feature of an object. The member functions of an interface represent the operations that make up the feature. In general, an object can support multiple interfaces and you can use

COMQueryInterface to get a pointer to any of them.

The Visual Fortran COM routines provide a Fortran interface to basic COM functions.

Automation Objects

The capabilities of an *Automation object* resemble those of a COM object. An Automation object is in fact a COM object that implements the interface IDispatch. An Automation object exposes:

- *Methods*, which are functions that perform an action on an object. These are very similar to the member functions of COM objects.
- *Properties*, which hold information about the state of an object. A property can be represented by a pair of methods; one for getting the property's current value, and one for setting the property's value.

The Visual Fortran AUTO routines provide a Fortran interface to invoking an automation object's methods and setting and getting its properties.

Object Servers

COM and Automation objects are made available to users by COM and Automation *servers*. A COM or Automation server can be implemented either as:

- A DLL that is loaded into your process
- A separate executable program. The separate executable program can reside on the same system as your application or on a different system.

The Role of the Module Wizard

To use COM and Automation objects from a Fortran program:

1. Find or install the object server on the system. COM and Automation objects can be registered:

   - By other programs you install.
   - By creating the object server yourself, for example, by using the Visual Fortran COM Server wizard, Visual C++, or Visual Basic.

   For example, the Microsoft visual development environment registers certain objects during installation (see the documentation on the Developer Studio object model).

   Creating an object server involves deciding what type of object and what type of interfaces or methods should be available. The object's server must be designed, coded, and tested like any other application. For information about object server creation, see Creating a COM Server.

2. Determine:

   - Whether the object has a COM interface, Automation interface, or both.
   - Where the object's type information is located.

   You should be able to obtain this information from the object's documentation. You can use the OLE-COM Object Viewer tool (provided in the Compaq Visual Fortran program folder) to determine the characteristics of an object on your system.

3. Use the Visual Fortran module wizard to generate code.

   The Visual Fortran module wizard is a application that interactively asks certain questions about the object, including its name, type, and other information. The information collected by the module wizard is used in the generated code. To learn about using the Visual Fortran module wizard, see Using the Module Wizard to Generate Code.

4. Write a Fortran 90 program to invoke the code generated by the Visual Fortran module wizard.

   To understand more about calling the interfaces and jacket routines created by the module wizard, see Calling Routines Generated by the Module Wizard.

Using the Module Wizard to Generate Code

To run the Visual Fortran Module Wizard, choose the Tools menu item Fortran Module Wizard. The module wizard asks a series of questions, including the name and type of the object as well as certain characteristics. If you have not already obtained the object's characteristics, see The Role of the Module Wizard.

The Visual Fortran Module Wizard presents a series of dialog boxes that allow you to select the type of information needed.

An object's type information contains programming language independent descriptions of the object's interfaces. Depending on the implementation of the object, type information can be obtained from the running object (see Automation Object below) or from a type library.

A type library is a collection of type information for any number of object classes, interfaces, and so on. A type library can also be used to describe the routines in a DLL. You can store a type library in a file of its own (usually with an extension of .TLB) or it can be part of another file. For example, the type library that describes a DLL can be stored in the DLL itself.

After you start the Module Wizard (Tools menu, Fortran Module Wizard), a dialog box requests the source of the type information that describes the object you need to use. You need to determine what type of object it is (or DLL) and how it makes its type information available. The choices are:

- Automation Object
- Type Library containing Automation information
- Type Library containing COM interface information
- Type Library containing DLL information
- DLL containing type information

Object servers typically contain the type library in the same file (either `.dll` or `.exe`) as the object implementation.

Many objects implement *dual interfaces*, which supports both COM and Automation. For an object that supports dual interfaces, you can choose either of these options:

- Type Library containing Automation information
- Type Library containing COM interface information

The COM object interfaces tend to be more efficient (better run-time performance).

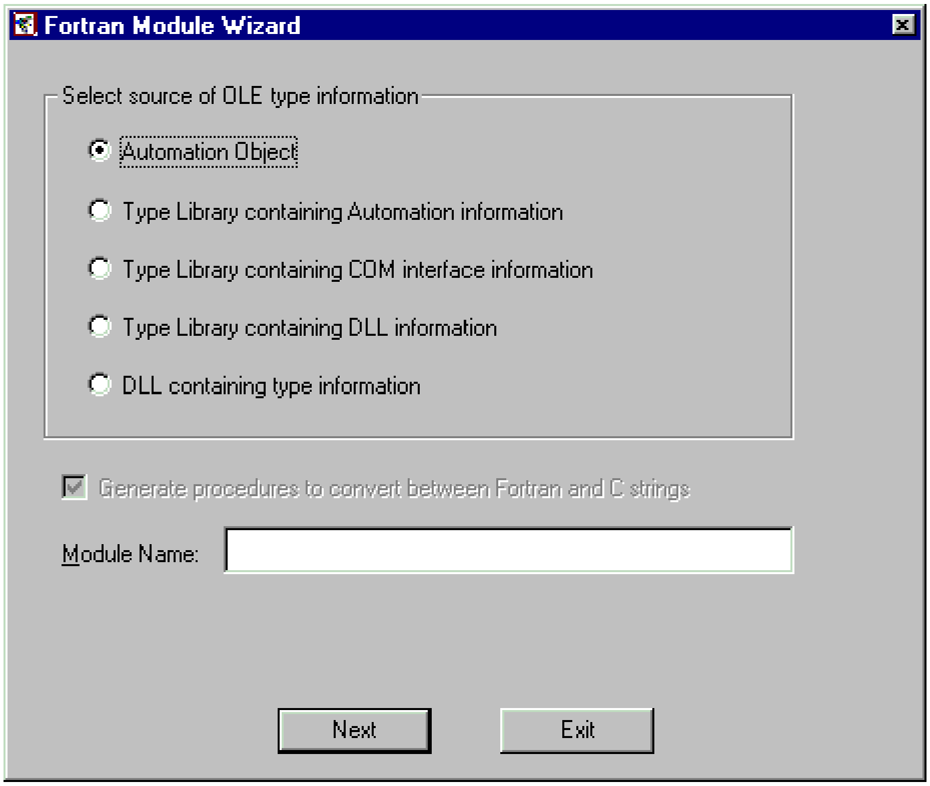
ActiveX controls implement an Automation interface. When using an ActiveX control, choose the Type Library containing Automation interface information option.

Most DLLs do not provide a type library that describes the programming interfaces in the DLL, and therefore cannot be used by the Module Wizard.

For these reasons, the Automation Information (second option) or COM Interface Information (third option) are the most commonly used.

The following initial screen appears after you select the Visual Fortran Module Wizard:

Initial Module Wizard Screen

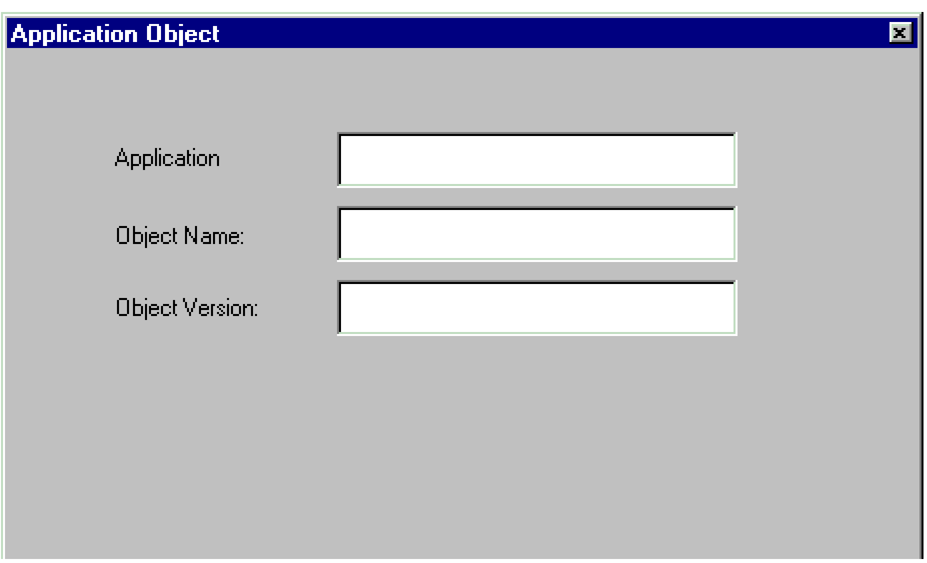


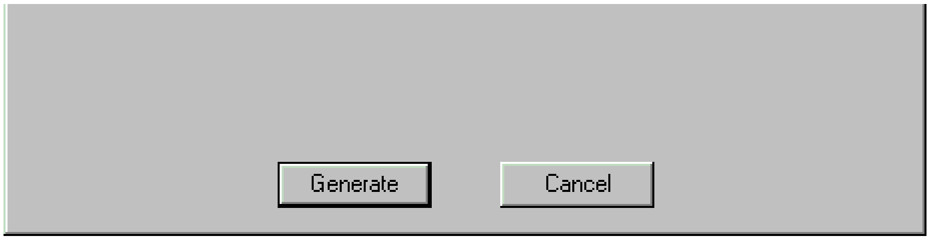
After you select one of the five choices, one of two different screens will appear depending on the selection made. The "Module Name" in the initial Module Wizard screen is used as the name of the Fortran module being generated. It is also used as the default file name of the generated source file.

If You Select Automation Object

If you select Automation Object, the following screen appears:

Application Object Screen





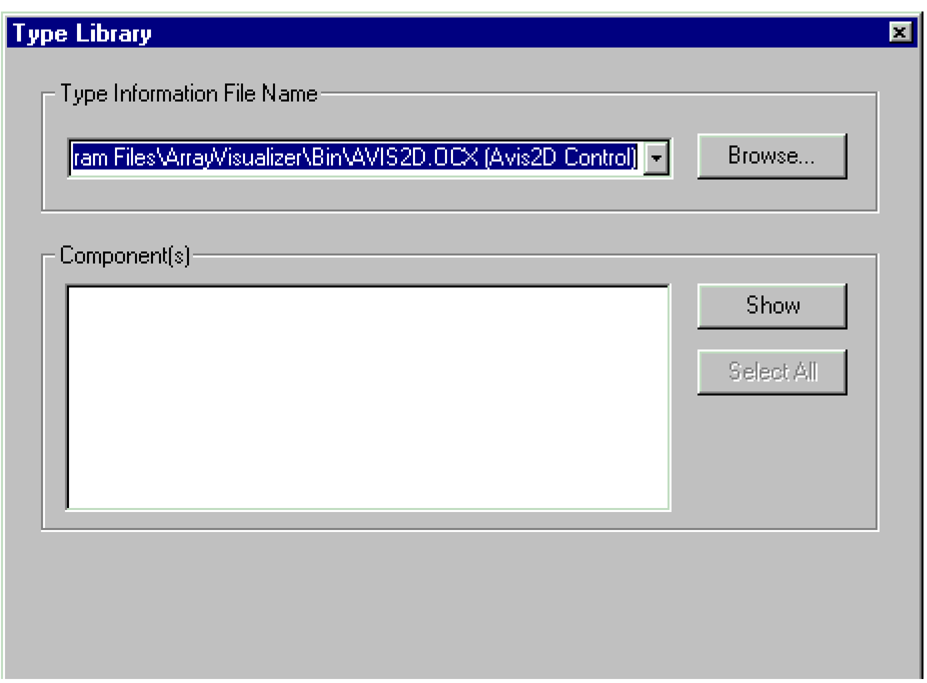
Microsoft recommends that object servers provide a type library. However some applications do not, but do provide type information dynamically when running. Use this option for such an application. Enter the name of the application, name of the object, and version number. The version number is optional. If you do not specify it, you will get the latest version of the object. Note that this method only works for objects that provide a programmatic identifier (ProgID). ProgIDs are entered into the system registry and identify, among other things, the executable program that is the object's server.

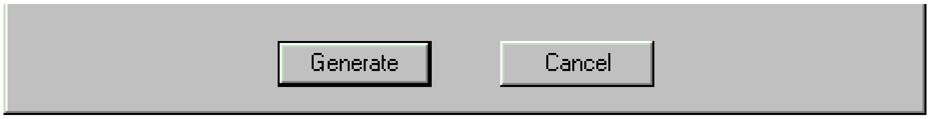
After entering the information and pressing the Generate button, the Fortran Module Wizard asks you for the name of the source file to be generated. It then asks COM to create an instance of the object identified by the ProgID that the wizard constructs using the supplied information. COM starts the object's server if it needs to do so. The wizard then asks the object for its type information and generates a file containing Fortran modules.

If You Select Other Options

After selecting any of the remaining options in the initial screen and press the "Next" button, the Module Wizard displays the following screen:

Type Library Screen





Choose the type library (or file containing the type library), and optionally specific components of the type library.

At the top of the dialog box is a combo box that lists all of the type libraries that have been registered with the system. You will notice a number of different file extensions, for example, .OLB (object libraries) and .OCX (ActiveX controls). Select a type library from the list or press Browse to find the file using the standard "Open" dialog box. Once you have selected a type library press the Show button to list the components you can select from the type library. By default, the Fortran Module Wizard will use all of the components. Optionally, you can select the ones desired from the list.

After entering the information and pressing the "Generate" button, the Fortran Module Wizard asks you for the name of the source file to be generated. It then asks COM to open the type library and generates a file containing Fortran modules.

The Fortran Module Wizard also has a command-line interface. The MODWIZ command has the following form:

MODWIZ [*options*] *typeinfo-name*

For a list of MODWIZ command options and an explanation of *typeinfo-name*, type the following command in a Fortran Command Prompt (available from the Visual Fortran program folder):

```
MODWIZ /?
```

Calling the Routines Generated by the Module Wizard

Although Fortran 95/90 does not support objects, it does provide Fortran 95/90 *modules*. A module is a set of declarations that are grouped together under a global name, and are made available to other program units by using the USE statement.

The Fortran Module Wizard generates a source file containing one or more modules. The types of information placed in the modules include:

- *Derived-type definitions* are Fortran equivalents of data structures that are found in the type information.
- *Constant definitions* are Fortran **PARAMETER** declarations that include

identifiers and enumerations found in the type information.
- *Procedure interface definitions* are Fortran interface blocks that describe the procedures found in the type information.
- *Procedure definitions* are Fortran functions and subroutines that are jacket routines for the procedures found in the type information.

The jacket routines make the external procedures easier to call from Fortran by handling data conversion and low-level invocation details.

The use of modules allows the Visual Fortran Module Wizard to encapsulate the data structures and procedures exposed by an object or DLL in a single place. You can then share these definitions in multiple Fortran programs.

The appropriate **USE** statement needs to be added in your program, as well as function invocations or subroutine calls.

The routines generated by the Visual Fortran Module Wizard are designed to be called from Fortran. These routines in turn call the appropriate system routines (not designed to be called from Fortran), thereby simplifying the coding needed to use COM and Automation objects.

Visual Fortran provides a set of run-time routines that present to the Fortran programmer a higher level abstraction of the COM and Automation functionality. The Fortran interfaces that the Wizard generates hide most of the differences between Automation objects and COM objects.

Depending on the options specified, the following routines can be present in the generated code:

DFCOM Routines (COM*xxxxx*)	
COMAddObject Reference	Adds a reference to an object's interface.
COMCLSIDFromProgID	Passes a programmatic identifier and returns the corresponding class identifier.
COMCLSIDFromString	Passes a class identifier string and returns the corresponding class identifier.
COMCreateObjectByGUID	Passes a class identifier and creates an instance of an object. It returns a pointer to the object's interface.
COMCreateObjectByProgID	Passes a programmatic identifier and creates an instance of an object. It returns a pointer to the object's IDispatch interface.
COMGetActiveObjectByGUID	Pass a class identifier and returns a pointer to the interface of a currently active object.

COMGetActiveObjectByProgID	Passes a programmatic identifier and returns a pointer to the IDispatch interface of a currently active object.
COMInitialize	Initializes the COM library. You must initialize the library before calling any other COM or AUTO routine.
COMIsEqualGUID	Determines if two GUIDs are the same.
COMGetFileObject	Passes a file name and returns a pointer to the IDispatch interface of an Automation object that can manipulate the file.
COMQueryInterface	Passes an interface identifier and it returns a pointer to an object's interface.
COMReleaseObject	Indicates that the program is done with a reference to an object's interface.
COMStringFromGUID	Passes a GUID and returns the corresponding string representation.
COMUninitialize	Uninitializes the COM library. This must be the last COM routine that you call.
DFAUTO Automation Routines (AUTO*xxxxx*)	
AUTOAddArg	Passes an argument name and value and adds the argument to the argument list data structure.
AUTOAllocateInvokeArgs	Allocates an argument list data structure that holds the arguments that you will pass to AUTOInvoke.
AUTODeallocateInvokeArgs	Deallocates an argument list data structure.
AUTOGetExceptInfo	Retrieves the exception information when a method has returned an exception status.
AUTOGetProperty	Passes the name or identifier of the property and gets the value of the Automation object's property.
AUTOGetPropertyByID	Passes the member ID of the property and gets the value of the Automation object's property into the argument list's first argument.
AUTOGetPropertyInvokeArgs	Passes an argument list data structure and gets the value of the Automation object's property specified in the argument list's first argument.
AUTOInvoke	Passes the name or identifier of an object's method and an argument list data structure. It invokes the method with the passed arguments.

AUTOSetProperty	Passes the name or identifier of the property and a value. It sets the value of the Automation object's property.
AUTOSetPropertyByID	Passes the member ID of the property and sets the value of the Automation object's property using the argument list's first argument.
AUTOSetPropertyInvokeArgs	Passes an argument list data structure and sets the value of the Automation object's property specified in the argument list's first argument.

Visual Fortran Samples include several projects in the ...\DF98 \SAMPLES\ADVANCED\COM folder that demonstrate the use of the Fortran Module Wizard. For example:

- AUTODICE uses Automation to drive Microsoft Excel® 97 to create a chart from Fortran data.
- DSBUILD uses Automation to drive the visual development environment to rebuild a project configuration.
- DSLINES uses COM to drive the Microsoft visual development environment to edit a Fortran source file and convert Debug lines (column 1) to IFDEF directives.
- IWEB uses COM interfaces to start a Web browser and direct the browser to open a specified URL.

Example of Generated Code Used by the DSLINES Sample

The DLINES Sample contains the code that invokes this and other Microsoft visual development environment functionality using COM interfaces.

The following code shows an annotated version of a portion of the code generated by the Fortran Module Wizard from the COM type information in ...\Common\MSDev98\Bin\devshl.dll. This COM type information describes the top-level objects in the Microsoft visual development environment object model.

```
INTERFACE
!  Saves the document to disk.            1

INTEGER*4 FUNCTION IGenericDocument_Save($OBJECT, vFilename, &
                                        vBoolPrompt, pSaved)         2
USE DFWINTY
INTEGER*4, INTENT(IN)  :: $OBJECT     ! Object Pointer

!DEC$ ATTRIBUTES VALUE :: $OBJECT                                     3

TYPE (VARIANT), INTENT(IN)  :: vFilename   ! (Optional Arg)           4
!DEC$ ATTRIBUTES VALUE      :: vFilename
TYPE (VARIANT), INTENT(IN)  :: vBoolPrompt     ! (Optional Arg)
!DEC$ ATTRIBUTES VALUE      :: vBoolPrompt
```

```
INTEGER*4, INTENT(OUT)      :: pSaved          ! Void                 5
!DEC$ ATTRIBUTES REFERENCE  :: pSaved
!DEC$ ATTRIBUTES STDCALL    :: IGenericDocument_Save
END FUNCTION IGenericDocument_Save
END INTERFACE

POINTER(IGenericDocument_Save_PTR, IGenericDocument_Save) ! routine pointer 6
```

Notes for this example:

1 If the type information provides a comment that describes the member function, then the comment is placed before the beginning of the procedure.

2 The first argument to the procedure is always $OBJECT. It is a pointer to the object's interface. The remaining argument names are determined from the type information. For information on how to get a pointer to an object's interface, see Getting a Pointer to an Object's Interface.

3 This is an example of an **ATTRIBUTES** directive statement used to specify the calling convention of an argument.

4 A VARIANT is a data structure that can contain any type of Automation data. It contains a field that identifies the type of data and a union that holds the data value. The use of a VARIANT argument allows the caller to use any data type that can be converted into the data type expected by the member function.

5 Nearly every COM member function returns a status of type HRESULT. Because of this, if a COM member function produces output it uses output arguments to return the values. In this example, the "pSaved" argument returns a routine specific status value.

6 The interface of a COM member function looks very similar to the interface for a dynamic link library function with one major exception. Unlike a DLL function, the address of a COM member function is never known at program link time. You must get a pointer to an object's interface at run-time, and the address of a particular member function is computed from that.

The following code shows an annotated version of the wrapper generated by the Fortran Module Wizard for the "Save" function. The name of a wrapper is the same as the name of the corresponding member function, prefixed with a "$" character.

```
! Saves the document to disk.
INTEGER*4 FUNCTION $IGenericDocument_Save($OBJECT, vFilename, &   1
                                      vBoolPrompt, pSaved)
!DEC$ ATTRIBUTES DLLEXPORT    :: $IGenericDocument_Save
IMPLICIT NONE
```

```
INTEGER*4, INTENT(IN) :: $OBJECT       ! Object Pointer
!DEC$ ATTRIBUTES VALUE        :: $OBJECT
TYPE (VARIANT), INTENT(IN), OPTIONAL  :: vFilename
!DEC$ ATTRIBUTES REFERENCE    :: vFilename
TYPE (VARIANT), INTENT(IN), OPTIONAL  :: vBoolPrompt
!DEC$ ATTRIBUTES REFERENCE    :: vBoolPrompt
INTEGER*4, INTENT(OUT)        :: pSaved       ! Void
!DEC$ ATTRIBUTES REFERENCE    :: pSaved

INTEGER*4 $RETURN
INTEGER*4 $VTBL                   ! Interface Function Table    2
POINTER($VPTR, $VTBL)
TYPE (VARIANT) :: $VAR_vFilename
TYPE (VARIANT) :: $VAR_vBoolPrompt
IF (PRESENT(vFilename)) THEN                                   3
    $VAR_vFilename = vFilename
ELSE
   $VAR_vFilename = OPTIONAL_VARIANT
END IF
IF (PRESENT(vBoolPrompt)) THEN
   $VAR_vBoolPrompt = vBoolPrompt
ELSE
  $VAR_vBoolPrompt = OPTIONAL_VARIANT
END IF
$VPTR = $OBJECT                  ! Interface Function Table     4
$VPTR = $VTBL + 84    ! Add routine table offset
IGenericDocument_Save_PTR = $VTBL
$RETURN = IGenericDocument_Save($OBJECT, $VAR_vFilename, &
$VAR_vBoolPrompt, pSaved)
$IGenericDocument_Save = $RETURN
END FUNCTION $IGenericDocument_Save
```

Notes for this example:

1 The wrapper takes the same argument names as the member function interface.

2 The wrapper computes the address of the member function from the interface pointer and an offset found in the interface's type information. In implementation terms, an interface pointer is a pointer to a pointer to an array of function pointers called an "Interface Function Table".

3 Arguments to a COM or Automation routine can be optional. The wrapper handles the invocation details for specifying an optional argument that is not present in the call.

4 The offset of the "Save" member function is 84. The code assigns the computed address to the function pointer IGenericDocument_Save_PTR, which was declared with the interface shown above, and then calls the function.

The DLINES Sample contains the code that invokes this and other Microsoft visual development environment functionality using COM interfaces.

Example of Generated Code Used by the DSBUILD Sample

The DSBUILD example contains the code that invokes this and other Microsoft visual development environment functionality using Automation interfaces.

The following code shows an annotated version of a portion of the code generated by the Fortran Module Wizard from the Automation type information in `...\Common\MSDev98\Bin\devshl.dll`.

```
! Rebuilds all files in a specified configuration.
SUBROUTINE IApplication_RebuildAll($OBJECT, Configuration, $STATUS) 1
!DEC$ ATTRIBUTES DLLEXPORT :: IApplication_RebuildAll
IMPLICIT NONE

INTEGER*4, INTENT(IN)            :: $OBJECT        ! Object Pointer
!DEC$ ATTRIBUTES VALUE           :: $OBJECT
TYPE (VARIANT), INTENT(IN), OPTIONAL :: Configuration
!DEC$ ATTRIBUTES REFERENCE          :: Configuration
INTEGER*4, INTENT(OUT), OPTIONAL    :: $STATUS       ! Method status
!DEC$ ATTRIBUTES REFERENCE          :: $STATUS
INTEGER*4 $$STATUS
INTEGER*4 invokeargs
invokeargs = AUTOALLOCATEINVOKEARGS()                          2
IF (PRESENT(Configuration)) CALL AUTOADDARG(invokeargs, '$ARG1', &
                                       Configuration, AUTO_ARG_IN)
$$STATUS = AUTOINVOKE($OBJECT, 28, invokeargs)                 3
IF (PRESENT($STATUS)) $STATUS = $$STATUS                       4
CALL AUTODEALLOCATEINVOKEARGS (invokeargs)                     5
END SUBROUTINE IApplication_RebuildAll
```

Notes for this example:

1 The first argument to the procedure is always $OBJECT. It is a pointer to an Automation object's IDispatch interface. The last argument to the procedure is always $STATUS. It is an optional argument that you can specify if you wish to examine the return status of the method. The IDispatch Invoke member function returns a status of type HRESULT. An HRESULT is a 32-bit value. It has the same structure as a Win32 error code. In between the $OBJECT and $STATUS arguments are the method arguments' names determined from the type information. Sometimes, the type information does not provide a name for an argument. The Fortran Module Wizard creates a "$ARGn" name in this case.

2 AUTOAllocateInvokeArgs allocates a data structure that is used to collect the arguments that you will pass to the method. AUTOAddArg adds an argument to this data structure.

3 AUTOInvoke invokes the named method passing the argument list. This returns a status result.

4 If the caller supplied a status argument, the code copies the status result to it.

5 AUTODeallocateInvokeArgs deallocates the memory used by the argument list data structure.

The DSBUILD Sample in the `...\DF98\Samples\Advanced\COM\` folder contains the code that invokes this and other Microsoft visual development environment functionality using Automation interfaces.

Getting a Pointer to an Object's Interface

Object Identification

Object identification enables the use of COM objects created by disparate groups of developers. To provide a method of uniquely identifying an object class regardless of where it came from, COM uses *globally unique identifiers* (GUIDs). A GUID is a 16-byte integer value that is guaranteed (for all practical purposes) to be unique across space and time. COM uses GUIDs to identify object classes, interfaces, and other things that require unique identification.

To create an instance of an object, you need to tell COM what the GUID of the object is. While using 16-byte integers for identification is fine for computers, it poses a challenge for the typical developer. So, COM also supports the use of a less precise, textual name called a *programmatic identifier* (ProgID). A ProgID takes the form:

```
application_name.object_name.object_version
```

Obtaining the Pointer to an Object's Interface

To use the routines generated by the Module Wizard, your application must get a pointer to an object's interface. This pointer is used as the value of the $OBJECT argument, which is the first argument of every interface generated by the Module Wizard.

Typically, your application obtains its first object pointer by calling the COM routine **COMCreateObject**. **COMCreateObject** creates a new instance of an object class. **COMCreateObject** is the generic name of the two subroutines **COMCreateObjectByProgID** and **COMCreateObjectByGUID**:

- Use COMCreateObjectByProgID to create Automation objects. It accepts the progID of an object and returns a pointer to the object's IDispatch interface.
- Use COMCreateObjectByGUID to create both COM and Automation objects.

The arguments to **COMCreateObjectByGUID** are as follows:

- The first argument is a class identifier (CLSID) that uniquely identifies the object's class. The Module Wizard defines a GUID parameter for each class selected from the Type library. These are given the name in the form: CLSID_*class-name*.
- The second argument allows you to limit the type(s) of server that the call will accept. Most of the time you can use CLSCTX_ALL to accept any type of server.
- The third argument is an interface identifier (IID) that specifies the particular object interface you are requesting:
  - To request an Automation interface, use IID_IDispatch.
  - To request a COM interface, the Module Wizard defines a GUID parameter for each interface selected from the type library. These are given a name in the form: IID_*interface-name*.
- The fourth argument is an output parameter that returns the object's interface pointer.

The **COMCreateObjectByProgID** and **COMCreateObjectByGUID** subroutines return an interface pointer of an object that the server has defined as being externally creatable. However, not all objects are externally creatable. Often, a server implements a hierarchy of objects, or *object model*. **COMCreateObject** is called to obtain a pointer to an interface of the root object in the hierarchy. Methods and/or properties of the root object are used to obtain pointers to child objects, and so on, down the hierarchy. You can see examples of this in the Autodice, Dlines, and DSbuild Visual Fortran samples.

All objects must implement the IUnknown interface. Every object also implements one or more additional interfaces. You can always get a pointer to any of the object's interfaces from any of the object's interface pointers by using the **COMQueryInterface** subroutine. It is important that you have a pointer to the correct object interface when calling a routine generated by the Module Wizard. If not, your application will likely crash.

Releasing the Pointer to an Object's Interface

When you have finished using an object's interface pointer, you must call COMReleaseObject with the pointer. This includes object pointers that you have received using any method, including **COMCreateObject**, COMQueryInterface, or by calling an object's method.

Additional Resources about COM and Automation

There are a number of published books and articles about COM and Automation.

Compaq lists some of these publications as additional resources to assist customers who want to learn more about the subject matter. This list does not comment—either negatively or positively—on any documents listed or not yet listed. Books and related resources about COM and Automation include:

- *Inside COM+ Base Services* by Guy Eddon, Henry Eddon. Published by Microsoft Press (Redmond, Washington) 1999
- *Understanding COM+* by David S. Platt. Published by Microsoft Press (Redmond, Washington) 1999
- *Inside Distributed COM* by Guy Eddon; Henry Eddon. Published by Microsoft Press (Redmond, Washington) 1998
- *Inside COM* by Dale Rogerson. Published by Microsoft Press (Redmond, Washington) 1996
- *Understanding ActiveX and OLE* by David Chappell. Published by Microsoft Press (Redmond, Washington) 1996
- *Automation Programmer's Reference* by Microsoft. Published by Microsoft Press (Redmond, Washington) 1997
- *ActiveX Controls Inside Out*, Second Edition by Adam Denning. Published by Microsoft Press (Redmond, Washington) 1997
- *Platform SDK* online version (HTML Help Viewer, provided with MSDN and Visual Fortran). Relevant titles include *Platform SDK, COM and ActiveX Object Services*.
- *Visual C++ User's Guide* online version (HTML Help Viewer, provided with MSDN and Visual Fortran)

Microsoft Press has a URL of http://mspress.microsoft.com.

Creating a COM Server

This section assumes that you are familiar with the COM-related terms and concepts presented in Using COM and Automation Objects and related sections, such as Overview of COM and Automation Objects. These sections (starting with Using COM and Automation Objects) discuss using COM and Automation objects from a Visual Fortran application, using the Fortran Module Wizard. That is, using a Visual Fortran application as a *client* of a COM server.

The Component Object Model (COM) supports a model of client server interaction between a user of an object, the client, and the implementor of the object, the server.

The Visual Fortran Professional and Enterprise Editions provide the capability to create a COM server. This section and its subsections discusses creating a COM *server* using Visual Fortran:

Advantages of a COM Server

A COM server consists of the implementation of one or more *object classes*. An object class is a type that describes the complete public calling interface ("signature") of an object. It describes the functionality that you want to make available to the users of the object. The COM server creates *instances* of the class, called *objects*, at the request of clients.

Some of the advantages of implementing your Fortran code as a COM server include:

- A COM server is a reusable component, which allows multiple applications to use the server. The classes specified by the server define a "contract" between the server and its clients. The server can change the specific implementation of the functionality without breaking the contract. That is, without requiring clients to be changed or rebuilt.
- A COM server is programming-language independent. Multiple development tools can be used to access the server's functionality, including Visual Basic, Visual C++, and Visual Fortran.
- A COM server is self-describing. The server provides a type library that describes the classes and interfaces. Many tools can take advantage of this information and relieve the client programmer from needing to understand low-level invocation details, such as calling conventions. This is a great improvement over multi-language programming with DLLs, where the client programmer has to understand the details of data types and calling conventions.
- A COM server is self-registering. The clients do not need to worry about where the server is located on their system, as COM finds this information in the system registry.
- A COM server can be implemented as an in-process server. Like a DLL, it is loaded into the client's process. A COM server can also be implemented as a separate application and can even reside on a separate machine.

Visual Fortran provides the Fortran COM Server Wizard. The wizard generates the Fortran code necessary to implement a COM server, and allows you to concentrate on the code that is specific to the functionality that your server provides to its clients.

As explained in Overview of COM and Automation Objects, COM supports two types of servers: COM servers and Automation servers. The Fortran COM Server Wizard can only create a COM server or a server that supports dual interfaces. The wizard cannot create an Automation-only interface.

For more information about creating COM servers using Visual Fortran, see What You Need to Do and What the COM Server Wizard Will Do.

What You Need to Provide and What the Fortran COM Server Wizard Will Do

The Fortran COM Server Wizard generates a Developer Studio project and a number of source files that implement all of the infrastructure of a COM server. You use the Fortran COM Server Wizard's user interface to define the implementation of one or more *object classes*, including its interface(s), and method(s). You need to define fields in the derived-type for each instance and to write code for those fields, if necessary. You also need to write code needed to implement each method.

What Information You Need to Provide

To use the Fortran COM Server Wizard to create a COM server, you first need to describe to the Fortran COM Server Wizard the class(es) that you want to implement.

A class implements one or more COM *interfaces*. In COM terminology, an interface is a semantically related set of functions. The interface as a whole represents a "feature", or set of related functionality, that is implemented by the class. An interface contains *methods*, otherwise known as member functions. A method is a routine that performs one of the actions that make up the feature. When using the Fortran COM Server Wizard, methods are Fortran functions that take arguments and return a value like any other Fortran function.

Consider a simple example of a class that we will create using the Fortran COM Server Wizard, called *AddingMachine*. The class contains a single interface that we call *IAdd*. By convention, all interface names begin with a capital letter "I". We define three methods in the IAdd interface:

- *Clear*, which takes no arguments and sets the current value of the adding machine to 0.
- *Add*, which takes a single REAL argument, the amount to add to the current value.
- *GetValue*, which returns the current value.

The Clear method, Add method, and GetValue method allow you to perform specific, distinct tasks with the IAdd interface from any language that supports a COM client. The Fortran COM Server Wizard provides a user interface to enter this information about the class (in this case the AddingMachine class), which is discussed later in Using the COM Server Wizard.

An interface can also contain *properties*. Properties are method pairs that set or return information about the state of an object. When you add a property to an interface, you are actually adding one or two methods. This is discussed further in Adding a Property.

Another important concept is the *data* associated with an object. A key concept of object-oriented programming is *encapsulation*. Encapsulation means that all of the details about how the object is implemented, including the data that it uses and the logic that it uses to perform its work, is hidden from the client. The client's only access to the object is through the interfaces that the object supports.

You need to define the data that the object uses and code the logic of the methods. For the data, the Fortran COM Server Wizard uses the model that each instance of the object has an associated instance of a Fortran derived-type. The code generated by the wizard takes care of creating and destroying the instances of the derived-type as objects are created and destroyed.

You define the fields of the derived-type. For example, with our AddingMachine, each AddingMachine object needs to store the current value. The derived-type associated with each AddingMachine object would contain a single field of type REAL. We name it CurrentValue. Note that each instance of the AddingMachine object has its own instance of the derived-type and its own CurrentValue. This means that the server could support multiple clients simultaneously and each client would see its own AddingMachine. That is, each client is unaffected by the existence of other clients. The derived-type associated with each object is discussed in detail in Creating a Fortran COM Server Project.

To summarize, at a high level, what you need to do to create a COM server using the Fortran COM Server Wizard:

- Define the class(es), interface(s), method(s), and properties using the Wizard's user interface.
- Define the fields in the derived-type that is associated with each instance of a class.
- Write code that initializes the fields in the derived-type (if necessary), and code that releases any resources used by the fields in the derived-type (if necessary).
- Write the code that implements the methods.

What the COM Server Will Provide

The Fortran COM Server Wizard generates a Developer Studio project and a number of source files that implement all of the infrastructure, or "plumbing", of the COM server. The generated files take care of such tasks as:

- Defining the GUIDs that uniquely identify your classes and interfaces. For a discussion of GUIDs, see Getting a Pointer to an Object's Interface.
- Registering the server and your classes and interfaces on the system.
- Implementing the class factory that creates instances of your object.

- Creating the Interface Definition Library (IDL) and type library that describes your classes and interfaces. For a discussion of type libraries, see Using the Module Wizard to Generate Code.
- Implementing the IUnknown and IDispatch interfaces for your object. All of the interfaces created by the Fortran COM Server Wizard are derived from IUnknown or IDispatch (dual interfaces).
- Creating and destroying instances of the derived-type associated with your object.
- Invoking the Fortran routines that implement your object's methods.

The majority of these source files are generated fully by the Fortran COM Server Wizard and are not modified by you. Other files contain the skeleton or template of your derived-type and methods. You edit these Fortran source files to fill in your implementation. You will see how this is done as we work through the AddingMachine example.

For information on using the Fortran COM Server Wizard user interface to create a COM server, see Using the COM Server Wizard.

Using the Fortran COM Server Wizard

This section shows how to create a project, specify the COM server characteristics, generate code for, and implement an example Fortran COM server project called Adder. It contains the following topics:

- Specifying the Fortran COM Server as a Developer Studio Add-in
- Creating a Fortran COM Server Project
- Using the Fortran COM Server Wizard to Define Your COM Server
- Adding a Property
- Working with the Hierarchy Pane
- Description of Property Pages
- Modifying the Generated Code
- Build Notes
- Visual C++ ClassView
- Using Example Clients
- Modifying Your COM Servers

Specifying the Fortran COM Server as a Developer Studio Add-in

The Fortran COM Server Wizard is implemented as a Developer Studio Add-in. After you install Visual Fortran, you need to register and load the Fortran COM Server Wizard on your system. If you have not already done so, do the following:

1. In the Tools menu, click Customize
2. Click the Add-in and Macros tab

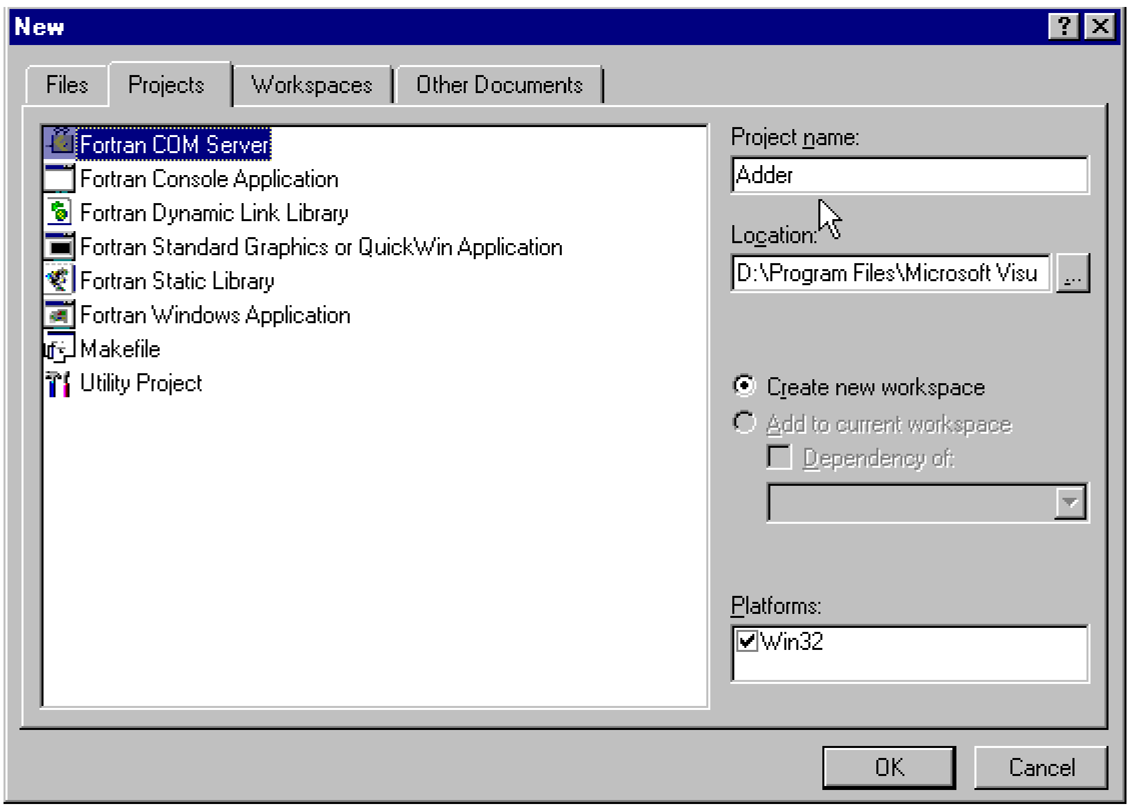
3. Enable the check box for the Fortran COM Server Wizard if it is displayed in the list
4. If it is not displayed, click the Browse button and find the CSAddin.dll file, in the `...\Microsoft Visual Studio\Common\MSDev98\Addins\Df98\` directory.
5. Click the Close button

You only need to perform this procedure once on your system.

Creating a Fortran COM Server Project

The first step in creating a Fortran COM Server is to create a new project. Start Developer Studio. In File menu, click New.

In the New Projects dialog box, select (click) the Fortran COM Server project type, as shown below (if Microsoft Visual C++ is installed on your system, additional project types will appear):

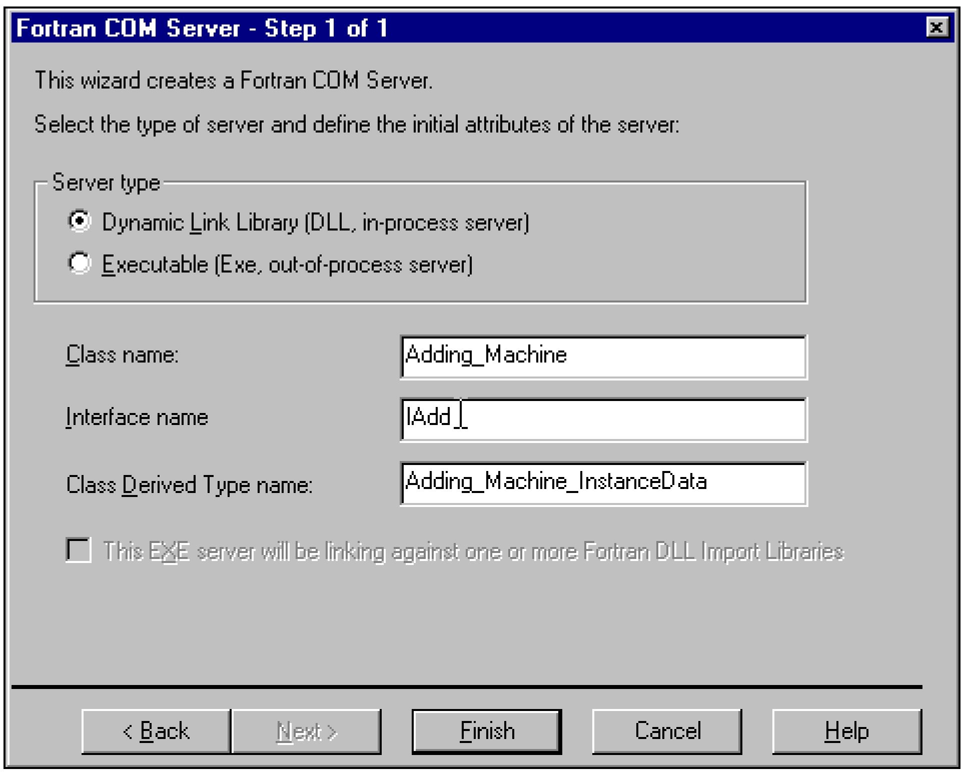


The Fortran COM Server Wizard is implemented as a Developer Studio Add-in and must be registered and loaded on your system. If you receive a message that begins with "The Fortran COM Server Wizard Add-in is not loaded into Developer Studio ...", follow the instructions in Initializing the Fortran COM Server as a Developer Studio Add-in.

In this case:

1. Enter "Adder" as the name of the project.
2. Accept or modify the project folder location.
3. Click the OK button. (If you click <Back, the previous screen appears, allowing you to change the name, location, or project type of the project being created.)

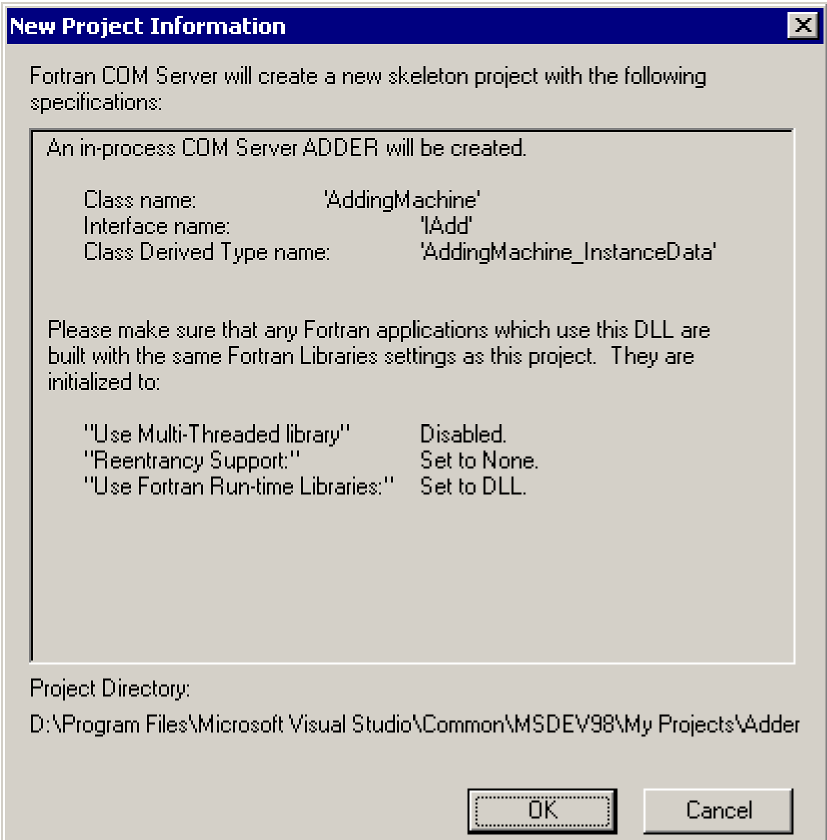
To define the initial attributes of the Fortran COM server project being created, additional information is requested. The following screen shows the Fortran COM Server AppWizard. You use the project AppWizard once per project to create the project files and skeleton template (as with other project types). The Fortran COM Server AppWizard requests the type of server (DLL or EXE), the class name, interface name, and the class derived type name:



In this case:

1. Accept the default server type (DLL).
2. Type the class name AddingMachine. Default text appears for the default interface name and class derived type name.
3. Shorten the default interface name to IAdd.
4. Accept the default class derived type name.
5. Click the Finish button. (If you click Cancel, project creation is terminated.)

A summary screen appears that summarizes the location and template information created for this project:



After you click OK, the project is created and the Fortran COM Server Wizard appears.

Using the Fortran COM Server Wizard to Define your COM Server

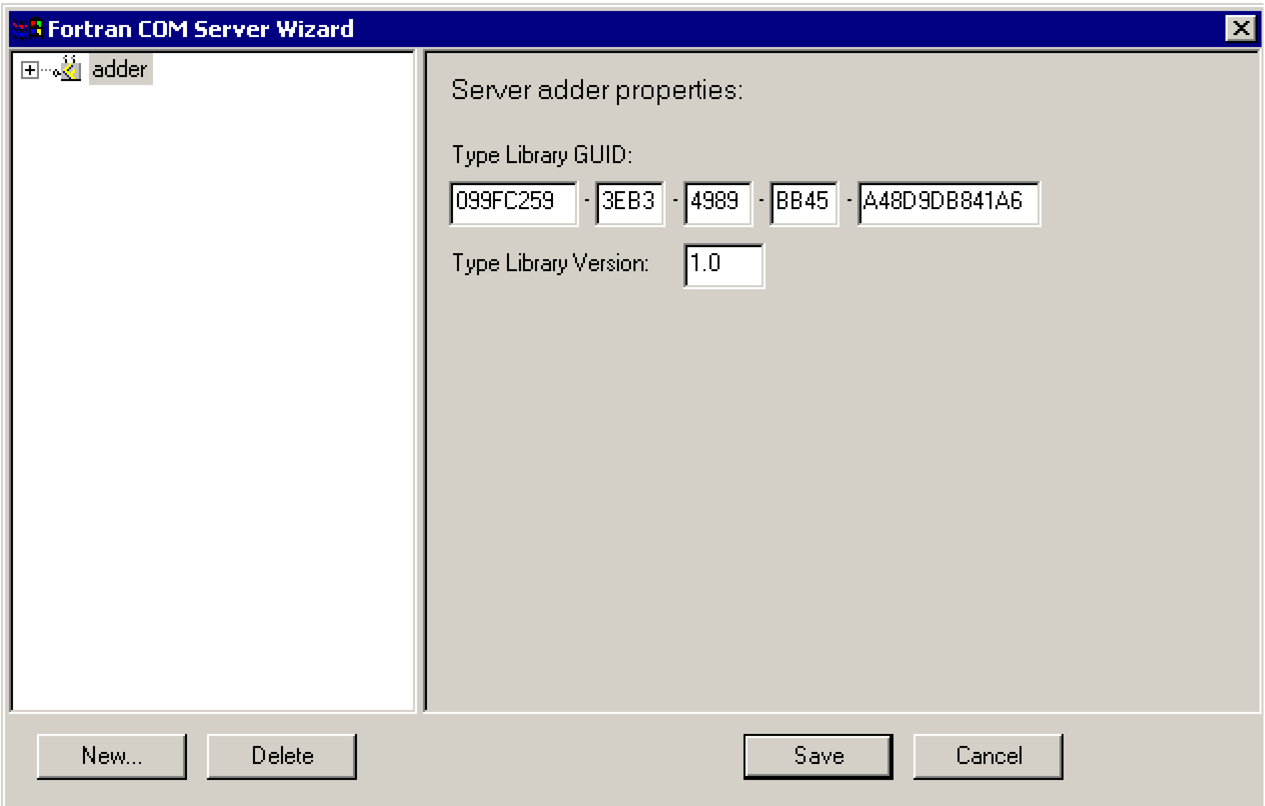
The Fortran COM Server Wizard lets you interactively define the attributes of your COM server. It lets you define and name classes, interfaces, methods, and so on. The user interface contains two panes:

- The left pane is a tree control that displays your classes, interfaces, methods, and so on in a hierarchy.
- The right pane is a property page that displays the properties of the selected element in the hierarchy.

The Fortran COM Server Wizard is automatically invoked by the Fortran COM Server AppWizard, so you can enter the initial definition of your server. You can, but you are not required to, fully define the server at this point. You can partially define your project and close your project workspace. Later, after you start Developer Studio and open the project workspace again, you can start the Fortran COM Server Wizard by clicking the Fortran COM Server Wizard menu item in the View menu.

With our example COM server, the initial screen of the Fortran COM Server

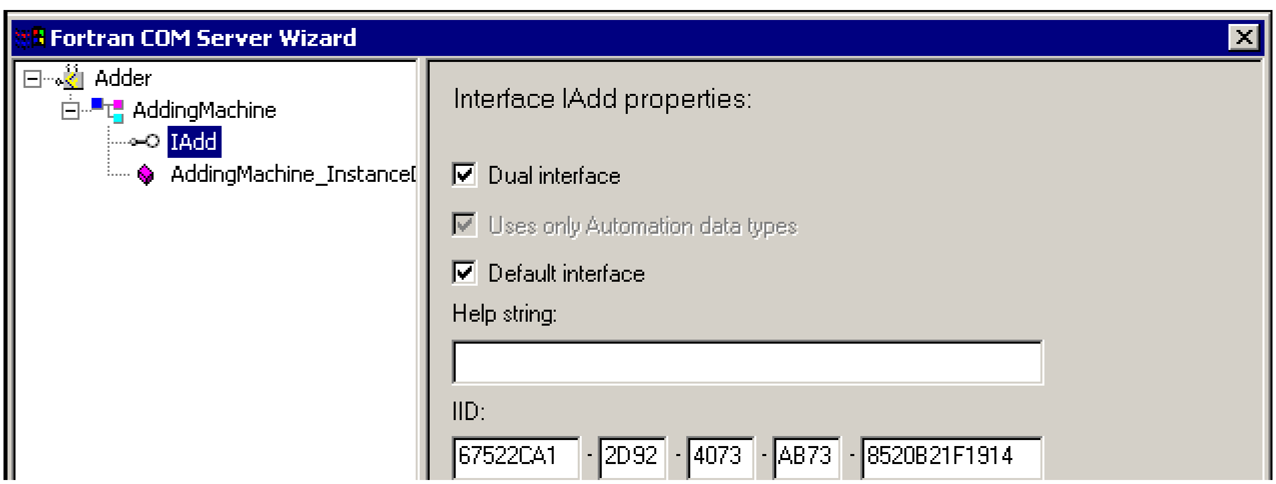
Wizard now appears, displaying the type library GUID and the type library version:

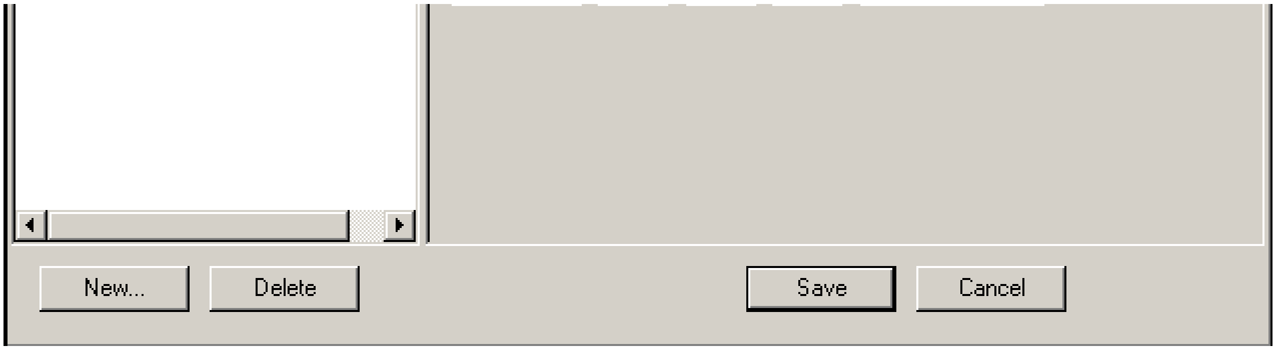


In this case, you need to expand the hierarchy to select the IAdd interface name:

1. Click the plus sign (+) to open the COM server name (and project name) Adder.
2. Click the plus sign (+) to open the class name AddingMachine.
3. Click the IAdd interface name.

The screen appears as follows:





If the Dual Interface check box is checked, click the Dual Interface check box to uncheck it. The Adder sample only supports a COM server interface.

The hierarchy is as follows:

- The root is the COM server itself, Adder. This is also the project name.
- The immediate children of the COM server are classes. Our hierarchy initially contains a single class, AddingMachine. You can add additional classes to the COM server.
- The immediate children of a class are interfaces and the class derived-type. Our hierarchy contains the interface IAdd and the class derived-type AddingMachine_InstanceData. Each class contains one, and only one, class derived-type. You can add additional interfaces to the class.
- The immediate children of an interface are methods (one or more).
- The immediate children of a method are the method arguments (one or more).

You can use the Fortran COM Server Wizard's graphical user interface to add a class, interface, method, property, or argument:

1. Select the parent item.
2. Click the Add button.
3. Type the requested name (and other requested text).
4. Click OK.

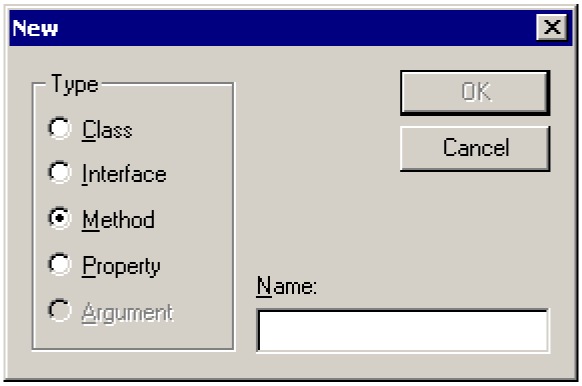
To delete an item:

1. Select the item to be deleted.
2. Click the Delete button.

For our example Adder COM server, add the methods to the IAdd interface:

1. Verify that the IAdd interface is selected (highlighted).
2. Click the New button.

The following screen appears:



The active buttons displayed depend on the selected (highlighted) item (COM server, class, interface, method, or argument) in the hierarchy. The active buttons represent the types that are valid in the current context. For example, the Argument button is inactive since an interface was selected and an Argument must be added to a method.

In this case:

1. Select the Method type.
2. Type Clear as the name of the first method of the IAdd interface.
3. Click OK.

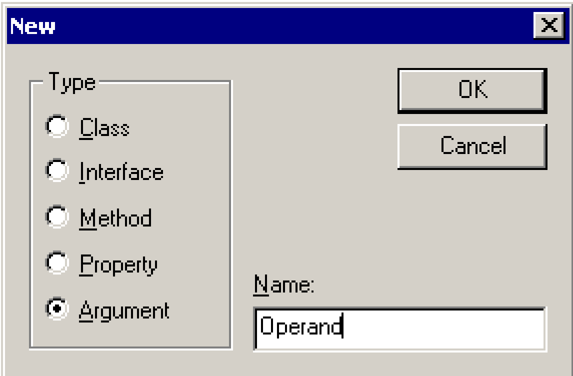
Because the Clear method takes no arguments, you can now add a second method, named Add:

1. Click (select) the IAdd interface.
2. Click the New button.
3. Type the second method name, Add.
4. Click OK.

The Add method requires an argument, which we will name Operand. To add the Operand argument:

1. Click (select) the Add method.
2. Click the New button.
3. Type the argument name, Operand.
4. Click OK.

Before you click OK, the screen appears as follows:

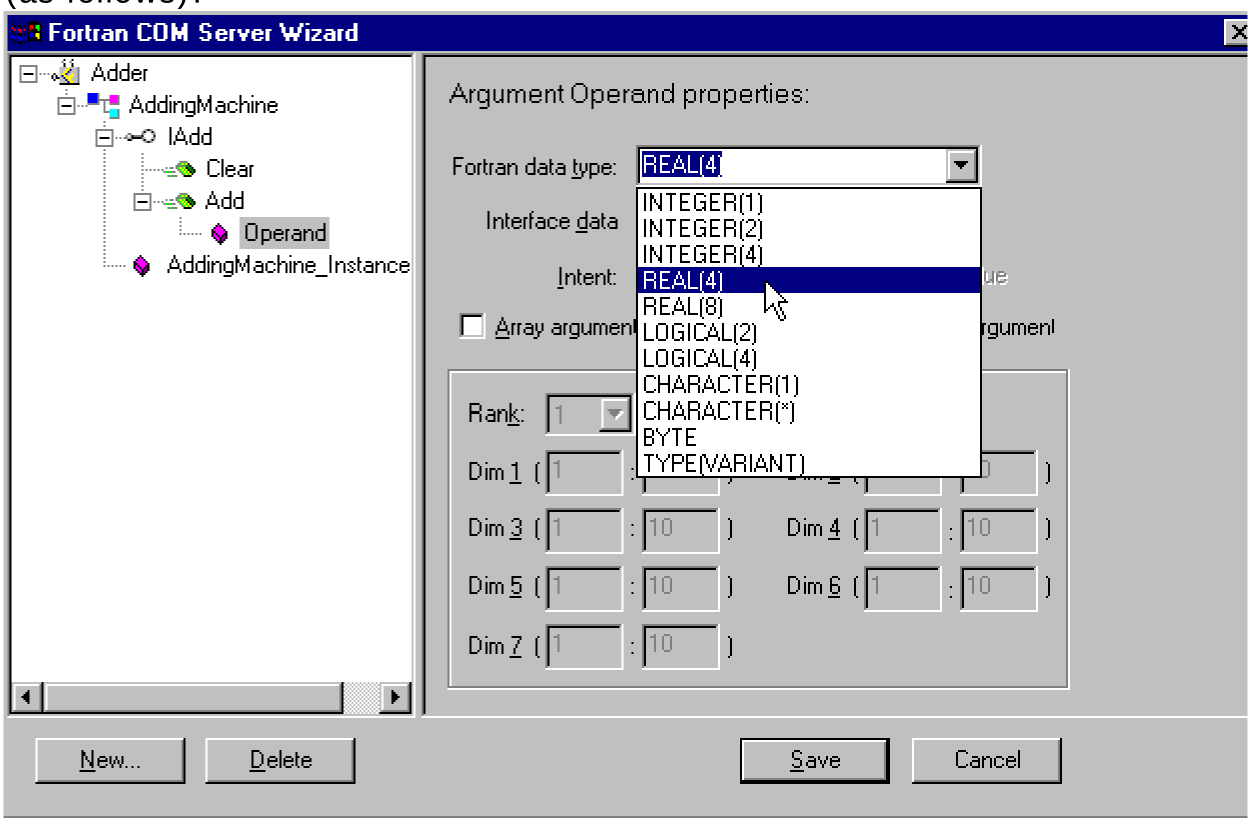


After you click OK, the Fortran COM Server Wizard screen adds the Operand argument and displays its properties.

The default data type of an argument is INTEGER(4).

In our example:

1. Use the Fortran data type combo box to change the data type to REAL(4) (as follows):



2. Leave the default values for Interface data and Intent.

We need to add the last method:

1. Click (select) the IAdd interface.

2. Click the New button.
3. Type the method name, GetValue.
4. Click OK.

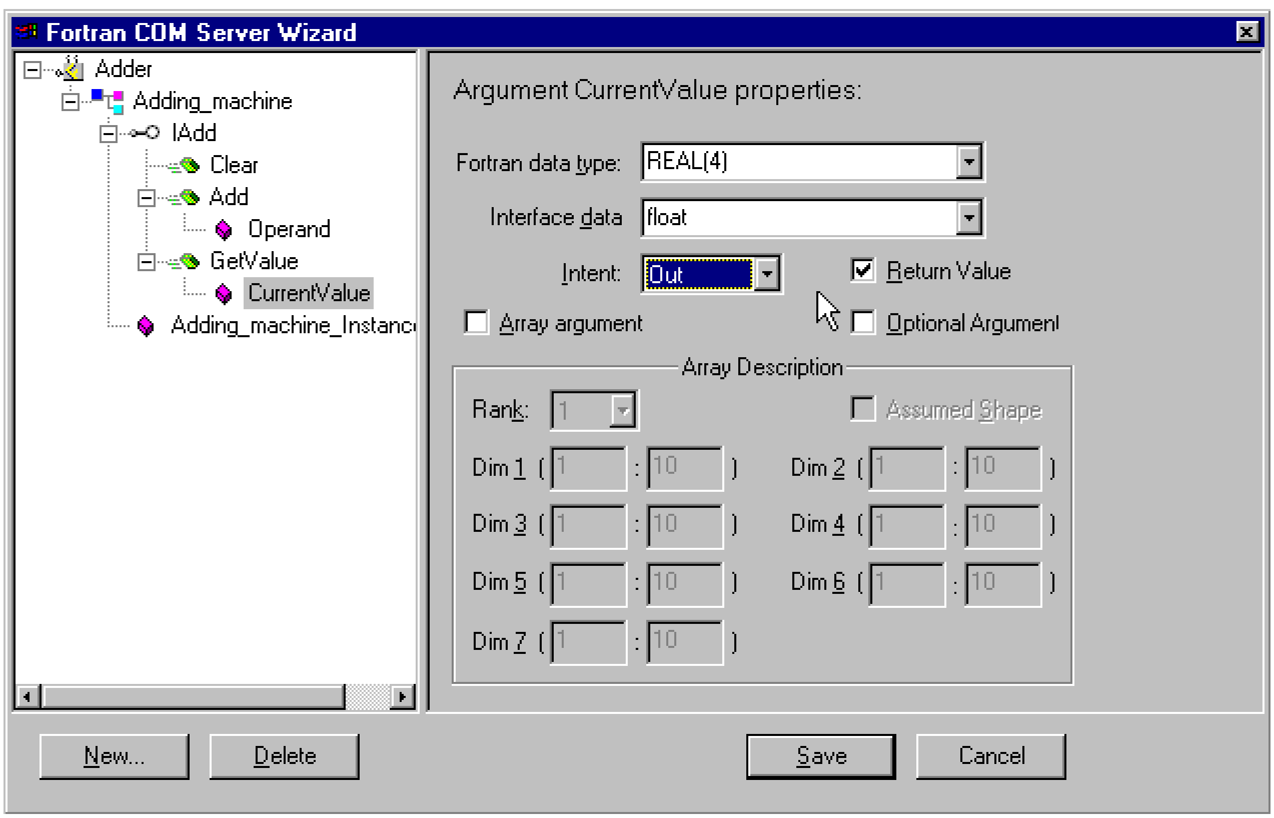
The GetValue method requires an argument, which we will name CurrentValue. To add the CurrentValue argument:

1. Select the GetValue method.
2. Click the New button.
3. Type the argument name, CurrentValue.
4. Click OK.

For the CurrentValue argument:

1. Use the Fortran data type combo box to change the data type to REAL(4)
2. Leave the default values for Interface data.
3. Change the Intent to Out.
4. Click the Return value check box.

The screen appears as follows:



In our example, the server definition is now complete. Click the Save button to dismiss the Fortran COM Server Wizard. The project is now displayed, including the TODO.TXT file, allowing you to modify the generated code.

For detailed information about the property pages (right pane) for server, class, interface, method, argument, or instance properties, see Description of Property Pages.

To change the definition of your server later, select the Fortran COM Server Wizard menu item in the View menu.

Adding a Property

In addition to methods, an interface can contain *properties*. Properties are method pairs that set or return information about the state of an object. Typically, a property corresponds to a field in the object's derived type. For example, in the AddingMachine example, we could have used a CurrentValue property rather than a GetValue (and SetValue) methods.

A property is primarily an Automation concept. In a COM interface, a property is implemented as one or two methods:

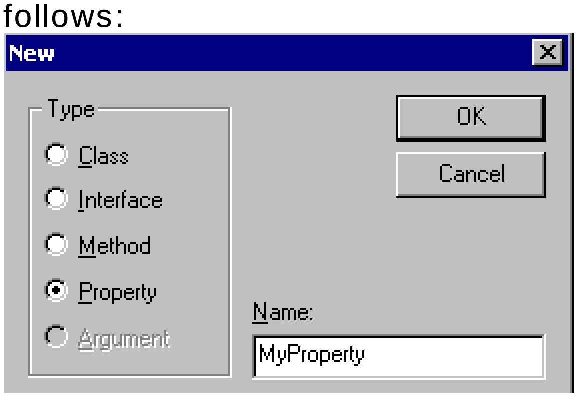
- A get_*property-name* method
- A put_*property-name* method

A property can be defined as read-only or write-only. In this case, there will be a single get_ or put_ method.

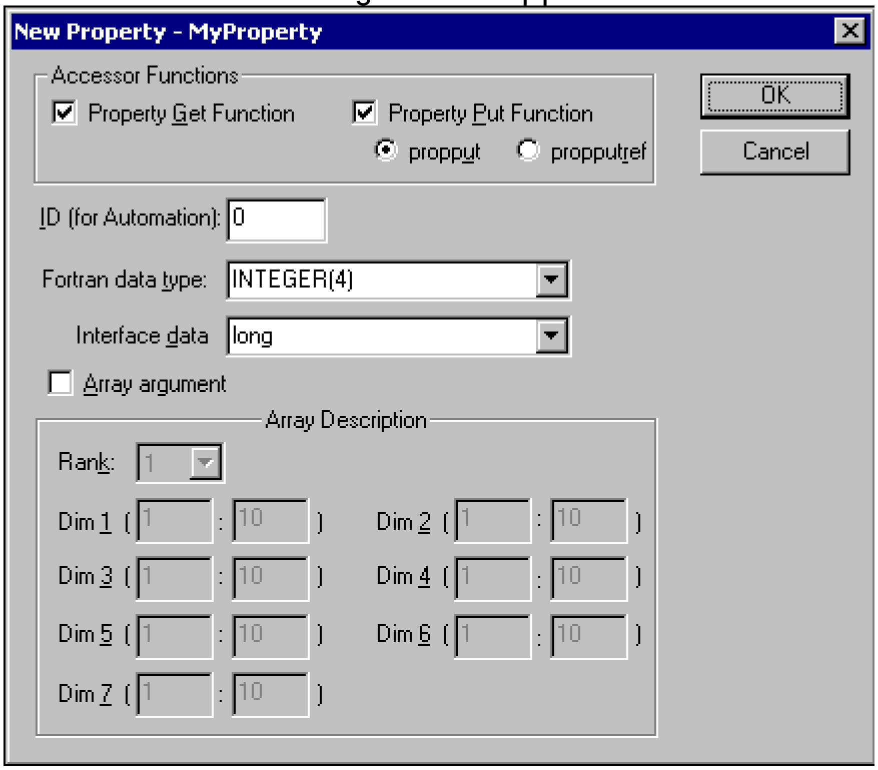
Defining an interface member as a property, rather than a method, can affect the syntax used by the client of your server. For example, Visual Basic uses a different syntax for getting or putting a property than for invoking a method. If the client language has a specific property syntax, it typically looks similar to setting a field in a record, rather than making a call.

To add a property to your interface:

1. Click (select) the interface in the hierarchy pane.
2. Click the New button. The New dialog appears. Do the following:
   - Select the Property type.
   - Type a name for the property. The completed screen appears as follows:



- Click OK. The following screen appears:



3. In the New Property dialog box, define the attributes of the property. This includes:
   - Whether the property has both get_ and put_ methods.
   - The integer Automation identifier of this property.
   - The data type of this property.
4. Click OK.

One or two methods are added to your interface. Two methods are added if you select both the get_ and put_ methods. One method is added if it is read-only or write-only. The properties methods and the argument that identifies the property value are fully defined and do not need to be modified.

A property method typically only has the single argument that represents the property value. You can add additional arguments if it makes sense. For example, additional arguments might be added if the property is an array of values, where an integer index argument is added to the property method.

When adding additional arguments to a property method, make sure that they are added before the property value argument. That is, the property value argument must always be the last argument to the property method. You can use drag-and-drop in the hierarchy pane to change the order of arguments. The order in the method is always the order that appears in the hierarchy pane.

Working with the Hierarchy Pane

As you have seen in the AddingMachine example, the hierarchy pane represents the definition of your server; that is, the classes, interfaces, methods, and so on. The hierarchy pane's user interface supports the following functionality:

Expand/contract an area	When the Fortran COM Server wizard is initially displayed, the hierarchy is fully contracted. Click the plus sign (+) next to an item to display its children. At this point, the + changes to a -. Click the - to hide the children. Double-clicking on an item also toggles its expand/contract state.
Add a new entry	To add a new entry to the hierarchy, select the entry that will precede the new entry in the hierarchy. Then click the New... button or click the right mouse button to display the pop-up hierarchy pane context menu and select one of the New... entries in the context menu.
Delete an entry	To delete an entry from the hierarchy, select the item to be deleted. Then click the Delete button or click the right mouse button to display the pop-up hierarchy pane context menu and select the Delete entry in the context menu. A confirmation dialog box is displayed to ensure that you do not accidentally delete items. All of an item's children are deleted when the item is deleted.
Rename a member	To rename an entry in the hierarchy, select the item to be renamed. Wait a few seconds (to avoid double-clicking) and then click the item again. The item's name will enter editing mode allowing you to change the name. Press the Enter key when you have finished editing the name.
Change the order of items	The order of some of the entries in the hierarchy is very important. In particular: • The order of the methods in an interface define the order of the methods in the class' VTBL. Changing the order of the methods will break an existing client. • The order of the arguments in a method define the order of the arguments in the method's interface. Changing the order of the arguments will break an existing client.

The hierarchy pane supports drag-and-drop to allow you to change the order of items. To move an item, click and drag the item and drop it on the item that you want to precede it in the hierarchy.

Description of Property Pages

Property pages appear in the right pane of the Fortran COM Server Wizard window. Different property pages apply to:

- Server Properties
- Class Properties
- Interface Properties
- Method Properties
- Argument Properties
- Instance Type Properties

Server Properties:

Type Library GUID	The unique identifier of the server's type library. There is usually no reason to change this from the default value generated by the Fortran COM Server Wizard.
Type Library Version	The current version of the Type Library.

Class Properties:

ProgID	The version independent program ID (or text alias) for the class. The ProgID can be used in calls such as COMCreateObjectByProgID.
Version	The current version of the class. It is appended to the ProgID to define the version-specific ProgID.
Short name	A short name for the class. It is used in some of the generated file names.
Description	A string used as the default value of the class' ProgID keys in the registry. This string is often used by tools, such as the OLE-COM Object Viewer, that display a list of the objects that are registered on the system.
Help String	A string used to set the class' help string attribute in the IDL file.

Threading model	The threading model of the class. The two choices are Apartment and Single. See Threading Models in Advanced COM Server Topics for information about the implications of this choice.
CLSID	The unique identifier of the class. There is usually no reason to change this from the default value generated by the Wizard.

Interface Properties:

Dual Interface	If checked, then the dual interface attribute is set in the IDL file. A dual interface supports both COM and Automation clients.
Uses only Automation data types	If checked, then the interface uses only Automation-compatible data types as described in Method Data Types.
Default interface	If checked, then the default interface attribute is set for this interface in the IDL file. The default attribute represents the default programmability interface of the object, and is intended for use by macro languages.
Help String	A string used to set the interface's help string attribute in the IDL file.
IID	The unique identifier of the interface. There is usually no reason to change this from the default value generated by the Wizard.

Method Properties:

ID	The identifier of the method used by Automation clients.
Help string	A string used to set the method's help string attribute in the IDL file.
Property Method	If checked, then the method is the get_ or put_ method of a property.

Argument Properties:

Fortran data type	The Fortran data type of the argument. Select one of the data types from the list, or type in the data type. See Method Data Types for a discussion of the implications of your choice.
Interface data type	The IDL data type. If you select one of the Fortran data types from the predefined list, then this field defaults to the corresponding IDL data type. Select one of the data types from the list, or type in the data type. See Method Data Types for a discussion of the implications of your choice
Intent	The INTENT of the argument, one of the following list: • In - the argument value is read but not modified by the method • Out - the argument value is not read, but is modified by the method • InOut - the argument value is both read and modified by the method
By Reference	Indicates that an argument is passed by reference rather than by value. Only valid with Intent In. Intent Out and Intent InOut are automatically passed by reference.
Return Value	If checked, the argument represents the return value of the method. Only valid with Intent Out.
Array argument	If checked, then the argument is an array rather than scalar argument. When checked, fill in the Array Description fields to describe the shape of the array.
Optional argument	If checked, then the argument is optional. Optional arguments are passed using the Variant data type.
Array Description fields	These fields describe the shape of an array argument. They are enabled when the Array argument field is checked.

Instance Type Properties:

Module	The name used for the module defined in the U*classname*TY.f90 file.
Constructor	The name used for the class constructor defined in the U*classname*TY.f90 file.

Destructor	The name used for the class destructor defined in the U*classname*TY.f90 file.

Modifying the Generated Code

After you either click the Save button to dismiss the Fortran COM Server Wizard or open the project workspace, the project is displayed, including the TODO.TXT file.

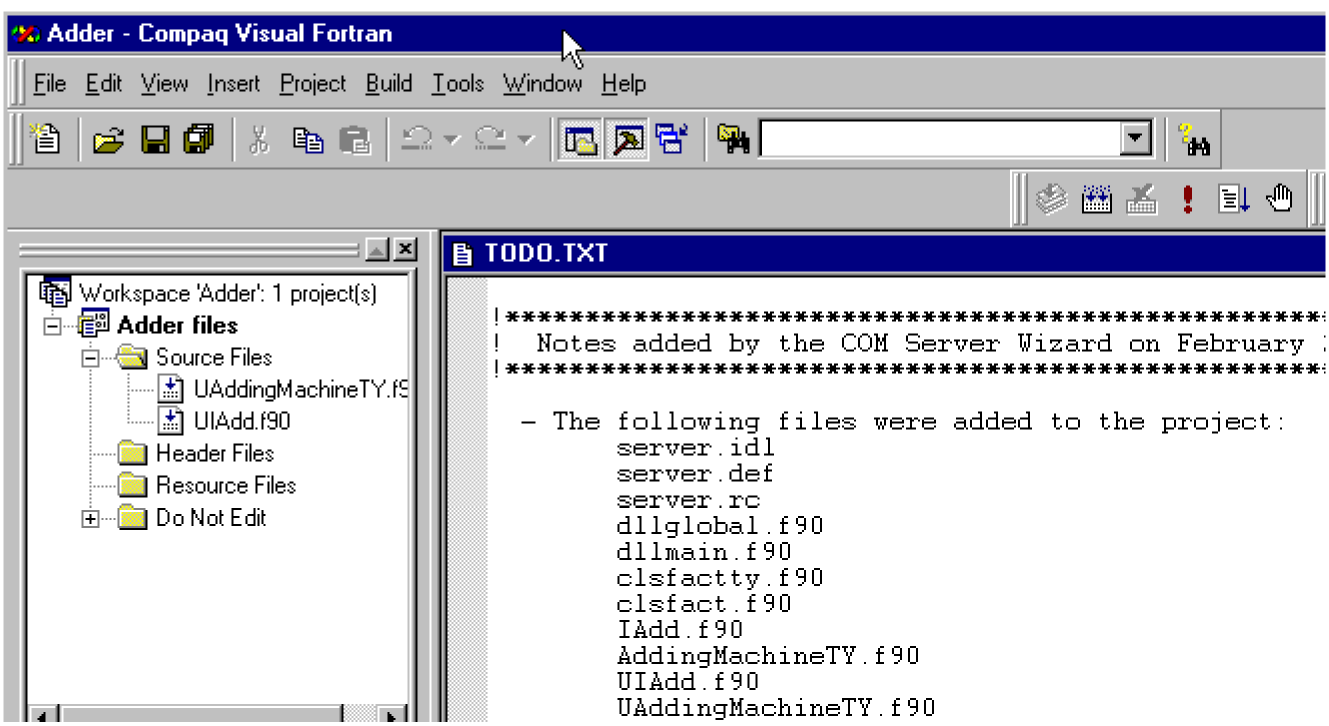
The TODO.TXT file informs you of changes made to your project by the Wizard, and lets you know when you need to make changes. After the initial invocation of the Wizard, TODO.TXT lists the files that were added to the project. The source files are added to two folders in your FileView pane:

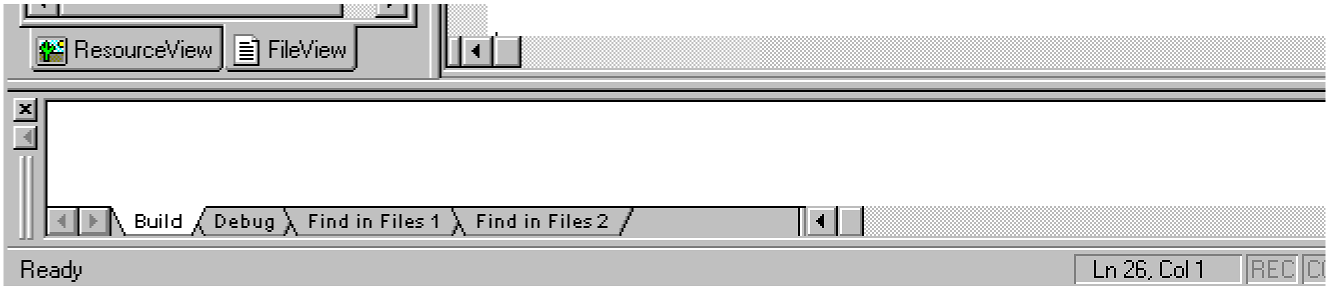
- Source files that you will need to modify are placed in the **Source Files** folder.
- Files that are totally generated by the Wizard are placed in the **Do Not Edit** folder. It is futile to modify the files in the **Do Not Edit** folder, since these files are regenerated each time you invoke the Wizard and change the definition of the server (edits you make to these files will be lost).

Click:

1. The plus sign (+) at the Adder files line
2. The plus sign (+) at the Source Files folder

The project screen appears as follows:

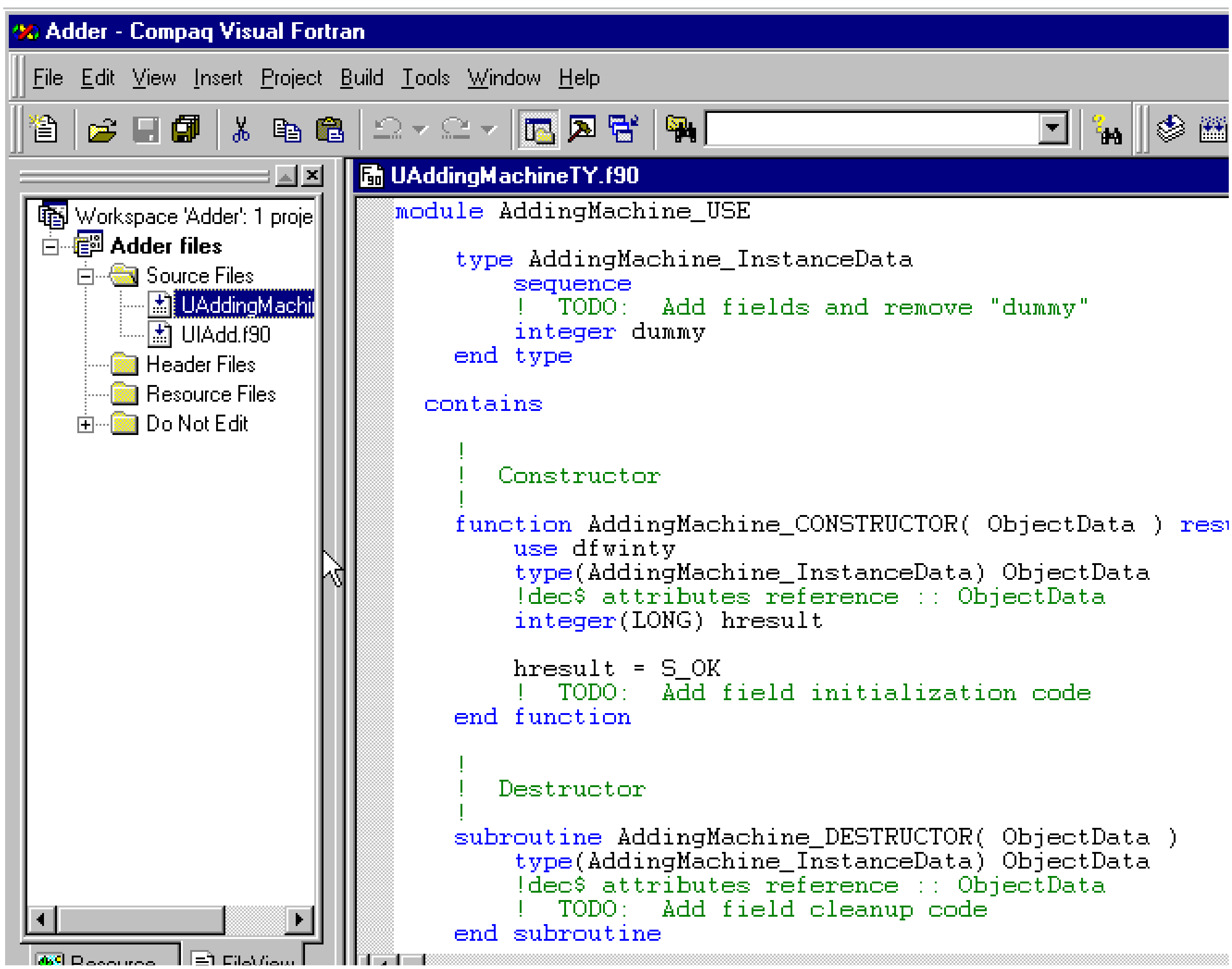




The two files that you need to modify with a text editor are in the Source Files folder:

- UAddingMachineTY.f90 contains a module that defines your class derived-type.
- UIAdd.f90 contains the implementation of the IAdd methods.

We will first modify the file UAddingMachineTY.f90. To edit the file UAddingMachineTY.f90, either double-click its file name in the FileView pane or use the Open menu item in the File menu. The original file UAddingMachineTY.f90 contains the following code:



A file named U*class-name*TY.f90 is created for each class defined by the server. The file contains a module named AddingMachine_USE (in the form *classname*_USE). There are three places in this module where you may need to add code specific to your class:

- The first entry in the module is your class derived-type. Initially it contains an "integer dummy" field to allow the module to be compiled without error. If your class has per-object data, remove the "integer dummy" field line and add your data to the derived-type. For the AddingMachine class, we add the following where the object stores the current value:

  ```
  real(4) CurrentValue
  ```

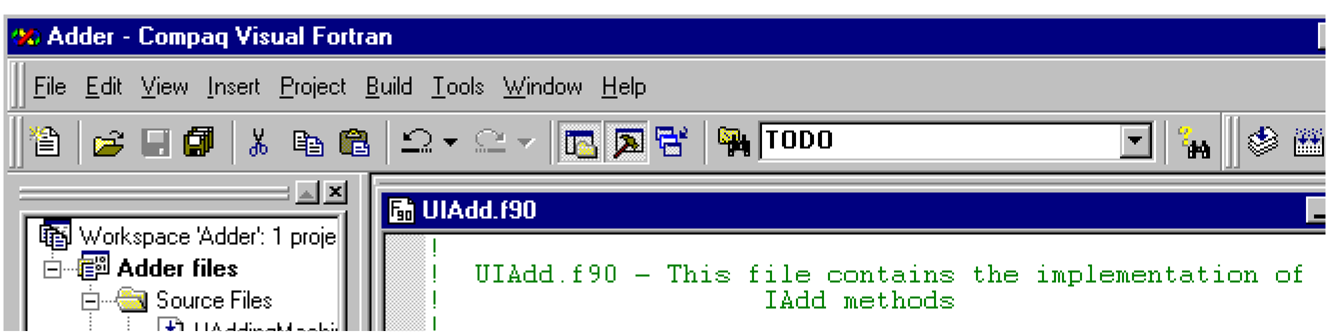
  The module also contains two module procedures by the names AddingMachine_CONSTRUCTOR and AddingMachine_DESTRUCTOR (referred to as *classname*_CONSTRUCTOR and *classname*_DESTRUCTOR below).

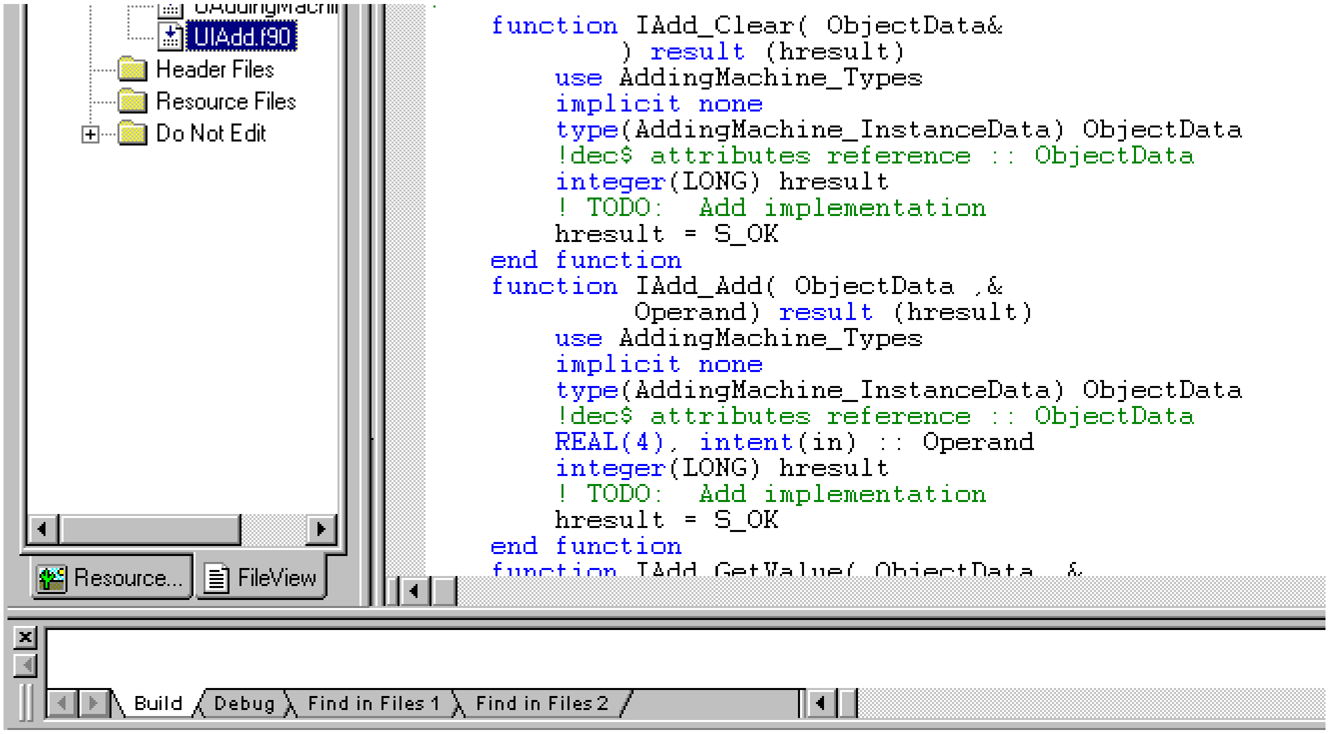
- The *classname*_CONSTRUCTOR procedure is called immediately after an instance of the class derived-type is created because of the creation of a new object. This function is where you initialize the fields of the class derived-type, if necessary. The new derived-type is passed as an argument to the function. For the AddingMachine class, we initialize the current value to 0 by adding the following statement:

  ```
  ObjectData%CurrentValue = 0
  ```

- The *classname*_DESTRUCTOR procedure is called immediately before an instance of the class derived-type is destroyed because an object is being destroyed. This function is where you release any resources used by the fields of the class derived-type, if necessary. The derived-type is passed as an argument to the function. For the AddingMachine class, there is nothing that needs to be added.

We will now modify the other source file UIAdd.f90. Either double-click its file name in the FileView pane or use the File menu, Open item. The original file UIAdd.f90 contains the following code:





A file by the name U*interfacename*.f90 (for example UIadd.f90) is created for each interface defined by the class. The file contains the methods of the class. Each method is named *interfacename_methodname*, for example: "IAdd_Clear". Each method is a function that is passed the class derived-type as the first argument. This gives the function access to the per-object data. Each function returns a 32-bit COM status code called an HRESULT. S_OK is a parameter that defines a success status. For additional information on COM status codes, see COM Status Codes: HRESULT.

You replace the "! TODO: Add implementation" line in each method with the code for the method. For the IAdd interface, below is the implementation of its three methods:

```
IAdd_Clear:    ObjectData%CurrentValue = 0

IAdd_Add:      ObjectData%CurrentValue = ObjectData%CurrentValue + Operand

IAdd_GetValue: CurrentValue = ObjectData%CurrentValue
```

Save the file and from the Build menu, click Build Adder.dll to build the server. The COM server is now complete.

Build Notes

The Developer Studio project created by the Fortran AppWizard performs two additional steps not done in a typical Fortran project:

- The build uses the MIDL compiler to compile the IDL file that describes the server. The MIDL compiler creates the server's Type library and generates C files that can be used in MIDL-based Marshalling (see Marshalling, Proxies and Stubs).

The MIDL compiler uses the Visual C++ preprocessor by default during compilation. If the AppWizard determined that Visual C++ was not installed, it sets the MIDL options to use the Fortran preprocessor FPP instead. The options added are:

```
/cpp_cmdfpp /cpp_opt  "/a /m/extend_source 132"
```

- A custom build step is added to register the COM server on your system. For a DLL COM server, registration is done using the REGSVR32 program. REGSVR32 could fail if the Window system directory is not on the Developer Studio's Executables Files list. On Windows NT and Windows 2000 systems, this is the `\Winnt\System32` directory. On Windows 9*x* systems, this is typically the `\Windows\System` directory. If the registration step fails, do the following:

  1. In the Tools menu, click Options.
  2. Scroll to the Directories tab.
  3. Select the Executable files from the list.
  4. Add the windows system directory at the bottom of the list of directories.
  5. Click OK

For an EXE COM server, the COM server itself is run with the /REGSERVER command-line option.

Visual C++ ClassView

If you also have Microsoft Visual C++ Version 6 installed on your system, you will notice that your server definition also appears in the Visual C++ ClassView pane. This occurs because the Visual C++ ClassView software can read and understand the IDL file created by the Fortran COM Server wizard.

Note: Do **not** attempt to use the Visual C++ ClassView pane to modify the your server's definition. Always use the Fortran COM Server wizard to modify classes created by the Fortran COM Server wizard.

Using Example Clients

The server is now ready to be called by any COM client. The completed Adder sample is provided in the ...`Df98\Samples\Advanced\COM\Adder` directory. This directory also contains three clients written in Visual Fortran, Visual Basic, and Visual C++.

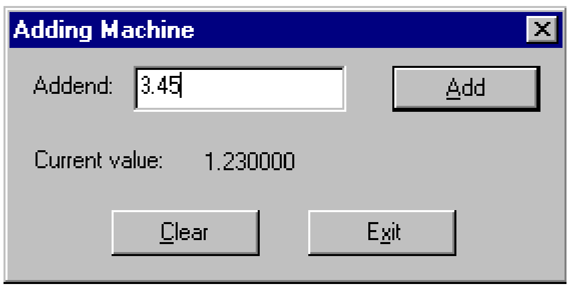
To build the sample clients, first build the Adder sample. The GUIDs used by the sample COM clients work with the Adder Sample (not the GUIDs created in the example).

If you followed the example COM server AddingMachine in earlier sections (starting with Creating a Fortran COM Server Project), the AddingMachine server that you created is identical to the Adder sample except for the GUID's assigned to the AddingMachine object. The Fortran COM Server AppWizard always generates new GUIDs for a new project.

Each client displays a dialog box that provides the user interface to the Adding Machine. Below are notes on each of the clients:

- VFAdder, the Visual Fortran client

  The VFAdder client is created using the Fortran Windows Application AppWizard. VFAdder is a simple Dialog Based Application. The main dialog box is defined to have Clear and Add buttons, an edit box to enter the addend, and a static text field that displays the current value:



  The Fortran Module Wizard creates the module (AddingMachine.f90) that defines the IAdd interface methods for use from Fortran. Code is added to the beginning of the WinMain routine to initialize COM and create an AddingMachine object:

```
call COMINITIALIZE(ret)
call COMCREATEOBJECTBYGUID (CLSID_AddingMachine, CLSCTX_ALL, IID_IAdd, &
& gAddingMachine, status)
call Check_Status(status,  " Unable to create AddingMachine object")
```

  The subroutine added as the handler of the Add button (VFAdderAdd) calls the $IAdd_Add routine and the $IAdd_GetValue routine:

```
!   Call the AddingMachine Add method
     lret = DlgGet(dlg, IDC_EDIT_ADDEND, text)
     read(text, *) addend
     status = $IAdd_Add(gAddingMachine, addend)
    call Check_Status(status,  " Add method returned failure status")

!   Set the Current Value text field
     status = $IAdd_GetValue(gAddingMachine, value)
```

```
write(text, *) value
call Check_Status(status,  " GetValue method returned failure status")
lret = DlgSet(dlg, IDC_CURRENTVALUE, text)
```

The subroutine added as the handler of the Clear button (VFAdderClear) calls the $IAdd_Clear routine in a similar way. Code is added at the end of the WinMain routine to uninitialize COM and release the AddingMachine object:

```
if (gAddingMachine /= NULL) then
        ret = COMReleaseObject(gAddingMachine)
endif
call COMUNINITIALIZE()
```

- VBAdder, the Visual Basic V6 client

  VBAdder is created from a new Standard EXE project. The form is modified to be similar to the VFAdder dialog box above. The first step in using the AddingMachine object from Visual Basic is to select the References menu item from the Project menu. Find AddingMachine 1.0 Type Library in the list and select it. Visual Basic reads the information from the type library and becomes aware of the AddingMachine object, the IAdd interface, and its methods. These will appear in the choices that the Visual Basic editor makes available to you as you enter code for the project.

  The following code is added to the VBAdder project:

  - An instance of the AddingMachine object is created by adding the following line to the General Declarations area:

    ```
    Dim Adder As New AddingMachine
    ```

  - The code for the Add button Click method is:

    ```
    Private Sub Add_Click()
       Dim Value As Single
       Adder.Add (Addend.Text)
       CurrentValue.Caption = Adder.GetValue
       Addend.Text = ""
    End Sub
    ```

  - The code for the Clear button Click method is:

    ```
    Private Sub Clear_Click()
       Adder.Clear
       CurrentValue.Caption = Adder.GetValue
    End Sub
    ```

  - The code for the Exit button Click method is:

    ```
    Private Sub Exit_Click()
       End
    End Sub
    ```

- VCAdder, the Visual C++ V6 client

  VCAdder is created using the MFC AppWizard (exe). The Dialog based option is selected in the wizard. The dialog box controls are copied from the VFAdder dialog box and pasted into the VCAdder dialog box.

  The following statement is added to VCAdder.h in order to give the source files access to the AddingMachine object, the IAdd interface and its methods:

```
#import "..\Adder.dll"
```

  A member variable is added to the CVCAdderApp application class to hold the pointer to the AddingMachine object:

```
AddingMachineLib::IAddPtr m_pIAdd;
```

  Code is added to the beginning of the CVCAdderApp::InitInstance method to initialize COM and create an AddingMachine object:

```
   CoInitialize(NULL);
   m_pIAdd.CreateInstance(__uuidof(AddingMachineLib::AddingMachine));
```

  The MFC Class Wizard is used to add:

  - A member variable for the Addend edit field, m_Addend
  - A member variable for the CurrentValue static text field, m_CurrentValue
  - Member functions for the clicked message on the Add, Clear, and Exit buttons - OnAdd, OnClear, and OnExit

  OnAdd calls the Add method and the GetValue method.

```
void CVCAdderDlg::OnAdd()
{
   HRESULT hr;
   UpdateData();
   double addend = atof(m_Addend);
   hr = theApp.m_pIAdd->Add((float)addend);
   float value = theApp.m_pIAdd->GetValue();
   char buffer[32];
   sprintf(buffer, "%10.10G", value);
   m_CurrentValue = buffer;
   m_Addend = "";
   UpdateData(FALSE);
}
```

  OnClear calls the Clear method and the GetValue method in a similar way.

  Code is added at the end of the CVCAdderApp::InitInstance method to release the AddingMachine object and uninitialize COM:

```
m_pIAdd.Release();
 CoUninitialize();
```

For design considerations and notes on using Visual Basic and Visual C++ clients, see Visual Basic and Visual C++ Client Notes.

Modifying Your COM Servers

You can modify the server to change the properties of any entry in the hierarchy, add new entries to the hierarchy, move entries in the hierarchy, or remove entries from the hierarchy.

You use the same user interface of the Fortran COM Server Wizard that you used to create the COM server, simplifying any additions, deletions, or changes to your COM server definition. However, you need to pay careful attention to the following files when you modify the COM server definition:

- View the TODO.TXT file. The TODO.TXT serves as a log of the changes you have made to the server definition. You may delete entries from TODO.TXT that are no longer useful to you. TODO.TXT is simply a text file that the wizard appends messages to.
- New versions of the source files in the Source files folder generated by the Fortran COM Server Wizard do not overwrite existing source files, since you may have modified existing source files. New source files are in the form of the original file name with a plus sign (+) appended, such as UIADD+.f90. Use the text editor to copy-and-paste the newly generated definitions into your previously modified source code (described below), as instructed by text in the TODO.TXT file.

The Fortran COM Server Wizard regenerates the files in the Do Not Edit folder whenever the server definition changes.

To display the Fortran COM Server Wizard:

1. Start Developer Studio
2. Open a COM server project created by the Fortran COM Server AppWizard
3. Click the Fortran COM Server Wizard menu item in the View menu (see Using the Fortran COM Server Wizard to Define your COM Server)

Once you have published an interface and clients are using it, COM rules state that you must not change the interface. Instead, you should create a new interface, in addition to the original one, and change the name. A common practice is to append a 2 to the name, for the second version of the interface. For example, IAdd would become IAdd2. The second version of your class should support both the original and new interfaces. Old clients continue to work using the original interface. New clients can use the new interface with the new functionality.

The new interface has a different interface ID (IID) than the original interface. The text name is for the convenience of programmers. The IID uniquely identifies the interface.

The Fortran COM Server Wizard adds messages to TODO.TXT anytime the Wizard makes a change to the project and anytime that you make a change to the server definition that requires you to manually edit one or more of the source files. For example, if you add a new method to the IAdd interface, SetValue, that sets the current value to a specific number, the Wizard generates new code to implement the new method in your server. Some of the new code is in the files in the Do Not Edit folder. The Wizard automatically changes these files.

However, a new method skeleton needs to be added to the UIADD.f90 file in the Source Files folder. The wizard never creates a new file with the same name as a file in the Source Files folder, because that would cause the edits that you have made to the files to be lost. Instead, the wizard generates a file with a plus sign (+) appended to the end of the name, for example: UIADD+.f90. The file UIADD+.f90 contains the skeleton of the new method, IAdd_SetValue. In this case, the following message is added to TODO.TXT, and TODO.TXT is opened in the Developer Studio text editor:

```
The file UIAdd+.f90 has been generated with the following changes.
You must merge these changes with the existing file UIAdd.f90.
The method IAdd_SetValue has been added.
```

You must use a text editor to copy the new method skeleton from the UIADD+.f90 file and paste it into the UIADD.f90 file.

Whenever a change is made to your server definition, "+" versions of the files in the Source Files folder are generated. You can ignore these files except when TODO.TXT informs you of an action you need to take.

Other changes that would require you to manually merge changes into your source files include:

- Adding a new property.
- Changing the arguments of an existing method.
- Renaming a class, interface or method.
- Deleting a class, interface or method.

Interface Design Considerations

This section provides information that should be considered when designing a Fortran COM server. It contains the following topics:

- Method and Properties Data Types
- COM Status Codes: HRESULT
- Visual Basic and Visual C++ Client Notes

Method and Properties Data Types

COM places some restrictions on the data types used in COM methods and properties. The reason for the restrictions is that COM can pass arguments between threads, processes and machines. This raises issues that are not present in older technologies, such as DLLs, that always run in the same address space as the caller.

COM defines set of data types called Automation-compatible data types. These are the only data types that can be used in Automation and Dual interfaces. There are two advantages to restricting your COM interface to these data types:

- Your server will be usable from clients written in the largest set of languages, including Visual Fortran, Visual Basic, and Visual C++.
- COM will automatically handle the passing of arguments between threads, processes and machines. This is called *Type Library Marshalling*. For more information, see Marshalling, Proxies and Stubs in Advanced COM Server Topics.

To restrict your server to Automation-compatible data types:

1. Select "Use only Automation data types" on the Interface property page. When defining a dual interface, this is automatically set.
2. Use only the following combinations of "Fortran data type" and "Interface data type" on the Argument property page.

   Note that Visual Fortran does not support the Currency, Decimal, or User Defined Type, Automation-compatible data types.

Fortran Date Type	Interface Data Type
INTEGER(1)	unsigned char
INTEGER(2)	short

INTEGER(4)	long SCODE Int
INTEGER(INT_PTR_KIND())	IUnknown* IDispatch*
REAL(4)	float
REAL(8)	double DATE
LOGICAL(2)	VARIANT_BOOL
LOGICAL(4)	long
CHARACTER(1)	unsigned char
CHARACTER(*)	BSTR
BYTE	unsigned char
TYPE(VARIANT)	VARIANT (containing one of the above types or SafeArray)

If you decide not to restrict your interface to Automation-compatible data types, the next approach is to restrict your interface to data types that can be described in the Interface Description Language (IDL).

The Fortran COM Server Wizard automatically generates the IDL file from the description of your server. The MIDL compiler compiles the IDL file into a type library. MIDL can also automatically generate the code needed handle the passing of arguments between threads, processes and machines. Note, however, that a C compiler is required to use this option. For more information, see Marshalling, Proxies and Stubs in Advanced COM Server Topics.

If you decide not to restrict your interface to IDL data types, your only remaining options are:

- Implement Custom Marshalling - For more information, see Marshalling, Proxies and Stubs in Advanced COM Server Topics.
- Decide that you will never use your server across apartment, thread, or process boundaries. The server will not be usable in this manner because there is no way to pass the arguments across these boundaries.

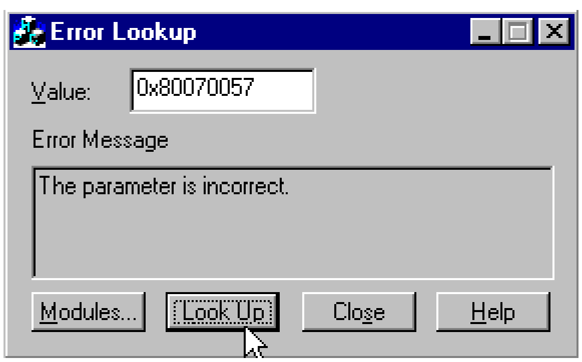
COM Status Codes: HRESULT

Each function returns a 32-bit COM status code called an HRESULT. An HRESULT is divided into fields:

- The top bit (31) indicates whether the function succeeded or failed. The bit is set if the function failed. In Fortran, you can compare the HRESULT to < 0 as a test to see if a function failed.
- Bits 16 to 27 contain a facility code to indicate the facility that issued the HRESULT. Microsoft pre-defines a number of facility codes for its own use. If you create your own status codes, use FACILITY_ITF. All other facility codes are reserved by Microsoft.
- The first 16 bits, or low word, contain the error code specific to the error that occurred.

A typical HRESULT error value could be a value such as 0x80070057. The first hex digit, 8, indicates that bit 31 is set and that this is an error value. Bits 16 to 27 contain the value 7. This indicates the facility FACILITY_WIN32. The low word contains the value 0057. This is the specific code that identifies the error as E_INVALIDARG.

To view the text description that corresponds to a system HRESULT value, use the Error Lookup tool in the Compaq Visual Fortran program folder. For example, entering the value 0x80070057 retrieves the text message "The parameter is incorrect ", as shown below:



You can also search for HRESULT values in the WINERROR.H file in the `\VC\INCLUDE` directory on the Visual Fortran CD-ROM.

A COM server can also provide extended error information through the ErrorInfo objects. See Adding Support for COM ErrorInfo Objects.

Visual Basic and Visual C++ Client Notes

To use an object from Visual Basic, you must add a "reference" to the object to the Visual Basic project. Use the References item in the Project menu to display a list of the registered objects. Select the object in the list to inform Visual Basic that you will be using the object.

Here are some points to be aware of when writing a server that can be used with Visual Basic clients:

- Use only the Automation-compatible data types (see Method and Property Data Types).
- Arguments to a method can be passed ByVal, ByRef, or they can be the function return value.
- An argument to be passed ByVal, must be defined with Intent set to In.
- An argument to be passed ByRef, must be defined with Intent set to InOut.
- A function return value must be defined with Intent set to Out. It must have the Return Value field checked. The argument must be the final argument of the method.
- An array is always passed as a SafeArray ByRef. Therefore it must be defined with Intent set to InOut.
- To use an argument of the Visual Basic Boolean data type, set the Fortran data type to LOGICAL(2) and set the Interface data type to VARIANT_BOOL.

To use an object from Visual C++, use the #import directive. The syntax of the #import directive is:

```
#import "filename" [attributes]
#import <filename> [attributes]
```

The filename is the name of the file containing the type library information. The directive makes the information in the type library available to your source file as a set of C++ classes. See the Visual C++ documentation for additional information and examples.

Advanced COM Server Topics

Advanced topics about Fortran COM Servers described in this section include:

Choosing Between DLL or EXE COM Servers

The basic tradeoff in choosing between a DLL (in-process) COM server and an EXE (out-of-process) COM server is one of performance vs. robustness:

- A DLL server provides the advantage of performance over an EXE server. Since the DLL server is loaded into the client's address space, there is less overhead involved in method calls. If the client code and the server object live in the same COM apartment, method calls are as efficient as DLL routine calls.
- An EXE server provides the advantage of robustness over a DLL server. Since the server object lives in a separate address space, the object cannot be affected by client memory handling bugs, and vice-versa. If the server crashes, the client doesn't necessarily crash — as long as the client checks the results of all method calls and takes steps to recover from a "dead" object.

In addition to the tradeoff between performance and robustness, the following factors should also be considered:

- With an EXE server, the object can run in a separate security context from the client. With a DLL server, the code of the object's methods executes using the client's access token.
- An EXE server can be run on a remote machine using COM's distributed object support.

You can load a DLL server into a "surrogate" to gain the benefits of an EXE server. This is explained in the next section.

DLL Server Surrogates

An in-process DLL server can be run in a separate process with the help of a *surrogate*. A surrogate runs as a separate process, loads the DLL server, and provides all of the mechanism that allows the DLL server to act as a local server. Windows provides a standard surrogate named DLLHOST.EXE. The primary advantage of using a surrogate is fault isolation. That is, if the server crashes it does not crash the client, and vice versa. The disadvantage is performance. There is significant performance overhead in executing methods in a separate application, as opposed to in a DLL.

A DLL server is associated with a surrogate via entries in the system registry. This is done by associating the DLL server with an AppID. An AppID is a GUID. When using the standard surrogate, you can use the CLSID of a class in the DLL as the AppID, or a newly generated GUID. To generate a new GUID, use GUIDGEN.EXE in the Developer Studio Tools subdirectory:

1. Under the HKEY_CLASSES_ROOT\CLSID\{xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxxx} key of the class, add an AppID entry with the value of the CLSID. Using the AddingMachine class as an example, the registry key would be HKEY_CLASSES_ROOT\CLSID\{904245FC-DD6D-11D3-9835-0000F875E193} and the AppID value would be {904245FC-DD6D-11D3-

9835-0000F875E193}.
2. Under the HKEY_CLASSES_ROOT\AppID key, add a key using the AppID. Using the AddingMachine class as an example, the registry key would be HKEY_CLASSES_ROOT\AppID\{904245FC-DD6D-11D3-9835-0000F875E193}. Use the class name for the default value of the key, for example, "AddingMachine Class". Add a "DllSurrogate" entry with an empty string for the value.

To use a surrogate, the system must be running Windows 2000, Windows NT 4.0 Service Pack 2 or later, Windows 98, Windows Me, or Windows 95 with the DCOM update.

The client must request CLSCTX_LOCAL_SERVER rather than CLSCTX_INPROC_SERVER to use the surrogate rather than loading the DLL server in-process. Using a surrogate requires that the DLL server have a proxy/stub registered since the method invocations are between different processes. For information on proxies/stubs, see Marshalling, Proxies and Stubs.

It is also possible to write a custom surrogate. See the online Win32 Platform SDK documentation for information.

Discussion of Wizard Code Generation

The Wizard generates the code for your project from the files in the subdirectory of your project named `*project-name*templates`. The *project-name*.hie file contains the definition of your COM server in an undocumented text language. You should not manually edit the *project-name*.hie file – the Wizard does this for you.

Most of the other files in the `*project-name*templates` directory are templates of the source files generated for your project. These templates contain source code that is copied "as-is" to the generated sources, and embedded directives that guide the Wizard in generating the code specific to the COM server that you define. The directives use the information in the *project-name*.hie file. The directives are undocumented and subject to change.

When you create a new Fortran COM Server project, the AppWizard creates the `*project-name*templates` directory and copies the templates from the Visual Fortran COM Server Wizard templates directory, `...\Df98\Templates\COMServer`.

The files in the COM Server Wizard templates directory may change with each release of Visual Fortran, but the templates in your `*project-name*templates` directory are never automatically updated. For example, if you create a COM server using Visual Fortran Version 6.5 and the next release of Visual Fortran (such as Version 6.5A) contains updated templates, the templates for your COM server are not automatically updated to the new 6.5A templates. If you modify the definition of your server, your project continues to use the 6.5 templates that it was created with. This has the advantage of not introducing different code into a project that you have developed and tested.

However, there are two cases where you may want to modify the templates that are used by your project:

- A new release of Visual Fortran may contain additional features that can be used in your COM server project. Some of the new features may depend upon the new templates. These features will not be available to a pre-existing project unless you update the templates in the *project-name*`templates` directory. You do this by copying all of the files in the Visual Fortran COM Server Wizard templates directory `...\Df98\Templates\COMServer` into the *project-name*`templates` directory, replacing all files with the same name. Your project will then use the new templates the next time that the definition of your server is modified and the project sources are regenerated.
- When you want to modify the code generated by the Wizard. You may edit a template in your *project-name*`templates` directory. Editing code that is copied "as-is" is straight forward. Attempting to modify the embedded directives is unsupported and could cause the Wizard to fail when using the modified template. The embedded directives begin with an @ (at-sign) character. The next character determines the type of directive. The end of many directives is also delimited by an @ character followed by the matching end character for the type of directive. For example, @[and @] are the delimiters for one type of directive.

The advantage of modifying a template is that you can customize the code generated by the Wizard. The disadvantages of modifying a template are:

- You must be very careful not to modify a template in a manner that causes the Wizard to generate bad code or fail.
- You will not be able to update the project templates with the templates from a new release of Visual Fortran without having to re-apply your modifications to the new templates.

Adding Support for COM ErrorInfo Objects

COM supports ErrorInfo objects to allow a server to return more complete error information than is returned in an HRESULT. An ErrorInfo object returns the contextual description of the error, the source of the error, and the interface ID of the interface that originated the error. The ErrorInfo object can also include a pointer to an entry in a help file that provides help information on dealing with the error.

To support ErrorInfo objects, your server must implement the ISupportErrorInfo interface. You can add a default implementation of this interface to your server:

- Select the class that you want to support ErrorInfo objects in the hierarchy pane.
- Click the right mouse button on the class to invoke the context-sensitive menu of the class and select the "Add Pre-defined Interface" menu item.
- Select ISupportErrorInfo in the "Select an Interface" dialog box and click OK.

ISupportErrorInfo contains a single method, InterfaceSupportsErrorInfo. The default implementation returns S_OK, which is sufficient if all of the interfaces of the class support ErrorInfo objects. Otherwise, you should modify the method to test the passed in interface ID and return S_OK for those interfaces that do support ErrorInfo objects, and E_FAIL for those that do not.

When an interface that supports ErrorInfo objects is going to return an error status in HRESULT, it should also initialize an ErrorInfo object using the ICreateErrorInfo interface. See the `...\Df98\SAMPLES\ADVANCED\COM\ERRORINFO` sample for an example of using ErrorInfo objects in Fortran. See the Platform SDK documentation for more information on ErrorInfo objects.

Threading Models

The Wizard supports two COM threading models for the classes that you create in a DLL COM server, Apartment and Single. The Wizard uses the Apartment threading model (also known as the Single Threaded Apartment model "STA") by default. The basic rules of the Apartment threading model are:

- If two objects, A and B, are created in the same STA thread, and A is processing a method call, no other client can call either A or B until A completes.
- If B is created in a different thread from A, B can accept a method call while A is still processing and vice versa.

This means that if the class shares any global data among its objects, the global data must be protected from simultaneous access using thread synchronization primitives. This is because two instances of the class could be running in different threads. However the per-object instance data, that is, the fields in the class derived-type, are protected from simultaneous access by COM mechanisms. This is true except in the case where an object calls out to another object that triggers a reentrant invocation of the first object.

A class using the Single threading model need not worry about simultaneous access to class global data, as well as per-object data. All objects of the class are created in a single thread and therefore only a single object of the class can be executing at any time.

An EXE COM server generated by the wizard is single threaded. All method invocations are serialized by the server's message queue. Therefore, with an EXE server, you need not worry about simultaneous access to class global data, as well as per-object data.

Explaining the COM threading models in detail is beyond the scope of this documentation. See the Win32 Platform SDK documentation for additional information.

Marshalling, Proxies and Stubs

COM supports the use of objects in separate processes (as when using an EXE server or a DLL surrogate), and the threading models described above, by the use of marshalling, proxies and stubs. This section presents an overview of marshalling, proxies and stubs. See the Win32 documentation for further information.

Marshalling is the process of reading the parameters for a method call and preparing them for transmission to another execution context (for example, thread, process, or machine). Marshalling is done by a *proxy*. From the client's perspective, a proxy has the same interface as the object itself. The proxy's job is to make the object look like an object in the same execution context as the client.

Proxies allow client code to be unconcerned about where the object actually lives. A proxy marshalls method parameters and transmits them to a *stub* associated with the object in the server. The stub unmarshalls the parameters and invokes the method in the server. From the server's perspective, this is no different than when it is called from a client in the same execution context. A server that is not an in-process DLL server always requires a proxy/stub pair. An in-process DLL server requires a proxy/stub pair when the client and object are in different apartments.

There are three ways to assign a proxy/stub pair to a server:

Type Library Marshalling:	If you use only Automation-compatible data types in your methods and properties, COM can automatically use the "Universal Marshaller" as the proxy/stub for the server. The Universal Marshaller uses the description of the server in the type library to decide how to marshall the parameters. This is known as type library marshalling. Using type library marshalling requires no effort on your part, other than restricting your server to Automation-compatible data types.

MIDL-based Marshalling:	Your project uses the MIDL compiler to compile the IDL description of the server into a type library. At the same time, the MIDL compiler also generates the C source code necessary to build a proxy/stub DLL for the server. You must have a C compiler to build a proxy/stub DLL from the MIDL generated code. The proxy/stub DLL is itself an in-process DLL server and needs to be registered with the system. You would need to use MIDL-based marshalling if your server uses non-Automation-compatible data types, and is used by a client in a different execution context.
Custom Marshalling:	Your server can implement its own marshalling by implementing the IMarshall interface. This approach typically involves a lot of work and is done for performance reasons.

A Map of the Generated "Do Not Edit" Code

This section presents an overview of which parts of the COM server functionality are implemented in which of the "Do Not Edit" source files generated by the wizard:

File Name	**Description**
server.idl	Contains the IDL description of the server. It is compiled by the MIDL compiler to produce the server's type library.
*servername*global.f90	Contains the global data and functions for the server.
dllmain.f90 (DLL server)	Contains the exported functions that are required of all COM Server DLLs. This includes DllMain, DLLRegisterServer, DLLUnregisterServer, DllGetClassObject, and DllCanUnloadNow.
server.def (DLL server)	Declares the exported functions for the linker.
exemain.f90 (EXE server)	Contains the main entry point of an EXE server. It also processes the command-line argument.
serverhelper.f90	Contains helper functions for the server.
clsfactty.f90	Contains definitions of the IClassFactory interface that is used to create instances of the classes defined by the server.

clsfact.f90	Contains methods of the IClassFactory interface that is used to create instances of the classes defined by the server.
*classname*TY.f90	Defines a module that contains definitions of parameters and types used in the implementation of the class. It also contains the implementation of the IUnknown methods of the class. A separate instance of this file is generated for each class defined in the server.
interfacename.f90	Defines a module that contains the Fortran interfaces of the methods in the interface. It also contains the implementation of the Fortran "wrappers" that are called directly from the class' VTBL and call the methods implemented by the user. A separate instance of this file is generated for each interface defined in the class.

Deploying the Server on Another System

When you have finished developing the COM server, you may want to deploy it on another system. Besides the server itself, you need to install the Fortran run-time DLLs and register the server:

1. Install (or copy) the COM server to an appropriate directory.

2. Register the server:

   - To register a DLL server, use the REGSVR32.EXE system tool, a command-line tool. To register the DLL server, specify the path to the DLL and its file name (*dll_path*) by typing the following command:

     ```
     REGSVR32 dll_path
     ```

     The file REGSVR32.EXE is in your system directory, such as the `\Winnt\System32` on Windows NT or Windows 2000 systems or `\Windows\System` on Windows 9*x* systems. If this directory is not in your PATH, include its path before the REGSVR32 command.

   - To register a an EXE server, run the server with the /REGSERVER command-line opton. For example:

     ```
     exe_path /REGSERVER
     ```

3. Use the VFRUN tool to install the necessary run-time DLLs and related files.

The VFRUN tool provides the run-time redistributable files for Visual Fortran applications, in the form of a self-installing kit. VFRUN is described in the *Compaq Visual Fortran Installing and Getting Started* and in the release notes. You can download the run-time redistributable files VFRUN kit from the Visual Fortran Web page (click Downloads area): http://www.compaq.com/fortran

If you are using MIDL-based Marshalling or Custom Marshalling, then the marshalling DLL also needs to be installed and registered. For information on marshalling, see Marshalling, Proxies and Stubs in Advanced COM Server Topics.

Programming with Mixed Languages

Mixed-language programming is the process of building programs in which the source code is written in two or more languages. It allows you to:

- Call existing code that is written in another language
- Use procedures that may be difficult to implement in a particular language
- Gain advantages in processing speeds

Mixed-language programming is possible among the 32-bit languages Visual Fortran, Visual C/C++, Visual Basic, and MASM. Mixed-language programming in Win32 is different from that in 16-bit environments, and in many respects it is easier.

To properly create mixed-language programs, rules must be established for naming variables and procedures, for stack use, and for argument passing among routines written in different languages. These rules, as a whole, are the calling convention.

A calling convention includes:

- Stack considerations
  - Does a routine receive a varying or fixed number of arguments?
  - Which routine clears the stack after a call?
- Naming conventions
  - Is lowercase or uppercase significant or not significant?
  - Are external names altered?
- Argument passing protocol
  - Are arguments passed by value or by reference?
  - What are the equivalent data types and data structures among languages?

This section provides information on the calling conventions available when writing routines written in Fortran, C, Visual C++, Visual Basic, and ia32 assembly language. It is organized into the following topics:

Overview of Mixed-Language Issues

Mixed-language programming involves a call from a routine written in one language to a function, procedure, or subroutine written in another language. For example, a Fortran main program may need to execute a specific task that you want to program separately in an assembly-language procedure, or you may need to call an existing DLL or system procedure.

Mixed-language programming is possible with Visual Fortran, Visual C/C++, Visual Basic, and assembly language (MASM) because each language implements functions, subroutines, and procedures in approximately the same way. The following table shows how different kinds of routines from each language correspond to each other. For example, a C main program could call an external void function, which is actually implemented as a Fortran subroutine.

Language Equivalents for Calls to Routines

Language	**Call with Return Value**	**Call with No Return Value**
Fortran	FUNCTION	SUBROUTINE
C and Visual C++	function	(void) function
Visual Basic	Function	Sub
Assembly language	Procedure	Procedure

There are some important differences in the way languages implement routines. Argument passing, naming conventions and other interface issues must be thoughtfully and consistently reconciled between any two languages to prevent program failure and indeterminate results. However, the advantages of mixed-language programming often make the extra effort worthwhile.

A summary of a few mixed-language advantages and restrictions follows:

- Fortran/Assembly Language

  Assembly-language routines are small and execute very quickly because they do not require initialization as do high-level languages like Fortran and C. Also, they allow access to hardware instructions unavailable to the high-level language user. In a Fortran/assembly-language program, compiling the main routine in Fortran gives the assembly code access to Fortran high-level procedures and library functions, yet allows freedom to tune the assembly-language routines for maximum speed and efficiency. The main program can also be an assembly-language program.

- Fortran/Visual Basic

  A mix of Fortran and Visual Basic 4.0 or higher (32-bit) allows you to use the easy-to-implement user-interface features of Visual Basic, yet do all your computation, especially floating-point math, in Fortran routines. In a Fortran/Visual Basic program, the main routine must be Visual Basic. It is not possible to call Basic routines from Fortran. You can call Visual Basic routines as callbacks, but the main program must be Visual Basic.

- Fortran/C (or C++)

  Generally, Fortran/C programs are mixed to allow one to use existing code written in the other language. Either Fortran or C can call the other, so the main routine can be in either language.

  To use the same Microsoft visual development environment for multiple languages, you must have the same version of the visual development environment for your languages (see Mixed-Language Development Support in *Compaq Visual Fortran Installing and Getting Started*).

This section provides an explanation of the keywords, attributes, and techniques you can use to reconcile differences between Fortran and other languages. Adjusting calling conventions, adjusting naming conventions and writing interface procedures are discussed in the next sections:

- Adjusting Calling Conventions in Mixed-Language Programming
- Adjusting Naming Conventions in Mixed-Language Programming
- Prototyping a Procedure in Fortran

After establishing a consistent interface between mixed-language procedures, you then need to reconcile any differences in the treatment of individual data types (strings, arrays, and so on). This is discussed in Exchanging and Accessing Data in Mixed-Language Programming .

> **Note:** This section uses the term "routine" in a generic way, to refer to functions, subroutines, and procedures from different languages.

Adjusting Calling Conventions in Mixed-Language Programming

The calling convention determines how a program makes a call to a routine, how the arguments are passed, and how the routines are named (discussed in the section on Adjusting Naming Conventions in Mixed-Language Programming). In a single-language program, calling conventions are nearly always correct, because there is one default for all routines and because header files or Fortran module files with interface blocks enforce consistency between the caller and the called routine.

In a mixed-language program, different languages cannot share the same header files. If, as a result, you link Fortran and C routines that use different calling conventions, the error is not apparent until the bad call is made at run-time. During execution, the bad call causes indeterminate results and/or a fatal error, often somewhere in the program that has no apparent relation to the actual cause: memory/stack corruption due to calling errors. Therefore, you should check carefully the calling conventions for each mixed-language call.

The discussion of calling conventions between languages applies only to external procedures. You cannot call internal procedures from outside the program unit that contains them.

A calling convention affects programming in five ways:

1. The caller routine uses a calling convention to determine the order in which to pass arguments to another routine; the called routine uses a calling convention to determine the order in which to receive the arguments passed to it. In Fortran, you can specify these conventions in a mixed-language interface with the **INTERFACE** statement or in a data or function declaration. 32-bit Visual C/C++ and Fortran both pass arguments in order from left to right.
2. The caller routine and the called routine use a calling convention to determine which of them is responsible for adjusting the stack in order to remove arguments when the execution of the called routine is complete. You can specify these conventions with ATTRIBUTES (*c***DEC$ ATTRIBUTES** compiler directive) options such as C or STDCALL.
3. The caller routine and the called routine use a calling convention to select the option of passing a variable number of arguments.
4. The caller routine and the called routine use a calling convention to pass arguments by value (values passed) or by reference (addresses passed). Individual Fortran arguments can also be designated with **ATTRIBUTES** option VALUE or REFERENCE.
5. The caller routine and the called routine use a calling convention to establish naming conventions for procedure names. You can establish any procedure name you want, regardless of its Fortran name, with the ALIAS directive (or **ATTRIBUTES** option ALIAS). This is useful because C anmd Basic are case sensitive, while Fortran is not.

Specific calling-convention issues are discussed in the following sections:

- ATTRIBUTES Properties and Calling Conventions
- Stack Considerations in Calling Conventions
- Fortran/C Calling Conventions
- Fortran/Visual Basic Calling Conventions
- Fortran/MASM Calling Conventions

ATTRIBUTES Properties and Calling Conventions

The ATTRIBUTES properties (or options) C, STDCALL, REFERENCE, VALUE, and VARYING all affect the calling convention of routines. You can specify:

- The C, STDCALL, REFERENCE, and VARYING properties for an entire routine.
- The VALUE and REFERENCE properties for individual arguments.

By default, Fortran passes all data by reference (except the hidden length argument of strings, which is passed by value). If the C or STDCALL option is used, the default changes to passing almost all data except arrays by value. However, in addition to the calling-convention options C and STDCALL, you can specify argument options, VALUE and REFERENCE, to pass arguments by value or by reference, regardless of the calling convention option. Arrays can only be passed by reference.

Different Fortran calling conventions can be specified by declaring the Fortran procedure to have certain attributes. For example, on ia32 systems:

```
INTERFACE
   SUBROUTINE MY_SUB (I)
       !DEC$ ATTRIBUTES C, ALIAS:'_My_Sub' :: MY_SUB   ! ia32 systems
       INTEGER I
   END SUBROUTINE MY_SUB
END INTERFACE
```

This code (on ia32 systems) declares a subroutine named `MY_SUB` with the C property and the external name `_My_Sub` set with the ALIAS property.

On ia64 systems, there is no leading underscore for external names like `MY_SUB`, so the correct !DEC$ ATTRIBUTES line is:

```
!DEC$ ATTRIBUTES C, ALIAS:'My_Sub' :: MY_SUB  ! ia64 systems
```

To write code for both ia32 and ia64 platforms, use the conditional compilation features of the IF Directive Construct, perhaps using the predefined preprocessor macros listed under the /define option (such as _M_IX86 and _M_IA64).

The following table summarizes the effect of the most common Fortran calling-convention directives.

Calling Conventions for ATTRIBUTES Options

	Default	**C**	**STDCALL**	**C, REFERENCE**	**STDCALL, REFERENCE**
Argument					
Scalar	Reference	Value	Value	Reference	Reference
Scalar [value]	Value	Value	Value	Value	Value
Scalar [reference]	Reference	Reference	Reference	Reference	Reference
String	Reference, either Len:Mixed or Len:End	String (1:1)	String (1:1)	Reference, either Len:Mixed or Len:End	Reference, either Len:Mixed or Len:End
String [value]	Error	String (1:1)	String (1:1)	String(1:1)	String(1:1)
String [reference]	Reference, either Len:Mixed or No Len	Reference, No Len	Reference, No Len	Reference, No Len	Reference, No Len
Array	Reference	Reference	Reference	Reference	Reference
Array [value]	Error	Error	Error	Error	Error
Array [reference]	Reference	Reference	Reference	Reference	Reference
Derived Type	Reference	Value, size dependent	Value, size dependent	Reference	Reference
Derived Type [value]	Value, size dependent	Value, size dependent	Value, size dependent	Value, size dependent	Value, size dependent
Derived Type [reference]	Reference	Reference	Reference	Reference	Reference

F90 Pointer	Descriptor	Descriptor	Descriptor	Descriptor	Descriptor
F90 Pointer [value]	Error	Error	Error	Error	Error
F90 Pointer [reference]	Descriptor	Descriptor	Descriptor	Descriptor	Descriptor
Procedure Name					
Suffix	*@n* (ia32 systems)	*none*	*@n* (ia32 systems)	*none*	*@n* (ia32 systems)
Case	Upper Case	Lower Case	Lower Case	Lower Case	Lower Case
Stack Cleanup	Callee	Caller	Callee	Caller	Callee

The terms in the above table mean the following:

[value]	Argument assigned the VALUE attribute.
[reference]	Argument assigned the REFERENCE attribute.
Value	The argument value is pushed on the stack. All values are padded to the next 4-byte boundary.
Reference	On ia32 systems, the 4-byte argument address is pushed on the stack. On ia64 systems, the 8-byte argument address is pushed on the stack.
Len:Mixed or Len:End	For certain string arguments: • Len:Mixed applies when /iface:mixed_str_len_arg is set. The length of the string is pushed (by value) on the stack immediately after the address of the beginning of the string. • Len:End applies when /iface:nomixed_str_len_arg is set. The length of the string is pushed (by value) on the stack after all of the other arguments.

Len:Mixed or No Len	For certain string arguments: • Len:Mixed applies when /iface:mixed_str_len_arg is set. The length of the string is pushed (by value) on the stack immediately after the address of the beginning of the string. • No Len applies when /iface:nomixed_str_len_arg is set. The length of the string is not available to the called procedure.
No Len	For string arguments, the length of the string is not available to the called procedure.
String(1:1)	For string arguments, the first character is converted to INTEGER(4) as in ICHAR(string(1:1)) and pushed on the stack by value.
Error	Produces a compiler error.
Descriptor	On ia32 systems, the 4-byte address of the array descriptor. On ia64 systems, the 8-byte address of the array descriptor.
@*n*	On ia32 systems, the at sign (@) followed by the number of bytes (in decimal) required for the argument list.
Size dependent	On ia32 systems, derived-type arguments specified by value are passed as follows: • Arguments from 1 to 4 bytes are passed by value. • Arguments from 5 to 8 bytes are passed by value in two registers (two arguments). • Arguments more than 8 bytes provide value semantics by passing a temporary storage address by reference.
Upper Case	Procedure name in all uppercase.
Lower Case	Procedure name in all lowercase.
Callee	The procedure being called is responsible for removing arguments from the stack before returning to the caller.
Caller	The procedure doing the call is responsible for removing arguments from the stack after the call is over.

The following table shows which Fortran ATTRIBUTES options match other language calling conventions.

Matching Calling Conventions

Other Language Calling Convention	Matching ATTRIBUTES Option
Visual C/C++ cdecl (default)	C
Visual C/C++ __stdcall	STDCALL
Visual Basic	none
Visual Basic CDECL keyword	C
MASM C (in PROTO and PROC declarations)	C
MASM STDCALL (in PROTO and PROC declarations)	STDCALL

The ALIAS option can be used with any other Fortran calling-convention option to preserve mixed-case names. You can also use the DECORATE option with ALIAS option so the external name specified in ALIAS has prefix and postfix decorations performed on it that are associated with the calling mechanism that is in effect.

Note: When interfacing to the Windows graphical user interface or making API calls, you will typically use STDCALL. See Creating Windows Applications for more information on Windows programming.

Stack Considerations in Calling Conventions

In the C calling convention, the calling routine always adjusts the stack immediately after the called routine returns control. This produces slightly larger object code because the code that restores the stack must exist at every point a procedure is called. In the STDCALL calling convention, the called procedure controls the stack. The code to restore the stack resides in the called procedure, so the code needs to appear only once.

However, the C calling convention makes calling with a variable number of arguments possible. Since in the C calling convention the caller cleans up the stack, it is possible to write a routine with a variable number of arguments. Therefore, it has the same address relative to the frame pointer, regardless of how many arguments are actually passed. Because of this, when the calling routine controls the stack, it knows how many arguments it passed, how big they are and where they reside in the stack. It can thus skip passing an argument and still keep track.

You can call routines with a variable number of arguments by including the **ATTRIBUTES** C and VARYING options in your interface to a routine. The VARYING option prevents Fortran from enforcing a matching number of arguments in routines. The VARYING option is not necessary with intrinsic Fortran 90 routines with optional arguments, where argument order and/or keywords determine which arguments are present and which are absent.

In MASM, stack control is also set by the C or STDCALL convention declared for the procedure, but you can write MASM code to control the stack within the procedure any way you wish. In addition, you can specify the USES option in the PROC directive to save and restore certain registers automatically.

Fortran / C Calling Conventions

In C and Visual C++ modules, you can specify the STDCALL calling convention by using the *__stdcall* keyword in a function prototype or definition. The *__stdcall* convention is also used by window procedures and API functions. As an example, the following C language prototype sets up a function call to a subroutine using the STDCALL calling convention:

```
extern void __stdcall FORTRAN_ROUTINE (int n);
```

Alternatively, instead of changing the calling convention of the C code, you can adjust the Fortran source code by using the C option. This is set with the ATTRIBUTES directive. For example, the following declaration assumes the subroutine is called with the C calling convention:

```
SUBROUTINE CALLED_FROM_C (A)
   !DEC$ ATTRIBUTES C :: CALLED_FROM_C
   INTEGER A
```

Fortran / Visual Basic Calling Conventions

You establish Fortran subroutines and functions in Visual Basic forms and the Fortran routines are then invoked from a Basic module. A Fortran routine has to be a DLL (dynamic-link library) to be called from Basic. For more information on DLLs, see Fortran Dynamic-Link Library Projects and Creating Fortran DLLs.

The calling-convention ALIAS directive (or ATTRIBUTES property ALIAS) is needed if mixed-case names are to be preserved (by default Fortran translates names to all uppercase). However, two special cases require different treatment:

- If a varying number of arguments are to be passed, the C and VARYING properties are needed in the Fortran procedure definition and the CDECL keyword needed in the Basic DECLARE statement in order to establish the

C calling and naming convention.
- When passing character arguments, the Fortran routine must not pass the hidden length of character arguments, such as by using the **ATTRIBUTES** property STDCALL for the routine and specifying the REFERENCE property for any character arguments. Since STDCALL also lowercases Fortran names, the Fortran subprogram name should be referenced in lowercase from the Visual Basic program.

The following Fortran and Visual Basic statements establish an example Fortran function to be called from Basic:

```
!  Fortran Subprogram establishing Fortran function.
       INTERFACE
          DOUBLE PRECISION FUNCTION GetFVal (r1)
             !DEC$ ATTRIBUTES ALIAS:'GetFVal' :: GetFVal
             !DEC$ ATTRIBUTES VALUE :: r1
             REAL r1
          END FUNCTION
       END INTERFACE

'FORM.FRM Basic Form to establish Fortran function
Declare Function GetFVal Lib "C:\f90\FVAL.DLL" (ByVal r1 As Single) As Double
```

Fortran / MASM Calling Conventions

You specify the calling convention for a MASM procedure in the PROTO and PROC directives. The STDCALL option in the PROTO and PROC directives tells the procedure to use the STDCALL calling convention. The C option in the PROTO and PROC directives tells the procedure to use the C calling convention. The USES option in the PROC directive specifies which registers to save and restore in the called MASM routine. The VARARG option to the PROTO and PROC directives specifies that the procedure allows a variable number of arguments.

For example, the following Fortran and MASM statements set up a MASM function that can be called from Visual Fortran, using the STDCALL calling convention:

```
! Fortran STDCALL interface prototype.
      INTERFACE
         INTEGER FUNCTION forfunc(I1, I2)
         !DEC$ ATTRIBUTES STDCALL :: forfunc
         INTEGER I1
         INTEGER(2) I2
      END INTERFACE
      WRITE (*,*) forfunc(I1,I2)
! End Fortran STDCALL interface

;MASM STDCALL Prototype
        .MODEL FLAT, STDCALL
forfunc PROTO STDCALL, forint: SDWORD, shorti: ptr SWORD
        .CODE
forfunc PROC STDCALL, forint: SDWORD, shorti: ptr SWORD
        ...
forfunc ENDP END
```

The following Fortran and MASM statements set up a Fortran-callable MASM function using the C calling convention:

```
! Fortran C interface prototype
     INTERFACE
        INTEGER FUNCTION Forfunc (I1, I2)
        !DEC$ ATTRIBUTES C, ALIAS:'Forfunc' :: Forfunc
        INTEGER I1
        INTEGER(2) I2
     END INTERFACE
     WRITE(*,*) Forfunc (I1, I2)
     END
! End Fortran C interface

;MASM C PROTOTYPE
        .MODEL FLAT, C
 Forfunc PROTO C, forint:SDWORD, shorti: ptr SWORD
        .CODE
 Forfunc PROC C, forint:SDWORD, shorti: ptr SWORD
        ...
 Forfunc ENDP END
```

Adjusting Naming Conventions in Mixed-Language Programming

The ATTRIBUTES options C and STDCALL determine naming conventions as well as calling conventions. Calling conventions specify how arguments are moved and stored; naming conventions specify how symbol names are altered when placed in an .OBJ file. Names are an issue for external data symbols shared among parts of the same program as well as among external routines. Symbol names (such as the name of a subroutine) identify a memory location that must be consistent among all calling routines.

Parameter names (names given in a procedure definition to variables that are passed to it) are never affected.

Names are altered because of case sensitivity (in C, Visual Basic, and MASM), lack of case sensitivity (in Fortran), name decoration (in Visual C++), or other issues. If naming conventions are not reconciled, the program cannot successfully link and you will receive an "unresolved external" error.

This section discusses:

- Visual C/C++ and Visual Basic Naming Conventions
- MASM Naming Conventions
- Naming Conventions for Fortran, C, Visual C++, Visual Basic, and MASM
- Reconciling the Case of Names
- Fortran Module Names and ATTRIBUTES

Visual C/C++ and Visual Basic Naming Conventions

Visual C/C++ and Visual Basic preserve case sensitivity in their symbol tables while Fortran by default does not, a difference that requires attention. Fortunately, you can use the Fortran directive **ATTRIBUTES** ALIAS option to resolve discrepancies between names, to preserve mixed-case names, or to override the automatic conversion of names to all uppercase by the Fortran default naming, or the automatic conversion to all lowercase by Fortran's STDCALL and C naming convention.

Visual C++ uses the same calling convention and argument-passing techniques as C, but naming conventions are different because of Visual C++ decoration of external symbols. When the C++ code resides in a `.cpp` file (created when you select C/C++ file from the visual development environment), C++ name decoration semantics are applied to external names, often resulting in linker errors. The extern "C" syntax makes it possible for a Visual C++ module to share data and routines with other languages by causing Visual C++ to drop name decoration.

The following example declares prn as an external function using the C naming convention. This declaration appears in Visual C++ source code:

```
extern "C" { void prn(); }
```

To call functions written in Fortran, declare the function as you would in C and use a "C" linkage specification. For example, to call the Fortran function FACT from Visual C++, declare it as follows:

```
extern "C" { int __stdcall FACT( int n ); }
```

The extern "C" syntax can be used to adjust a call from Visual C++ to other languages, or to change the naming convention of Visual C++ routines called from other languages. However, extern "C" can only be used from within Visual C++. If the Visual C++ code does not use extern "C" and cannot be changed, you can call Visual C++ routines only by determining the name decoration and generating it from the other language. Such an approach should only be used as a last resort, because the decoration scheme is not guaranteed to remain the same between versions.

Use of extern "C" has some restrictions:

- You cannot declare a member function with extern "C".
- You can specify extern "C" for only one instance of an overloaded function; all other instances of an overloaded function have Visual C++ linkage.

For more information on the extern "C" linkage specification, see the *Microsoft Visual C++ Language Reference*.

MASM Naming Conventions

In MASM (Microsoft Assembler, for ia32 systems), specifying the C or STDCALL naming convention in PROC and PROTO statements preserves case sensitivity if no CASEMAP option exists. The MASM OPTION CASEMAP directive (and the command line option /C) also sets case sensitivity and overrides naming conventions specified within PROTO and PROC statements:

- CASEMAP: NONE (equivalent to /Cx) preserves the case of identifiers in PUBLIC, COMM, EXTERNDEF, EXTERN, PROTO, and PROC declarations.
- CASEMAP: NOTPUBLIC (equivalent to /Cp) preserves the case of all user identifiers; this is the default.
- CASEMAP: ALL (equivalent to /Cu) translates all identifiers to uppercase.

Naming Conventions for Fortran, C, Visual C++, Visual Basic, and MASM

The following table summarizes how Fortran, Visual C/C++, Visual Basic and MASM handle procedure names. Note that for MASM, the table does not apply if the CASEMAP: ALL option is used.

Naming Conventions in Fortran, C, Visual C++, Visual Basic, and MASM

Language	**Attributes**	**Name Translated As**	**Case of Name in .OBJ File**
Fortran	*c***DEC$ ATTRIBUTES** C	*_name*	All lowercase
Fortran	*c***DEC$ ATTRIBUTES** STDCALL	*_name@n*	All lowercase
Fortran	default	*_name@n*	All uppercase
C	cdecl (default)	*_name*	Mixed case preserved
C	__stdcall	*_name@n*	Mixed case preserved
Visual C++	Default	*_name@@decoration*	Mixed case preserved
Visual Basic	Default	*_name@n*	Mixed case preserved

MASM	C (in PROTO and PROC declarations)	*_name*	Mixed case preserved
MASM	STDCALL (in PROTO and PROC declarations)	*_name@n*	Mixed case preserved

In the preceding table:

- The leading underscore (such as *_name*) is used on ia32 systems only (not on ia64 systems).
- *@n* represents the stack space, in decimal notation, occupied by parameters on ia32 only (not on ia64 systems).

For example, assume a function is declared in C as:

```
extern int __stdcall Sum_Up( int a, int b, int c );
```

Each integer occupies 4 bytes, so the symbol name placed in the .OBJ file on ia32 systems is:

```
_Sum_Up@12
```

On ia64 systems, the symbol name placed in the .OBJ file is:

```
Sum_Up
```

Reconciling the Case of Names

The following summarizes how to reconcile names between languages:

- All-Uppercase Names

  If you call a Fortran routine that uses Fortran defaults and cannot recompile the Fortran code, then in C and Visual Basic you must use an all-uppercase name to make the call. In MASM you must either use an all-uppercase name or set the OPTION CASEMAP directive to ALL, which translates all identifiers to uppercase. Use of the __stdcall convention in C code or STDCALL in MASM PROTO and PROC declarations is not enough, because __stdcall and STDCALL always preserve case in these languages. Fortran generates all-uppercase names by default and the C or MASM code must match it.

  For example, these prototypes establish the Fortran function FFARCTAN (angle) where the argument angle has the **ATTRIBUTES** VALUE property:

  - In C:

```
extern float __stdcall FFARCTAN( float angle );
```

- In Visual Basic:

```
 Declare Function FFARCTAN Lib "C:\f90ps\FBAS.DLL" (ByVal angle As Singl
```

- In MASM:

```
.MODEL FLAT, STDCALL
FFARCTAN PROTO STDCALL, angle: REAL4
...
FFARCTAN PROC STDCALL, angle: REAL4
```

- All-Lowercase Names

  If the name of the routine appears as all lowercase in C or MASM, then naming conventions are automatically correct when the C or STDCALL option is used in the Fortran declaration. Any case may be used in the Fortran source code, including mixed case since the C and STDCALL options change the name to all lowercase. You cannot call a Visual Basic routine from Fortran directly (see Fortran/Visual Basic Mixed-Language Programs), so Basic routine names are never translated.

- Mixed-Case Names

  If the name of a routine appears as mixed-case in C or MASM and you cannot change the name, then you can resolve this naming conflict by using the Fortran **ATTRIBUTES** ALIAS option. ALIAS is required in this situation because otherwise Fortran will not preserve the mixed-case name.

  To use the ALIAS option, place the name in quotation marks exactly as it is to appear in the .OBJ file. The following is an example on ia32 systems for referring to the C function My_Proc:

```
!DEC$ ATTRIBUTES ALIAS:'_My_Proc' :: My_Proc
```

  On ia64 systems, this would be coded without the leading underscore as:

```
!DEC$ ATTRIBUTES ALIAS:'My_Proc' :: My_Proc
```

Fortran Module Names and ATTRIBUTES

Fortran module entities (data and procedures) have external names that differ from other external entities. Module names use the convention:

_MODULENAME_mp_ENTITY [@stacksize]

MODULENAME is the name of the module and is all uppercase by default. *ENTITY* is the name of the module procedure or module data contained within *MODULENAME*. *ENTITY* is also uppercase by default. *_mp_* is the separator between the module and entity names and is always lowercase.

For example:

```
MODULE mymod
   INTEGER a
CONTAINS
   SUBROUTINE b (j)
      INTEGER j
   END SUBROUTINE
END MODULE
```

This results in the following symbols being defined in the compiled .OBJ file on ia32 systems:

```
_MYMOD_mp_A
_MYMOD_mp_B@4
```

Or, on ia64 systems:

```
MYMOD_mp_A
MYMOD_mp_B
```

Compiler options can affect the naming of module data and procedures.

Note: Except for ALIAS, **ATTRIBUTES** options do not affect the module name, which remains uppercase.

The following table shows how each ATTRIBUTES option affects the subroutine in the previous example module.

Effect of ATTRIBUTES options on Fortran Module Names

ATTRIBUTES Option Given to Routine 'b'	Procedure Name in .OBJ file on ia32 Systems	Procedure Name in .OBJ file on ia64 Systems
None	_MYMOD_mp_B@4	MYMOD_mp_B
C	_MYMOD_mp_b	MYMOD_mp_b
STDCALL	_MYMOD_mp_b@4	MYMOD_mp_b

ALIAS	Overrides all others, name as given in the alias	Overrides all others, name as given in the alias
VARYING	No effect on name	No effect on name

You can write code to call Fortran modules or access module data from other languages. As with other naming and calling conventions, the module name must match between the two languages. Generally, this means using the C or STDCALL convention in Fortran, and if defining a module in another language, using the ALIAS option to match the name within Fortran. Examples are given in the section Using Modules in Mixed-Language Programming.

Prototyping a Procedure in Fortran

You define a prototype (interface block) in your Fortran source code to tell the Fortran compiler which language conventions you want to use for an external reference. The interface block is introduced by the **INTERFACE** statement. See Program Units and Procedures, for a more detailed description of the **INTERFACE** statement.

The general form for the **INTERFACE** statement is:

> **INTERFACE**
> *routine statement*
> [*routine* ***ATTRIBUTE*** *options*]
> [*argument* ***ATTRIBUTE*** *options*]
> *formal argument declarations*
> **END** *routine name*
> **END INTERFACE**
>
> The *routine statement* defines either a **FUNCTION** or a **SUBROUTINE**, where the choice depends on whether a value is returned or not, respectively. The optional *routine* ***ATTRIBUTE*** *options* (such as C and STDCALL) determine the calling, naming, and argument-passing conventions for the routine in the prototype statement. The optional *argument* ***ATTRIBUTE*** *options* (such as VALUE and REFERENCE) are properties attached to individual arguments. The *formal argument declarations* are Fortran data type declarations. Note that the same **INTERFACE** block can specify more than one procedure.

For example, suppose you are calling a C function that has the following prototype:

```
extern void My_Proc (int i);
```

The Fortran call to this function should be declared with the following **INTERFACE** block on ia32 systems:

```
INTERFACE
   SUBROUTINE my_Proc (I)
    !DEC$ ATTRIBUTES C, ALIAS:'_My_Proc' :: my_Proc
    INTEGER I
   END SUBROUTINE my_Proc
END INTERFACE
```

Note that:

- On ia64 systems, the leading underscore in `_My_Proc` should be omitted. The **ATTRIBUTES** line on ia64 systems contains:

  ```
  !DEC$ ATTRIBUTES C, ALIAS:'My_Proc' :: my_Proc
  ```

- Except in the ALIAS string, the case of My_Proc in the Fortran program does not matter.

Exchanging and Accessing Data in Mixed-Language Programming

You can use several approaches to sharing data between mixed-language routines, which can be used within the individual languages as well. These approaches are:

- Passing Arguments in Mixed-Language Programming
- Using Modules in Mixed-Language Programming
- Using Common External Data in Mixed-Language Programming

Generally, if you have a large number of parameters to work with or you have a large variety of parameter types, you should consider using modules or external data declarations. This is true when using any given language, and to an even greater extent when using mixed languages.

Passing Arguments in Mixed-Language Programming

You can pass data between Fortran and C, Visual C++, Visual Basic, and MASM through calling argument lists just as you can within each language (for example, the argument list a, b and c in CALL MYSUB(a,b,c)). There are two ways to pass individual arguments:

- *By value*, which passes the argument's value.
- *By reference*, which passes the address of the arguments. On ia32 systems, Fortran, Visual Basic, C, and Visual C++ use 4-byte addresses. On ia64 systems, Fortran uses 8-byte addresses.

You need to make sure that for every call, the calling program and the called routine agree on how each argument is passed. Otherwise, the called routine receives bad data.

The Fortran technique for passing arguments changes depending on the calling convention specified. By default, Fortran passes all data by reference (except the hidden length argument of strings, which is passed by value).

If the ATTRIBUTES C or STDCALL option is used, the default changes to passing all data by value except arrays. If the procedure has the REFERENCE option as well as the C or STDCALL option, all arguments by default are passed by reference.

In Fortran, in addition to establishing argument passing with the calling-convention options C and STDCALL, you can specify argument options, VALUE and REFERENCE, to pass arguments by value or by reference. In mixed-language programming, it is a good idea to specify the passing technique explicitly rather than relying on defaults.

> **Note:** In addition to **ATTRIBUTES**, the compiler option /iface also establishes some default argument passing conventions (such as for hidden length of strings).

Examples of passing by reference and value for C, Visual Basic and MASM follow. All are interfaces to the example Fortran subroutine `TESTPROC` below. The definition of `TESTPROC` declares how each argument is passed. The REFERENCE option is not strictly necessary in this example, but using it makes the argument's passing convention conspicuous.

```
SUBROUTINE TESTPROC( VALPARM, REFPARM )
   !DEC$ ATTRIBUTES VALUE :: VALPARM
   !DEC$ ATTRIBUTES REFERENCE :: REFPARM
   INTEGER VALPARM
   INTEGER REFPARM
END SUBROUTINE
```

- Fortran/C example of arguments passed by value and reference

  In C and Visual C++ all arguments are passed by value, except arrays, which are passed by reference to the address of the first member of the array. Unlike Fortran, C and Visual C++ do not have calling-convention directives to affect the way individual arguments are passed. To pass non-array C data by reference, you must pass a pointer to it. To pass a C array by value, you must declare it as a member of a structure and pass the structure. The following C declaration sets up a call to the example Fortran `TESTPROC` subroutine:

```
extern void __stdcall TESTPROC( int ValParm, int *RefParm );
```

- Fortran/Visual Basic example of arguments passed by value and reference

  In Visual Basic, arguments are passed by reference by default. To pass arguments by value, you use the keyword BYVAL in front of the argument in the DECLARE statement. For example:

  ```
  Declare Sub TESTPROC Lib "C:\f90\TESTPROC.DLL"

      (ByVal Valparm As Long, Refparm As Long)
  ```

  Strings are a special case (see the discussion on character strings in Handling Character Strings).

  Arrays of numbers require special handling (see data type considerations in Calling Visual Fortran from Visual Basic.

- Fortran/MASM example of arguments passed by value and reference

  In MASM, arguments are passed by value by default. Arguments to be passed by reference are designated with PTR in the PROTO and PROC directives. For example:

  ```
  TESTPROC PROTO STDCALL, valparm: SDWORD, refparm: PTR SDWORD
  ```

  To use an argument passed by value, use the value of the variable. For example:

  ```
  mov eax, valparm ; Load value of argument
  ```

  This statement places the value of valparm into the EAX register.

  To use an argument passed by reference, use the address of the variable. For example:

  ```
  mov ecx, refparm ; Load address of argument
  mov eax, [ecx]   ; Load value of argument
  ```

  These statements place the value of refparm into the EAX register.

The following table summarizes how to pass arguments by reference and value. An array name in C is equated to its starting address because arrays are normally passed by reference. You can assign the REFERENCE property to a procedure, as well as to individual arguments.

Passing Arguments by Reference and Value

Language	ATTRIBUTE	Argument Type	To Pass by Reference	To Pass by Value
Fortran	Default	Scalars and derived types	Default	VALUE option
	C or STDCALL option	Scalars and derived types	REFERENCE option	Default
	Default	Arrays	Default	Cannot pass by value
	C or STDCALL option	Arrays	Default	Cannot pass by value
Visual C/C++		Non-arrays	Pointer argument_name	Default
		Arrays	Default	Struct {type} array_name
Visual Basic		All types	Default	ByVal
Assembler (ia32) MASM		All types	PTR	Default

This table does not describe argument passing of strings and Fortran 95/90 pointer arguments in Visual Fortran, which are constructed differently than other arguments. By default, Fortran passes strings by reference along with the string length. String length placement depends on whether the compiler option /iface:mixed_str_len_arg (immediately after the address of the beginning of the string) or /iface:nomixed_str_len_arg (after all arguments) is set.

Fortran 95/90 array pointers and assumed-shape arrays are passed by passing the address of the array descriptor.

For a discussion of the effect of attributes on passing Fortran 95/90 pointers and strings, see Handling Fortran 90 Pointers and Allocatable Arrays and Handling Character Strings.

Using Modules in Mixed-Language Programming

Modules are the simplest way to exchange large groups of variables with C, because Visual Fortran modules are directly accessible from Visual C/C++. The following example declares a module in Fortran, then accesses its data from C.

The Fortran code:

```
! F90 Module definition
    MODULE EXAMP
       REAL A(3)
       INTEGER I1, I2
       CHARACTER(80) LINE
       TYPE MYDATA
          SEQUENCE
          INTEGER N
          CHARACTER(30) INFO
       END TYPE MYDATA
    END MODULE EXAMP
```

The C code:

```
\* C code accessing module data *\
extern float EXAMP_mp_A[3];
extern int EXAMP_mp_I1, EXAMP_mp_I2;
extern char EXAMP_mp_LINE[80];
extern struct {
           int N;
           char INFO[30];
} EXAMP_mp_MYDATA;
```

When the C++ code resides in a `.cpp` file (created when you select C/C++ file from the visual development environment), C++ semantics are applied to external names, often resulting in linker errors. In this case, use the extern "C" syntax (see Visual C/C++ and Visual Basic Naming Conventions):

```
\* C code accessing module data in .cpp file*\
extern "C" float EXAMP_mp_A[3];
extern "C" int EXAMP_mp_I1, EXAMP_mp_I2;
extern "C" char EXAMP_mp_LINE[80];
extern "C" struct {
           int N;
           char INFO[30];
} EXAMP_mp_MYDATA;
```

You can also define a module procedure in C and make that routine part of a Fortran module by using the ALIAS directive. The C code:

```
 // C procedure
void pythagoras (float a, float b, float *c)
{
    *c = (float) sqrt(a*a + b*b);
}
```

Using the same example when the C++ code resides in a `.cpp` file, use the extern "C" syntax (see Visual C/C++ and Visual Basic Naming Conventions):

```
// C procedure
extern "C" void pythagoras (float a, float b, float *c)
{
    *c = (float) sqrt(a*a + b*b);
}
```

The Fortran code to define the module CPROC:

```
   ! Fortran 95/90 Module including procedure
      MODULE CPROC
         INTERFACE
            SUBROUTINE PYTHAGORAS (a, b, res)
             !DEC$ ATTRIBUTES C :: PYTHAGORAS
             !DEC$ ATTRIBUTES REFERENCE :: res
  ! res is passed by REFERENCE because its individual attribute
  ! overrides the subroutine's C attribute
               REAL a, b, res
  ! a and b have the VALUE attribute by default because
  ! the subroutine has the C attribute
            END SUBROUTINE
         END INTERFACE
      END MODULE
```

The Fortran code to call this routine using the module CPROC:

```
   ! Fortran 95/90 Module including procedure
      USE CPROC
         CALL PYTHAGORAS (3.0, 4.0, X)
         TYPE *,X
      END
```

Using Common External Data in Mixed-Language Programming

Common external data structures include Fortran common blocks, and C structures and variables that have been declared global or external. All of these data specifications create external variables, which are variables available to routines outside the routine that defines them.

This section applies only to Fortran/C and Fortran/MASM mixed-language programs because there is no way to share common data with Visual Basic. You must pass all data between Visual Basic and Fortran as arguments. This process can be streamlined by passing user-defined types between them, described in Handling User-Defined Types.

External variables are case sensitive, so the cases must be matched between different languages, as discussed in the section on naming conventions. Common external data exchange is described in the following sections:

- Using Global Variables
- Using Fortran Common Blocks and C Structures

Using Global Variables in Mixed-Language Programming

A variable can be shared between Fortran and C or MASM by declaring it as global (or **COMMON**) in one language and accessing it as an external variable in the other language. Visual Basic cannot access another language's global data or share its own. In Fortran/Basic programs, variables must be passed as arguments.

In Fortran, a variable can access a global parameter by using the EXTERN option for ATTRIBUTES. For example:

```
!DEC$ ATTRIBUTES C, EXTERN :: idata
INTEGER idata (20)
```

EXTERN tells the compiler that the variable is actually defined and declared global in another source file. If Fortran declares a variable external with EXTERN, the language it shares the variable with must declare the variable global.

In C, a variable is declared global with the statement:

```
int idata[20]; // declared as global (outside of any function)
```

MASM declares a parameter global (PUBLIC) with the syntax:

PUBLIC [*langtype*] *name*

where *name* is the name of the global variable to be referenced, and the optional *langtype* is STDCALL or C. The option *langtype*, if present, overrides the calling convention specified in the .MODEL directive.

Conversely, Fortran can declare the variable global (**COMMON**) and other languages can reference it as external:

```
! Fortran declaring PI global
 REAL PI
 COMMON /PI/ PI ! Common Block and variable have the same name
```

In C, the variable is referenced as an external with the statement:

```
//C code with external reference to PI
extern float PI;
```

Note that the global name C references is the name of the Fortran common block, not the name of a variable within a common block. Thus, you cannot use blank common to make data accessible between C and Fortran. In the preceding example, the common block and the variable have the same name, which helps keep track of the variable between the two languages. Obviously, if a common block contains more than one variable they cannot all have the common block name. (See Using Fortran Common Blocks and C Structures.)

MASM can also access Fortran global (**COMMON**) parameters with the **ATTRIBUTES** EXTERN directive. The syntax is:

EXTERN [*langtype*] *name*

where *name* is the name of the global variable to be referenced, and the optional *langtype* is STDCALL or C.

Using Fortran Common Blocks and C Structures

To reference C structures from Fortran common blocks and vice versa, you must take into account the way the common blocks and structures differ in their methods of storing member variables in memory. Fortran places common block variables into memory in order as close together as possible, with the following rules:

- A single BYTE, INTEGER(1), LOGICAL(1), or CHARACTER variable in common block list begins immediately following the previous variable or array in memory.
- All other types of single variables begin at the next even address immediately following the previous variable or array in memory.
- All arrays of variables begin on the next even address immediately following the previous variable or array in memory, except for CHARACTER arrays which always follow immediately after the previous variable or array.
- All common blocks begin on a four-byte aligned address.

Because of these padding rules, you must consider the alignment of C structure elements with Fortran common block elements and assure matching either by making all variables exactly equivalent types and kinds in both languages (using only 4-byte and 8-byte data types in both languages simplifies this) or by using the C pack pragmas in the C code around the C structure to make C data packing like Fortran's. For example:

```
#pragma pack(2)
struct {
        int N;
        char INFO[30];
} examp;
#pragma pack()
```

To restore the original packing, you must add #pragma pack( ) at the end of the structure. (Remember: Fortran module data can be shared directly with C structures with appropriate naming.)

Once you have dealt with alignment and padding, you can give C access to an entire common block or set of common blocks. Alternatively, you can pass individual members of a Fortran common block in an argument list, just as you can any other data item. Use of common blocks for mixed-language data exchange is discussed in the following sections:

- Accessing Common Blocks and C Structures Directly

- Passing the Address of a Common Block

Accessing Common Blocks and C Structures Directly

You can access Fortran common blocks directly from C by defining an external C structure with the appropriate fields, and making sure that alignment and padding between Fortran and C are compatible. The C and ALIAS **ATTRIBUTES** options can be used with a common block to allow mixed-case names.

As an example, suppose your Fortran code has a common block named `Really`, as shown:

```
!DEC$ ATTRIBUTES ALIAS:'Really' :: Really
REAL(4) x, y, z(6)
REAL(8) ydbl
COMMON / Really / x, y, z(6), ydbl
```

You can access this data structure from your C code with the following external data structure:

```
#pragma pack(2)
extern struct {
  float x, y, z[6];
  double ydbl;
} Really;
#pragma pack()
```

You can also access C structures from Fortran by creating common blocks that correspond to those structures. This is the reverse case from that just described. However, the implementation is the same because after common blocks and structures have been defined and given a common address (name), and assuming the alignment in memory has been dealt with, both languages share the same memory locations for the variables.

Passing the Address of a Common Block

To pass the address of a common block, simply pass the address of the first variable in the block, that is, pass the first variable by reference. The receiving C or Visual C++ module should expect to receive a structure by reference.

In the following example, the C function `initcb` receives the address of a common block with the first variable named `n`, which it considers to be a pointer to a structure with three fields:

Fortran source code:

```
!
  INTERFACE
     SUBROUTINE initcb (BLOCK)
        !DEC$ ATTRIBUTES C :: initcb
        !DEC$ ATTRIBUTES REFERENCE :: BLOCK
```

```
      INTEGER BLOCK
    END SUBROUTINE
  END INTERFACE
!
  INTEGER n
  REAL(8) x, y
  COMMON /CBLOCK/n, x, y
    .  .  .
  CALL initcb( n )
```

C source code:

```
//
#pragma pack(2)
struct block_type
{
  int n;
  double x;
  double y;
};
#pragma pack()
//
void initcb( struct block_type *block_hed )
 {
   block_hed->n = 1;
   block_hed->x = 10.0;
   block_hed->y = 20.0;
}
```

Handling Data Types in Mixed-Language Programming

Even when you have reconciled calling conventions, naming conventions, and methods of data exchange, you must still be concerned with data types, because each language handles them differently. The following table lists the equivalent data types among Fortran, C, Visual Basic, and MASM:

Equivalent Data Types

Fortran Data Type	C Data Type	Visual Basic Data Type	MASM Data Type
INTEGER(1)	char	---	SBYTE
INTEGER(2)	short	Integer	SWORD
INTEGER(4)	int, long	Long	SDWORD
INTEGER(8)	_int64	---	QWORD
REAL(4)	float	Single	REAL4
REAL(8)	double	Double	REAL8

CHARACTER(1)	unsigned char	---	BYTE
CHARACTER*(*)	See Handling Character Strings		
COMPLEX(4)	struct complex4 { float real, imag; };	---	COMPLEX4 STRUCT 4 real REAL4 0 imag REAL4 0 COMPLEX4 ENDS
COMPLEX(8)	struct complex8 { double real, imag; };	---	COMPLEX8 STRUCT 8 real REAL8 0 imag REAL8 0 COMPLEX8 ENDS
All LOGICAL types	Use integer types for C, MASM, and Visual Basic		

The following sections describe how to reconcile data types between the different languages:

- Handling Numeric, Complex, and Logical Data Types
- Handling Fortran 90 Array Pointers and Allocatable Arrays
- Handling Compaq Fortran Pointers
- Handling Arrays and Visual Fortran Array Descriptors
- Handling Character Strings
- Handling User-Defined Types

Handling Numeric, Complex, and Logical Data Types

Normally, passing numeric data does not present a problem. If a C program passes an unsigned data type to a Fortran routine, the routine can accept the argument as the equivalent signed data type, but you should be careful that the range of the signed type is not exceeded.

The table of Equivalent Data Types summarizes equivalent numeric data types for Fortran, MASM, and Visual Visual C/C++.

C, Visual C++, and MASM do not directly implement the Fortran types COMPLEX (4) and COMPLEX(8). However, you can write structures that are equivalent. The type COMPLEX(4) has two fields, both of which are 4-byte floating-point numbers; the first contains the real-number component, and the second contains the imaginary-number component. The type COMPLEX is equivalent to the type COMPLEX(4). The type COMPLEX(8) is similar except that each field contains an 8-byte floating-point number.

Note: On ia32 systems, Fortran functions of type COMPLEX place a hidden COMPLEX argument at the beginning of the argument list. C functions that implement such a call from Fortran must declare this hidden argument explicitly, and use it to return a value. The C return type should be void.

Following are the Visual C/C++ structure definitions for the Fortran COMPLEX types:

```
struct complex4 {
   float real, imag;
};
struct complex8 {
   double real, imag;
};
```

The MASM structure definitions for the Fortran COMPLEX types follow:

```
COMPLEX4 STRUCT 4
  real REAL4 0
  imag REAL4 0
COMPLEX4 ENDS
COMPLEX8 STRUCT 8
  real REAL8 0
  imag REAL8 0
COMPLEX8 ENDS
```

A Fortran LOGICAL(2) is stored as a 2-byte indicator value (0=false, and the /fpscomp:[no]logicals compiler option determines how true values are handled). A Fortran LOGICAL(4) is stored as a 4-byte indicator value, and LOGICAL(1) is stored as a single byte. The type LOGICAL is the same as LOGICAL(4), which is equivalent to type int in C.

You can use a variable of type LOGICAL in an argument list, module, common block, or global variable in Fortran and type int in C for the same argument. Type LOGICAL(4) is recommended instead of the shorter variants for use in common blocks.

The Visual C++ class type has the same layout as the corresponding C struct type, unless the class defines virtual functions or has base classes. Classes that lack those features can be passed in the same way as C structures.

Handling Fortran 95/90 Array Pointers and Allocatable Arrays

How Fortran 95/90 array pointers and arrays are passed is affected by the **ATTRIBUTES** options in effect, and by the **INTERFACE**, if any, of the procedure they are passed to. If the **INTERFACE** declares the array pointer or array with deferred shape (for example, ARRAY(:)), its descriptor is passed. This is true for array pointers and all arrays, not just allocatable arrays. If the **INTERFACE** declares the array pointer or array with fixed shape, or if there is no interface, the array pointer or array is passed by base address of a contiguous array for non-contiguous array slices, which is like passing the first element of an array.

When a Fortran 95/90 array pointer or array is passed to another language, either its descriptor or its base address can be passed.

The following shows how allocatable arrays and Fortran 95/90 array pointers are passed with different attributes in effect:

- If the property of the array pointer or array is none, it is passed by descriptor, regardless of the property of the passing procedure (None; C; STDCALL; C, REFERENCE; or STDCALL, REFERENCE).
- If the property of the array pointer or array is VALUE, an error is returned, regardless of the property of the passing procedure.
- If the property of the array pointer or array is REFERENCE, it is passed by descriptor, regardless of the property of the passing procedure.

Note that the VALUE option cannot be used with descriptor-based arrays.

When you pass a Fortran array pointer or an array by descriptor to a non-Fortran routine, that routine needs to know how to interpret the descriptor. Part of the descriptor is a pointer to address space, as a C pointer, and part of it is a description of the pointer or array properties, such as its rank, stride, and bounds.

For information about the Visual Fortran array descriptor format, see Handling Arrays and Visual Fortran Array Descriptors.

Fortran 95/90 pointers that point to scalar data contain the address of the data and are not passed by descriptor.

For information about performance implications of passing different types of array arguments, see Use Arrays Efficiently.

Handling Compaq Fortran Pointers

Compaq Fortran (integer) pointers are not the same as Fortran 90 pointers, but are instead like C pointers. On ia32 systems, Compaq Fortran pointers are 4-byte **INTEGER** quantities. On ia64 systems, Compaq Fortran pointers are 8-byte **INTEGER** quantities.

When passing a Compaq Fortran pointer to a routine written in another language:

- The argument should be declared in the non-Fortran routine as a pointer of the appropriate data type.
- The argument passed from the Fortran routine should be the Compaq

Fortran pointer name, not the pointer-based variable name.

For example, on ia32 systems:

```
! Fortran main program.
     INTERFACE
        SUBROUTINE Ptr_Sub (p)
        !DEC$ ATTRIBUTES C, ALIAS:'_Ptr_Sub' :: Ptr_Sub
           INTEGER p
        END SUBROUTINE Ptr_Sub
     END INTERFACE
     REAL A(10), VAR(10)
     POINTER (p, VAR) ! VAR is the pointer-based
                      ! variable, p is the int.
     p = LOC(A)

     CALL Ptr_Sub (p)
     WRITE(*,*) 'A(4) = ', A(4)
     END
 !

 //C subprogram
     void Ptr_Sub (float *p)
     {
        p[3] = 23.5;
     }
```

On ia64 systems, the alias name for `Ptr_Sub` should not have a leading underscore, as follows:

```
!DEC$ ATTRIBUTES C, ALIAS:'Ptr_Sub' :: Ptr_Sub
```

When the main Fortran program and C function are built and executed, the following output appears:

```
A(4) = 23.50000
```

When receiving a pointer from a routine written in another language:

- The argument should be declared in the non-Fortran routine as a pointer of the appropriate data type and passed as usual.
- The argument received by the Fortran routine should be declared as a Compaq Fortran pointer name, then the **POINTER** statement should associate it with a pointer-based variable of the appropriate data type (matching the data type of the passing routine). When inside the Fortran routine, use the pointer-based variable to set and access what the pointer points to.

For example, on ia32 systems:

```
! Fortran subroutine.
     SUBROUTINE Iptr_Sub (p)
     !DEC$ ATTRIBUTES C, ALIAS:'_Iptr_Sub' :: Iptr_Sub
        integer VAR(10)
        POINTER (p, VAR)
```

```
        OPEN (8, FILE='STAT.DAT')
        READ (8, *) VAR(4) ! Read from file and store the
                           ! fourth element of VAR
     END SUBROUTINE Iptr_Sub
!

//C main program
extern void Iptr_Sub(int *p);

main ( void )
{
  int a[10];
  Iptr_Sub (&a[0]);
  printf("a[3] = %i\n", a[3]);
}
```

On ia64 systems, the alias name for `Iptr_Sub` should not have a leading underscore, as follows:

```
!DEC$ ATTRIBUTES C, ALIAS:'Iptr_Sub' :: Iptr_Sub
```

When the main C program and Fortran subroutine are built and executed, the following output appears if the STAT.DAT file contains 4:

```
a[3] = 4
```

Handling Arrays and Visual Fortran Array Descriptors

Fortran 95/90 allows arrays to be passed as array elements, as array subsections, or as whole arrays referenced by array name. Within Fortran, array elements are ordered in column-major order, meaning the subscripts of the lowest dimensions vary first.

When using arrays between Fortran and another language, differences in element indexing and ordering must be taken into account. You must reference the array elements individually and keep track of them. Fortran, Visual Basic, MASM and C vary in the way that array elements are indexed. Array indexing is a source-level consideration and involves no difference in the underlying data.

Visual Basic stores arrays and character strings as descriptors: data structures that contain array size and location. This storage difference is transparent to the user, however.

To pass an array from Visual Basic to Fortran, pass the first element of the array. By default, Visual Basic passes variables by reference, so passing the first element of the array will give Fortran the starting location of the array, just as Fortran expects. Visual Basic indexes the first array element as 0 by default, while Fortran by default indexes it as 1. Visual Basic indexing can be set to start with 1 using the statement:

```
Option Base 1
```

Alternatively, in the array declaration in either language you can set the array lower bound to any integer in the range -32,768 to 32,767. For example:

```
' In Basic
Declare Sub FORTARRAY Lib "fortarr.dll" (Barray as Single)
DIM barray (1 to 3, 1 to 7) As Single
Call FORTARRAY(barray (1,1))

! In Fortran
Subroutine FORTARRAY(arr)
   REAL arr(3,7)
```

In MASM, arrays are one-dimensional and array elements must be referenced byte-by-byte. The assembler stores elements of the array consecutively in memory, with the first address referenced by the array name. You then access each element relative to the first, skipping the total number of bytes of the previous elements. For example:

```
xarray    REAL4     1.1, 2.2, 3.3, 4.4 ; initializes
                      ; a four element array with
                      ; each element 4 bytes
```

Referencing xarray in MASM refers to the first element, the element containing 1.1. To refer to the second element, you must refer to the element 4 bytes beyond the first with xarray[4] or xarray+4. Similarly:

```
yarray     BYTE      256 DUP     ; establishes a
                ; 256 byte buffer, no initialization
zarray SWORD 100 DUP(0) ; establishes 100
                ; two-byte elements, initialized to 0
```

Fortran and C arrays differ in two ways:

- The value of the lower array bound is different. By default, Fortran indexes the first element of an array as 1. C and Visual C++ index it as 0. Fortran subscripts should therefore be one higher. (Fortran also provides the option of specifying another integer lower bound.)
- In arrays of more than one dimension, Fortran varies the left-most index the fastest, while C varies the right-most index the fastest. These are sometimes called column-major order and row-major order, respectively.

In C, the first four elements of an array declared as X[3][3] are:

```
X[0][0] X[0][1] X[0][2] X[1][0]
```

In Fortran, the first four elements are:

```
X(1,1) X(2,1) X(3,1) X(1,2)
```

The order of indexing extends to any number of dimensions you declare. For example, the C declaration:

```
int arr1[2][10][15][20];
```

is equivalent to the Fortran declaration:

```
INTEGER arr1( 20, 15, 10, 2 )
```

The constants used in a C array declaration represent extents, not upper bounds as they do in other languages. Therefore, the last element in the C array declared as int arr[5][5] is arr[4][4], not arr[5][5].

The following table shows equivalencies for array declarations.

Equivalent Array Declarations for Different Languages

Language	**Array Declaration**	**Array Reference from Fortran**
Fortran	**DIMENSION** x(i, k) -or- *type* x(i, k)	x(i, k)
Visual Basic	DIM x(i, k) As *type*	x(i -1, k -1)
Visual C/C++	*type* x[k] [i]	x(i -1, k -1)
MASM	Declare and reference arrays as elements in consecutive storage	

Visual Fortran Array Descriptor Format

For cases where Fortran 95/90 needs to keep track of more than a pointer memory address, the Visual Fortran compiler uses an *array descriptor*, which stores the details of how an array is organized.

When using an explicit interface (by association or procedure interface block), Visual Fortran will generate a descriptor for the following types of array arguments:

- Pointers to arrays (array pointers)
- Assumed-shape arrays

Certain data structure arguments do not use a descriptor, even when an appropriate explicit interface is provided. For example, explicit-shape and assumed-size arrays do not use a descriptor. In contrast, array pointers and allocatable arrays use descriptors regardless of whether they are used as arguments.

When calling between Visual Fortran and a non-Fortran language (such as C), using an *implicit* interface allows the array argument to be passed *without* a Visual Fortran descriptor (see Passing Array Arguments Efficiently). However, for cases where the called routine needs the information in the Visual Fortran descriptor, declare the routine with an *explicit* interface and specify the dummy array as either an assumed-shape array or with the pointer attribute.

You can associate a Fortran 95/90 pointer with any piece of memory, organized in any way desired (so long as it is "rectangular" in terms of array bounds). You can also pass Fortran 95/90 pointers to other languages, such as C, and have the other language correctly interpret the descriptor to obtain the information it needs.

However, using array descriptors can increase the opportunity for errors and is not portable:

- If the descriptor is not defined correctly, the program might access the wrong memory address, possibly causing a General Protection Fault.
- Array descriptor formats are specific to each Fortran compiler. Code that uses array descriptors is *not* portable to other compilers or platforms. For example, the Visual Fortran array descriptor format (for Win32 systems) differs from the array descriptor format for Compaq Fortran on Compaq Tru64 UNIX and Compaq OpenVMS systems. The Visual Fortran array descriptor format is the same format used by Microsoft Fortran PowerStation.
- The array descriptor format might change in the future.

The components of the current Visual Fortran array descriptor on ia32 systems follow:

- The first longword (bytes 0 to 3) contains the base address. The base address plus the offset defines the first memory location (start) of the array.
- The second longword (bytes 4 to 7) contains the size of a single element of the array.
- The third longword (bytes 8 to 11) contains the offset. The offset is added to the base address to define the start of the array.
- The fourth longword (bytes 12 to 15) contains the low-order bit set if the array has been defined (storage allocated). Other bits may also be set by the compiler within this longword, for example, to indicate a contiguous array.
- The fifth longword (bytes 16 to 19) contains the number of dimensions (rank) of the array.

- The remaining longwords (bytes 20 up to 103) contain information about each dimension (up to seven). Each dimension is described by three additional longwords:
  - The number of elements (extent)
  - The distance between the starting address of two successive elements, in bytes.
  - The lower bound

An array of rank one would require three additional longwords for a total of in eight longwords (5 + 3*1) and end at byte 31. An array of rank seven would be described in a total of 26 longwords (5 + 3*7) and end at byte 103.

For example, consider the following declaration:

```
integer,target :: a(10,10)
integer,pointer :: p(:,:)
p => a(9:1:-2,1:9:3)
call f(p)
.
.
.
```

The descriptor for actual argument p would contain the following values:

- The first longword (bytes 0 to 3) contain the base address (assigned at run-time).
- The second longword (bytes 4 to 7) is set to 4 (size of a single element).
- The third longword (bytes 8 to 11) contain the offset (assigned at run-time).
- The fourth longword (bytes 12 to 15) contains 1 (low bit is set).
- The fifth longword (bytes 16 to 19) contains 2 (rank).
- The sixth, seventh, and eighth longwords (bytes 20 to 31) contain information for the first dimension, as follows:
  - 5 (extent)
  - -8 (distance between elements)
  - 1 (the lower bound)
- For the second dimension, the ninth, tenth, and eleventh longwords (bytes 32 to 43) contain:
  - 3 (extent)
  - 120 (distance between elements)
  - 1 (the lower bound)
- Byte 43 is the last byte for this example.

For information about performance implications of passing different types of array arguments, see Passing Array Arguments Efficiently.

Handling Character Strings

By default, Visual Fortran passes a hidden length argument for strings. The hidden length argument consists of an unsigned 4-byte integer (ia32 systems) or unsigned 8-byte integer (ia64 systems), always passed by value, immediately following the address of the character string. You can alter the default way strings are passed by using attributes. The following table shows the effect of various attributes on passed strings.

Effect of ATTRIBUTES Options on Character Strings Passed as Arguments

Argument	Default	C	STDCALL	C, REFERENCE	STDCALL, REFERENCE
String	Passed by reference, along with length	First character converted to INTEGER (4) and passed by value	First character converted to INTEGER (4) and passed by value	Passed by reference, along with length	Passed by reference, along with length
String with VALUE option	Error	First character converted to INTEGER (4) and passed by value	First character converted to INTEGER (4) and passed by value	First character converted to INTEGER(4) and passed by value	First character converted to INTEGER(4) and passed by value
String with REFERENCE option	Passed by reference, possibly along with length	Passed by reference, no length	Passed by reference, no length	Passed by reference, no length	Passed by reference, no length

The important things to note about the above table are:

- Character strings without the VALUE or REFERENCE attribute that are passed to C or STDCALL routines are not passed by reference. Instead, only the first character is passed and it is passed by value.
- Character strings with the VALUE option passed to C or STDCALL routines are not passed by reference. Instead, only the value of the first character is

passed.

- For string arguments with default **ATTRIBUTES**, **ATTRIBUTES** C, REFERENCE, or **ATTRIBUTES** STDCALL, REFERENCE:
  - When /iface:mixed_str_len_arg is set, the length of the string is pushed (by value) on the stack immediately after the address of the beginning of the string.
  - When /iface:nomixed_str_len_arg is set, the length of the string is pushed (by value) on the stack after all of the other arguments.
- For string arguments passed by reference with default ATTRIBUTES:
  - When /iface:mixed_str_len_arg is set, the length of the string is pushed (by value) on the stack immediately after the address of the beginning of the string.
  - When /iface:nomixed_str_len_arg is set, the length of the string is not available to the called procedure.

Since all strings in C are pointers, C expects strings to be passed by reference, without a string length. In addition, C strings are null-terminated while Fortran strings are not. There are two basic ways to pass strings between Fortran and C: convert Fortran strings to C strings, or write C routines to accept Fortran strings.

To convert a Fortran string to C, choose a combination of attributes that passes the string by reference without length, and null terminate your strings. For example, on ia32 systems:

```
INTERFACE
   SUBROUTINE Pass_Str (string)
     !DEC$ ATTRIBUTES C, ALIAS:'_Pass_Str' :: Pass_Str
     CHARACTER*(*) string
     !DEC$ ATTRIBUTES REFERENCE :: string
   END SUBROUTINE
END INTERFACE
CHARACTER(40) forstring
DATA forstring /'This is a null-terminated string.'C/
```

On ia64 systems, the first !DEC$ ATTRIBUTES line would omit the leading underscore and be as follows:

```
!DEC$ ATTRIBUTES C, ALIAS:'Pass_Str' :: Pass_Str
```

This example shows the extension of using the null-terminator for the string in the Fortran **DATA** statement (see C Strings):

```
DATA forstring /'This is a null-terminated string.'C/
```

The C interface is:

```
void Pass_Str (char *string)
```

To get your C routines to accept Fortran strings, C must account for the length argument passed along with the string address. For example:

```
! Fortran code
INTERFACE
   SUBROUTINE Pass_Str (string)
   CHARACTER*(*) string
END INTERFACE
```

The C routine must expect two arguments:

```
void __stdcall PASS_STR (char *string, unsigned int length_arg )
```

This interface handles the hidden-length argument, but you must still reconcile C strings that are null-terminated and Fortran strings that are not. In addition, if the data assigned to the Fortran string is less than the declared length, the Fortran string will be blank padded.

Rather than trying to handle these string differences in your C routines, the best approach in Fortran/C mixed programming is to adopt C string behavior whenever possible. Another good reason for using C strings is that Win32 APIs and most C library functions expect null-terminated strings.

Fortran functions that return a character string using the syntax `CHARACTER*(*)` place a hidden string argument and the address of the string at the beginning of the argument list.

C functions that implement such a Fortran function call must declare this hidden string argument explicitly and use it to return a value. The C return type should be void. However, you are more likely to avoid errors by not using character-string return functions. Use subroutines or place the strings into modules or global variables whenever possible.

Visual Basic strings must be passed by value to Fortran. Visual Basic strings are actually stored as structures containing length and location information. Passing by value dereferences the structure and passes just the string location, as Fortran expects. For example:

```
! In Basic
 Declare Sub forstr  Lib "forstr.dll" (ByVal Bstring as String)
 DIM bstring As String * 40 Fixed-length string
 CALL forstr(bstring)
! End Basic code

! In Fortran
 SUBROUTINE forstr(s)
 !DEC$ ATTRIBUTES STDCALL :: forstr
 !DEC$ ATTRIBUTES REFERENCE :: s
 CHARACTER(40) s
 s = 'Hello, Visual Basic!'
 END
```

The Fortran directive !DEC$ ATTRIBUTES STDCALL and the **ATTRIBUTES** REFERENCE property on variable argument s together inform Fortran not to expect the hidden length arguments to be passed from the Visual Basic calling program. The name in the Visual Basic program is specified as lowercase since STDCALL makes the Fortran name lowercase.

MASM does not add either a string length or a null character to strings by default. To append the string length, use the syntax:

lenstring BYTE "String with length", LENGTHOF lenstring

To add a null character, append it by hand to the string:

```
nullstring BYTE "Null-terminated string", 0
```

Handling User-Defined Types

Fortran 95/90 supports user-defined types (data structures similar to C structures). User-defined types can be passed in modules and common blocks just as other data types, but the other language must know the type's structure. For example:

Fortran Code:

```
    TYPE LOTTA_DATA
        SEQUENCE
        REAL A
        INTEGER B
        CHARACTER(30) INFO
        COMPLEX CX
        CHARACTER(80) MOREINFO
     END TYPE LOTTA_DATA
     TYPE (LOTTA_DATA) D1, D2
     COMMON /T_BLOCK/ D1, D2
```

In the Fortran code above, the SEQUENCE statement preserves the storage order of the derived-type definition.

C Code:

```
 /* C code accessing D1 and D2 */
 extern struct {
    struct {
       float a;
       int b;
       char info[30];
       struct {
          float real, imag;
          } cx;
       char moreinfo[80];
    } d1, d2;
} T_BLOCK;
```

Visual Fortran / Visual C++ Mixed-Language Programs

When you understand and reconcile the calling, naming and argument passing conventions between Fortran and C, you are ready to build an application.

If you are using Visual C/C++ you can edit, compile and debug your code within the Microsoft visual development environment. If you are using another C compiler, you can edit your code within the visual development environment by selecting File/New and choosing Visual C/C++ source in the File tab or, after activating the editor, by selecting the View menu Properties item and selecting from the drop-down list.

However, if you are not using Visual C/C++, you must compile your code outside the Microsoft visual development environment and either build the Fortran/C program on the command line or add the compiled C .OBJ file to your Fortran project in the Microsoft visual development environment.

As an example of building from the command line, if you have a main C program CMAIN.C that calls Fortran subroutines contained in FORSUBS.F90, you can create the CMAIN application with the following commands:

```
cl /c cmain.c
DF cmain.obj forsubs.f90
```

The Fortran (DF) compiler accepts an object file for the main program written in C and compiled by the C compiler. The DF compiler compiles the .F90 file and then has the linker create an executable file under the name CMAIN.EXE using the two object files.

Either compiler can do the linking, regardless of which language the main program is written in; however, if you use the DF compiler first, you must include DFOR.LIB with the C compiler, and you might experience some difficulty with the version of LIBC.LIB used by the C compiler. For these reasons, you may prefer to use the C compiler first or get your project settings for both Fortran and C to agree on the default C library to link against making sure that your application links against one and only one copy of the C library.

When using the visual development environment to build your application, Fortran uses default libraries depending on the information specified in the Fortran tab in the Project menu, Settings item (Project Settings dialog box). You can also specify linker settings with the Linker tab in the Project Settings dialog box.

In the Fortran tab, within the Libraries category, the following options determine the default libraries selected:

- Use Fortran Run-time Libraries (see Types of Projects)
- Use Multi-threaded Libraries (see /[no]threads)
- Use C Debug Libraries (see /[no]dbglibs)

The combinations of these options use the following libraries:

Static or DLL Project?	Use Multi-Theaded Libraries?	Use C Debug Libraries?	Fortran Link Library Used	C Link Library Used
Static	No	No	dfor.lib	libc.lib
Static	No	Yes	dfor.lib	libcd.lib
Static	Yes	No	dformt.lib	libcmt.lib
Static	Yes	Yes	dformt.lib	libcmtd.lib
DLL	No	No	dfordll.lib (dforrt.dll)	msvcrt.lib (msvcrt.dll)
DLL	No	Yes	dfordlld.lib (dforrtd.dll)	msvcrtd.lib (msvcrtd.dll)
DLL	Yes	No	dformd.lib (dformd.dll)	msvcrt.lib (msvcrt.dll)
DLL	Yes	Yes	dformdd.lib (dformdd.dll)	msvcrtd.lib (msvcrtd.dll)

For example, if you select the Single-threaded item in the Use Run-Time Libraries list in the Libraries category of the Fortran tab, this specifies that static (/libs:static), single-threaded (/nothreads), and non-debug (/nodbglibs) libraries will be linked against, namely Fortran library dfor.lib and C/C++ library libc.lib.

If you select Debug Multi-threaded DLL in the Use Run-Time Libraries list in the Libraries category of the Fortran tab, this specifies that DLL (/libs:DLL), multi-threaded (/threads), and debug (/dbglibs) libraries will be linked against, namely Fortran import library dformdd.lib and its DLL library dformdd.dll and C/C++ import library msvcrtd.lib and its DLL library msvcrtd.dll.

The way Visual C++ chooses libraries is also based upon the Project menu Settings item, but within the C/C++ tab. In the Code Generation category, the "Use run-time library" item lists the following C libraries:

Menu Item Selected	CL Option or Project Type Enabled	Default Library Specified in Object File
Single-threaded	/ML	libc.lib
Multithreaded	/MT	libcmt.lib
Multithreaded DLL	/MD	msvcrt.lib (msvcrt.dll)
Debug Single-threaded	/MLd	libcd.lib
Debug Multithreaded	/MTd	libcmtd.lib
Debug Multithreaded DLL	/MDd	msvcrtd.lib (msvcrtd.dll)

If you are using Microsoft Visual C/C++, the Microsoft visual development environment can create mixed Fortran/C applications transparently, with no special directives or steps on your part. You can edit and browse your C and Fortran programs with appropriate syntax coloring for the language. You can add C source files to your Fortran project or Fortran source files to a C project, and they will be compiled and linked automatically.

When you debug a mixed Visual C/Fortran application, the debugger will adjust to the code type as it steps through: the C or Fortran expression evaluator will be selected automatically based on the code being debugged, and the stack window will show Fortran data types for Fortran procedures and C data types for C procedures.

When printing from Visual C++ programs while calling Fortran subprograms that also print, the output may not appear in the order you expect. In Visual C++, the output buffer contents are not written immediately, but written when the buffer is full, the I/O stream is closed or the program terminates normally. The buffer is said to be "flushed" when this occurs.

To make sure interleaving Visual C++ and Fortran program units print in the order expected, you can explicitly flush the Visual C++ buffers after an output command with the flushall, fflush, fclose, setbuf, or setvbuf Visual C++ library calls.

Multithreaded applications should have full multithread support, so if you use DFORMT.LIB, be sure LIBCMT.LIB is specified as a default library.

Fortran / Visual Basic Mixed-Language Programs

Visual Fortran and Visual Basic mixed-language programs typically use:

- Visual Basic for the user-interface features
- Visual Fortran for computation

In Fortran/Visual Basic programs, the Visual Basic must be 32-bit (at least Version 5.0). You can also use the Visual Basic for Applications (VBA) included with Microsoft Excel to call Fortran subprograms.

The Visual Basic development environment is separate from the Visual Fortran Version 6 development environment. However, the two languages can coexist in the same final application.

The usual case is to call Fortran subprograms from Visual Basic. Because Visual Basic subprograms are interpreted and not compiled, they cannot be called directly from compiled language programs like Fortran. Instead, Visual Basic creates OLE objects that export properties and routines.

It is also possible for Visual Basic to pass the address of its procedures to a Fortran program, to be called later by that Fortran program as callbacks. Refer to the Visual Fortran Sample in the `...\DF98\SAMPLES\MIXLANG\VB\CALLBACK` folder for an example of Visual Fortran calling Visual Basic callback routines.

When calling a Fortran subprogram from Visual Basic, you need to:

1. Create the Visual Fortran subprogram as a Fortran DLL project
2. Reference the DLL from Visual Basic with a `Declare Sub` or `Declare Func` statement

The following sections discuss Visual Basic calling a Fortran DLL subprogram:

- Calling Visual Fortran from Visual Basic
- Visual Basic Debugging Considerations
- Examples of Fortran/Visual Basic Programs

Calling Visual Fortran from Visual Basic

When calling a Visual Fortran DLL from Visual Basic, important argument passing and data type considerations are:

- Visual Basic uses the STDCALL standard of argument passing with one exception: it does not append the "@n" count to the name on ia32 systems.

- Within Visual Basic, you declare the name of the routine that will be called and the arguments to be passed to it. Scalar numeric arguments can be directly passed from Basic and directly used by Fortran, but strings, arrays, and types require some extra handling.

This section discusses the following topics:

Declaring the Fortran Routine in Visual Basic

When you declare a Fortran routine in Basic the routine name is exported in exactly the same case as you declared it. Optionally, you can specify a directory path to the Fortran DLL in the declaration.

The following Visual Basic example declares a Fortran subroutine named FortranCall that takes two single-precision arguments:

```
Declare Sub FortranCall Lib "d:\MyProjects\FCall.dll" (A1 as Single,
                                                       A2 as Single)
```

The following example declares a Fortran function named FortranFunc that takes two integer (32-bit) arguments and returns a single precision value:

```
Declare Function FortranFunc Lib "d:\MyProject\FFun.dll" (A1 as Long,
                                                         A2 as Long)
                                                         As Single
```

Exporting the Routine from the Fortran DLL

When you create the Fortran DLL, you need to add two additional attributes to the function or subroutine declaration so that it can be accessed from outside the DLL.

The Fortran routine name must be exported from the DLL, and it must be aliased to match exactly the name expected by Basic. The ATTRIBUTES (*c***DEC$ ATTRIBUTES** compiler directive) and ALIAS declarations export the name and alias, as shown below for a Fortran subroutine:

```
    SUBROUTINE FortranCall
  !DEC$ ATTRIBUTES DLLEXPORT :: FortranCall             ! This exports the name
  !DEC$ ATTRIBUTES ALIAS : "FortranCall" :: FortranCall !This sets it
```

This is also true for Fortran functions, which must be exported and aliased to match exactly the name expected by Basic:

```
    REAL Function FortranFunc
  !DEC$ ATTRIBUTES DLLEXPORT :: FortranFunc
```

```
!DEC$ ATTRIBUTES ALIAS : "FortranFunc" :: FortranFunc
```

Data Type Considerations

When you pass data between Visual Basic and Visual Fortran, you need to keep in mind the calling standard used by the two languages, the size of the data, and the on-disk format of the data.

The following table summaries the calling considerations for the data types:

Data Type	Calling Considerations
Integer	By default, both Visual Basic and Visual Fortran pass integers by reference. The default integer size in Basic is 2 bytes, equivalent to INTEGER(2) in Fortran. No extra action is required by either language to access integer arguments.
Floating point	By default, both Visual Basic and Visual Fortran pass single- and double-precision floating point numbers by reference. The size of a single-precision floating point number is 4 bytes in both languages. The size of a double-precision floating point number is 8 bytes in both languages. No extra action is required by either language to access floating point arguments.
Logical	By default, both Basic and Fortran pass logical data by reference. The default logical size in Basic is two bytes, equivalent to LOGICAL (2) in Fortran. No extra action is required by either language to access logical arguments.
Strings	By default, Basic passes strings in a structure called a BSTR. By default, Fortran passes strings in two arguments: the string's address and a hidden argument containing the string's length. These defaults can be easily overridden by making changes in the Basic declaration, and sometimes in the Fortran declaration too. Whenever you pass a string from Basic to Fortran, the passing mechanism should be declared as ByVal. See the String Passing Examples.
Arrays	By default, Basic arrays are 0-based. Fortran arrays are 1-based by default. When you declare a Basic array to be of size *n*, *n*+1 elements are allocated, including the 0th element. This can be overridden, as show in the Array Passing Examples. To pass arrays of numbers from Basic to Fortran, whether they are integer or floating-point numbers, pass the first element. In the

	Fortran code declare the argument to be an array. Usually the Basic code will pass the number of elements in the array. To pass arrays of strings or types from Basic to Fortran requires the use of COM utilities to read the structures created by Basic. The arrays are passed as is from Basic, and then extracted in the Fortran code using SafeArray*xx* utilities. For more detail, please refer to the Visual Fortran Samples found in the MixLang\VB\arrays and MixLang\VB\typearrays folders.
Types	Basic-declared types can be passed from Basic to Fortran. The Basic-declared type will also have to be declared in Fortran; care should be taken to keep the two structures the same. In Fortran, the TYPE should be declared to be packed, usually PACK:2. You should be aware of the default sizes of the TYPE elements in the two languages, and adjust the defaults accordingly. Note that strings in Basic-declared types are stored as Unicode, which can be declared in Fortran as an array of Integer*2. To access these strings from Fortran, use the Natural Language System (NLS) API calls. For information, see Using National Language Support Routines and the Visual Fortran Samples found in the MixLang\VB\typearrays folder.

String Passing Examples

The following example shows passing strings using the usual case, where the string will have varying length, and the length must also be passed to Fortran ByVal:

Visual Basic code:

```
Declare Sub FortString1 Lib "forttest" (ByVal S1 as String,
                                        ByVal L1 as Long)
Dim S1 as String * 12
Call FortString1(S1, Len(S1))
```

Visual Fortran code:

```
Subroutine FortString1 (mystring)
!DEC$ ATTRIBUTES DLLEXPORT, ALIAS : "FortString1" :: FortString1
CHARACTER*(*) mystring
```

The following example shows shows passing strings where the length of the string will be constant and known by both the Basic and Fortran code, so you do not need to pass the length to Fortran, but you need to tell Fortran not to expect its length:

Visual Basic code:

```
Declare Sub FortString2 Lib "forttest" (ByVal S2 as String)
Dim S2 as String * 25
```

Visual Fortran code:

```
Subroutine FortString2 (mystring)
!DEC$ ATTRIBUTES DLLEXPORT, ALIAS : "FortString2" :: FortString2
!DEC$ ATTRIBUTES REFERENCE :: mystring
CHARACTER*25 mystring
```

Array Passing Examples

The following example shows shows passing arrays:

Visual Basic code:

```
Basic declaration:
   Declare Sub FortArray1 Lib "forttest" (A1 as Long, NumElem as long)
   Dim A1(1:3) as Long
   Call FortArray1(A1(1), 3)
```

Visual Fortran code:

```
Subroutine FortArray1 (Array1, N)
   !DEC$ ATTRIBUTES DLLEXPORT, ALIAS : "FortArray1" :: FortArray1
   Integer array1(N)
```

Visual Basic Debugging Considerations

This section describes how to debug the Fortran code in the DLL being called by Visual Basic. It is not intended to describe how to debug the Visual Basic code itself. This section describes the following:

- Debugging the Fortran DLL
- Visual Basic Error 53: File not found: yy.dll
- Visual Basic Error 453: Can't find DLL entry point xx in yy.dll

Debugging the Fortran DLL

In Visual Basic, create an executable of your project. Use the pull down menu item File-Make myproject.exe. Note where the executable was created.

In the Visual Fortran development environment:

1. In the Project menu, click Settings
2. Click the Debug tab
3. In the box labelled "Executable for debug session," enter the full path and

filename of the executable you created above.

You can now use the full power of the visual development environment debugger to debug your DLL.

If you are using VBA within Microsoft Excel, the steps are similar for debugging your DLL. Enter the full path and filename for Excel into the box labelled "Executable for debug session". Optionally, you can enter the name of the worksheet into the box labeled "Program arguments:". You can now use the visual development environment to debug your DLL.

For a sample Fortran debugging session, see Debugging the Squares Example Program.

Visual Basic Error 53: File not found: *yy.dll*

If you get the error message "File not found: yy.dll" when you run the Visual Basic application, check the following:

- If you built the DLL on one system and copied it to another, did you also copy the Fortran run-time DLLs?

  These files are DFORRT.DLL, DFORMD.DLL, and MSVCRT.DLL on the Visual Fortran CD-ROM. They can be freely distributed with your application (see *Compaq Visual Fortran Installing and Getting Started*).

- Is the correct path to *yy.dll* specified in the Basic declaration?

  Carefully check the path and file name in the Visual Basic `Declare` statement.

Visual Basic Error 453: Can't find DLL entry point *xx* in *yy.dll*

If you get the error message "Can't find DLL entry point xx in *yy.dll*," check the following:

- Make sure the Fortran code has specified the **ATTRIBUTES** DLLEXPORT for the routine name (see the cDEC$ ATTRIBUTES compiler directive).
- Make sure the Fortran code has specified an **ATTRIBUTES** ALIAS name that exactly matches the name declared by the Basic code (see the cDEC$ ALIAS directive, which also can be used as an **ATTRIBUTES** option ALIAS).
- Make sure you are referencing the correct *yy.dll*.

For an example of calling a Fortran DLL from Visual Basic, see Examples of Fortran/Visual Basic Programs.

Examples of Fortran/Visual Basic Programs

The following brief code demonstrates the interface for a Fortran subroutine and function (free-form Fortran source):

1. In the visual development environment, create a new project of type *Fortran Dynamic-Link Library*. Name the project FCALL.
2. Create a new free-form source file (Project menu, Add to Project, New) for the project named FCALL.F90 with the following code:

```
! Fortran Code  establishing subroutine
! Computes the MOD of R1 and 256.0 and stores the
! result in the argument NUM

 SUBROUTINE FortranCall (r1, num)


! Specify that the routine name is to be made available to callers of the
! DLL and that the external name should not have any prefix or suffix

!DEC$ ATTRIBUTES DLLEXPORT :: FortranCall
!DEC$ ATTRIBUTES ALIAS:'FortranCall' :: FortranCall

  REAL,INTENT(IN) :: r1           ! Input argument
  REAL,INTENT(OUT) :: num

  num = MOD (r1, 256.0)

END SUBROUTINE
```

3. Build the Fortran DLL as described in Building and Using Dynamic-Link Libraries.
4. Start Visual Basic and create a new *Standard EXE* project:
   - On the control toolbar, click the CommandButton icon and then, with the cursor over the form, draw out a button.
   - In the button's Properties box, double-click on Caption and change the caption to "Do it!".
   - Click the TextBox icon and, in the same fashion, draw a text box on the form. In its Properties box, find the Text property and change it to an empty string.
5. Double-click the Command button on the form - a code window will appear. Fill in the code so that it looks like this:

```
Private Sub Command1_Click()
r1 = 456.78
Call FortranCall(r1, Num)
Text1.Text = Str$(Num)
End Sub
```

6. Select Project..Add Module and click Open to create a new module. Add the following code to the module:

```
Declare Sub FortranCall Lib"c:\MyProjects\Fcall\Debug\Fcall.dll"
         (r1 As Single, Num As Single)
```

Replace the filename with the location of the Fortran DLL, if it is different.

7. Run the Basic program by pressing F5. Click the *Do it!* button. The Fortran routine will be called to compute the modulus, returning the result to the Basic code. The Basic code will then convert the result to a string and display it in the text box.

Visual Basic, like Fortran, passes numeric values (such as integers and reals) by reference, so it is not necessary to change the passing mechanism on either side. The ALIAS attribute is required because Visual Basic, even though it uses the STDCALL calling mechanism, does not "decorate" routine names with the @n suffix. If the Fortran routine were also to be called by other Fortran code, it would be appropriate to use the Alias option on the Basic side to name it with the proper suffix.

Fortran / MASM Mixed-Language Programs

With Microsoft Macro Assembler (MASM), you can combine the unique strengths of assembly-language programming with Visual Fortran. If you structure your assembly-language procedures appropriately, you can call them from Visual Fortran programs and subprograms. MASM works with Visual Fortran, C, and Visual C++. These high-level languages can call MASM procedures, and each of the languages can be called from MASM programs. Details of the MASM interfaces with the other languages can be found in the *Microsoft MASM Programmer's Guide*.

Compile your Fortran source module with Visual Fortran, and assemble your assembly-language procedure with the MASM assembler. Then, link the two object files. The following example shows how to call a MASM assembler-language program from Fortran.

The Fortran code:

```
INTERFACE
  INTEGER (4) FUNCTION POWER2 (V,E)
  !DEC$ ATTRIBUTES STDCALL :: Power2
  INTEGER V, E
  END FUNCTION
END INTERFACE
```

The MASM code:

```
POWER2 PROTO STDCALL, v, e
...
POWER2 PROC STDCALL, v, e
...
POWER2 ENDP
END
```

In the example, the Fortran call to MASM is `power2(v,e)`, which is identical to a Fortran function call. Visual Fortran also provides sample mixed-language programs that show calls between Visual Fortran and MASM (see Examples of Fortran/MASM Programming).

There are two differences between this mixed-language call and a call between two Fortran modules:

1. The subprogram `power2(v,e)` is implemented in MASM using standard MASM syntax. The PROTO declaration in MASM specifies that the procedure use the STDCALL calling convention.
2. The **INTERFACE** statement in the Fortran module specifies the STDCALL calling convention, so the Fortran program uses same convention that the MASM procedure specifies.

This section covers the following topics:

- Creating a MASM Procedure
- Fortran/MASM Alignment and Return Value Considerations
- Examples of Fortran/MASM Programming

Creating a MASM Procedure

Normally you follow these steps in creating a MASM procedure:

1. Set up the procedure, defining compatible segments and declaring the procedure.
2. Enter the procedure and set up an appropriate stack frame.
3. Preserve register values by pushing any registers on the stack that you modify later.
4. Reserve space on the stack for any local data (optional).
5. Access arguments in the main body of your procedure.
6. Deallocate any local data by returning space from the stack.
7. Restore register values by popping any preserved registers from the stack.
8. If you called the procedure as a function, return a value (optional).
9. Set up the caller routine by restoring the caller stack frame.
10. Exit the procedure and return to the caller program.

Fortran/MASM Alignment and Return Value Considerations

Visual Fortran allows you to specify alignment for all data objects. Requesting alignment specifies that bytes may be added as padding, so that the object and its data start on a natural boundary (see Data Alignment Considerations). The MASM default is byte-alignment, so you should specify an alignment of 4 for MASM structures or use the Fortran compiler option /alignment:*keyword* (or /Zp*n*).

Your MASM procedure can return a value to your Fortran routine if you prototype it as a function. All return values of 4 bytes or less (except for floating-point values) are returned in the EAX register.

Procedures that return floating-point values return their results on the floating-point processor stack. This is possible because there is always a coprocessor or emulator available for 32-bit compilers.

To return REAL and COMPLEX floating-point values, records, arrays, and values larger than 4 bytes and return user-defined types larger than 8 bytes from assembly language to Fortran, you must use a special convention. Fortran creates space in the stack segment to hold the actual return value and passes an extra parameter as the last parameter pushed onto the stack. This extra parameter contains the address of the stack space that contains the return value. For user-defined types, values of 4 bytes or less are returned in EAX and values of 5 to 8 bytes are returned in EAX:EDX.

In the assembly procedure, put the data for the return value at the location pointed to by the return value offset. Then copy the return-value offset (located at EBP+8 if you've created a stack frame in your assembly code) to EAX. This is necessary because the calling module expects EAX to point to the return value.

The following table summarizes ways to return values.

Summary of Ways to Return Values

Type of Value to Return	**Method of Returning Value**
Integer, logical variable, or user-defined type of size 4 bytes or less	Return value in EAX register
Floating-point variable	Return value on the FPU stack
Variable of size more than 4 bytes (strings, complex values) or user-defined types more than 8 bytes	Return value on stack, address of value in EAX register
User-defined structures between 5 and 8 bytes	Return value in EAX:EDX registers.

Examples of Fortran/MASM Programming

Several Visual Fortran sample programs have been provided that illustrate Visual Fortran routines that call MASM procedures. These samples are located in subfolders of the `...\DF98\SAMPLES\MIXLANG\MASM` folder and include simple, vecprod, and allocabl.

Creating Multithread Applications

Visual Fortran provides support for creating multithread applications. You should consider using more than one thread if your application needs to manage multiple activities, such as simultaneous keyboard input and calculations. One thread can process keyboard input while a second thread performs data transformation calculations. A third thread can update the display screen based on data from the keyboard thread. At the same time, other threads can access disk files, or get data from a communications port.

When using Windows NT 4 or Windows 2000 on a multiprocessor machine (sometimes called an "SMP machine") you can achieve a substantial speedup on numerically intensive problems by dividing the work among different threads; the operating system will assign the different threads to different processors (symmetric multiprocessing or parallel execution). Even if you have a single-processor machine, multiple-window applications might benefit from multithreading because threads can be associated with different windows; one thread can be calculating while another is waiting for input.

While you might gain execution speed by having a program executed in multiple threads, there is overhead involved in managing the threads. You need to evaluate the requirements of your project to determine whether you should run it with more than one thread.

If your multithreaded code calls functions from the run-time library or does input/output, you must also link your code to the multithreaded version of the run-time libraries instead of the regular single-threaded ones. This is described in Compiling and Linking Multithread Programs and Building Programs and Libraries.

For additional resources about threads, processes, and multithreading, see Other Sources of Information.

For more information:

- Basic Concepts of Multithreading
- Writing a Multithread Program
- Compiling and Linking Multithread Programs
- Other Sources of Information

Basic Concepts of Multithreading

A *thread* is a path of execution through a program. It is an executable entity that belongs to one and only one process. Each process has at least one thread of execution, automatically created when the process is created. Your main program runs in the first thread. A Win32 thread consists of a stack, the state of the CPU registers, a security context, and an entry in the execution list of the system scheduler. Each thread shares all of the process's resources.

A *process* consists of one or more threads and the code, data, and other resources of a program in memory. Typical program resources are open files, semaphores (a method of interthread communication), and dynamically allocated memory. A program executes when the system scheduler gives one of its threads execution control. The scheduler determines which threads should run and when they should run. Threads of lower priority might need to wait while higher priority threads complete their tasks. On multiprocessor machines, the scheduler can move individual threads to different processors to balance the CPU load.

Because threads require less system overhead and are easier to create than an entire process, they are useful for time- or resource-intensive operations that can be performed concurrently with other tasks. Threads can be used for operations such as background printing, monitoring a device for input, or backing up data while it is being edited.

When threads, processes, files, and communications devices are opened, the function that creates them returns a *handle*. Each handle has an associated Access Control List (ACL) that is used to check the security credentials of the process. Processes and threads can inherit a handle or give one away using functions described in this section. Objects and handles regulate access to system resources. For more information on handles and security, see the Win32 Application Programming Interface reference (such as the Platform SDK online title).

All threads in a process execute independently of one another. Unless you take special steps to make them communicate with each other, each thread operates while completely unaware of the existence of other threads in a process. Threads sharing common resources must coordinate their work by using semaphores or another method of interthread communication. For more information on interthread communication, see Sharing Resources.

Writing a Multithread Program

Multiple threads are best used for:

- Background tasks such as data calculations, database queries, and input gathering, which do not directly involve window management or user interface.
- Operations that are independent from one another that can benefit from concurrent processing.
- Asynchronous tasks such as polling on a serial port.

If your application contains tasks that require a private address space and private resources, you can protect them from the activities of other threads by creating multiple processes rather than multiple threads. See Working with Multiple Processes.

The sections that follow discuss the steps you need to consider in creating a multithread application:

Modules for Multithread Programs

A module called DFMT.MOD is supplied with Visual Fortran. It contains interface statements to the underlying Win32 API routines as well as parameter and structure definitions used by the routines. You need to include a **USE DFMT** statement in the declarations section of every Fortran program unit (program, subroutine, function, or module) that uses multithread API routines.

The source code for the DFMT module (file name DFMT.F90) contains type definitions and external function declarations. You can use it as an added reference for the calling syntax, number, and type of arguments for a multithread procedure.

Other Windows APIs that support multithreading tasks (such as window management functions) are included in the DFWIN.F90 module, available to your programs with the **USE DFWIN** statement. For information about creating a Fortran Windows application, see Creating Windows Applications.

Starting and Stopping Threads

When you add threads to a process, you need to consider the costs to your process. Create only the number of threads that help your application respond and perform better. You can save time by multitasking, but remember that additional CPU time is needed to keep track of multiple threads. When you are deciding how many threads to create, you also need to consider what data can be process-specific, and what data is thread-specific. Sharing Resources discusses synchronizing access to variables and data.

One single call to the CreateThread function creates a thread, specifies security attributes and memory stack size, and names the routine for the thread to run. Windows allocates memory for the thread stack in the virtual address space of the application that contains the thread. Once a thread has finished processing, the CloseHandle routine frees the resources used by the thread.

For more information:

- Starting Threads
- Stopping Threads
- Other Thread Support Functions

Starting Threads

The function CreateThread creates a new thread. Its return value is an INTEGER (4) thread handle, used in communicating to the thread and when closing it. The syntax for this function is:

CreateThread (*security*, *stack*, *thread_func*, *argument*, *flags*, *thread_id*)

All arguments are INTEGER(4) variables except for *thread_func*, which names the routine for CreateThread to run. Minimum requirements for *thread_func* are discussed in Thread Routine Format. The arguments are as follows:

security	This argument uses the SECURITY_ATTRIBUTES type, defined in DFMT.F90. If *security* is zero, the thread has the default security attributes of the parent process. For more information about setting security attributes for processes and threads, see the Platform SDK online reference.
stack	Defines the stack size of the new thread. All of an application's default stack space is allocated to the first thread of execution. As a result, you must specify how much memory to allocate for a separate stack for each additional thread your program needs. The CreateThread call allows you to specify the value for the stack size on each thread you create. A value of zero indicates the stack has the same size as the application's primary thread. The size of the stack is increased dynamically, if necessary, up to a limit of 1 MB.
thread_func	The starting address for the thread function.
argument	An optional argument for *thread_func*. Your program defines this parameter and how it is used.

flags	This argument lets you create a thread that will not begin processing until you signal it. The *flags* argument can take either of two values: 0 or CREATE_SUSPENDED. If you specify 0, the thread is created and runs immediately after creation. If you specify CREATE_SUSPENDED, the thread is created, but does not run until you call the ResumeThread function.
thread_id	This argument is returned by CreateThread. It is a unique identifier for the thread, which you can use when calling other multithread routines. While the thread is running, no other thread has the same identifier. However, the operating system may use the identifier again for other threads once this one has completed. A thread can be referred to by its handle as well as its unique thread identifier. Synchronization functions such as WaitForSingleObject and WaitForMultipleObjects take the thread handle as an argument.

Stopping Threads

The ExitThread routine allows a thread to stop its own execution. The syntax is:

CALL EXITTHREAD ([*Termination Status*])

Termination status may be queried by another thread. A termination status of 0 indicates normal termination. You can assign other termination status values and their meaning in your program.

When the called thread is no longer needed, the calling thread needs to close the handle for the thread. Use the CloseHandle routine to free memory used by the thread. A thread object is not deleted until the last thread handle is closed.

It is possible for more than one handle to be open to a thread: for example, if a program creates two threads, one of which waits for information from the other. In this case, two handles are open to the first thread: one from the thread requesting information, the other from the thread that created it. All handles are closed implicitly when the enclosing process terminates.

The TerminateThread routine allows one thread to terminate another, if the security attributes are set appropriately for both threads. DLLs attached to the thread are not notified that the thread is terminating, and its initial stack is not deallocated. Use Terminate Thread for emergencies only.

Other Thread Support Functions

Scheduling thread priorities is supported through the functions GetThreadPriority and SetThreadPriority. Use the priority class of a thread to differentiate between applications that are time critical and those that have normal or below normal scheduling requirements. If you need to manipulate priorities, be very careful not to give a thread too high a priority, or it can consume all of the available CPU time. A thread with a base priority level above 11 interferes with the normal operation of the operating system. Using REALTIME_PRIORITY_CLASS may cause disk caches to not flush, hang the mouse, and so on.

When communicating with other threads, a thread uses a *pseudohandle* to refer to itself. A pseudohandle is a special constant that is interpreted as the current thread handle. Pseudohandles are only valid for the calling thread; they cannot be inherited by other threads. The GetCurrentThread function returns a pseudohandle for the current thread. The calling thread can use this handle to specify itself whenever a thread handle is required. Pseudohandles are not inherited.

To get the thread's identifier, use the GetCurrentThreadId function. The identifier uniquely identifies the thread in the system until it terminates. You can use the identifier to specify the thread itself whenever an identifier is required.

Use GetExitCodeThread to find out if a thread is still active, or if it is not, to find its exit status. Call GetLastError for more detailed information on the exit status. If one routine depends on a task being performed by a different thread, use the wait functions described in Synchronizing Threads instead of GetExitCodeThread.

Thread Routine Format

A function or subroutine that runs in a separate thread from the main program can take an argument. The code below shows a skeleton for a function and a subroutine:

```
  INTEGER(4) FUNCTION thrdfnc(arg)
     USE DFMT
     integer(4) arg
!DEC$ ATTRIBUTES VALUE :: arg
     arg = arg + 1      ! Sample only; real work goes here.
     thrdfnc = 0        ! Sets exit code to 0.
  END FUNCTION

  SUBROUTINE thrdfnc2 (arg2)
     USE DFMT
     integer(4) arg2
!DEC$ ATTRIBUTES VALUE :: arg2
           ! Subroutine work goes here.
     Call exitthread(0) ! Exit code is 0.
  END SUBROUTINE
```

The arguments arg or arg2 are passed to the function or subroutine when the main program calls CreateThread, as the fourth argument. The arguments arg or arg2 are passed by value.

Threads automatically terminate when the function or subroutine terminates.

Sharing Resources

Each thread has its own stack and its own copy of the CPU registers. Other resources, such as files, units, static data, and heap memory, are shared by all threads in the process. Threads using these common resources must coordinate their work. There are several ways to synchronize resources:

- Critical section – A block of code that accesses a non-shareable resource. Critical sections are typically used to restrict access to data or code that can only be used by one thread at a time within a process (for example, modification of shared data in a common block).
- MUTual EXclusion object (Mutex) – A mechanism that allows only one thread at a time to access a resource. Mutexes are typically used to restrict access to a system resource that can only be used by one thread at a time (for example, a printer), or when sharing might produce unpredictable results.
- Semaphore – A counter that regulates the number of threads that can use a resource. Semaphores are typically used to control access to a specified number of identical resources.
- Event – An event object announces that an event has happened to one or more threads.

The state of each of these objects is either signaled or not-signaled. A signaled state indicates a resource is available for a process or thread to use it. A not-signaled state indicates the resource is in use.

The routines described in the following sections manage the creation, initialization, and termination of resource sharing mechanisms. Some of them change the state to signaled from not-signaled. The routines WaitForSingleObject and WaitForMultipleObjects also change the signal status of an object. For information on these functions, see Synchronizing Threads.

This section also contains information about:

- Memory Use and Thread Stacks
- I/O Operations

For resources about coordinating and synchronizing Win32 threads, see Other Sources of Information.

Critical Sections

Before you can synchronize threads with a critical section, you must initialize it by calling InitializeCriticalSection. Call EnterCriticalSection when beginning to process the global variable, and LeaveCriticalSection when the application is finished with it. Both EnterCriticalSection and LeaveCriticalSection can be called several times within an application. For Multithreaded Visual Fortran Samples that use Critical Sections, see PEEKAPP.F90 or PEEKAPP3.F90.

Mutexes

CreateMutex creates a mutex object. It returns an error if the mutex already exists (one by the same name was created by another process or thread). Call GetLastError after calling CreateMutex to look for the error status ERROR_ALREADY_EXISTS. You can also use the OpenMutex function to determine whether or not a named mutex object exists. When called, OpenMutex returns the object's handle if it exists, or null if a mutex with the specified name is not found. Using OpenMutex does not change a mutex object to a signaled state; this is accomplished by one of the wait routines described in Synchronizing Threads.

ReleaseMutex changes a mutex from the not-signaled state to the signaled state. This function only has an effect if the thread calling it also owns the mutex. When the mutex is in a signaled state, any thread waiting for it can acquire it and begin executing.

Semaphores

Functions for handling semaphores are nearly identical to functions that manage mutexes. CreateSemaphore creates a semaphore, specifying an initial as well as a maximum count for the number of threads that can access the resource. OpenSemaphore, like OpenMutex, returns the handle of the named semaphore object, if it exists. The handle can then be used in any function that requires it (such as one of the wait functions described in Synchronizing Threads). Calling OpenSemaphore does not reduce a resource's available count; this is accomplished by the function waiting for the resource.

Use ReleaseSemaphore to increase the available count for a resource by a specified amount. You can call this function when the thread is finished with the resource. Another possible use is to call CreateSemaphore, specifying an initial count of zero to protect the resource from access during an initialization process. When the application has finished its initialization, call ReleaseSemaphore to increase the resource's count to its maximum.

Events

Event objects can trigger execution of other threads. You can use events if one thread provides data to several other threads. An event object is created by the CreateEvent function. The creating thread specifies the initial state of the object and whether it is a manual-reset or auto-reset event. A manual-reset event is one whose state remains signaled until it is explicitly reset by a call to ResetEvent. An auto-reset event is automatically reset by the system when a single waiting thread is released.

Use either SetEvent or PulseEvent to set an event object's state to signaled. OpenEvent returns a handle to the event, which can be used in other function calls. ReleaseEvent releases ownership of the event.

Memory Use and Thread Stacks

Because each thread has its own stack, you can avoid potential collisions over data items by using as little static data as possible. Design your program to use automatic stack variables for all data that can be private to a thread. All the variables declared in a multithread routine are by default static and shared among the threads. If you do not want one thread to overwrite a variable used by another, you can do one of the following:

- Declare the variable as AUTOMATIC.
- Create a vector of variable values, one for each thread, so that the variable values for different threads are in different storage locations. (You can use the single integer parameter passed by CreateThread as an index to identify the thread.)
- Use Thread Local Storage (TLS).

Variables declared as automatic are placed on the stack, which is part of the thread context saved with the thread. Automatic variables within procedures are discarded when the procedure completes execution.

I/O Operations

Although files and units are shared between threads, you may not need to coordinate the use of these shared resources by threads. Fortran treats each input/output statement as an atomic operation. If two separate threads try to write to the same unit and one thread's output operation has started, the operation will complete before the other thread's output operation can begin.

The operating system does not impose an ordering on threads' access to units or files. For example, the non-determinate nature of multithread applications can cause records in a sequential file to be written in a different order on each execution of the application as each thread writes to the file. Direct access files might be a better choice than sequential files in such a case. If you cannot use direct access files, use mutexes to impose an ordering constraint on input or output of sequential files.

Certain restrictions apply to blocking functions for input procedures in QuickWin programs. For details on these restrictions, see Using QuickWin.

Thread Local Storage

Thread Local Storage (TLS) calls allow you to store per-thread data. TLS is the method by which each thread in a multithreaded process can allocate locations in which to store thread-specific data.

Dynamically bound (run-time) thread-specific data is supported by routines such as TlsAlloc (allocates an index to store data), TlsGetValue (retrieves values from an index), TlsSetValue (stores values into an index), and TlsFree (frees the dynamic storage). Threads allocate dynamic storage and use TlsSetValue to associate the index with a pointer to that storage. When a thread needs to access the storage, it calls TlsGetValue, specifying the index.

When all threads have finished using the index, TlsFree frees the dynamic storage.

Synchronizing Threads

The routines WaitForSingleObject and WaitForMultipleObjects enable threads to wait for a variety of different occurrences, such as thread completion or signals from other threads. They enable threads and processes to wait efficiently, consuming no CPU resources, either indefinitely or until a specified timeout interval has elapsed.

WaitForSingleObject takes an object handle as the first parameter and does not return until the object referenced by the handle either reaches a signaled state or until a specified timeout value elapses. The syntax is:

WaitResult = **WaitForSingleObject** (*ObjectHandle*, [*Timeout*])

If you are using a timeout, specify the value in milliseconds as the second parameter. The value WAIT_INFINITE represents an infinite timeout, in which case the function waits until *ObjectHandle* completes.

WaitForMultipleObjects is similar, except that its second parameter is an array of Windows object handles. Specify the number of handles to wait for in the first parameter. This can be less than the total number of threads created, and its maximum is 64. The function can either wait until all events have completed, or resume as soon as any one of the objects completes.

Deadlocks occur when a thread waits for objects that never become available. Use the timeout parameter when there is a chance that the thread you are waiting for may never terminate. See Detecting Deadlocks in Multithreaded Win32 Applications," by Ruediger Asche, in the *Microsoft Systems Journal*, vol. 8, for a discussion of how to find and avoid potential resource collisions.

Suspending and Resuming Threads

You can use SuspendThread to stop a thread from executing. SuspendThread is not particularly useful for synchronization because it does not control the point in the code at which the thread's execution is suspended. However, you could suspend a thread if you need to confirm a user's input that would terminate the work of the thread. If confirmed, the thread is terminated; otherwise, it resumes.

If a thread is created in a suspended state, it does not begin to run until ResumeThread is called with a handle to the suspended thread. This can be useful for initializing the thread's state before it begins to run. Suspending a thread at creation can be useful for one-time synchronization, because ResumeThread ensures that the suspended thread will resume running at the starting point of its code.

Handling Errors in Multithread Programs

Use the GetLastError function to obtain error information if any of the multithreading routines returns an error code. Remember that it returns the error code of the last error, not necessarily the error status of the last call.

Error codes are 32-bit values. Bit 29 is reserved for application-defined error codes. You can set this bit and use SetLastError if you are creating your own dynamic-link library, to emulate Win32 API behavior. Win32 functions only call SetLastError when they fail, not when they succeed.

The last error code value is kept in Thread Local Storage, so that multiple threads do not overwrite each other's values.

Working with Multiple Processes

The multithread libraries provide a number of routines for working with multiple processes. An application can use multiple processes for functions that require a private address space and private resources, to protect them from the activities of other threads. It is usually more efficient to implement multitasking by creating several threads in one process, rather than by creating multiple processes, for these reasons:

- The system can create and execute threads more quickly than it can create processes, since the code for threads has already been mapped into the address space of the process, while the code for a new process must be loaded.

- All threads of a process share the same address space and can access the process's global variables, which can simplify communications between threads.
- All threads of a process can use open handles to resources such as files and pipes.

If you want to create an independent process that runs concurrently with the current one, use CreateProcess. CreateProcess returns a 32-bit process identifier that is valid until the process terminates. ExitProcess stops the process and notifies all DLLs the process is terminating.

Different processes can share mutexes, events, and semaphores (but not critical sections). Processes can also optionally inherit handles from the process that created them (see online help for CreateProcess).

You can obtain information about the current process by calling GetCurrentProcess (returns a pseudohandle to its own process), and GetCurrentProcessId (returns the process identifier). The value returned by these functions can be used in calls to communicate with other processes. GetExitCodeProcess returns the exit code of a process, or an indication that it is still running.

The OpenProcess function opens a handle to a process specified by its process identifier. OpenProcess allows you to specify the handle's access rights and inheritability.

A process terminates whenever one of the following occurs:

- Any thread of the process calls ExitProcess
- The primary thread of the process returns
- The last thread of the process terminates
- TerminateProcess is called with a handle to the process

ExitProcess is the preferred way to terminate a process because it notifies all attached DLLs of the termination, and ensures that all threads of the process terminate. DLLs are not notified after a call to TerminateProcess.

Table of Multithread Routines

The following table lists routines available for multithread programs. For information about the calling syntax of these routines, see the *Platform SDK* title in HTML Help Viewer.

Routine	Description
CloseHandle	Closes an open object handle.
CreateEvent	Creates a named or unnamed event object.
CreateMutex	Creates a named or unnamed mutex object.
CreateProcess	Creates a new process and its primary thread.
CreateSemaphore	Creates a named or unnamed semaphore object.
CreateThread	Creates a thread to execute within the address space of the calling process.
DeleteCriticalSection	Releases all resources used by an unowned critical section object.
DuplicateHandle	Duplicates an object handle.
EnterCriticalSection	Waits for ownership of the specified critical section object.
ExitProcess	Ends a process and all its threads.
ExitThread	Ends a thread.
GetCurrentProcess	Returns a pseudohandle for the current process.
GetCurrentProcessId	Returns the process identifier of the calling process.
GetCurrentThread	Returns a pseudohandle for the current thread.
GetCurrentThreadId	Returns the thread identifier of the calling thread.
GetExitCodeProcess	Retrieves the termination status of the specified process.
GetExitCodeThread	Retrieves the termination status of the specified thread.
GetLastError	Returns the calling thread's last-error code value.
GetPriorityClass	Returns the priority class for the specified process.
GetThreadPriority	Returns the priority value for the specified thread.
InitializeCriticalSection	Initializes a critical section object.

LeaveCriticalSection	Releases ownership of the specified critical section object.
OpenEvent	Returns a handle of an existing named event object.
OpenMutex	Returns a handle of an existing named mutex object.
OpenProcess	Returns a handle of an existing process object.
OpenSemaphore	Returns a handle of an existing named semaphore object.
PulseEvent	As a single operation, sets (to signaled) and then resets the state of the specified event object after releasing the appropriate number of waiting threads.
ReleaseMutex	Releases ownership of the specified mutex object.
ReleaseSemaphore	Increases the count of the specified semaphore object by a specified amount.
ResetEvent	Sets the state of the specified event object to nonsignaled.
ResumeThread	Decrements a thread's suspend count. When the suspend count is zero, execution of the thread resumes.
SetEvent	Sets the state of the specified event object to signaled.
SetLastError	Sets the last-error code for the calling thread.
SetPriorityClass	Sets the priority class for the specified process.
SetThreadPriority	Sets the priority value for the specified thread.
SuspendThread	Suspends the specified thread.
TerminateProcess	Terminates the specified process and all of its threads.
TerminateThread	Terminates a thread.
TlsAlloc	Allocates a thread local storage (TLS) index.
TlsFree	Releases a thread local storage (TLS) index, making it available for reuse.

TlsGetValue	Retrieves the value in the calling thread's thread local storage (TLS) slot for a specified TLS index.
TlsSetValue	Stores a value in the calling thread's thread local storage (TLS) slot for a specified TLS index.
WaitForMultipleObjects	Returns either any one or all of the specified objects are in the signaled state or when the time-out interval elapses.
WaitForSingleObject	Returns when the specified object is in the signaled state or the time-out interval elapses.

If a function mentioned in this section is not listed in the preceding table, it is only available through the **USE DFWIN** statement.

Compiling and Linking Multithread Programs

The support library DFORMT.LIB is a re-entrant library for creating statically linked multithread programs. The DFORMD.LIB library, which calls code in the shared DFORMD.DLL, is also re-entrant. Programs built with DFORMT.LIB do not share Fortran run-time library code or data with any dynamic-link libraries they call. You must link with DFORMD.LIB if you plan to call a DLL.

To build a multithread application that uses the Fortran run-time libraries, you must tell the linker to use a special version of the libraries. You can specify the /threads compiler option from the command line, or in the Microsoft visual development environment in the Project Settings dialog box, as described in the following paragraph.

A sample multithread project THREADS is included in the `...\DF98\SAMPLES\ADVANCED\WIN32\THREADS` folder. To build this sample, open the project workspace file and choose Build All from the Build menu. Listed following are the steps for compiling and linking your own multithread program using the visual development environment.

To compile and link your multithread program:

1. Create a new project. Choose the Project tab, then specify the project type. (The sample THREADS.F90 is a Fortran Windows project.)
2. Add the file containing the source code to the project.
3. From the Project menu, select Settings.
   The Project Settings dialog box appears.
4. Choose the Fortran tab, Fortran Libraries category, and set the Use Multi-Threaded Library check box and set the Use Runtime Libraries to Static (DFORMT.LIB) or DLL (DFORMD.LIB).

5. Create the executable file by choosing Build All from the Build menu.

The following steps describe how to compile and link the sample multithread program from the command line.

To compile and link the sample multithread program from the command line:

1. Make sure the library files directory is specified in your LIB environment variable.
2. Compile and link the program with the DF command-line option /threads. For example:

```
DF /threads  MYTHREAD.F90
```

The /threads compiler option (automatically set when you specify a multithread application in the visual development environment) tells the linker to use DFORMT.LIB as a default library.

To compile and link the THREADS.F90 sample, the command is:

```
DF /winapp /threads THREADS.F90
```

The /threads compiler option causes the linker to search the multithread library; the /winapp requests a Fortran Windows application.

Select the compiler options /libs=dll and /threads if you are using both multithread code and DLLs. You can use the /libs=dll and /threads options only with Fortran Console projects, not QuickWin applications.

Other Sources of Information

For a thorough discussion of threads, processes, and multithreading, see Helen Custer's book *Inside Windows NT*, available from Microsoft Press. Articles on how to accomplish multithreading have also been published in the Microsoft Developer Network (MSDN) CD-ROM and the *Microsoft Systems Journal*:

- The Microsoft Developer Network CD-ROM contains several articles on multithreading:
  - "Multiple Threads in the User Interface," by Nancy Winnick Cluts, discusses the ramifications of adding multiple threads to the user interface. This article not only offers alternatives to multiple threads, but also covers window management and message loops for multithreading.
  - "Multithreading for Rookies," by Ruediger R. Asche, focuses on practical applications of multithreading.
  - "Detecting Deadlocks in Multithreaded Win32 Applications," by

Ruediger R. Asche, presents deadlock detection techniques. A deadlock is a condition in which the application hangs because two or more threads are waiting for each other to release a shared resource before resuming execution.
    - "Moving Unix Applications to Windows NT," provides an overview of Windows multithreading calls, contrasting them with Unix fork() calls.

- The Microsoft Systems Journal is also a source of information on multithreading:
    - "Coordinate Win32 threads using manual-reset and auto-reset events," by Jeffrey Richter. October 1993, v8 n10.
    - "Synchronizing Win32 threads using critical sections, semaphores, and mutexes," by Jeffrey Richter. August 1993, v8 n8.

Data Representation

Visual Fortran expects numeric data to be in native little endian order, in which the least-significant, right-most zero bit (bit 0) or byte has a lower address than the most-significant, left-most bit (or byte). For information on using nonnative big endian and Compaq VAX floating-point formats, see Converting Unformatted Numeric Data.

The symbol :A in any figure specifies the address of the byte containing bit 0, which is the starting address of the represented data element.

The following table lists the intrinsic data types used by Visual Fortran, the storage required, and valid ranges. For information on declarating Fortran intrinsic data types, see Type Declaration Statements. For example, the declaration INTEGER(4) is the same as INTEGER(KIND=4) and INTEGER*4.

Compaq Fortran Data Types and Storage

Data Type	**Storage**	**Description**
BYTE INTEGER(1)	1 byte (8 bits)	A BYTE declaration is a signed integer data type equivalent to INTEGER(1).
INTEGER	See INTEGER (2), INTEGER (4), and INTEGER (8).	Signed integer, either INTEGER(2), INTEGER(4), or INTEGER(8). The size is controlled by the /integer_size:*nn* compiler option. The default is /integer_size:32 (INTEGER(4)).
INTEGER(1)	1 byte (8 bits)	Signed integer value from -128 to 127.
INTEGER(2)	2 bytes (16 bits)	Signed integer value from -32,768 to 32,767.
INTEGER(4)	4 bytes (32 bits)	Signed integer value from -2,147,483,648 to 2,147,483,647.
INTEGER(8)	8 bytes (64 bits)	Signed integer value from -9,223,372,036,854,775,808 to 9,223,372,036,854,775,807.

REAL(4) REAL	4 bytes (32 bits)	Single-precision real floating-point values in IEEE S_floating format ranging from 1.17549435E-38 to 3.40282347E38. Values between 1.17549429E-38 and 1.40129846E-45 are denormalized (subnormal).
REAL(8) DOUBLE PRECISION	8 bytes (64 bits)	Double-precision real floating-point values in IEEE T_floating format ranging from 2.2250738585072013D-308 to 1.7976931348623158D308. Values between 2.2250738585072008D-308 and 4.94065645841246544D-324 are denormalized (subnormal).
COMPLEX(4) COMPLEX	8 bytes (64 bits)	Single-precision complex floating-point values in a pair of IEEE S_floating format parts: real and imaginary. The real and imaginary parts range from 1.17549435E-38 to 3.40282347E38. Values between 1.17549429E-38 and 1.40129846E-45 are denormalized (subnormal).
COMPLEX(8) DOUBLE COMPLEX	16 bytes (128 bits)	Double-precision complex floating-point values in a pair of IEEE T_floating format parts: real and imaginary. The real and imaginary parts each range from 2.2250738585072013D-308 to 1.7976931348623158D308. Values between 2.2250738585072008D-308 and 4.94065645841246544D-324 are denormalized (subnormal).
LOGICAL	See LOGICAL (2), LOGICAL (4), and LOGICAL (8).	Logical value, either LOGICAL(2), LOGICAL(4), or LOGICAL(8). The size is controlled by the /integer_size:*nn* compiler option. The default is /integer_size:32 (LOGICAL(4)).
LOGICAL(1)	1 byte (8 bits)	Logical values .TRUE. or .FALSE.
LOGICAL(2)	2 bytes (16 bits)	Logical values .TRUE. or .FALSE.
LOGICAL(4)	4 bytes (32 bits)	Logical values .TRUE. or .FALSE.

LOGICAL(8)	8 bytes (64 bits)	Logical values .TRUE. or .FALSE.
CHARACTER	1 byte (8 bits) per character	Character data represented by character code convention. Character declarations can be in the form CHARACTER(LEN=*n*) or CHARACTER**n*, where *n* is the number of bytes or *n* is (*) to indicate passed-length format.
HOLLERITH	1 byte (8 bits) per Hollerith character	Hollerith constants.

In addition, you can define binary (bit) constants as explained in the *Language Reference.*

The following sections discuss the intrinsic data types in more detail:

- Integer Data Representations
- Logical Data Representations
- Native IEEE Floating-Point Representations
- Character Representation
- Hollerith Representation

Integer Data Representations

Integer data lengths can be 1-, 2-, 4-, or 8-bytes in length.

The default data size used for an INTEGER data declaration is INTEGER(4) (same as INTEGER(KIND=4)), unless the /integer_size:16 or the /integer_size:64 option was specified.

Integer data is signed with the sign bit being 0 (zero) for positive numbers and 1 for negative numbers.

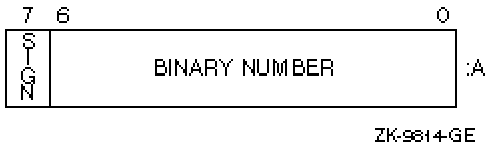
The following sections discuss integer data:

- INTEGER(KIND=1) Representation
- INTEGER(KIND=2) Representation
- INTEGER(KIND=4) Representation
- INTEGER(KIND=8) Representation

INTEGER(KIND=1) Representation

INTEGER(1) values range from -128 to 127 and are stored in 1 byte, as shown below.

INTEGER(1) Data Representation



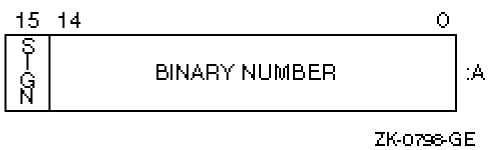
Integers are stored in a two's complement representation. For example:

```
+22 = 16(hex)
 -7 = F9(hex)
```

INTEGER(KIND=2) Representation

INTEGER(2) values range from -32,768 to 32,767 and are stored in 2 contiguous bytes, as shown below:

INTEGER(2) Data Representation



Integers are stored in a two's complement representation. For example:

```
+22 = 0016(hex)
 -7 = FFF9(hex)
```

INTEGER(KIND=4) Representation

INTEGER(4) values range from -2,147,483,648 to 2,147,483,647 and are stored in 4 contiguous bytes, as shown below.

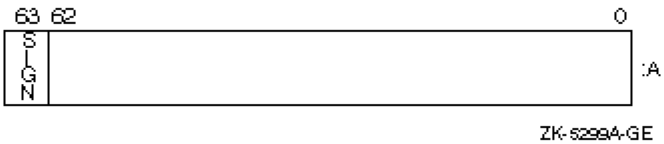
INTEGER(4) Data Representation

Integers are stored in a two's complement representation.

INTEGER(KIND=8) Representation

INTEGER(8) values range from -9,223,372,036,854,775,808 to 9,223,372,036,854,775,807 and are stored in 8 contiguous bytes, as shown below.

INTEGER(8) Data Representation



Integers are stored in a two's complement representation.

Logical Data Representations

Logical data lengths can be 1-, 2-, 4-, or 8-bytes in length.

The default data size used for a LOGICAL data declaration is LOGICAL(4) (same as LOGICAL(KIND=4)), unless the /integer_size:16 or /integer_size:64 option was specified.

To improve performance on ia64 systems, use LOGICAL(4) (or LOGICAL(8)) rather than LOGICAL(2) or LOGICAL(1).

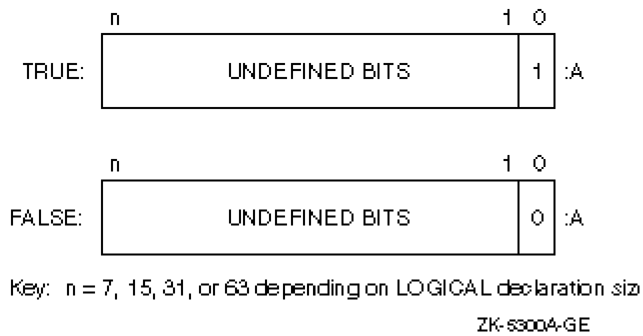
LOGICAL(KIND=1) values are stored in 1 byte. In addition to having logical values .TRUE. and .FALSE., LOGICAL(1) data can also have values in the range -128 to 127. Logical variables can also be interpreted as integer data.

In addition to LOGICAL(1), logical values can also be stored in 2 (LOGICAL(2)), 4 (LOGICAL(4)), or 8 (LOGICAL(8)) contiguous bytes, starting on an arbitrary byte boundary.

If the /fpscomp:nological compiler option is set (the default), the low-order bit determines whether the logical value is true or false. Specify /fpscomp:logical for Microsoft Fortran PowerStation logical values, where 0 (zero) is false and non-zero values are true.

LOGICAL(1), LOGICAL(2), LOGICAL(4), and LOGICAL(8) data representation (when /fpscomp:nological option was set) appears below.

LOGICAL(1), LOGICAL(2), LOGICAL(4), and LOGICAL(8) Data Representations



Native IEEE Floating-Point Representations

The REAL(4) (S_floating) and REAL(8) (T_floating) formats are stored in standard little endian IEEE binary floating-point notation. (See IEEE Standard 754 for additional information about IEEE binary floating point notation.) COMPLEX() and COMPLEX() formats use a pair of REAL(KIND=4) or REAL(8) values to denote the real and imaginary parts of the data.

For IEEE S_floating and T_floating formats, fractions are represented in sign-magnitude notation, with the binary radix point to the right of the most-significant bit. Fractions are assumed to be normalized, and therefore the most-significant bit is not stored (this is called "hidden bit normalization"). This bit is assumed to be 1 unless the exponent is 0. If the exponent equals 0, then the value represented is denormalized (subnormal) or plus or minus zero.

The following sections discuss floating-point data:

- REAL(KIND=4) (REAL) Representation
- REAL(KIND=8) (DOUBLE PRECISION) Representation
- COMPLEX(KIND=4) (COMPLEX) Representation
- COMPLEX(KIND=8) (DOUBLE COMPLEX) Representation

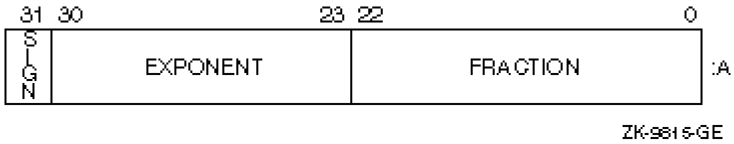
For more information:

- On using the BitViewer tool, see Viewing Floating-Point Representations with BitViewer.
- Reading or writing floating-point data other than native IEEE little endian data, see Converting Unformatted Numeric Data.
- Using floating-point numbers, see The Floating-Point Environment.

REAL(KIND=4) (REAL) Representation

REAL(4) (same as REAL(KIND=4)) data occupies 4 contiguous bytes stored in IEEE S_floating format. Bits are labeled from the right, 0 through 31, as shown below.

REAL(4) Floating-Point Data Representation



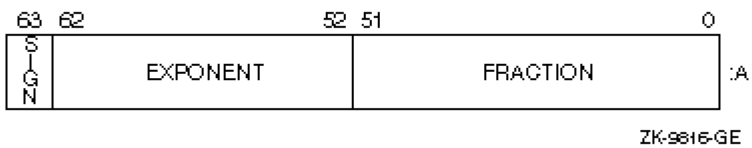
The form of REAL(4) data is sign magnitude, with bit 31 the sign bit (0 for positive numbers, 1 for negative numbers), bits 30:23 a binary exponent in excess 127 notation, and bits 22:0 a normalized 24-bit fraction including the redundant most-significant fraction bit not represented.

The value of data is in the approximate range: 1.17549435E-38 (normalized) to 3.40282347E38. The IEEE denormalized (subnormal) limit is 1.40129846E-45. The precision is approximately one part in 2**23; typically 7 decimal digits.

REAL(KIND=8) (DOUBLE PRECISION) Representation

REAL(8) (same as REAL(KIND=8)) data occupies 8 contiguous bytes stored in IEEE T_floating format. Bits are labeled from the right, 0 through 63, as shown below.

REAL(8) Floating-Point Data Representation



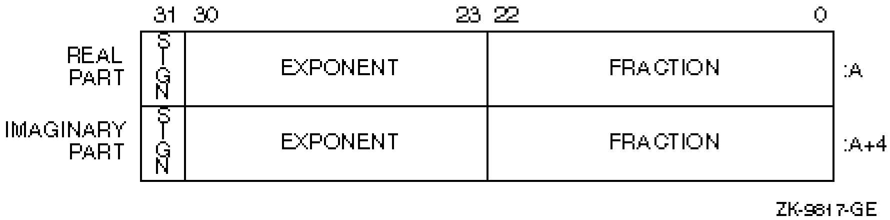
The form of REAL(8) data is sign magnitude, with bit 63 the sign bit (0 for positive numbers, 1 for negative numbers), bits 62:52 a binary exponent in excess 1023 notation, and bits 51:0 a normalized 53-bit fraction including the redundant most-significant fraction bit not represented.

The value of data is in the approximate range: 2.2250738585072013D-308 (normalized) to 1.7976931348623158D308. The IEEE denormalized (subnormal) limit is 4.94065645841246544D-324. The precision is approximately one part in 2**52; typically 15 decimal digits.

COMPLEX(KIND=4) (COMPLEX) Representation

COMPLEX(4) (same as COMPLEX(KIND=4) and COMPLEX*8) data is 8 contiguous bytes containing a pair of REAL(4) values stored in IEEE S_floating format. The low-order 4 bytes contain REAL(4) data that represents the real part of the complex number. The high-order 4 bytes contain REAL(4) data that represents the imaginary part of the complex number, as shown below.

COMPLEX(4) Floating-Point Data Representation

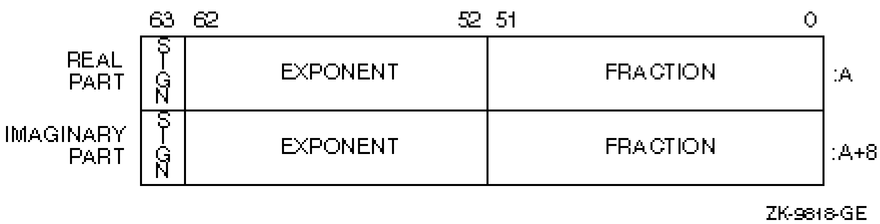


The limits and underflow characteristics for REAL(4) apply to the two separate real and imaginary parts of a COMPLEX(4) number. Like REAL(4) numbers, the sign bit representation is 0 (zero) for positive numbers and 1 for negative numbers.

COMPLEX(KIND=8) (DOUBLE COMPLEX) Representation

COMPLEX(8) (same as COMPLEX(KIND=8) and COMPLEX*16) data is 16 contiguous bytes containing a pair of REAL(8) values stored in IEEE T_floating format. The low-order 8 bytes contain REAL(8) data that represents the real part of the complex data. The high-order 8 bytes contain REAL(8) data that represents the imaginary part of the complex data, as shown below.

COMPLEX(8) Floating-Point Data Representation

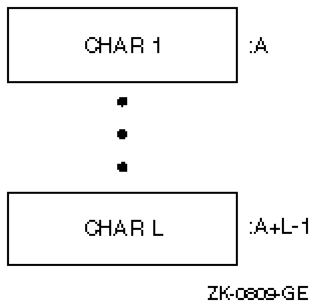


The limits and underflow characteristics for REAL(8) apply to the two separate real and imaginary parts of a COMPLEX(8) number. Like REAL(8) numbers, the sign bit representation is 0 (zero) for positive numbers and 1 for negative numbers.

Character Representation

A character string is a contiguous sequence of bytes in memory, as shown below.

CHARACTER Data Representation

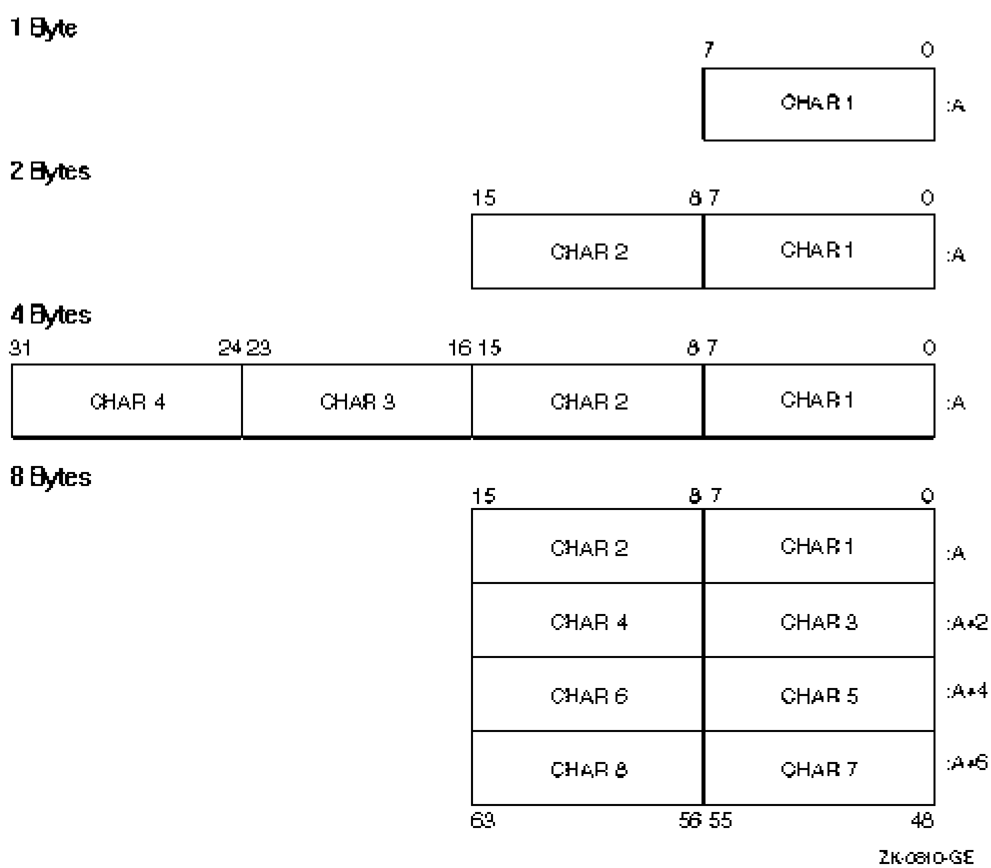


A character string is specified by two attributes: the address A of the first byte of the string, and the length L of the string in bytes. The length L of a string is in the range 1 through 2,147,483,647 (2**31-1) .

Hollerith Representation

Hollerith constants are stored internally, one character per byte, as shown below.

Hollerith Data Representation



Handling Run-Time Errors

This section contains information on the following topics:

- Default Run-Time Error Processing, which describes the message format and values returned at program termination.
- Methods of Handling Errors, which describes using the END, EOR, and ERR I/O statement branch specifiers and the IOSTAT specifier.
- Locating Run-Time Errors, which describes suggested compiler options and information about debugging exceptions.
- Using Traceback Information, which describes techniques to help you locate the cause of severe run-time errors.
- Obtaining Traceback Information with TRACEBACKQQ, which explains how to call a routine to obtain traceback information from your application.
- Run-Time Environment Variables, which describes environment variables that allow program continuation under certain conditions, disable the display of certain dialog boxes under certain conditions, and allow just-in-time debugging.

During execution, your program may encounter errors or exception conditions. These conditions can result from any of the following:

- Errors that occur during I/O operations
- Invalid input data
- Argument errors in calls to the mathematical library
- Arithmetic errors
- Other system-detected errors

The Visual Fortran run-time system (Run-Time Library or RTL) generates appropriate messages and takes action to recover from errors whenever possible.

For a description of each Visual Fortran run-time error message, see Run-Time Errors.

Default Run-Time Error Processing

The Visual Fortran run-time system processes a number of errors that can occur during program execution. A default action is defined for each error recognized by the Visual Fortran run-time system. The default actions described throughout this chapter occur unless overridden by explicit error-processing methods.

The way in which the Visual Fortran run-time system actually processes errors depends upon the following factors:

- The severity of the error. For instance, the program usually continues executing when an error message with a severity level of warning or info (informational) is detected.
- For certain errors associated with I/O statements, whether or not an I/O error-handling specifier was specified.
- For certain errors, whether or not the default action of an associated signal was changed.
- For certain errors related to arithmetic operations (including floating-point exceptions), compilation options can determine whether the error is reported and the severity of the reported error.

How arithmetic exception conditions are reported and handled depends on the cause of the exception and how the program was compiled. Unless the program was compiled to handle exceptions, the exception might not be reported until *after* the instruction that caused the exception condition.

For more information:

- About where Visual Fortran run-time message are displayed and their format, see Run-Time Message Display and Format.
- On the Visual Fortran return values at program termination, see Values Returned at Program Termination.
- On locating errors and the compiler options related to handling errors and exceptions, see Locating Run-Time Errors and Using Traceback Information.
- On DF command options and their categories in the visual development environment (Project Settings, Fortran tab), see Categories of Compiler Options.
- On Compaq Fortran intrinsic data types and their ranges, see Data Representation.
- On the floating-point environment, see The Floating-Point Environment.
- On creating exception and termination handlers, see Advanced Exception and Termination Handling Considerations.

Run-Time Message Display and Format

When errors occur during program execution (run time) of a program, the Visual Fortran run-time system issues diagnostic messages. Where Fortran run-time messages are displayed depends upon the Fortran project type:

Project Type	**Where Fortran Run-Time Messages Appear**
Fortran Console applications	Run-time error messages are displayed on the standard error device (unless redirected).
Fortran QuickWin and Fortran Standard Graphics applications	Run-time error messages are displayed in a separate QuickWin message box.
Fortran Windows applications	Run-time error messages are displayed in a separate message box.

Fortran run-time messages have the following format:

*forrtl***:** *severity* (*number*)**:** *message-text*

where:

- *forrtl*
  Identifies the source as the Visual Fortran run-time system (Run-Time Library or RTL).

- *severity*
  The severity levels are: *severe*, *error*, *warning*, or *info* (abbreviation of information).

- *number*
  This is the message number, also the IOSTAT value for I/O statements.

- *message-text*
  Explains the event that caused the message.

The following table explains the severity levels of run-time messages, in the order of greatest to least severity.

Severity Levels of Run-Time Messages

Severity	**Description**

severe	Must be corrected. The program's execution is terminated when the error is encountered unless the program's I/O statements use the END, EOR, or ERR branch specifiers to transfer control, perhaps to a routine that uses the IOSTAT specifier (see the section Using the END, EOR, and ERR Branch Specifiers and the section Using the IOSTAT Specifier and Fortran Exit Codes). For severe errors, a hexadecimal dump of the call stack (program counter trace) is displayed after the error message. If the /traceback option was specified, the displayed call stack program counter trace includes the source file name, routine name, and source line number of your Fortran source code.
error	Should be corrected. The program might continue execution, but the output from this execution may be incorrect.
warning	Should be investigated. The program continues execution, but output from this execution may be incorrect.
info	For informational purposes only; the program continues.

For a description of each Visual Fortran run-time error message, see Visual Fortran Run-Time Errors

Values Returned at Program Termination

A Visual Fortran program can terminate in one of several ways:

- The program runs to normal completion. A value of zero is returned to the shell.
- The program stops with a **STOP** statement. A value of zero is returned to the shell.
- The program stops because of a signal that is caught but does not allow the program to continue. A value of 1 is returned to the shell.
- The program stops because of a severe run-time error. The error number for that run-time error is returned to the shell. Error numbers are listed in Visual Fortran Run-Time Errors.
- The program stops with a **CALL EXIT** statement. The value passed to **EXIT** is returned to the shell.

Methods of Handling Errors

Whenever possible, the Visual Fortran RTL does certain error handling, such as generating appropriate messages and taking necessary action to recover from errors. You can explicitly supplement or override default actions by using the following methods:

- To transfer control to error-handling code within the program, use the END, EOR, and ERR branch specifiers in I/O statements, see Using the END, EOR, and ERR Branch Specifiers.
- To identify Fortran-specific I/O errors based on the value of Visual Fortran RTL error codes, use the I/O status specifier (IOSTAT) in I/O statements (or call the **ERRSNS** subroutine), see Using the IOSTAT Specifier and Fortran Exit Codes.

These error-processing methods are complementary; you can use any or all of them within the same program to obtain Visual Fortran run-time error codes.

Using the END, EOR, and ERR Branch Specifiers

When a severe error occurs during Visual Fortran program execution, the default action is to display an error message and terminate the program. To override this default action, there are three branch specifiers you can use in I/O statements to transfer control to a specified point in the program:

- The END branch specifier handles an end-of-file condition.
- The EOR branch specifier handles an end-of-record condition for nonadvancing reads.
- The ERR branch specifier handles all error conditions.

If you use the END, EOR, or ERR branch specifiers, no error message is displayed and execution continues at the designated statement, usually an error-handling routine.

You might encounter an unexpected error that the error-handling routine cannot handle. In this case, do one of the following:

- Modify the error-handling routine to display the error message number.
- Remove the END, EOR, or ERR branch specifiers from the I/O statement that causes the error.

After you modify the source code, compile, link, and run the program to display the error message. For example:

```
READ (8,50,ERR=400)
```

If any severe error occurs during execution of this statement, the Visual Fortran RTL transfers control to the statement at label 400. Similarly, you can use the END specifier to handle an end-of-file condition that might otherwise be treated as an error. For example:

```
READ (12,70,END=550)
```

When using nonadvancing I/O, use the EOR specifier to handle the end-of-record condition. For example:

```
150 FORMAT (F10.2, F10.2, I6)
    READ (UNIT=20, FMT=150, SIZE=X, ADVANCE='NO', EOR=700) A, F, I
```

You can also use ERR as a specifier in an OPEN, CLOSE, or INQUIRE statement. For example:

```
    OPEN (UNIT=10, FILE='FILNAM', STATUS='OLD', ERR=999)
```

If an error is detected during execution of this **OPEN** statement, control transfers to the statement at label 999.

Using the IOSTAT Specifier and Fortran Exit Codes

You can use the IOSTAT specifier to continue program execution after an I/O error and to return information about I/O operations. As described in Visual Fortran Run-Time Errors, certain errors are *not* returned in IOSTAT.

Although the IOSTAT specifier transfers control, it can only return information returned by the Visual Fortran RTL. For additional error handling capabilities, see the GERROR and PERROR routines.

The IOSTAT specifier can supplement or replace the END, EOR, and ERR branch transfers.

Execution of an I/O statement containing the IOSTAT specifier suppresses the display of an error message and defines the specified integer variable, array element, or scalar field reference as one of the following, which is returned as an exit code if the program terminates:

- A value of -2 if an end-of-record condition occurs with nonadvancing reads.
- A value of -1 if an end-of-file condition occurs.
- A value of 0 for normal completion (not an error condition, end-of-file, or end-of-record condition).
- A positive integer value if an error condition occurs. (This value is one of the Fortran-specific IOSTAT numbers listed in Visual Fortran Run-Time Errors.)

Following the execution of the I/O statement and assignment of an IOSTAT value, control transfers to the END, EOR, or ERR statement label, if any. If there is no control transfer, normal execution continues. For more information on transfer of control, see Branch Statements.

You can include the `iosdef.for` file in your program to obtain symbolic definitions for the values of IOSTAT.

The following example uses the IOSTAT specifier and the iosdef.for file to handle an **OPEN** statement error (in the FILE specifier).

Error Handling OPEN Statement File Name

```
      CHARACTER(LEN=40) :: FILNM
      INCLUDE 'iosdef.for'

      DO I=1,4
        FILNM = ''
        WRITE (6,*)  'Type file name '
        READ (5,*) FILNM
        OPEN (UNIT=1, FILE=FILNM, STATUS='OLD', IOSTAT=IERR, ERR=100)
        WRITE (6,*) 'Opening file: ', FILNM
!         (process the input file)
        CLOSE (UNIT=1)
        STOP

  100   IF (IERR .EQ. FOR$IOS_FILNOTFOU) THEN
          WRITE (6,*) 'File: ', FILNM, ' does not exist '
        ELSE IF (IERR .EQ. FOR$IOS_FILNAMSPE) THEN
           WRITE (6,*) 'File: ', FILNM, ' was bad, enter new file name'
        ELSE
          PRINT *, 'Unrecoverable error, code =', IERR
          STOP
        END IF
      END DO
      WRITE (6,*) 'File not found. Locate correct file with Explorer and run again'
    END PROGRAM
```

Within the **DO** loop, instead of the **READ** statement that assigns a value to variable FILNM, you could instead call the GetOpenFileName Win32 routine, which requests the file name using a dialog box. For an example of how to call the GetOpenFileName routine, see the Visual Fortran Sample GetOpenFileName in `...Df98\Samples\Advanced\Win32\GetOpenFileName`.

Locating Run-Time Errors

This section provides some guidelines for locating the cause of exceptions and run-time errors. Visual Fortran run-time error messages do not usually indicate the exact source location causing the error.

To locate the cause of errors use the various compiler options to isolate programming errors at compile-time and run-time or use the debugger to locate the cause of exceptions:

- The /[no]warn options control compile-time diagnostic messages, which in some circumstances can help determine the cause of a run-time error. In the Microsoft visual development environment, specify the Warning Level in the General Compiler Option Category or specify individual Warning Options in the Compiler Diagnostics Compiler Option Category.

- The /check:*keyword* options generate extra code to catch certain conditions at run-time (see /check or in the visual development environment, specify the Runtime Error Checking items in the Run time Compiler Option Category). For example:

    - The /check:bounds option generates extra code to catch access to data beyond the array or string boundaries.
    - The /check:overflow option generates extra code to catch integer overflow conditions.
    - The /check:noformat, /check:nooutput_conversion, and /check:nopower options reduce the severity level of the associated run-time error to allow program continuation (see /check).
    - The /check:underflow option controls the reporting of floating-point underflow exceptions at run-time.

- The /traceback option allows program counter to source file line correlation, which simplifies the task of locating the cause of severe run-time errors. Without /traceback, a link map file and source listing are usually needed to locate the cause of the error. Certain traceback-related information accompanies severe run-time errors, as described in Using Traceback Information.

- The /fpe option controls the handling of floating-point arithmetic exceptions (IEEE arithmetic) at run-time. In the visual development environment, specify the Floating-Point Exception Handling in the Floating Point Compiler Option Category.

  For example, if you specified /fpe:3, exceptions related to exceptional IEEE values are not reported and your application may generate exceptional IEEE values, which later in your application may generate an exception or unexpected values. By recompiling the application at /fpe:0, any exceptional IEEE values generated will cause the program to terminate and report an error message earlier.

  The FOR_GET_FPE and FOR_SET_FPE routines are also available to examine and set the run-time handling of certain arithmetic exceptions.

- You can use the debugger to help you locate exceptions, as described in Locating Run-Time Errors in the Debugger.

Using Traceback Information

When a Fortran program terminates due to a severe error condition, the Fortran run-time system displays additional diagnostic information after the run-time message.

The Fortran run-time system attempts to walk back up the call chain and produce a report of the calling sequence leading to the error as part of the default diagnostic message report. The minimum information displayed includes:

- The standard Fortran run-time error message text that explains the error condition.
- A tabular report that contains one line per call stack frame. This information includes at least the image name and a hexadecimal PC in that image.

The information displayed under the Routine, Line, and Source columns depends upon whether your program was compiled with the /traceback option. In the visual development environment, the default is /traceback in the debug configuration, but must be requested for the release configuration (Run Time category of Project settings).

For example, if /traceback were specified, the displayed information might resemble the following:

```
forrtl: severe (24): end-of-file during read, unit 10, file E:\USERS\xxx.dat
Image              PC        Routine            Line        Source
DFORRT.dll         1000A3B2  Unknown            Unknown   Unknown
DFORRT.dll         1000A184  Unknown            Unknown   Unknown
DFORRT.dll         10009324  Unknown            Unknown   Unknown
DFORRT.dll         10009596  Unknown            Unknown   Unknown
DFORRT.dll         10024193  Unknown            Unknown   Unknown
teof.exe           004011A9  AGAIN                   21   teof.for
teof.exe           004010DD  GO                      15   teof.for
teof.exe           004010A7  WE                      11   teof.for
teof.exe           00401071  HERE                     7   teof.for
teof.exe           00401035  TEOF                     3   teof.for
teof.exe           004013D9  Unknown            Unknown   Unknown
teof.exe           004012DF  Unknown            Unknown   Unknown
KERNEL32.dll       77F1B304  Unknown            Unknown   Unknown
```

If the same program was *not* compiled with the /traceback option (/notraceback):

- The Routine name, Line number, and Source file columns would be reported as "Unknown."
- A link map file and source listing are usually needed to locate the cause of the error.

The /traceback option provides program counter to source file line correlation information to appear in the displayed error message information, which simplifies the task of locating the cause of severe run-time errors. For Fortran objects generated with /traceback, the compiler generates additional information used by the Fortran run-time system to automatically correlate PC (program counter) values to the routine name in which they occur, Fortran source file, and line number in the source file. This information is displayed in the run-time error diagnostic report.

Automatic PC correlation is only supported for Fortran code. For non-Fortran code, only the hexadecimal PC locations are reported.

The following sections describe traceback-related tools, lists traceback-related environment variables, discuss tradeoffs and restrictions, and provide examples:

- Tools to Help You Understand Traceback Output
- Relevant Fortran Run-Time Environment Variables
- Tradeoffs and Restrictions
- Example Programs and Traceback Information

Tools to Help You Understand Traceback Output

When an application fails and you need to diagnose the error, there are a few tools and aids that are helpful. Compiler-generated machine code listings and linker-generated map files can help you understand the affects of compiler optimizations and to see how your application is laid out in memory. They may help you interpret the information provided in a stack trace at the time of the error:

To generate a complete listing (.lst) file:

- When using the Microsoft visual development environment:
  1. Choose Settings from the Project menu
  2. Click the Fortran tab
  3. Select the Listing Files category
  4. Click (check) "Source Listing"
  5. Click "Machine Code"
  6. Click "Include Files"
  7. Make any other changes needed to the Project Settings, then click OK.

- When compiling from the command line, specify /list with /show:all:

```
DF file.f90 /list /show:all
```

To generate a link map (.map) file:

- When using the visual development environment:
  1. Choose Settings from the Project menu
  2. Click the Link tab
  3. Select the General or Debug category
  4. Select Generate mapfile
  5. Make any other changes needed to the Project Settings, then click OK.

- When compiling from the command line, specify /map:

```
DF file.f90 /map
```

To see what sections are defined in an executable image (.exe) file:

- Specify the /traceback compile option. This requests that the compiler generate PC correlation information to be used at run-time in the event of an error.

- This information is gathered up by the linker in the executable image in a section named ".trace". To see what sections are in an image, use the command:

  link -dump -summary *your_app_name*.exe

  To see more detailed information, use the command:

  link -dump -headers *your_app_name*.exe

Relevant Fortran Run-Time Environment Variables

The Fortran Run-Time library checks certain environment variables that you can use to customize run-time diagnostic error reporting:

- FOR_DIAGNOSTIC_LOG_FILE

  If set to the name of a file, writes diagnostic output to the specified file. The Fortran run-time system attempts to open that file (append output) and write the error information (ASCII text) to the file. The setting of FOR_DIAGNOSTIC_LOG_FILE is independent of FOR_DISABLE_DIAGNOSTIC_DISPLAY, so you can disable the screen display of information but still capture the error information in a file. The text string you assign for the file name is used literally so you must specify the full name. If the file open fails, no error is reported and the run-time system continues diagnostic processing.

- FOR_DISABLE_DIAGNOSTIC_DISPLAY

  If set to true, disables the display of all error information. This might be helpful if you just want to test the error status of your program and do not want the Fortran run-time system to display any information about an abnormal program termination.

- FOR_DISABLE_STACK_TRACE

  If set to true, disables the display of call stack information that follows the displayed severe error message text. The Fortran run-time error message is displayed whether or not FOR_DISABLE_STACK_TRACE is set to true.

- FOR_ENABLE_VERBOSE_STACK_TRACE

  If set to true, more detailed call stack information is displayed in the event of an error.

  The default brief output is usually sufficient to determine where an error occurred. Brief output includes up to twenty stack frames, reported one line per stack frame. For each frame, the image name containing the PC, the PC, routine name, line number, and source file are given.

  The verbose output, if selected, will provide in addition to the information in brief output, the exception context record if the error was a machine exception (machine register dump), and for each frame, the return address, frame pointer and stack pointer and possible parameters to the routine. This output can be quite long (but limited to 16K bytes) and use of the environment variable FOR_DIAGNOSTIC_LOG_FILE is recommended if you want to capture the output accurately. Most situations should not require the use of verbose output.

- FOR_FULL_SRC_FILE_SPEC

  By default, the traceback output displays only the file name and extension in the source file field. To display complete file name information including the path, set the environment variable FOR_FULL_SRC_FILE_SPEC to true.

Tradeoffs and Restrictions

The following tradeoffs and restrictions apply to using traceback:

- Effect on image size using /traceback

  Using the /traceback option to get automatic PC correlation does increase the size of an image. For any application, the developer must decide if the increase in image size is worth the benefit of automatic PC correlation or if manually correlating PC's with a map file is acceptable.

  The approach of providing automatic correlation information in the image was used so that no run-time penalty is incurred by building the information "on the fly" as your application executes. No run-time diagnostic code is invoked unless your application is terminating due to a severe error.

- The C Compiler Frame Pointer Omission Option (/Oy) on ia32 Systems

  At the heart of the stack walking code is the Win32 routine StackWalk( )

found in imagehlp.dll. In the ia32 systems environment, there are no firm software calling standards documented. Compiler developers are under no constraints to use machine registers in any particular way or to hook up procedures in any particular way. The StackWalk( ) routine therefore, bases its decisions on how to walk the call stack on a set of heuristics. That is, it makes a "best guess" to determine how a program reached a particular point in the call chain. With C code that has been compiled with Visual C++ with the Frame Pointer Omission Option (/Oy) enabled, this "best guess" is not usually the correct one.

If you are mixing Fortran and C code and you are concerned about stack tracing, consider disabling this option (/Oy-) in your C compiles. Otherwise traceback will most likely not work for you.

- Linker /incremental:no option

  When incremental linking is enabled, automatic PC correlation does not work. Use of incremental linking always disables automatic PC correlation even if you specify /traceback during compilation.

  When you use incremental linking, the default hexadecimal (hex) PC values will still appear in the output. To correlate from the hexadecimal PC values to routine containing the PC addresses requires use of a linker map file. However, if you request a map file during linking, incremental linking becomes disabled. Thus to allow any PC values generated for a run-time problem to be helpful, incremental linking must be disabled.

  In the visual development environment, you can use the Call stack display, so incremental linking is not a problem.

- When the Stack Trace Fails For Some Reason

  Programs can fail for a multitude of reasons with unpredictable consequences. Memory corruption by erroneously executing code is always a possibility. Stack memory may be corrupted in such a way that the attempt to trace the call stack will result in access violations or other undesirable consequences. The stack tracing run-time code is guarded with a local exception filter. Should the traceback attempt fail due to a hard detectable condition, the run-time will report this in its diagnostic output message as:

  ```
  Stack trace terminated abnormally
  ```

  Be forewarned, however, it is also possible for memory to be corrupted in such a way that a stack trace can seem to complete successfully with no hint of a problem. The bit patterns it finds in corrupted memory where the stack used to be, and then uses to access memory, may constitute perfectly valid memory addresses for the program to be accessing. They just do not happen to have any connection to what the stack used to look like. So, if it appears that the stack walk completed normally, but the reported PC's make no sense to you, then consider ignoring the stack trace output in diagnosing your problem.

You may also see the stack trace fail if the run-time system cannot dynamically load imagehlp.dll or cannot find the routines from that library it needs to do the stack walk. In this case, you would still get the basic run-time diagnostic message. You just will not get any call stack information.

Another condition that will disable the stack trace process is your program exiting because it has exhausted virtual memory resources.

Example Programs and Traceback Information

The following sections provide example programs that show the use of traceback to locate the cause of the error:

- Example: End-of-File Condition, Program teof
- Example: Machine Exception Condition, Program ovf
- Example: Using Traceback in Mixed Fortran/C Applications, Program FPING and CPONG

Example: End-of-File Condition, Program teof

In the following example, a **READ** statement creates an End-Of-File error, which the application has not handled:

```
program teof
integer*4 i,res
i=here( )
end

integer*4 function here( )
here = we( )
end

integer*4 function we( )
we = go( )
end

integer*4 function go( )
go = again( )
end

integer*4 function again( )
integer*4 a
open(10,file='xxx.dat',form='unformatted',status='unknown')
read(10) a
again=a
end
```

The diagnostic output that results when this program is built with traceback enabled and linked against the single-threaded, DLL Fortran run-time library on the ia32 platform:

```
forrtl: severe (24): end-of-file during read, unit 10, file E:\USERS\xxx.dat
Image              PC        Routine            Line      Source
DFORRT.dll         1000A3B2  Unknown            Unknown   Unknown
DFORRT.dll         1000A184  Unknown            Unknown   Unknown
DFORRT.dll         10009324  Unknown            Unknown   Unknown
DFORRT.dll         10009596  Unknown            Unknown   Unknown
DFORRT.dll         10024193  Unknown            Unknown   Unknown
teof.exe           004011A9  AGAIN                   21   teof.for
teof.exe           004010DD  GO                      15   teof.for
teof.exe           004010A7  WE                      11   teof.for
teof.exe           00401071  HERE                     7   teof.for
teof.exe           00401035  TEOF                     3   teof.for
teof.exe           004013D9  Unknown            Unknown   Unknown
teof.exe           004012DF  Unknown            Unknown   Unknown
KERNEL32.dll       77F1B304  Unknown            Unknown   Unknown
```

The first line of the output is the standard Fortran run-time error message. What follows is the result of walking the call stack in reverse order to determine where the error originated. Each line of output represents a call frame on the stack. Since the application was compiled with /traceback, the PC's that fall in Fortran code are correlated to their matching routine name, line number and source module. PC's which are not in Fortran code are not correlated and are reported as "Unknown."

The first five frames show the calls to routines in the Fortran run-time library (in reverse order). Since the application was linked against the single threaded DLL version of the library, the image name reported is DFORRT.dll. These are the run-time routines that were called to do the **READ** and upon detection of the EOF condition, were invoked to report the error. In the case of an unhandled I/O programming error, there will always be a few frames on the call stack down in run-time code like this.

The stack frame of real interest to the Fortran developer is the first frame in image teof.exe which shows that the error originated in the routine named AGAIN in source module teof.for at line 21. Looking in the source code at line 21, we see the Fortran **READ** statement that incurred the end-of-file condition.

The next four frames show that completes the trail of calls in the Fortran user code that led to the routine that got the error (TEOF->HERE->WE->GO->AGAIN).

Finally, the bottom three frames are routines which handled the startup and initialization of the program.

If this program had been linked against the single-threaded, static Fortran run-time library, the output would then look like:

```
forrtl: severe (24): end-of-file during read, unit 10, file E:\USERS\xxx.dat
Image          PC        Routine          Line      Source
teof.exe       004067D2  Unknown          Unknown   Unknown
teof.exe       0040659F  Unknown          Unknown   Unknown
teof.exe       00405754  Unknown          Unknown   Unknown
teof.exe       004059C5  Unknown          Unknown   Unknown
teof.exe       00403543  Unknown          Unknown   Unknown
teof.exe       004011A9  AGAIN                 21   teof.for
teof.exe       004010DD  GO                    15   teof.for
teof.exe       004010A7  WE                    11   teof.for
teof.exe       00401071  HERE                   7   teof.for
teof.exe       00401035  TEOF                   3   teof.for
teof.exe       004202F9  Unknown          Unknown   Unknown
teof.exe       00416063  Unknown          Unknown   Unknown
KERNEL32.dll   77F1B304  Unknown          Unknown   Unknown
```

Notice that the initial five stack frames now show routines in image teof.exe, not DFORRT.DLL. The routines are the same five run-time routines as previously reported for the DLL case but since the application was linked against the static Fortran run-time library (dfor.lib), the object modules containing these routines were linked into the application image (teof.exe). Using the map file, you can determine that the PC reported in the top stack frame, 004067D2, is from routine _for_stack_trace, in module for_diags.obj of library dfor.lib (004067a0 < PC=004067D2 < 004079f0):

```
 ...
 0001:000057a0       _for_stack_trace            004067a0 f dfor:for_diags.obj
 0001:000069f0       _for__find_trace_info_file  004079f0 f dfor:for_diags.obj
 ...
```

Now suppose the application was compiled *without* traceback enabled and once again, linked against the single-threaded, static Fortran library. The diagnostic output would then appear as follows:

```
forrtl: severe (24): end-of-file during read, unit 10, file E:\USERS\xxx.dat
Image            PC        Routine          Line      Source
teof.exe         00406792  Unknown          Unknown   Unknown
teof.exe         0040655F  Unknown          Unknown   Unknown
teof.exe         00405714  Unknown          Unknown   Unknown
teof.exe         00405985  Unknown          Unknown   Unknown
teof.exe         00403503  Unknown          Unknown   Unknown
teof.exe         00401169  Unknown          Unknown   Unknown
teof.exe         004010A8  Unknown          Unknown   Unknown
teof.exe         00401078  Unknown          Unknown   Unknown
teof.exe         00401048  Unknown          Unknown   Unknown
teof.exe         0040102F  Unknown          Unknown   Unknown
teof.exe         004202B9  Unknown          Unknown   Unknown
teof.exe         00416023  Unknown          Unknown   Unknown
KERNEL32.dll     77F1B304  Unknown          Unknown   Unknown
```

Without the correlation information in the image that /traceback previously supplied, the Fortran run-time system cannot correlate PC's to routine name, line number, and source file. You can still use the map file to at least determine the routine names and what modules they are in. Look at the beginning of the entry point list in the map file for this image:

```
 Address         Publics by Value      Rva+Base   Lib:Object

0001:00000000       _TEOF              00401000 f teof.obj
0001:00000000       _TEOF@0            00401000 f teof.obj
0001:00000000       _MAIN__            00401000 f teof.obj
0001:0000003d       _HERE              0040103d f teof.obj
0001:0000003d       _HERE@0            0040103d f teof.obj
0001:0000006d       _WE@0              0040106d f teof.obj
0001:0000006d       _WE                0040106d f teof.obj
0001:0000009d       _GO                0040109d f teof.obj
0001:0000009d       _GO@0              0040109d f teof.obj
0001:000000cd       _AGAIN             004010cd f teof.obj
0001:000000cd       _AGAIN@0           004010cd f teof.obj
0001:00000180       _for_rtl_init_     00401180 f dfor:for_init.obj
...
```

After determining that the first five stack frames fall in run-time code (using portions of the map file not shown here), the sixth frame shows a PC of 00401169. Using the fragment of the map file shown above, it can be seen that this PC is greater than 004010cd but less than 00401180 and is therefore in routine _AGAIN, the first Fortran routine on the call stack. The remaining PC's can be manually correlated in a similar fashion to reconstruct the calling sequence.

Remember that compiling with /traceback increases the size of your application's image because of the extra PC correlation information included in the image. You can see if the extra traceback information is included in an image (checking for the presence of a .trace section) by typing:

```
link -dump -summary your_app.exe
```

For the teof.exe example, the following is displayed:

```
Microsoft (R) COFF Binary File Dumper Version x.xx.xxxx
Copyright (C) Microsoft Corp 1992-1998. All rights reserved.

Dump of file teof.exe

File Type: EXECUTABLE IMAGE

   Summary

      1000 .data
      1000 .idata
      1000 .rdata
      1000 .text
      1000 .trace
```

Check the file size with a simple directory command. Here's the teof.exe example linked against the dynamic Fortran library with traceback:

```
 03/03/98  01:45p                 5,120 teof.exe
              1 File(s)           5,120 bytes
```

Without traceback, the following appears:

```
03/03/98  01:46p                   4,608 teof.exe
               1 File(s)           4,608 bytes
```

For this simple example, the traceback correlation information added 512 bytes to the image size. In a real application, this would probably be much larger. For any application, the developer must decide if the increase in image size is worth the benefit of automatic PC correlation or if manually correlating PC's with a map file is acceptable.

For command-line use and in the release configuration in the visual development environment, traceback information is not included by default in Fortran compiles (default is /notraceback). In the visual development environment, the default is /traceback in the debug configuration. For the release configuration, request traceback in the Run Time category of the Project Settings dialog box.

If an error occurs when traceback was requested during compilation, the run-time library will produce the correlated call stack display.

If an error occurs when traceback was disabled during compilation, the run-time library will produce the uncorrelated call stack display.

If you do not want to see the call stack information displayed, you can set the environment variable FOR_DISABLE_STACK_TRACE to true. You will still get the Fortran run-time error message:

```
forrtl: severe (24): end-of-file during read, unit 10, file E:\USERS\xxx.dat
```

Example: Machine Exception Condition, Program ovf

The following program generates a floating-point overflow exception when compiled with /fpe:0:

```
program ovf
real*4 a
a=1e37
do i=1,10
   a=hey(a)
end do
print *, 'a= ', a
end

real*4 function hey(b)
real*4 b
hey = watch(b)
end

real*4 function watch(b)
real*4 b
```

```
watch = out(b)
end

real*4 function out(b)
real*4 b
out = below(b)
end

real*4 function below(b)
real*4 b
below = b*10.0e0
end
```

When this program is compiled on an ia32 system with /traceback, /fpe:0, and /optimization:0, the traceback output appears as follows:

```
forrtl: error (72): floating overflow
Image              PC        Routine            Line        Source
ovf.exe            00401161  BELOW                    29  ovf.f90
ovf.exe            0040113C  OUT                      24  ovf.f90
ovf.exe            0040111B  WATCH                    19  ovf.f90
ovf.exe            004010FA  HEY                      14  ovf.f90
ovf.exe            0040105B  OVF                       7  ovf.f90
ovf.exe            00432429  Unknown             Unknown  Unknown
ovf.exe            00426C74  Unknown             Unknown  Unknown
KERNEL32.dll       77F1B9EA  Unknown             Unknown  Unknown
```

Notice that unlike the previous example of an unhandled I/O programming error, the stack walk can begin right at the point of the exception. There are no run-time routines on the call stack to dig through. The overflow occurs in routine BELOW at PC 00401161 which is correlated to line 29 of the source file ovf.f90.

When the program is compiled at a higher optimization level, /optimization:4, with /fpe:0 and /traceback, the traceback output appears as follows:

```
forrtl: error (72): floating overflow
Image              PC        Routine            Line        Source
ovf.exe            00401070  OVF                      29  ovf.f90
ovf.exe            004323E9  Unknown             Unknown  Unknown
ovf.exe            00426C34  Unknown             Unknown  Unknown
KERNEL32.dll       77F1B9EA  Unknown             Unknown  Unknown
```

With /optimize:4, the entire program has been inlined. We can see this with a quick look in the listing file:

```
...
                                        .CODE
                                        PUBLIC  _MAIN__
             0000          _MAIN__      PROC
55           0000                       push    ebp
EC8B         0001                       mov     ebp, esp
30EC83       0003                       sub     esp, 48
000000E8     0006                       call _for_check_flawed_pentium@0
00
04EC83       000B                       sub     esp, 4
0020058D     000E                       lea     eax, dword ptr .literal$+32
```

```
0000
50          0014        push    eax
000000E8    0015        call    _for_set_fpe_@4
00
001C058D    001A        lea     eax, dword ptr .literal$+28
0000
50          0020        push    eax
000000E8    0021        call    _for_set_reentrancy@4
00
04C483      0026        add     esp, 4
001805D9    0029        fld     dword ptr .literal$+24                  ; 0
0000
00000DD8    002F        fmul    dword ptr .literal$
0000
9B          0035        fwait
00000DD8    0036        fmul    dword ptr .literal$
0000
9B          003C        fwait
00000DD8    003D        fmul    dword ptr .literal$
0000
9B          0043        fwait
00000DD8    0044        fmul    dword ptr .literal$
0000
9B          004A        fwait
00000DD8    004B        fmul    dword ptr .literal$
0000
9B          0051        fwait
00000DD8    0052        fmul    dword ptr .literal$
0000
9B          0058        fwait
00000DD8    0059        fmul    dword ptr .literal$
0000
9B          005F        fwait
00000DD8    0060        fmul    dword ptr .literal$
0000
9B          0066        fwait
00000DD8    0067        fmul    dword ptr .literal$
0000
FC5DD9      006D        fstp    dword ptr -4[ebp]
9B          0070        fwait
D233        0071        xor     edx, edx
0014058D    0073        lea     eax, dword ptr .literal$+20
0000
03D045C7    0079        mov     dword ptr -48[ebp], 3
000000
D44589      0080        mov     dword ptr -44[ebp], eax
000C0D8D    0083        lea     ecx, dword ptr .literal$+12
0000
DC458D      0089        lea     eax, .T1_               ; eax, dword ptr -3
DC5589      008C        mov     .T1_, edx               ; dword ptr -36[ebp
04EC83      008F        sub     esp, 4
D0558D      0092        lea     edx, dword ptr -48[ebp]
52          0095        push    edx
51          0096        push    ecx
84FF0068    0097        push    126156544
07
FFFFFF68    009C        push    -1
FF
50          00A1        push    eax
000000E8    00A2        call    _for_write_seq_lis
00
18C483      00A7        add     esp, 24
FC458B      00AA        mov     eax, dword ptr -4[ebp]
D04589      00AD        mov     dword ptr -48[ebp], eax
```

```
04EC83       00B0              sub     esp, 4
D0558D       00B3              lea     edx, dword ptr -48[ebp]
00040D8D     00B6              lea     ecx, dword ptr .literal$+4
0000
DC458D       00BC              lea     eax, .T1_                        ; eax, dwor
52           00BF              push    edx
51           00C0              push    ecx
50           00C1              push    eax
000000E8     00C2              call    _for_write_seq_lis_xmit
00
10C483       00C7              add     esp, 16
E58B         00CA              mov     esp, ebp
000001B8     00CC              mov     eax, 1
00
5D           00D1              pop     ebp
C3           00D2              ret
_MAIN__                        ENDP

...
```

The main program, OVF, no longer calls routine HEY. While the output is not quite what one might have expected intuitively, it is still entirely correct. You need to keep in mind the effects of compiler optimization when you interpret the diagnostic information reported for a failure in a release image.

If the same image were executed again but with environment variable FOR_ENABLE_VERBOSE_STACK_TRACE set to true, you would also see a dump of the exception context record at the time of the error. Here is an excerpt of how that would appear on an ia32 system:

```
forrtl: error (72): floating overflow

Hex Dump Of Exception Record Context Information:

Exception Context:  Processor Control and Status Registers.

EFlags:  00010212
CS:  0000001B  EIP:  00401161  SS:   00000023  ESP:  0012FE38  EBP:  0012FE60

Exception Context:  Processor Integer Registers.

EAX: 00444488  EBX:  00000009  ECX:  00444488  EDX:  00000002
ESI: 0012FBBC  EDI:  F9A70030

Exception Context:  Processor Segment Registers.

DS:  00000023  ES:   00000023  FS:   00000038  GS:   00000000

Exception Context:  Floating Point Control and Status Registers.

ControlWord:  FFFF0262  ErrorOffset:    0040115E  DataOffset:    0012FE5C
StatusWord:   FFFFF8A8  ErrorSelector:  015D001B  DataSelector:  FFFF0023
TagWord:      FFFF3FFF  Cr0NpxState:    00000000

Exception Context:  Floating Point RegisterArea.

RegisterArea[00]:  4080BC143F4000000000  RegisterArea[10]:  F7A0FFFFFFFF77F9D860
RegisterArea[20]:  00131EF0000800060012  RegisterArea[30]:  00000012F7C002080006
RegisterArea[40]:  02080006000000000000  RegisterArea[50]:  0000000000000012F7D0
RegisterArea[60]:  00000000000000300000  RegisterArea[70]:  FBBC000000300137D9EF
```

...

Example: Using Traceback in Mixed Fortran/C Applications, Program FPING and CPONG

Consider the following example that shows how the traceback output might appear in a mixed Fortran/C application. The main program is a Fortran program named FPING. Program FPING triggers a chain of function calls which are alternately Fortran and C code. Eventually, the C routine named Unlucky is called, which produces a floating divide by zero error.

Source module FPING.FOR contains the Fortran function definitions, each of which calls a C routine from source module CPONG.C. FPING.FOR is compiled with the /fpe:0 /optimize:0 /traceback options enabled, on the ia32 platform. Here's the program traceback output:

```
forrtl: error (73): floating divide by zero
Image              PC        Routine            Line      Source
fping.exe          00401161  Unknown            Unknown   Unknown
fping.exe          004010DC  DOWN4                   58   fping.for
fping.exe          0040118F  Unknown            Unknown   Unknown
fping.exe          004010B6  DOWN3                   44   fping.for
fping.exe          00401181  Unknown            Unknown   Unknown
fping.exe          00401094  DOWN2                   31   fping.for
fping.exe          00401173  Unknown            Unknown   Unknown
fping.exe          00401072  DOWN1                   18   fping.for
fping.exe          0040104B  FPING                    5   fping.for
fping.exe          004013B9  Unknown            Unknown   Unknown
fping.exe          004012AF  Unknown            Unknown   Unknown
KERNEL32.dll       77F1B304  Unknown            Unknown   Unknown
```

Notice that the stack frames contributed by Fortran routines can be correlated to a routine name, line number, and source module but those frames contributed by C routines cannot be correlated. Remember, even though the stack can be walked in reverse, and PC's reported, the information necessary to correlate the PC to a routine name, line number, and so on, is contributed to the image from the objects generated by the Fortran compiler. The C compiler does not have this capability. Also remember that you only get the correlation information if you specify the /traceback option for your Fortran compiles.

The top stack frame cannot be correlated to a routine name because it is in C code. By examining the map file for the application, we can see that the reported PC, 00401161, is greater than the start of routine _Unlucky, but less than the start of routine _down1_C, so we at least know the error occurred in routine _Unlucky. Here is the pertinent section of the map file:

```
  Address         Publics by Value        Rva+Base   Lib:Object

 0001:00000000       _FPING               00401000 f fping.obj
 0001:00000000       _FPING@0             00401000 f fping.obj
 0001:00000000       _MAIN__              00401000 f fping.obj
 0001:0000005f       _DOWN1               0040105f f fping.obj
 0001:0000005f       _DOWN1@4             0040105f f fping.obj
```

```
 0001:00000083       _DOWN2@4              00401083 f fping.obj
 0001:00000083       _DOWN2                00401083 f fping.obj
 0001:000000a5       _DOWN3                004010a5 f fping.obj
 0001:000000a5       _DOWN3@4              004010a5 f fping.obj
 0001:000000c7       _DOWN4@4              004010c7 f fping.obj
 0001:000000c7       _DOWN4                004010c7 f fping.obj
 0001:00000100       _Fact                 00401100 f cpong.obj
 0001:00000127       _Pythagoras           00401127 f cpong.obj

******************************************************
The reported PC lies between the start of _Unlucky and
the start of _down1_C...
******************************************************

 0001:0000014d       _Unlucky              0040114d f cpong.obj
 0001:00000167       _down1_C              00401167 f cpong.obj

 0001:00000175       _down2_C              00401175 f cpong.obj
 0001:00000183       _down3_C              00401183 f cpong.obj
 0001:00000192       _for_check_flawed_pentium@0 00401192 f dfordll:DFORRT.dll
 0001:00000198       _for_set_fpe_@4        00401198 f dfordll:DFORRT.dll
 0001:0000019e       _for_set_reentrancy@4 0040119e f dfordll:DFORRT.dll
 etc...
```

In a similar manner, the other PC's reported as "Unknown" can be correlated to a routine name using the map file.

When examining traceback output (or any type of diagnostic output for that matter), it is always important to keep in mind the affects of compiler optimization. The Fortran source module in the above example was built with optimization turned off, /optimize:0. Look at the output when optimizations are enabled, /optimize:4:

```
forrtl: error (73): floating divide by zero
Image           PC        Routine     Line     Source
fping.exe       00401111  Unknown     Unknown  Unknown
fping.exe       0040109D  DOWN4            58  fping.for
fping.exe       0040113F  Unknown     Unknown  Unknown
fping.exe       00401082  DOWN3            44  fping.for
fping.exe       00401131  Unknown     Unknown  Unknown
fping.exe       0040106B  DOWN2            31  fping.for
fping.exe       00401123  Unknown     Unknown  Unknown
fping.exe       00401032  FPING            18  fping.for
fping.exe       00401369  Unknown     Unknown  Unknown
fping.exe       0040125F  Unknown     Unknown  Unknown
KERNEL32.dll    77F1B304  Unknown     Unknown  Unknown
```

From the traceback output, it would appear that routine DOWN1 was never called. In fact, it has not been called. At the higher optimization level, the compiler has inlined function DOWN1 so that the call to routine down1_C is now made from FPING. The correlated line number still points to the correct line in the source code. You can see that DOWN1 was inlined by looking in the listing file, FPING.LST:

```
                                .CODE
                                PUBLIC   _MAIN__
             0000      _MAIN__  PROC
55           0000               push     ebp
```

```
EC8B         0001            mov     ebp, esp
04EC83       0003            sub     esp, 4
53           0006            push    ebx
000000E8     0007            call    _for_check_flawed_pentium@0
00
04EC83       000C            sub     esp, 4
0008058D     000F            lea     eax, dword ptr .literal$+8
0002
50           0015            push    eax
000000E8     0016            call    _for_set_fpe_@4
00
0004058D     001B            lea     eax, dword ptr .literal$+4
0002
50           0021            push    eax
000000E8     0022            call    _for_set_reentrancy@4
00
000035FF     0027            push    dword ptr .literal$          ; 000018
0000
000035FF     0027            push    dword ptr .literal$          ; 000018
0000

*******************************************************************
Call _down1_C from MAIN__ here, no call to DOWN1 Fortran routine...
*******************************************************************

000000E8     002D            call    _down1_C
00
C0DD         0032            ffree   st(0)
F7D9         0034            fincstp
08C483       0036            add     esp, 8
000001B8     0039            mov     eax, 1                       ; 000006
A0
5B           003E            pop     ebx
E58B         003F            mov     esp, ebp
5D           0041            pop     ebp
C3           0042            ret
_MAIN__                     ENDP
```

Finally, suppose the example Fortran code is redesigned with each of the Fortran routines split into separate source modules. Here is what the traceback output would look like with the redesigned code:

```
forrtl: error (73): floating divide by zero
Image           PC        Routine     Line     Source
fpingmain.exe   00401171  Unknown     Unknown  Unknown
fpingmain.exe   004010ED  DOWN4            12  fping4.for
fpingmain.exe   0040119F  Unknown     Unknown  Unknown
fpingmain.exe   004010C1  DOWN3            11  fping3.for
fpingmain.exe   00401191  Unknown     Unknown  Unknown
fpingmain.exe   00401099  DOWN2            11  fping2.for
fpingmain.exe   00401183  Unknown     Unknown  Unknown
fpingmain.exe   00401073  DOWN1            11  fping1.for
fpingmain.exe   0040104B  FPING             5  fpingmain.for
fpingmain.exe   004013C9  Unknown     Unknown  Unknown
fpingmain.exe   004012BF  Unknown     Unknown  Unknown
KERNEL32.dll    77F1B304  Unknown     Unknown  Unknown
```

Notice that the line number and source file correlation information has changed to reflect the new design of the code.

Here are the sources used in the above examples:

```
**********************************
FPING.FOR
**********************************
        program fping

        real*4 a,b
        a=-10.0
        b=down1(a)
        end

        real*4 function down1(b)
        real*4 b
!DEC$ IF DEFINED(_X86_)
        INTERFACE TO REAL*4 FUNCTION down1_C [C,ALIAS:'_down1_C'] (n)
!DEC$ ELSE
        INTERFACE TO REAL*4 FUNCTION down1_C [C,ALIAS:'down1_C'] (n)
!DEC$ ENDIF
        REAL*4 n [VALUE]
        END
        real*4 down1_C
        down1 = down1_C(b)
        end

        real*4 function down2(b)
        real*4 b [VALUE]
!DEC$ IF DEFINED(_X86_)
        INTERFACE TO REAL*4 FUNCTION down2_C [C,ALIAS:'_down2_C'] (n)
!DEC$ ELSE
        INTERFACE TO REAL*4 FUNCTION down2_C [C,ALIAS:'down2_C'] (n)
!DEC$ ENDIF
        REAL*4 n [VALUE]
        END
        real*4 down2_C
        down2 = down2_C(b)
        end

        real*4 function down3(b)
        real*4 b [VALUE]
!DEC$ IF DEFINED(_X86_)
        INTERFACE TO REAL*4 FUNCTION down3_C [C,ALIAS:'_down3_C'] (n)
!DEC$ ELSE
        INTERFACE TO REAL*4 FUNCTION down3_C [C,ALIAS:'down3_C'] (n)
!DEC$ ENDIF
        REAL*4 n [VALUE]
        END
        real*4 down3_C
        down3 = down3_C(b)
        end

        real*4 function down4(b)
        real*4 b [VALUE]
!DEC$ IF DEFINED(_X86_)
        INTERFACE TO SUBROUTINE Unlucky [C,ALIAS:'_Unlucky'] (a,c)
!DEC$ ELSE
        INTERFACE TO SUBROUTINE Unlucky [C,ALIAS:'Unlucky'] (a,c)
!DEC$ ENDIF
        REAL*4 a [VALUE]
        REAL*4 c [REFERENCE]
        END
        real*4 a
        call Unlucky(b,a)
        down4 = a
        end
```

```
************************************
CPONG.C
************************************
#include <math.h>

extern float __stdcall DOWN2 (float n);
extern float __stdcall DOWN3 (float n);
extern float __stdcall DOWN4 (float n);

int Fact( int n )
{
    if (n > 1)
        return( n * Fact( n - 1 ));
    return 1;
}

void Pythagoras( float a, float b, float *c)
{
    *c = sqrt( a * a + b * b );
}

void Unlucky( float a, float *c)
{
float b=0.0;
    *c = a/b;
}

float down1_C( float a )
{
    return( DOWN2( a ));
}

float down2_C( float a )
{
    return( DOWN3( a ));
}

float down3_C( float a )
{
    return( DOWN4( a ));
}

************************************
FPINGMAIN.FOR
************************************
        program fping

        real*4 a,b
        a=-10.0
        b=down1(a)
        end

************************************
FPING1.FOR
************************************
        real*4 function down1(b)
        real*4 b
!DEC$ IF DEFINED(_X86_)
        INTERFACE TO REAL*4 FUNCTION down1_C [C,ALIAS:'_down1_C'] (n)
!DEC$ ELSE
        INTERFACE TO REAL*4 FUNCTION down1_C [C,ALIAS:'down1_C'] (n)
!DEC$ ENDIF
```

```
        REAL*4 n [VALUE]
        END
        real*4 down1_C
        down1 = down1_C(b)
        end

************************************
FPING2.FOR
************************************
        real*4 function down2(b)
        real*4 b [VALUE]
!DEC$ IF DEFINED(_X86_)
        INTERFACE TO REAL*4 FUNCTION down2_C [C,ALIAS:'_down2_C'] (n)
!DEC$ ELSE
        INTERFACE TO REAL*4 FUNCTION down2_C [C,ALIAS:'down2_C'] (n)
!DEC$ ENDIF
        REAL*4 n [VALUE]
        END
        real*4 down2_C
        down2 = down2_C(b)
        end

************************************
FPING3.FOR
************************************
        real*4 function down3(b)
        real*4 b [VALUE]
!DEC$ IF DEFINED(_X86_)
        INTERFACE TO REAL*4 FUNCTION down3_C [C,ALIAS:'_down3_C'] (n)
!DEC$ ELSE
        INTERFACE TO REAL*4 FUNCTION down3_C [C,ALIAS:'down3_C'] (n)
!DEC$ ENDIF
        REAL*4 n [VALUE]
        END
        real*4 down3_C
        down3 = down3_C(b)
        end

************************************
FPING4.FOR
************************************
        real*4 function down4(b)
        real*4 b [VALUE]
!DEC$ IF DEFINED(_X86_)
        INTERFACE TO SUBROUTINE Unlucky [C,ALIAS:'_Unlucky'] (a,c)
!DEC$ ELSE
        INTERFACE TO SUBROUTINE Unlucky [C,ALIAS:'Unlucky'] (a,c)
!DEC$ ENDIF
        REAL*4 a [VALUE]
        REAL*4 c [REFERENCE]
        END
        real*4 a
        call Unlucky(b,a)
        down4 = a
        end
```

Obtaining Traceback Information with TRACEBACKQQ

You can obtain traceback information in your application by calling the

TRACEBACKQQ routine.

TRACEBACKQQ allows an application to initiate a stack trace. You can use this routine to report application detected errors, use it for debugging, and so on. It uses the standard stack trace support in the Visual Fortran run-time system to produce the same output that the run-time system produces for unhandled errors and exceptions (severe error message). The **TRACEBACKQQ** subroutine generates a stack trace showing the program call stack as it was leading up to the point of the call to **TRACEBACKQQ**.

The error message string normally included from the run-time support is replaced with the user-supplied message text or omitted if no user string is specified. Traceback output is directed to the target destination appropriate for the application type, just as it is when traceback is initiated internally by the run-time support. See the sections Using Traceback Information and Run-Time Message Display and Format for more information.

In the most simple case, a user can generate a stack trace by coding the call to TRACEBACKQQ with no arguments:

```
CALL TRACEBACKQQ()
```

This call causes the run-time library to generate a traceback report with no leading header message, from wherever the call site is, and terminate execution.

You can specify arguments that generate a stack trace with the user-supplied string as the header and instead of terminating execution, return control to the caller to continue execution of the application. For example:

```
CALL TRACEBACKQQ(STRING="Done with pass 1",USER_EXIT_CODE=-1)
```

By specifying a user exit code of -1, control returns to the calling program. Specifying a user exit code with a positive value requests that specified value be returned to the operating system. The default value is 0, which causes the application to abort execution.

The following example demonstrates the use of the EPTR argument when calling from a user defined exception filter function. The premise of the example is a Fortran DLL containing entry points protected by a C try/except construct, such as:

```
__declspec(dllexport) void FPE_TEST_WRAPPER ()
{
__try {
      /*
      **  call the Fortran code...
      */
      FPE_TEST() ;
      }
```

```
__except ( CHECK_EXCEPTION_INFO ( GetExceptionInformation() ) )
      {
      /*
      **  noncontinuable exception handling here, if any.
      */
      }
```

The C function shown above is guarding against a floating-point divide-by-zero exception. This function calls the user-supplied FPE_TEST (not shown). The Fortran function CHECK_EXCEPTION_INFO shown below (called in the __except filter expression above) can use **TRACEBACKQQ** to get a stack trace as follows:

```
   INTEGER*4 FUNCTION CHECK_EXCEPTION_INFO ( ExceptionInfo )
   !DEC$ ATTRIBUTES DLLEXPORT::CHECK_EXCEPTION_INFO
   USE DFWINTY
   !DEC$ ATTRIBUTES REFERENCE :: ExceptionInfo
   TYPE(T_EXCEPTION_POINTERS) ExceptionInfo


   TYPE(T_EXCEPTION_RECORD) erecptr
   TYPE(T_CONTEXT) ctxptr

   POINTER(eptr,erecptr)
   POINTER(ctxp,ctxptr)

   INTEGER(4) EXIT_CODE,STS
   CHARACTER(LEN=70) MYSTR

! Init the arguments to TRACEBACKQQ appropriately for your needs...

   EXIT_CODE=-1

   eptr = ExceptionInfo.ExceptionRecord
   ctxp = ExceptionInfo.ContextRecord

   IF ( erecptr.ExceptionCode .EQ. STATUS_FLOAT_DIVIDE_BY_ZERO ) THEN
          PRINT *, 'Saw floating divide by zero.'
          PRINT '(1x,a,z8.8)', 'ContextRecord.FloatSave.StatusWord = ', &
                  ctxptr.FloatSave.StatusWord
          MYSTR = "FLTDIV EXCEPTION IN MY APPLICATION"
          CALL TRACEBACKQQ(MYSTR,EXIT_CODE,STS, %LOC(ExceptionInfo))
   END IF
   .
   .
   .
   CHECK_EXCEPTION_INFO = 1
   END
```

To return a pointer to C run-time exception information pointers within a user-defined handler that was established with SIGNALQQ (or directly with the C signal function), you can call the GETEXCEPTIONPTRSQQ routine.

For an example of how to establish a signal handler with **SIGNALQQ** (or the C signal() function) and use the **TRACEBACKQQ** and **GETEXCEPTIONPTRSQQ** routines to generate a traceback display from the handler, see the Visual Fortran Sample GetEptrs (in `...\Df98\Samples\ExceptionHandling\GetEptrs`).

Run-Time Environment Variables

The Visual Fortran run-time system recognizes the following environment variables:

Environment Variable	Description
FOR_ACCEPT	The **ACCEPT** statement does not include an explicit logical unit number. Instead, it uses an implicit internal logical unit number and the FOR_ACCEPT environment variable. If FOR_ACCEPT is *not* defined, the code `ACCEPT f,iolist` reads from CONIN$ (standard input). If FOR_ACCEPT is defined (as a filename optionally containing a path), the specified file would be read.
FORT_BUFFERED	Lets you request that buffered I/O should be used at run-time for output of all Fortran I/O units, except those with output to the terminal. This provides a run-time mechanism to support the /assume:buffered_io compiler option.
FOR_DEFAULT_PRINT_DEVICE	Lets you specify the print device other than the default print device PRN (LPT1) for files closed (**CLOSE** statement) with the DISPOSE='PRINT' specifier. To specify a different print device for the file associated with the **CLOSE** statement DISPOSE='PRINT' specifier, set the environment variable FOR_DEFAULT_PRINT_DEVICE to any legal DOS print device before executing the program.
FOR_DIAGNOSTIC_LOG_FILE	If set to the name of a file, writes diagnostic output to the specified file. For information on using stack trace information, see Locating Run-Time Errors and Using Traceback Information.

FOR_DISABLE_DIAGNOSTIC_DISPLAY	If set to true, disables the display of all error information. This might be helpful if you just want to test the error status of your program and do not want the Fortran run-time system to display any information about an abnormal program termination. For information on using stack trace information, see Using Traceback Information.
FOR_DISABLE_STACK_TRACE	If set to true, disables the call stack trace information that follows the displayed severe error message text. For information on locating the cause of run-time errors using stack trace information, see Locating Run-Time Errors and Using Traceback Information.
FOR_ENABLE_VERBOSE_STACK_TRACE	If set to true, displays more detailed call stack information in the event of an error. For information on using stack trace information, see Using Traceback Information.
FOR_FULL_SRC_FILE_SPEC	By default, the traceback output displays only the file name and extension in the source file field. To display complete file name information including the path, set the environment variable FOR_FULL_SRC_FILE_SPEC to true. For more information, see Using Traceback Information.
FOR_GENERATE_DEBUG_EXCEPTION	In Visual Fortran Version 6, you no longer need to set this environment variable for the program to stop in the debugger when a severe error occurs. Regardless of whether this environment variable is set, you can view the Call Stack display. For more information, see Locating Run-Time Errors in the Debugger.

FOR_IGNORE_EXCEPTIONS	If set to true, disables the default run-time exception handling, for example, to allow just-in-time debugging. The run-time system exception handler returns EXCEPTION_CONTINUE_SEARCH to the operating system, which looks for other handlers to service the exception. For information on just-in-time debugging, see Running Fortran Applications and the Visual C++ Development Environment User's Guide.
FOR_NOERROR_DIALOGS	If set to true, disables the display of dialog boxes when certain exceptions or errors occur. This is useful when running many test programs in batch mode to prevent a failure from stopping execution of the entire test stream.
FOR_PRINT	Neither the **PRINT** statement nor a **WRITE** statement with an asterisk (*) in place of a unit number includes an explicit logical unit number. Instead, both use an implicit internal logical unit number and the FOR_PRINT environment variable. If FOR_PRINT is *not* defined, the code `PRINT f,iolist` or `WRITE (*,f) iolist` writes to CONOUT$ (standard output). If FOR_PRINT is defined (as a filename optionally containing a path), the specified file would be written to.
FOR_READ	A READ statement that uses an asterisk (*) in place of a unit number does not include an explicit logical unit number. Instead, it uses an implicit internal logical unit number and the FOR_READ environment variable. If FOR_READ is *not* defined, the code `READ (*,f) iolist` or `READ f,iolist` reads from CONIN$ (standard input). If FOR_READ is defined (as a filename optionally containing a path), the specified file would be read.

FOR_RUN_FLAWED_PENTIUM	If set to true, allows the continuation of the executing program when /check:flawed_pentium (default) is in effect and a flawed Pentium chip is detected. For more information, see Intel Pentium Floating-Point Flaw.
FOR_TYPE	The **TYPE** statement does not include an explicit logical unit number. Instead, it uses an implicit internal logical unit number and the FOR_TYPE environment variable. If FOR_TYPE is *not* defined, the code `TYPE f,iolist` writes to CONOUT$ (standard output). If FOR_TYPE is defined (as a filename optionally containing a path), the specified file would be written to.
FORT*n*	Lets you specify the file name for a particular unit number (*n*), when a file name is not specified in the **OPEN** statement or an implicit **OPEN** is used, and the compiler option /fpscomp:filesfromcmd was *not* specified. Preconnected files attached to units 0, 5, and 6 are by default associated with system standard I/O files.
FORT_CONVERT*n*	Lets you specify the data format for an unformatted file associated with a particular unit number (*n*), as described in Methods of Specifying the Data Format.
FORT_CONVERT.*ext* FORT_CONVERT_*ext*	Lets you specify the data format for unformatted files with a particular file extension suffix (*ext*), as described in Methods of Specifying the Data Format.

On the command line, the SET command lets you:

- Set an *environment variable* to a *value*:

  ```
  SET environment-variable=value
  ```

  For example:

  ```
  SET FOR_GENERATE_DEBUG_EXCEPTION=TRUE
  ```

- To view the current value of an environment variable, use the SET command with only the environment variable name:

```
SET FOR_GENERATE_DEBUG_EXCEPTION
FOR_GENERATE_DEBUG_EXCEPTION=TRUE
```

From within your program, you can set the appropriate environment variable by calling the SETENVQQ routine:

```
program ENVVAR
use dflib
LOGICAL(4) res
! Add other data declarations here
! call SETENVQQ as a function
res=SETENVQQ("FOR_GENERATE_DEBUG_EXCEPTION=T")
...
```

For a list of environment variables used with the DF command, see Environment Variables Used with the DF Command.

The Floating-Point Environment

This section describes the Visual Fortran numeric environment using IEEE arithmetic. The following topics are covered:

When the term floating-point unit (FPU) appears, it refers to your math processor. The descriptions in this section minimize hardware-specific terminology.

Representing Numbers

Fortran's numeric environment is flexible, which helps make Fortran a strong language for intensive numerical calculations. The Fortran standard purposely leaves the precision of numeric quantities and the method of rounding numeric results unspecified. This allows Fortran to operate efficiently for diverse applications on diverse systems.

The effect of math computations on integers is straightforward:

- Integers of KIND=4 consist of a maximum positive integer (2,147,483,647), a minimum negative integer (-2,147,483,648), and all integers between them including zero.
- Integers of KIND=8 consist of a maximum positive integer (-9,223,372,036,854,775,808), a minimum negative integer (9,223,372,036,854,775,807), and all integers between them including zero.

Operations on integers result in other integers within this range. The only arithmetic rule to remember is that integer division results in truncation (for example, 8/3 evaluates to 2).

Computations on real numbers, however, may not yield what you expect. This happens because the hardware must represent numbers in a finite number of bits.

There are several effects of using finite floating-point numbers. The hardware is not able to represent every real number exactly, but must approximate exact representations by rounding or truncating to finite length. In addition, some numbers lie outside the range of representation of the maximum and minimum exponents and can result in calculations that underflow and overflow. As an example of one consequence, finite precision produces many numbers that, although non-zero, behave in addition as zero.

You can minimize the effects of finite representation with programming techniques; for example, by not using floating-point numbers in LOGICAL comparisons or by giving them a tolerance (for example, IF (x <= 10.001)), and by not attempting to combine or compare numbers that differ by more than the number of significant bits. (For more information on programming methods to reduce the effects of imprecision, see Rounding Errors.)

For further discussion of how floating-point numbers are represented, see:

- Floating-Point Numbers
- Retrieving Parameters of Numeric Representations
- Native IEEE Floating-Point Representations

Floating-Point Numbers

This version of Visual Fortran uses a close approximation to the IEEE floating-point standard (ANSI/IEEE Std 754-1985, *IEEE Standard for Binary Floating-Point Arithmetic*, 1985). This standard is common to many microcomputer-based systems due to the availability of fast math coprocessors that implement the required characteristics.

You should choose the appropriate setting of the /fpe compiler option to select the type of default floating-point exception handling provided by the Visual Fortran run-time system.

This section outlines the characteristics of the standard and its implementation for Visual Fortran. Except as noted, the description includes both the IEEE standard and the Visual Fortran implementation. The following topics are discussed:

- Floating-Point Formats
- Floating-Point Representation
- Viewing Floating-Point Representations with BitViewer
- Special Values (Signed Zero, NaN, Signed Infinity)

Floating-Point Formats

The IEEE Standard 754 specifies values and requirements for floating-point representation (such as base 2). The standard outlines requirements for two formats: basic and extended, and for two word-lengths within each format:

single and double.

Visual Fortran supports single-precision format (REAL(4)) and double-precision format (REAL(8)) floating-point numbers. Visual Fortran sets the process control word by default to use double-precision run-time intermediate calculations. At some levels of optimization, some single-precision numbers are stored on the floating-point stack (which defaults to double precision) rather than being stored back into memory where they would be truncated to single precision. The compiler option /fltconsistency can control floating-point consistency and request that results be stored in memory rather than on the floating-point stack.

Floating-Point Representation

Floating-point numbers approximate real numbers with a finite number of bits. You can see the bits representing a floating-point number with the BitViewer tool. The bits are calculated as shown in the following formula. The representation is binary, so the base is 2. The bits *b*n represent binary digits (0 or 1). The precision *P* is the number of bits in the nonexponential part of the number (the significand), and *E* is the exponent. With these parameters, binary floating-point numbers approximate real numbers with the values:

$$(-1)^s\, b_0 \,.\, b_1 b_2 \ldots b_{P-1} \times 2^E$$

where s is 0 or 1 (+ or -), and $E_{min} <= E <= E_{max}$

The following table gives the standard values for these parameters for single, double, and extended-double formats and the resulting bit widths for the sign, the exponent, and the full number.

Parameters for IEEE Floating-Point Formats

Parameter	**Single**	**Double**	**Extended Double**
Sign width in bits	1	1	1
P	24	53	64
E_{max}	+127	+1023	+16383
E_{min}	- 126	- 1022	- 16382
Exponent *bias*	+127	+1023	+16383
Exponent width in bits	8	11	15
Format width in bits	32	64	80

The standard requires that the single and double formats be normalized, so b_0 is always 1. The actual number of bits needed to represent the precisions 24 and 53 is therefore 23 and 52, respectively, because b_0 is chosen to be 1 implicitly.

Extended-double format need not be normalized, so it uses the full 64 bits for precision. A *bias* is added to all exponents so that only positive integer exponents occur. This expedites comparisons of exponent values. The stored exponent is actually:

$$e = E + bias$$

For more information:

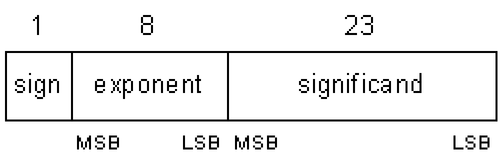
- On the floating-point representation, see Native IEEE Floating-Point Representations.
- On using the BitViewer tool, see Viewing Floating-Point Representations with BitViewer.
- On rReading or writing floating-point data other than native IEEE little endian data, see Converting Unformatted Numeric Data.

Viewing Floating-Point Representations with BitViewer

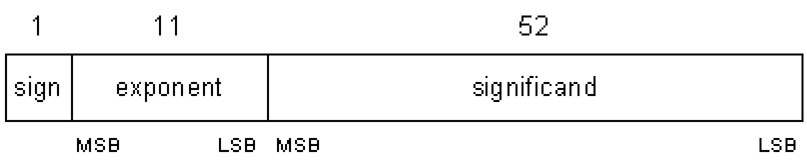
The BitViewer utility lets you view the binary representation of real numbers in single and double format. To access this tool from the command line, type the command BITVIEW. By default, Visual Fortran installs the BitViewer utility in the folder `...\Microsoft Visual Studio\Df98\BIN`.

The following figure shows the logical layout of the single and double formats. The figure shows the contents of each field, its width, and the location of the most significant bit (MSB) and the least significant bit (LSB).

Logical Structure of the IEEE Single and Double Formats

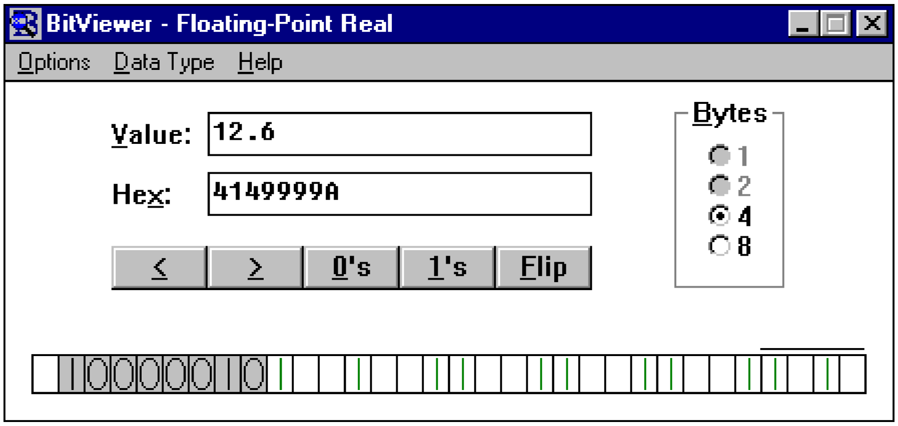


Double Format

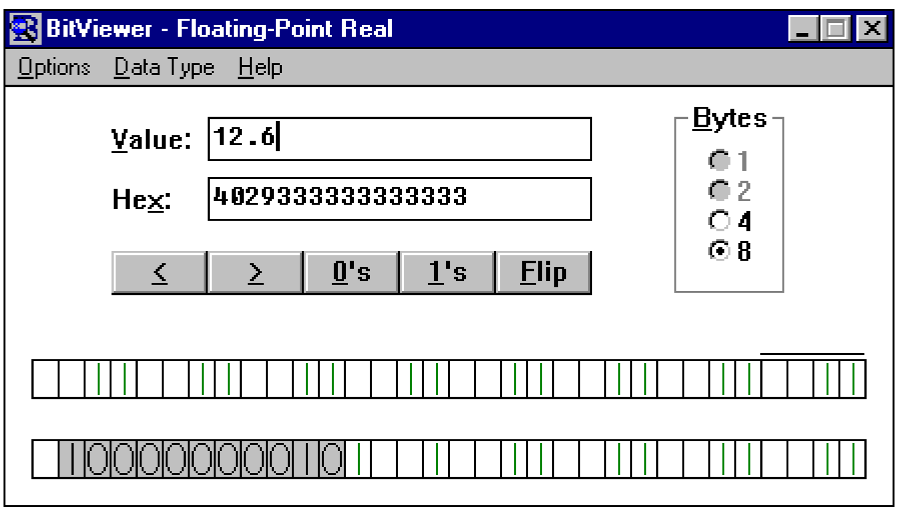


To view floating-point numbers in BitViewer, open the Data Type menu, then choose Floating-Point Real (or use the `F9` shortcut key). Set the precision by selecting one of the choices in the Bytes box. Four bytes, REAL(4), displays the number in single format (23-bit precision). Eight bytes, REAL(8), displays the number in double format (52-bit precision). The following figures show the BitViewer display of the memory storage for a 4-byte real number and an 8-byte real number, both equal to 12.6. In the double format display, the most significant part is on the bottom and the least significant 32 bits above.

Single Format in BitViewer



Double Format in BitViewer



Note: BitViewer lets you view and manipulate integer and character data as well as floating-point, and to translate between different data types. Refer to the BitViewer online Help file (Help menu) for more information.

Special Values

Special cases of the exponent-significand combination represent four types of special values in addition to the normalized numbers. The following table shows all five types of values.

IEEE Floating-Point Values

Name	Quantity	Exponent	Significand
Signed zero	± 0	$E = E_{min} - 1$	*sig* = 0
Denormalized number	$\pm\ 0\ .\ sig \times 2^{E_{min}}$	$E = E_{min} - 1$	*sig* not equal 0
Normalized number	$\pm\ 1\ .\ sig \times 2^{E}$	$E_{min} <= E <= E_{max}$	*sig*
Signed infinity	± infinity	$E = E_{max} + 1$	*sig* = 0
Not a Number	NaN	$E = E_{max} + 1$	*sig* not equal 0

These special values are interpreted as follows:

- Signed zero

  Visual Fortran treats zero as signed by default. The sign of zero is the same as the sign of a nonzero number. If you use the intrinsic function **SIGN** with zero as the second argument, the sign of the zero will be transferred. Comparisons, however, consider +0 to be equal to -0. A signed zero is useful in certain numerical analysis algorithms, but in most applications the sign of zero is invisible.

- Denormalized numbers

  Denormalized numbers (denormals) fill the gap between the smallest positive number and the smallest negative number. Otherwise only (±) 0 occurs in that interval. Denormalized numbers permit gradual underflow for intermediate results calculated internally in extended-double format. A status flag (on ia32 systems, the precision bit in the FPU Status Word exception field) is set when a number loses precision due to denormalization.

- Signed infinity

  Infinities are the result of arithmetic in the limiting case of operands with arbitrarily large magnitude. They provide a way to continue when an overflow occurs. The sign of an infinity is simply the sign you obtain for a finite number in the same operation as the finite number approaches an infinite value. By retrieving the status flags described in Setting and Retrieving Floating-Point Status and Control Words in this section, you can differentiate between an infinity that results from an overflow and one that results from division by zero. Visual Fortran treats infinity as signed by default. The output value of infinity is `Infinity` or `-Infinity`.

- Not a Number

  Not a Number (NaN) results from an operation involving one or more invalid operands. For instance 0/0 and SQRT(-1) result in NaN. In general, an operation involving a NaN produces another NaN. Because the fraction of a NaN is unspecified, there are many possible NaNs. Visual Fortran treats all NaNs identically, but provide two different types:

  - Signaling NAN, which has an initial fraction bit of 0 (zero).
  - Quiet NaN, which has an initial fraction bit of 1.

  The output value of NaN is `NaN`.

Retrieving Parameters of Numeric Representations

Visual Fortran includes several intrinsic functions that return details about the numeric representation. These are listed in the following table and described fully in the *Language Reference*.

Functions that Return Numeric Parameters

Name	**Description**	**Argument/Function Type**
DIGITS	**DIGITS**(*x*). Returns number of significant digits for data of the same type as *x*.	*x*: Integer or Real result: INTEGER(4)
EPSILON	**EPSILON**(*x*). Returns the smallest positive number that when added to one produces a number greater than one for data of the same type as *x*.	*x*: Real result: same type as *x*
EXPONENT	**EXPONENT**(*x*). Returns the exponent part of the representation of *x*.	*x*: Real result: INTEGER(4)
FRACTION	**FRACTION**(*x*). Returns the fractional part (significand) of the representation of *x*.	*x*: Real result: same type as *x*

HUGE	**HUGE**(*x*). Returns largest number that can be represented by data of type *x*.	*x*: Integer or Real result: same type as *x*
MAXEXPONENT	**MAXEXPONENT**(*x*). Returns the largest positive decimal exponent for data of the same type as *x*.	*x*: Real result: INTEGER(4)
MINEXPONENT	**MINEXPONENT**(*x*). Returns the largest negative decimal exponent for data of the same type as *x*.	*x*: Real result: INTEGER(4)
NEAREST	**NEAREST**(*x*, *s*). Returns the nearest different machine representable number to *x* in the direction of the sign of *s*.	*x*: Real *s*: Real and not zero result: same type as *x*
PRECISION	**PRECISION**(*x*). Returns the number of significant digits for data of the same type as *x*.	*x*: Real or Complex result: INTEGER(4)
RADIX	**RADIX**(*x*). Returns the base for data of the same type as *x*.	*x*: Integer or Real result: INTEGER(4)
RANGE	**RANGE**(*x*). Returns the decimal exponent range for data of the same type as *x*.	*x*: Integer, Real or Complex result: INTEGER(4)
RRSPACING	**RRSPACING**(*x*). Returns the reciprocal of the relative spacing of numbers near *x*.	*x*: Real result: same type as *x*
SCALE	**SCALE**(*x*, *i*). Multiplies *x* by 2 raised to the power of *i*.	*x*: Real *i*: Integer result: same type as *x*
SET_EXPONENT	**SET_EXPONENT**(*x*,*i*). Returns a number whose fractional part is *x* and whose exponential part is *i*.	*x*: Real *i*: Integer result: same type as *x*
SPACING	**SPACING**(*x*). Returns the absolute spacing of numbers near *x*.	*x*: Real result: same type as *x*
TINY	**TINY**(*x*). Returns smallest positive number that can be represented by data of type *x*.	*x*: Real result: same type as *x*

Loss of Precision Errors: Rounding, Special Values, Underflow, and Overflow

If a real number is not exactly one of the representable floating-point numbers, then the nearest floating-point number must represent it. The rounding error is the difference between the exact real number and its nearest floating-point representation. The floating-point number representing a rounded real number is called *inexact*.

Normally, calculations proceed when an inexact value results. Almost any floating-point operation can produce an inexact result. The rounding mode (round up, round down, round nearest, truncate) is determined by the floating-point control word.

If an arithmetic operation does not result in an exact, valid floating-point number, which includes numbers that have been rounded to an exactly representable floating-point number, it results in a special value: signed zero, signed infinity, NaN, or a denormal. Special-value results are a limiting case of the arithmetic operation involved. Special values can propagate through your arithmetic operations without causing your program to fail, and often providing usable results.

If an arithmetic operation results in an exact value, but the value is invalid, the operation causes underflow or overflow:

- Underflow occurs when an arithmetic result is too small for the math processor to handle. Depending on the setting of the /fpe compiler option, underflows are set to zero (they are usually harmless) or they are left as is (denormalized).
- Overflow occurs when an arithmetic result is too large for the math processor to handle. Overflows are more serious than underflows, and may indicate an error in the formulation of a problem (for example, unintended exponention of a large number by a large number). Overflows produce an appropriately signed infinity value.

Inexact numbers, special values, underflows, and overflows are floating-point exceptions. You can select how rounding is done and how exceptions are handled by setting the floating-point control word. Setting the control word is described in Setting and Retrieving Floating-Point Status and Control Words (ia32 only) and exception handling in Handling Floating-Point Exceptions (ia32 only).

For a further discussion of rounding errors see:

- Rounding Errors

Rounding Errors

Although the rounding error for one real number might be acceptably small in your calculations, at least two problems arise because of it. If you test for exact equality between what you consider to be two exact numbers, the rounding error of either or both floating-point representations of those numbers may prevent a successful comparison and produce spurious results. Also, when you calculate with floating-point numbers the rounding errors may accumulate to a meaningful loss of numerical significance.

Carefully consider the numerics of your solution to minimize rounding errors or their effects. You might benefit from using double-precision arithmetic or restructuring your algorithm, or both. For instance, if your calculations involve arrays of linear data items, you might reduce the loss of numerical significance by subtracting the mean value of each array from each array element and by normalizing each element of such an array to the standard deviation of the array elements.

The following code segment can execute differently on different systems and produce different results for n, x, and s. It also produces different results if you use the /fltconsistency (ia32 systems only) or /nofltconsistency compiler options. Rounding error accumulates in x because the floating-point representation of 0.2 is inexact, then accumulates in s, and affects the final value for n:

```
  INTEGER n
  REAL s, x
  n = 0
  s = 0.
  x = 0.
1 n = n + 1
  x = x + 0.2
  s = s + x
  IF ( x .LE. 10. ) GOTO 1 ! Will you get 51 cycles?
  WRITE(*,*) 'n = ', n, '; x = ', x, '; s = ', s
```

This example illustrates a common coding problem: carrying a floating-point variable through many successive cycles and then using it to perform an **IF** test. This process is common in numerical integration. There are several remedies. You can compute x and s as multiples of an integer index, for example, replacing the statement that increments x with x = n * 0.2 to avoid round-off accumulation. You might test for completion on the integer index, such as IF (n <= 50) GOTO 1, or use a **DO** loop, such as DO n= 1,51. If you must test on the real variable that is being cycled, use a realistic tolerance, such as IF (x <= 10.001).

Floating-point arithmetic does not always obey the standard rules of algebra exactly. Addition is not precisely associative when round-off errors are considered. You can use parentheses to express the exact evaluation you require to compute a correct, accurate answer. This is recommended when you specify optimization for your generated code, since associativity may otherwise be unpredictable.

The expressions (x + y) + z and x + (y + z) can give unexpected results in some cases, as the Visual Fortran Sample ASSOCN.F90 in the `...\DF98\SAMPLES\TUTORIAL` folder shows. This example demonstrates the danger of combining two numbers whose values differ by more than the number of significant digits.

The Sample INTERVAL.F90 in the `...\DF98\SAMPLES\TUTORIAL` folder shows how changing the rounding precision and rounding mode in the floating-point control word between calculations affects the calculated result of the following simple expression:

```
(q*r + s*t) / (u + v)
```

The Visual Fortran Sample EPSILON.F90 in the `...\DF98\SAMPLES\TUTORIAL` folder illustrates difficulties that rounding errors can cause in expressions like 1.0 + eps, where eps is just significant compared to 1.0.

The compiler uses the default rounding mode (round-to-nearest) during compilation. The compiler performs more compile-time operations that eliminate run-time operations as the optimization level increases. If you set rounding mode to a different setting (other than round-to-nearest), that rounding mode is used only if that computation is performed at run-time. For example, the Sample INTERVAL.F90 is compiled at /optimize:0, which disables certain compile-time optimizations, including constant propagation and inlining.

For more information:

- ULPs, Relative Error, and Machine Epsilon

ULPs, Relative Error, and Machine Epsilon

Several terms describe the magnitude of rounding error. A floating-point approximation to a real constant or to a computed result may err by as much as 1/2 unit in the last place (the b_{P-1} bit). The abbreviation *ULP* represents the measure "unit in the last place." Another measure of the rounding error uses the relative error, which is the difference between the exact number and its approximation divided by the exact number. The relative error that corresponds to 1/2 *ULP* is bounded by:

$$1/2\ 2^{-P} <= 1/2\ ULP <= 2^{-P}.$$

The upper bound $EPS = 2^{-P}$, the machine epsilon, is commonly used in discussions of rounding errors because it expresses the smallest floating-point number that you can add to 1.0 with a result that does not round to 1.0.

Additional guard bits are included in floating-point hardware to allow rounding on the order of *EPS*. The result of any one floating-point operation is therefore tolerably imprecise, but the total error that results from many such operations on propagated numbers accumulates unavoidably.

Setting and Retrieving Floating-Point Status and Control Words (ia32 only)

The FPU (floating-point unit) on ia32 systems contains eight floating-point registers the system uses for numeric calculations, for status and control words, and for error pointers. You normally need to consider only the status and control words, and then only when customizing your floating-point environment.

The FPU status and control words correspond to 16-bit registers whose bits hold the value of a state of the FPU or control its operation. Visual Fortran defines a set of symbolic constants to set and reset the proper bits in the status and control words. For example:

```
USE DFLIB
CALL SETCONTROLFPQQ(FPCW$OVERFLOW .AND. FPCW$CHOP)
! set the floating-point control word to allow overflows
! and to round by truncation
```

The status and control symbolic constants (such as FPCW$OVERFLOW and FPCW$CHOP in the preceding example) are defined as INTEGER(2) parameters in the module DFLIB.F90 in the `...\DF98\INCLUDE` folder. The status and control words are made of logical combinations (such as with .AND.) of different parameters for different FPU options.

The name of a symbolic constant takes the general form *name*$*option*. The prefix *name* is one of the following:

Prefixes for Parameter Flags

name	**Meaning**
FPSW	Floating-point status word
FPCW	Floating-point control word
SIG	Signal
FPE	Floating-point exception

MTH	Math function

The suffix *option* is one of the options available for that *name*. The parameter *name*$*option* corresponds either to a status or control option (for example, FPSW$ZERODIVIDE, a status word parameter that shows whether a zero-divide exception has occurred or not) or *name*$*option* corresponds to a mask, which sets all symbolic constants to 1 for all the options of *name*. You can use the masks in logical functions (such as **IAND**, **IOR**, and **NOT**) to set or to clear all options for the specified *name*. The following sections define the *option*s and illustrate their use with examples.

You can control the floating-point processor options (on ia32 systems) and find out its status with the run-time library routines GETSTATUSFPQQ (ia32 only), GETCONTROLFPQQ (ia32 only), SETCONTROLFPQQ (ia32 only), and MATHERRQQ (ia32 only). Examples of using these routines also appear in the following sections.

For more information:

- Floating-Point Status Word (ia32 only)
- Floating-Point Control Word (ia32 only)

Floating-Point Status Word (ia32 only)

On ia32 systems, the FPU status word includes bits that show the floating-point exception state of the processor. The status word parameters describe six exceptions: invalid result, denormalized result, zero divide, overflow, underflow and inexact precision. These are described in the section, Loss of Precision Errors: Rounding, Special Values, Underflow, and Overflow. When one of the bits is set to 1, it means a past floating-point operation produced that exception type. (Visual Fortran initially clears all status bits. It does not reset the status bits before performing additional floating-point operations after an exception occurs. The status bits accumulate.)

The following table shows the floating-point exception status parameters:

Parameter Name	Value in Hex	Description
FPSW$MSW_EM	#003F	Status Mask (set all bits to 1)
FPSW$INVALID	#0001	An invalid result occurred
FPSW$DENORMAL	#0002	A denormal (very small number) occurred

FPSW$ZERODIVIDE	#0004	A divide by zero occurred
FPSW$OVERFLOW	#0008	An overflow occurred
FPSW$UNDERFLOW	#0010	An underflow occurred
FPSW$INEXACT	#0020	Inexact precision occurred

You can find out which exceptions have occurred by retrieving the status word and comparing it to the exception parameters. For example:

```
USE DFLIB
INTEGER(2) status
CALL GETSTATUSFPQQ(status)
IF ((status .AND. FPSW$INEXACT) > 0) THEN
   WRITE (*, *) "Inexact precision has occurred"
ELSE IF ((status .AND. FPSW$DENORMAL) > 0) THEN
   WRITE (*, *) "Denormal occurred"
END IF
```

To clear the status word flags, call the CLEARSTATUSFPQQ (ia32 only) routine.

Floating-Point Control Word (ia32 only)

On ia32 systems, the FPU control word includes bits that control the FPU's precision, rounding mode, and whether exceptions generate signals if they occur. You can read the control word value with GETCONTROLFPQQ (ia32 only) to find out the current control settings, and you can change the control word with SETCONTROLFPQQ (ia32 only).

Each bit in the floating-point control word corresponds to a mode of the floating-point math processor. The DFLIB.F90 module file in the `...\DF98\INCLUDE` folder contains the INTEGER(2) parameters defined for the control word, as shown in the following table:

Parameter Name	Value in Hex	Description
FPCW$MCW_IC	#1000	Infinity control mask
FPCW$AFFINE	#1000	Affine infinity
FPCW$PROJECTIVE	#0000	Projective infinity
FPCW$MCW_PC	#0300	Precision control mask
FPCW$64	#0300	64-bit precision
FPCW$53	#0200	53-bit precision

FPCW$24	#0000	24-bit precision
FPCW$MCW_RC	#0C00	Rounding control mask
FPCW$CHOP	#0C00	Truncate
FPCW$UP	#0800	Round up
FPCW$DOWN	#0400	Round down
FPCW$NEAR	#0000	Round to nearest
FPCW$MCW_EM	#003F	Exception mask
FPCW$INVALID	#0001	Allow invalid numbers
FPCW$DENORMAL	#0002	Allow denormals (very small numbers)
FPCW$ZERODIVIDE	#0004	Allow divide by zero
FPCW$OVERFLOW	#0008	Allow overflow
FPCW$UNDERFLOW	#0010	Allow underflow
FPCW$INEXACT	#0020	Allow inexact precision

The control word defaults are:

- 53-bit precision
- Round to nearest (rounding mode)
- The denormal, underflow, overflow, invalid, and inexact precision exceptions are disabled (do not generate an exception). To change exception handling, you can use the /fpe compiler option or the FOR_SET_FPE routine.

For more information:

- Exception Parameters
- Precision Parameters
- Rounding Parameters

Exception Parameters

An exception is disabled if its bit is set to 1 and enabled if its bit is cleared to 0. If an exception is disabled (exceptions can be disabled by setting the flags to 1 with SETCONTROLFPQQ (ia32 only)), it will not generate an interrupt signal if it occurs. The floating-point process will return an appropriate special value (for example, NaN or signed infinity), but the program continues. You can find out which exceptions (if any) occurred by calling GETSTATUSFPQQ (ia32 only).

If errors on floating-point exceptions are enabled (by clearing the flags to 0 with **SETCONTROLFPQQ** (ia32 only)), the operating system generates an interrupt when the exception occurs. By default these interrupts cause run-time errors, but you can capture the interrupts with SIGNALQQ and branch to your own error-handling routines.

You should remember not to clear all existing settings when changing one. The values you want to change should be combined with the existing control word in an inclusive-OR operation (OR, IOR, .OR.) if you do not want to reset all options. For example:

```
USE DFLIB
INTEGER(2) control, newcontrol
CALL GETCONTROLFPQQ(control)
newcontrol = (control .OR. FPCW$INVALID)
! Invalid exception set (disabled).
CALL SETCONTROLFPQQ(newcontrol)
```

Precision Parameters

On ia32 systems, the precision bits control the precision to which the FPU rounds floating-point numbers. For example:

```
USE DFLIB
INTEGER(2) control, holdcontrol, newcontrol
CALL GETCONTROLFPQQ(control)
! Clear any existing precision flags.
holdcontrol = (control .AND. (.NOT. FPCW$MCW_PC))
newcontrol = holdcontrol .OR. FPCW$64
! Set precision to 64 bits.
CALL SETCONTROLFPQQ(newcontrol)
```

The precision options are mutually exclusive. If you set more than one, you may get an invalid mode or a mode other than the one you want. Therefore, you should clear the precision bits before setting a new precision mode.

Rounding Parameters

On ia32 systems, the rounding flags control the method of rounding that the FPU uses. For example:

```
USE DFLIB
INTEGER(2) control, clearcontrol, newcontrol
CALL GETCONTROLFPQQ(control)
! Clear any existing rounding flags.
clearcontrol = (control .AND. (.NOT. FPCW$MCW_RC))
newcontrol = clearcontrol .OR. FPCW$UP
! Set rounding mode to round up.
CALL SETCONTROLFPQQ(newcontrol)
```

The rounding options are mutually exclusive. If you set more than one, you may get an invalid mode or a mode other than the one you want. Therefore, you should clear the rounding bits before setting a new rounding mode.

Handling Arithmetic Exceptions

Two levels of arithmetic exceptions occur in Visual Fortran. Low-level exceptions result from floating-point exceptions. High-level exceptions result from arithmetic errors that occur during execution of the mathematical functions. You have some flexibility in handling each type of exception.

The following sections describe:

- Floating-Point Exceptions
- Handling Run-Time Math Exceptions (ia32 only)

Handling Floating-Point Exceptions

If a floating-point exception is disabled (set to 1), it will not generate an interrupt signal if it occurs. The floating-point process will return an appropriate special value (for example, NaN or signed infinity), and the program will continue. If a floating-point exception is enabled (set to 0), it will generate an interrupt signal (software interrupt) if it occurs. The following table lists the floating-point exception signals:

Parameter Name	Value in Hex	Description
FPE$INVALID	#81	Invalid result
FPE$DENORMAL	#82	Denormal operand
FPE$ZERODIVIDE	#83	Divide by zero
FPE$OVERFLOW	#84	Overflow
FPE$UNDERFLOW	#85	Underflow
FPE$INEXACT	#86	Inexact precision

If a floating-point exception interrupt occurs and you do not have an exception handling routine, the run-time system will respond to the interrupt according to the behavior selected by the compiler options /fpe and /math_library. Remember, interrupts only occur if an exception is enabled (set to 0).

If you do not want the default system exception handling, you need to write your own interrupt handling routine:

- Write a function that performs whatever special behavior you require on the interrupt.
- Register that function as the procedure to be called on that interrupt with SIGNALQQ.

Note that your interrupt handling routine must use the ATTRIBUTES C directive.

The drawback of writing your own routine is that your exception-handling routine cannot return to the process that caused the exception. This is because when your exception-handling routine is called, the floating-point processor is in an error condition, and if your routine returns, the processor is in the same state, which will cause a system termination. Your exception-handling routine can therefore either branch to another separate program unit or exit (after saving your program state and printing an appropriate message). You cannot return to a different statement in the program unit that caused the exception-handling routine, because a global **GOTO** does not exist, and you cannot reset the status word in the floating-point processor.

If you need to know when exceptions occur and also must continue if they do, you must disable exceptions so they do not cause an interrupt, then poll the floating-point status word at intervals with GETSTATUSFPQQ (ia32 only) to see if any exceptions occurred. To clear the status word flags, call the CLEARSTATUSFPQQ (ia32 only) routine.

Obviously, polling the floating-point status word at intervals creates processing overhead for your program. In general, you will want to allow the program to terminate if there is an exception. An example of an exception-handling routine follows. The exception-handling routine hand_fpe and the program that invokes it are both contained in SIGTEST.F90 in the Visual Fortran Samples folder `...\DF98\SAMPLES\TUTORIAL`. The comments at the beginning of the SIGTEST.F90 file describe how to compile this example.

```
 ! SIGTEST.F90
 !Establish the name of the exception handler as the
 ! function to be invoked if an exception happens.
 ! The exception handler hand_fpe is attached below.
   USE DFLIB
      INTERFACE
        FUNCTION hand_fpe (sigid, except)
           !DEC$ ATTRIBUTES C :: hand_fpe
           INTEGER(4) hand_fpe
           INTEGER(2) sigid, except
        END FUNCTION
      END INTERFACE

 INTEGER(4) iret
 REAL(4) r1, r2
 r1 = 0.0
 iret = SIGNALQQ(SIG$FPE, hand_fpe)
 WRITE(*,*) 'Set exception handler. Return = ', iret
 ! Cause divide by zero exception
```

```
r1 = 0.0
r2 = 3/r1
END

! Exception handler routine hand_fpe
  FUNCTION hand_fpe (signum, excnum)
    !DEC$ ATTRIBUTES C :: hand_fpe
    USE DFLIB
    INTEGER(2) signum, excnum
    WRITE(*,*) 'In signal handler for SIG$FPE'
    WRITE(*,*) 'signum = ', signum
    WRITE(*,*) 'exception = ', excnum
    SELECT CASE(excnum)
      CASE( FPE$INVALID )
        STOP ' Floating point exception: Invalid number'
      CASE( FPE$DENORMAL )
        STOP ' Floating point exception: Denormalized number'
      CASE( FPE$ZERODIVIDE )
        STOP ' Floating point exception: Zero divide'
      CASE( FPE$OVERFLOW )
        STOP ' Floating point exception: Overflow'
      CASE( FPE$UNDERFLOW )
        STOP ' Floating point exception: Underflow'
      CASE( FPE$INEXACT )
        STOP ' Floating point exception: Inexact precision'
      CASE DEFAULT
        STOP ' Floating point exception: Non-IEEE type'
    END SELECT
    hand_fpe = 1
  END
```

Handling Run-Time Math Exceptions (ia32 only)

On ia32 systems, the run-time subroutine MATHERRQQ (ia32 only) handles floating-point exceptions that occur in the math functions, such as **SIN** and **LOG10**.

If you use the default version of **MATHERRQQ**, which the linker automatically includes in your executable program, then math exceptions result in a standard run-time error (such as `forrtl: severe (nnnn): sqrt: domain error`). If you want to alter the behavior of one or more math exceptions, you need to provide your own version of **MATHERRQQ**. You have more flexibility in the way you handle run-time math exceptions than floating-point exceptions, because your error handling routine can return to the program unit that caused the exception.

The module DFLIB.F90 in the `...\DF98\INCLUDE` folder contains the definitions of the run-time math exceptions. These are listed in the following table:

Parameter Name	Value	Description
MTH$E_DOMAIN	1	Argument domain error
MTH$E_SINGULARITY	2	Argument singularity

MTH$E_OVERFLOW	3	Overflow range error
MTH$E_UNDERFLOW	4	Underflow range error
MTH$E_TLOSS	5	Total loss of precision
MTH$E_PLOSS	6	Partial loss of precision

A domain error means that an argument is outside the math function's domain, for example, SQRT(-1). A singularity error means that an argument is a singularity value for the math function, and the result is not defined for that value, for example, LOG10(0.0). Overflow and underflow errors are the same as floating-point counterparts, and precision loss the same as floating-point inexact results.

You can write a **MATHERRQQ** subroutine that resolves errors generated by math functions. Your **MATHERRQQ** can issue a warning, assign a default value if an error occurs, or take other action. If you do not provide your own **MATHERRQQ** subroutine, a default **MATHERRQQ** provided with the floating-point library will terminate the program. The following gives an example of an alternative **MATHERRQQ** subroutine (in MATHERR.F90 in the `.../DF98/SAMPLES/TUTORIAL` folder):

```
SUBROUTINE MATHERRQQ( name, length, info, retcode)
  USE DFLIB
  INTEGER(2) length, retcode
  CHARACTER(length) name
  RECORD /MTH$E_INFO/ info
  PRINT *, "Entered MATHERRQQ"
  PRINT *, "Failing function is: ", name
  PRINT *, "Error type is: ", info.errcode
  IF ((info.ftype == TY$REAL4 ).OR.(info.ftype == TY$REAL8)) THEN
      PRINT *, "Type: REAL"
      PRINT *, "Enter the desired function result: "
      READ(*,*) info.r8res
      retcode = 1
  ELSE IF ((info.ftype == TY$CMPLX8 ).OR.(info.ftype == TY$CMPLX16)) THEN
      PRINT *, "Type: COMPLEX"
      PRINT *, "Enter the desired function result: "
      READ(*,*) info.c16res
      retcode = 1
  END IF
END
```

The following is a Visual Fortran Sample program (MATHTEST.F90 in the `.../DF98/SAMPLES/TUTORIAL` folder) that causes **MATHERQQ** to be called:

```
REAL(4) r1, r2 /-1.0/
REAL(8) r3, r4 /-1.0/
COMPLEX(4) c1, c2 /(0.0, 0.0)/
r1 = LOG(r2)
r3 = SQRT(r4)
c1 = CLOG(c2)
```

```
WRITE(*, *) r1
WRITE(*, *) r3
WRITE(*, *) c1
END
```

Intel Pentium Floating-Point Flaw (ia32 only)

Certain versions of the Intel (ia32) Pentium 586 processor have a flaw in rare floating-point division operations, which can also manifest itself in floating-point **TAN**, **ATAN**, and **MOD** operations. Since the number of input cases that cause this problem is very small and the associated error in the results is also very small, it is unlikely that you will ever see a problem due to this flaw. It has been estimated that only 1 out of 9 billion operations will produce even the slightest inaccuracy.

To request a check for a flawed Pentium chip, you can use the default compiler option /check:flawed_pentium option on code you suspect demonstrates the Pentium flaw, such as the code shown below. This compiler option generates run-time calls to the run-time routine FOR_CHECK_FLAWED_PENTIUM. The default, /check:flawed_pentium, *does* issue a run-time error message for this condition and stops program execution. To allow program execution to continue when this condition occurs, set the environment variable FOR_RUN_FLAWED_PENTIUM to true and rerun the program (see Run-Time Environment Variables).

Visual Fortran does not include a software workaround for the flawed Pentium problems, and these operations could produce incorrect results on a flawed Pentium processor.

To determine if you have a flawed Pentium, you can run the following program with the /check:flawed_pentium compiler option:

```
PROGRAM go
REAL(8) op1, op2
COMMON /divide_check/ op1, op2
DATA op1 /3145727.0/, op2 /4195835.0/
IF( op2/op1 > 1.3338 ) THEN
   PRINT *,'This computer always divides correctly.'
ELSE
   PRINT *,'This computer can have divide problems.'
ENDIF
END
```

If you compile and run this program without any compiler options (the default is /check:flawed_pentium), a run-time error occurs when it is run on a flawed Pentium system.

Your operating system can also work around flawed Pentium processors by using software emulation for floating-point operations. Refer to your operating system documentation for more information. If the operating system has been configured for software emulation, then all floating-point operations in Visual Fortran will always operate correctly, including the above program. Note that the performance cost of an operating system fix can be very high, and if your program is run on another machine without the same operating system fix, it will execute incorrectly.

If you distribute software that is susceptible to the floating-point problems of a flawed Pentium, and want your program to halt if it is run on a system with such a processor, you can check the processor when your application starts. To do this, convert the program above into a simple subroutine, call the subroutine at the start of your application, and use the **STOP** statement to stop the application before it begins if a flawed Pentium processor is detected. If you distribute your software, you should compile it with the /check:flawed_pentium compiler option.

All the run-time libraries that come with Visual Fortran have been compiled to be safe with respect to the Pentium divide and **MOD** problems.

For more information on the Intel Pentium flaw, or to request a replacement Pentium processor, you can contact Intel in the United States at 1-800-628-8686.

Advanced Exception and Termination Handling Considerations

This chapter provides a detailed discussion of exception and termination handling issues for those building Visual Fortran applications for ia32 systems. The following topics are discussed:

- Default Exception Handling, Console Event Handling, and Termination Handling
- Structure of a Visual Fortran Application
- When to Provide Your Own Exception/Termination Handler
- How to Provide Your Own Exception/Termination Handler

To fully appreciate this discussion, you will need knowledge of Windows structured exception handling (SEH). A good reference on this subject is Chapter 16 in the book *Advanced Windows* (Third Edition) by Jeffrey Richter.

To employ some of the exception handling techniques presented, you will need a C language compiler, such as Microsoft's Visual C++ product (part of Visual Studio), which has support for try-except constructs or some other form of support for structured exception handling.

Default Exception Handling, Console Event Handling, and Termination Handling

The Visual Fortran run-time system provides minimal default support for exception handling, console event handling, and application termination rundown. This section and its subsections describe the default support provided:

- General Default Exception Handling
- How the Floating-Point Exception Handling (/fpe) Compiler Option Works
- Default Console Event Handling
- General Default Termination Handling

General Default Exception Handling

The default exception handling support provided depends on the type of application (project type) being developed:

- A default exception handler is included with Fortran Console, Fortran QuickWin, and Fortran Standard Graphics applications.
- No default exception handler is included with Fortran Windows or Fortran DLL applications.

Most exceptions captured by the Visual Fortran default handler are dealt with as severe errors. When an exception occurs, the Fortran run-time system will display an error message and traceback output as described in Handling Run-Time Errors. A run-time error with a severe status causes the Visual Fortran run-time system to terminate the application. Most I/O programming errors are also severe and will terminate an application.

I/O programming errors are not exceptions and cannot be caught by an exception handler. An unhandled I/O programming error is reported through a different mechanism in the Visual Fortran run-time system. Regardless of the application (project) type, unhandled I/O programming error will generate an error message and traceback output.

How the Floating-Point Exception Handling (/fpe) Compiler Option Works

Whether the default handler treats floating-point exceptions as severe or non-severe depends upon the chosen /fpe and the /check:underflow compiler options. The /fpe option controls more than the behavior of the default exception handler, however.

The /fpe option selects a particular floating-point exception behavior. There are currently two supported behaviors:

- Using /fpe:3, the default on ia32 systems, implies full IEEE support. There are no floating-point traps in this mode, although floating-point exceptions are detected and recorded in the floating-point status word.
- The second option, /fpe:0, enables trapping on floating-point exceptions and flushing of underflow results to 0.0.

The full consequences of the /fpe compiler option depend upon the type of application you are building. You only get the full support for the chosen behavior in a Fortran Console or QuickWin/Standard Graphics application, assuming you do not override the default run-time exception handler. The work to achieve the full behavior is done partly by each of the default run-time handler, the Fortran compiler, the math library, the underlying hardware, and the operating system.

The following sections discuss:

- Floating-Point Exceptions in Fortran Console, Fortran QuickWin, and Fortran Standard Graphics Applications
- Floating-Point Exceptions in Fortran DLL Applications
- Floating-Point Exceptions in Fortran Windows Applications

Floating-Point Exceptions in Fortran Console, Fortran QuickWin, and Fortran Standard Graphics Applications

When you build a console application, the compiler generates a few calls at the beginning of your Fortran main program to Fortran run-time routines that initialize the environment, either with default options or in accordance with your selected compile-time options.

- For floating-point exception handling, /fpe:3 is the default on ia32 platforms. The run-time system initializes the hardware to mask all exceptions. With /fpe:3:
  - The Visual Fortran run-time system does this initialization automatically (no call from the compiled code).
  - The ia32 hardware automatically generates the default IEEE result for exceptional results.
  - Because traps are masked with /fpe:3, there are no traps and you see exceptional values like Nan's, Infinities, and denormalized numbers in your computations.

  Users can poll the floating-point status word with GETSTATUSFPQQ to see if an exception has occurred and can clear the status register with CLEARSTATUSFPQQ.

- If you specify /fpe:0, the compiler generates a call to a Visual Fortran run-time routine, FOR_SET_FPE, with an argument that unmasks all floating-point traps in the floating-point control word. In this case, the hardware does not supply the default IEEE result. It traps to the operating system, which then looks for a handler.

  In a Fortran console or Fortran QuickWin application, the Visual Fortran run-time system provides a default handler unless you establish your own. For all exceptions except underflow, the run-time system just prints out an error message and aborts the application. For underflow, the run-time system replaces the result with zero. This treatment of denormalized numbers with /fpe:0 is called *abrupt underflow* to 0 (zero), as opposed to *gradual underflow* to 0 provided with /fpe:3.

  There are no denormalized numbers with /fpe:0. Further, if you also select /check:underflow with /fpe:0, you get a message at run-time for each of the first two occurrences of a floating-point underflow and a total count of underflows when the application exits. The /check:underflow option is not supported with /fpe:3.

Fixing up underflow results to zero can significantly degrade the performance of your ia32 application. If you are experiencing a large number of underflows, consider changing your code to avoid underflows or consider masking underflow traps and allowing the hardware to operate on denormalized numbers. The ia32 hardware is designed to operate correctly in the denormalized range and doing so is much faster than trapping to fix up a result to zero.

Another important point to understand about selecting the /fpe option is that the generated code must support the trapping mode. When an ia32 floating-point instruction generates an exceptional result, you do not necessarily get a trap. The instruction must be followed by an fwait instruction or another floating-point operate instruction to cause the trap to occur.

The Visual Fortran compiler generates machine code to support these requirements in accordance with your selected /fpe option setting. In other words, the generated code must support the trapping mode. You can see this by compiling a simple test program and look at the machine code listing with /fpe:0 first, then /fpe:3. There are no fwait instructions in the /fpe:3 code. Even if you replace the default run-time exception handler with your own handler, you may still want to compile with /fpe:0 to generate code that supports trapping.

Floating-Point Exceptions in Fortran DLL Applications

In a DLL, there is no main Fortran program (unless you have written your main program in Fortran), so there is no automatic calling of run-time routines to initialize the environment. Even if you select /fpe:0, there is nothing that causes the run-time system to unmask traps in the hardware so you won't see traps. You will continue to see the hardware generated default IEEE results (Nan's, Infinities, and and denormalized numbers in your computations). The generated code will still do its part by supplying the fwait instructions, and so on, but unless the traps are unmasked somehow, no traps will occur. You can use SETCONTROLFPQQ or FOR_SET_FPE to unmask traps in the floating-point control word.

There is also no default exception handling in a DLL. The main application that calls the DLL must provide this, or the code in the DLL must provide something when it is called. Since underflow processing (fixup to 0, and so on) is done by the default Fortran run-time system handler, a DLL won't have that feature automatically.

A typical strategy is to compile with /fpe:0, but only unmask floating divide by zero, floating overflow, and floating invalid traps in the floating-point control word. By leaving floating-point underflow traps masked, the hardware will continue to provide gradual underflow through the denormalized range, but other floating-point exceptions will generate traps, which the user then handles as desired.

Floating-Point Exceptions in Fortran Windows Applications

In a Fortran Windows application, the situation is similar to a Fortran DLL application. You define a WinMain routine in your Fortran code as the main entry point for your application. The Fortran run-time system does not define the main routine as it does in a Fortran console or Fortran QuickWin (or Standard Graphics) application. Your code is not protected by the default handler and the default run-time initialization routines are not called.

Default Console Event Handling

When the Fortran run-time system is initialized, it establishes a default console event handler through the SetConsoleCtrlHandler Win32 API routine. The default handler will respond to the following event types:

- CTRL_C_EVENT
- CTRL_BREAK_EVENT
- CTRL_CLOSE_EVENT

These event types will result in an orderly program abort with an appropriate diagnostic message.

Other console events such as a CTRL_LOGOFF_EVENT or CTRL_SHUTDOWN_EVENT are not handled by the default handler. The handler is notified of these events but returns FALSE to the operating system. This allows a Visual Fortran application activated as a Windows service to continue execution when a user logs off.

General Default Termination Handling

When a Fortran Console, Fortran QuickWin, or Fortran Standard Graphics application terminates execution, either by normal termination or due to a severe error or exception, the following actions are taken by the Fortran run-time system:

- If the default exception handler is used and the compiler /check:underflow and /fpe:0 options were selected, a count of the total number of floating point underflows is reported.
- Any Open files are closed and the requested DISPOSITION operations are performed.
- With a QuickWin application, any open QuickWin windows are closed.
- The C run-time exit() routine is called with the status code to return to the operating system. The C run-time exit() routine will call the Win32 routine ExitProcess to terminate the process. (See crt0dat.c in the C run-time sources).

In a Fortran DLL or Fortran Windows application, any unhandled I/O programming errors will cause the following actions:

- Any Open files are closed and the requested DISPOSITION operations are performed.
- The C run-time exit() routine is called with the status code to return to the operating system. The C run-time exit() routine will call the Win32 API routine ExitProcess to terminate the process. (See crt0dat.c in the C run-time sources.)

Any unhandled exceptions that occur in a Fortran DLL or Fortran Windows application will have application dependent behavior. Since there is no Fortran default handler present, the behavior depends on what you provide for a handler. If you do not explicitly provide a handler, the default mechanisms provided in your main program will determine the behavior. In a Fortran Windows application, the C run-time system will terminate the application.

Structure of a Visual Fortran Application

To understand how Visual Fortran handlers are incorporated into your application, and how you might incorporate your own handlers, you should understand how each application type is constructed. The following sections describe handlers for the various application (project) types:

- Fortran Console Applications
- Fortran QuickWin and Standard Graphics Applications
- Fortran DLL Applications
- Fortran Windows Applications

Fortran Console Applications

Fortran Console applications actually look like C applications under the hood, with the Visual Fortran run-time system providing the C main() function.

The entry point for a console application is specified as the C library's mainCRTStartup() routine (see module crt0.c in the C run-time sources). This initializes the C run-time system, wraps the Fortran run-time system main() in a try-except construct using the C run-time's exception filter (_XcptFilter()), and calls the Fortran run-time system main() routine in run-time module for_main.c. In simplified form, it looks like this:

```
 mainCRTStartup()
{
   C initialization code here
   __try {
        more initialization code here
        mainret = main()      /* calls Fortran run-time main() */
        exit(mainret)
   } __except ( _XcptFilter() )
          { _exit ( GetExceptionCode() ) }
}
```

In the Fortran run-time system, main() initializes the Fortran run-time system (if not already initialized), wraps a try-except construct around MAIN__ (the entry point to the Fortran code) with a filter expression that invokes the Fortran run-time system default handler on exceptions, and calls MAIN__. It also wraps a try-finally construct around all of this so run-time system clean up gets done (with FOR_RTL_FINISH_) when the program exits. In simplified form, it looks like this:

```
main()
{
   __try {
      __try {
            for_rtl_init()
            MAIN__
      } __except ( expression-invoking-fortran-default-handler )
                  { }
   } __finally { for_rtl_finish() }
}
```

In the Fortran code, symbol MAIN__ is the entry point called by the run-time system's main() routine. MAIN__ has the code to do any further run-time initialization or checks. For example, if the user compiled with the non-default /fpe:0 option, there would be a call to FOR_SET_FPE to tell the run-time system how to setup/react to floating-point exceptions.

Fortran QuickWin and Standard Graphics Applications

A Fortran QuickWin (including Fortran Standard Graphics) application is a specialized windows application where Visual Fortran provides the WinMain() function.

The entry point for a QuickWin application is specified as the C library WinMainCRTStartup() routine (see module crt0.c in the C run-time sources). This gets the C run-time initialized, wraps the Visual Fortran defined WinMain() in a try-except construct using the C run-time exception filter (_XcptFilter()) and calls the Visual Fortran defined WinMain() routine. In simplified form, it looks like this:

```
WinMainCRTStartup()
{
   C initialization code here
   __try {
         more initialization code here
         mainret = WinMain()      /* calls CVF qwin library WinMain() */
         exit(mainret)
   } __except ( _XcptFilter() )
            { _exit ( GetExceptionCode() ) }
}
```

In the QuickWin library, WinMain() performs some initialization specific to QuickWin, creates a new thread which begins execution at QWINForkMain, and then sits in a message loop directing the action. The message loop is wrapped in a try-except-finally construct which invokes the Fortran run-time system default handler if an exception occurs, and calls FOR_RTL_FINISH_ at exit. QWINForkMain() running in the other thread calls the Fortran run-time system main(), which in turn calls MAIN__. In simplified form, it looks like this:

```
WinMain()
{
   Initialization code here
   BeginThreadEx (..., QWINForkMain, ... )
   __try {
      __try {
            the message loop...
            for_rtl_finish()
            return (msg.wParam)
      } __except ( expression-invoking-default-fortran-handler )
               { }
   } __finally {
         for_rtl_finish()
         return (msg.wParam)
   }
}
```

QWINForkMain resembles the following:

```
QWINForkMain()
{
   main()      /* calls the CVF rtl main() which calls MAIN__ */
   cleanup and exit...
}
```

The routines main() and MAIN__ are the same as previously described for a Fortran Console application.

Fortran DLL Applications

A Fortran DLL is a collection of one or more routines that you generally call from some other main program. As such, the routines execute in the structure and environment created by the code which calls into the DLL. You can provide DLL initialization through a DllMain() function, but you probably would control general application initialization from the main program.

There are no automatic provisions for any exception handler in a DLL. There is no environment initialization except what you provide. Of course, if your main application is also written in Fortran, you will get the default Fortran handlers provided by that application type.

Fortran Windows Applications

A Fortran Windows application has as its entry point WinMainCRTStartup() and each user writes the code for the WinMain function declaration and interface. Examples are provided to show how to do this in Fortran code. The compiler still generates symbol MAIN__ with the initialization code in place, but nothing calls MAIN__. Also, nothing connects up to the run-time system's main() so there's no try-except construct to hook in the default Visual Fortran handler, and no run-time system initialization or cleanup. In simplified form, it looks like this:

```
WinMainCRTStartup()
{
   C initialization code
   __try {
         more initialization code
         mainret = WinMain()      /* calls the user's WinMain() */
         exit(mainret)
   } __except ( _XcptFilter() )
            { _exit ( GetExceptionCode() ) }
}
```

The Fortran code contains:

```
integer(4) function WinMain( HANDLE, HANDLE, LPSTR, int )
...
 ! whatever Fortran the user codes here...
...
end
```

When to Provide Your Own Exception/Termination Handler

For Fortran Console, Fortran QuickWin, and Fortran Standard Graphics applications, the default exception and termination handlers are probably sufficient to meet most needs. As described in Structure Of a Visual Fortran Application, Fortran DLL and Fortran Windows applications do not have default handlers.

Whenever the default exception and termination handlers do not meet all your needs, consider providing your own handler. This is really a question you need to answer for each specific application. Some examples:

- Suppose your application creates some files during the course of its execution and you do not want to leave them on the disk if an unexpected error or exception occurs. The default termination actions only cause the files to be closed if you specifically opened them with DISPOSE='DELETE'. But suppose you do not want them deleted under normal termination. If an unexpected event occurs, you need to get control so you can clean up these files as needed.
- Perhaps your application can recover from a particular situation, for example, an integer divide-by-zero operation. You want to gain control if that exception occurs and deal with it.
- Perhaps you just want to output an application-specific error message when an exception occurs.
- You are building a Fortran DLL to run under a Visual Basic GUI and you do

not want the DLL to crash the application if an exception occurs in the DLL.
- Your code takes a lock on a global resource and you want to be sure and release the resource if an unexpected event occurs.

The list of possibilities is endless and only the application developer can anticipate his or her particular needs.

See How to Provide Your Own Exception/Termination Handler for some ideas on how to deal with unexpected events when implementing a handler for your application.

How to Provide Your Own Exception/Termination Handler

The most general way to establish your own handler is to use Windows structured exception handling capabilities (SEH). For lighter-weight exception handling requirements, you can use SIGNALQQ.

The following sections discuss ways to implement handlers for Fortran applications:

Using Windows Structured Exception Handling (SEH)

Windows provides a robust exception and termination handling mechanism called Structured Exception Handling (SEH). Structured exception handling requires support in both the operating system and compilers. Unfortunately, Visual Fortran does not include extensions for SEH support, but you can still take advantage of this powerful tool. By introducing a bit of C code in your application, you can use SEH to meet your exception handling needs.

You will need a C compiler with some form of SEH support. In this discussion, the syntax supported by Microsoft Visual C++ is used. Other compilers may provide SEH support, but use a different syntax.

Structured exception handling includes both exception and termination handling. Both mechanisms will be shown and explained through working examples.

The following topics are discussed:

Custom Handlers for Fortran Console, Fortran QuickWin, and Fortran Standard Graphics Applications

Fortran Console and Fortran QuickWin (and Fortran Standard Graphics) applications have the full benefit of the Fortran default exception and error handling processing facilities. You may, however, want to supplement or replace the default facilities. Two Visual Fortran samples show how you can accomplish this:

- Sample Program CSLEXCP2
- Sample Program CSLEXCP4

Sample Program CSLEXCP2

The following discussion refers to the sample program CSLEXCP2 provided with the Visual Fortran kit in the `...\SAMPLES\EXCEPTIONHANDLING` folder.

Suppose you have the problem described earlier of deciding what to do about open files your application has created in the event something unexpected occurs during execution of your application. Sample application CSLEXCP2 shows one way you might approach solving the problem.

Looking at CSLEXCP2.F90, there is a main program CSLEXCP2, and three additional routines, MY_CODE, MY_EXCEPTION_FILTER_CODE, and MY_TERMINATION_HANDLER_CODE. Routine MY_CODE is the main body of Fortran code in the application. It opens (**OPEN** statement) a data file and sits in a loop prompting for two integers, and writes (**WRITE** statement) the result of dividing the first by the second integer to the data file.

If the user enters the sentinel value of 99 for variable I (and not 0 for J), the application exits normally and the data file is closed (**CLOSE** statement) by the Fortran run-time system as a result of the call to the EXIT subroutine, but not deleted. If the user enters a 0 (zero) for variable J, an integer divide by zero exception occurs. This is the code we want to protect with a custom exception handler.

Look at the main program, CSLEXCP2:

```
PROGRAM CSLEXCP2

INTERFACE
    SUBROUTINE MY_CODE_WRAPPER()
    !DEC$ IF DEFINED(_X86_)
       !DEC$ATTRIBUTES C, ALIAS:'_MY_CODE_WRAPPER' :: MY_CODE_WRAPPER
    !DEC$ ELSE
```

```
        !DEC$ATTRIBUTES C, ALIAS:'MY_CODE_WRAPPER' :: MY_CODE_WRAPPER
     !DEC$ ENDIF
     END SUBROUTINE
 END INTERFACE

 CALL MY_CODE_WRAPPER()

 END
```

All CSLEXCP2 does is call a routine named MY_CODE_WRAPPER. MY_CODE_WRAPPER is a C routine that implements the custom handler. To see how this is done, look at file `wrapper.c`. MY_CODE_WRAPPER wraps a try-except construct around a call to the main body of the Fortran application, MY_CODE. It also wraps a try-finally construct around the try-except construct. If an exception occurs during execution of MY_CODE, the operating system will evaluate the except filter expression to see if this handler wishes to handle the event. The except filter expression is just a call to the Fortran routine MY_EXCEPTION_FILTER_CODE.

If MY_EXCEPTION_FILTER_CODE returns EXCEPTION_EXECUTE_HANDLER, the operating system continues execution in the except handler block, which in this case is empty. Execution would then continue in the __finally block which calls the general termination handler for the application, MY_TERMINATION_HANDLER_CODE. Routine MY_EXCEPTION_FILTER_CODE queries the user to see if the data file should be deleted or not. That is all the basic code needed to handle the exception situation. Routine MY_TERMINATION_HANDLER_CODE just prints a message and calls the EXIT subroutine to exit the application.

Note, if MY_EXCEPTION_FILTER_CODE returns EXCEPTION_CONTINUE_SEARCH, the operating system continues searching its list of exception handlers and finds the default Fortran run-time exception filter. The code in the __finally block would never be executed because the default run-time handler will exit the process as part of its default handling of the exception. You can experiment with this when you reply to the handler query "Enter A to exercise the termination handler code path,...or B to pass the exception to the default handler."

There are a couple of points to notice in this example. First, remember that this is a console application and its infrastructure basically looks like a C program. The entry point for the application is mainCRTStartup in the C run-time system. Routine mainCRTStartup() initializes the C run-time system and calls the Fortran run-time system main() routine. The Fortran run-time main() routine initializes the Fortran run-time system and calls entry point _MAIN__ in the Fortran code.

If you build the sample and request a listing with machine code from the Fortran compiler, you can see the bit of prolog code that the Fortran compiler generates which provides further initialization before actually executing your Fortran code. Here is an excerpt of that listing:

```
                                   .CODE
                                   PUBLIC  _MAIN__
             0000        _MAIN__   PROC
55           0000                  push    ebp
EC8B         0001                  mov     ebp, esp
24EC83       0003                  sub     esp, 36
53           0006                  push    ebx
000000E8     0007                  call    _for_check_flawed_pentium@0
01
04EC83       000C                  sub     esp, 4
0004058D     000F                  lea     eax, dword ptr .literal$+4
0002
50           0015                  push    eax
000000E8     0016                  call    _for_set_fpe_@4
01
04C483       001B                  add     esp, 4
04EC83       001E                  sub     esp, 4
00001D8D     0021                  lea     ebx, dword ptr .literal$
0002
53           0027                  push    ebx
000000E8     0028                  call    _for_set_reentrancy@4
01
04C483       002D                  add     esp, 4
000000E8     0030                  call    _MY_CODE_WRAPPER
```

Notice the calls to the Fortran run-time routines _for_check_flawed_pentium@0, _for_set_fpe_@4, and _for_set_reentrancy@4 that occur prior to the call to _MY_CODE_WRAPPER. This code was compiled with /fpe:0 selected, so you can see the call to _for_set_fpe_@4 to set up the non-default floating-point behavior on ia32 systems. This call would not be there with the default /fpe:3 option. The sample does not do any floating-point calculation (the /fpe:0 option was chosen just to illustrate the point). Likewise, if you deselect the check for flawed Pentium run-time option, the call to _for_check_flawed_pentium@0 would not be generated.

This prolog code is only executed as a result of the underlying structure of Fortran Console, Fortran QuickWin, and Fortran Standard Graphics applications. It would not be executed in a Fortran Windows application or Fortran DLL because there would be no Fortran run-time system main() routine present to call MAIN__.

Most of the work of handling the exception is really done in the course of executing the filter expression. The same is true of the Fortran default handler. So, if you allow an exception to be passed to the default run-time system handler, you will not get control again because the default handler will exit the process from within its exception filter in almost all cases. This short circuits any exception unwinding so your termination handler (the __finally construct) will never execute.

The default run-time exception handler plays a role in how an application behaves when exceptions occur while running under the debugger. Normally, the occurrence of an exception while debugging would cause the default handler to do its normal activities except it would not exit the process. Instead, it returns EXCEPTION_CONTINUE_SEARCH so the operating system will give the debugger a second chance at handling the exception and the debugger will stop in your code with the cursor pointing where the unhandled exception happened. If you are more interested in seeing where the exception happened than you are to see your termination handler execute, you can return EXCEPTION_CONTINUE_SEARCH from your exception filter and let the default run-time system handler get the application stopped in the debugger as usual.

In this (CSLEXCP2) example, no traceback output is produced to show where the integer divide by zero happened. This is normally done by the default handler, but we have overridden that handler. The next example shows that you can generate the traceback output in your custom handler using the TRACEBACKQQ routine.

Sample Program CSLEXCP4

The following discussion refers to the sample program CSLEXCP4 provided with the Visual Fortran kit in the `...\SAMPLES\EXCEPTIONHANDLING` folder.

Suppose you want to allow the default handler to handle some exceptions, for example, floating-point underflow with /fpe:0. You would like to have the default handler provide the result fix up to zero for this case. Also, suppose you want to turn an exception into a simple program status code which your code can then act upon. Sample CSLEXCP4 will demonstrate a few techniques to accomplish this.

The premise of sample CSLEXCP4 is that a Fortran subroutine is to be called which may generate floating point exceptions. We would like to detect floating point divide by zero exceptions and take some useful action to shut down the application gracefully. The application is to be compiled /fpe:0 and it is desired to have the default Fortran run-time system handler continue handling floating point underflow exceptions.

Looking at the code in CSLEXCP4.F90, the subroutine to be protected is called DIVIDE. In a real application, the protected subroutine could be any complex sequence you like, but in this sample, the subroutine simply does a divide of two input numbers and prints the result. The main Fortran program does not call DIVIDE directly. It makes the call through a C wrapper function called DIVIDE_WRAPPER.

The DIVIDE_WRAPPER function, in file WRAPPER.C, wraps the call to DIVIDE in a try-except construct. In this simple example, it is assumed that if DIVIDE returns without an exception, then all is well and DIVIDE_WRAPPER sets the rtn_sts variable accordingly. If no exception occurs, the except filter expression is never evaluated and the except block is never executed. Execution continues with the return statement just below the except handler block that returns rtn_sts.

If an exception does occur during execution of DIVIDE, the except filter expression is evaluated by the operating system. The filter expression takes two actions:

1. It captures the exception code related to the event in a local variable, ecode, for use in the exception handler code block. If the exception handler code block is executed, it will examine the exception code to determine a status value to return in rtn_sts.
2. It calls a Fortran function called CHECK_EXCEPTION_INFO, passing it the value returned from the Win32 routine GetExceptionInformation.

If function CHECK_EXCEPTION_INFO returns EXCEPTION_EXECUTE_HANDLER, the operating system will execute the except handler code block. The handler block will examine the exception code and set rtn_sts to a value indicating a divide by zero occurred or to a value indicating some other exception occurred. Execution then continues with the return statement that returns the value of rtn_sts.

If function CHECK_EXCEPTION_INFO returns EXCEPTION_CONTINUE_SEARCH, the operating system will continue looking back up the list of exception filters looking for one that wants to handle the exception. In this sample, the next exception filter is the default Fortran run-time system exception filter.

The value passed to CHECK_EXCEPTION_INFO is the address of a data structure which contains pointers to an operating system supplied exception record and context record. CHECK_EXCEPTION_INFO uses this information to determine what happened and how to proceed. If this was a floating-point divide by zero, CHECK_EXCEPTION_INFO calls **TRACEBACKQQ** to produce a stack trace along with an application specific message. It then sets the return value of the function to EXCEPTION_EXECUTE_HANDLER and returns.

If this was a floating-point underflow exception, CHECK_EXCEPTION_INFO calls **TRACEBACKQQ** again, only so you can see what is happening in the application output. Then, it sets the return value of the function to EXCEPTION_CONTINUE_SEARCH. When the operating system sees this return value, it evaluates the Fortran run-time default except filter expression, which causes the floating underflow result to be fixed up with zero, and execution will continue in the main program at the point of the exception.

The main program initializes two arrays with a set of three values that will demonstrate each path of execution. A DO loop is traversed for three iterations:

1. The first trip around the loop shows what happens when there are no exceptions.
2. The second iteration shows a floating underflow being flushed to zero in the

default handler.
3. The third (final) iteration shows a floating divide by zero being processed. The program takes action to shutdown the application with a simple STOP statement and message.

Custom Handlers For Fortran DLL Applications

There are two aspects of creating custom handlers for Fortran DLL applications:

- Containing Errors and Exceptions in Fortran DLL's
- Enabling Floating-Point Traps in Fortran DLL's

Containing Errors and Exceptions in Fortran DLL's

If you are building a Fortran DLL and intend to call it from a Visual Basic GUI or a main program written in some other language, you want to be careful that errors and exceptions in the DLL do not crash your main application. Here are a few basic principles to keep in mind if you are building a Fortran DLL:

- Construct your library routines so that they return a status to the caller and let the caller decide what to do.

  In order to return an expected status to the caller, you need to be defensive in your library code, so consider these other principles:

- Where it makes sense, have the library code check input arguments passed in from the caller to make sure they are valid for whatever the library routine is going to do with them. For example, suppose the routine implements some numerical algorithm that has a valid domain of inputs it can act on and still produce well defined behavior. You can check the input arguments before you execute the algorithm and avoid unexpected behavior that might otherwise result (like unexpected floating-point exceptions). You might use Fortran intrinsic procedures like ISNAN and FP_CLASS to detect exceptional IEEE numbers. Your DLL code needs to return a status to the caller indicating the problem and let the caller take the appropriate action (gracefully shut down the application, try again with different input, etc.).

- In your library code, *always* check the success or failure of calls to I/O routines and dynamic memory allocation/deallocation. In Fortran, the I/O statements have optional ERR, END, EOR, and IOSTAT arguments that you can use to determine if the I/O requested was successful. Dynamic memory ALLOCATE and DEALLOCATE statements have an optional STAT specifier that allows you to obtain the status of the dynamic memory allocation/deallocation and prevent program termination.

  If you do not specify an action to take on an error, the Fortran run-time system has no choice but to deal with the error as an unhandled severe error and terminate the program. For a specific example of using IOSTAT and ERR to deal gracefully with an **OPEN** statement that gets a file-not-found error, see Using the IOSTAT Specifier and Fortran Exit Codes. You can do the same sort of thing in your code, but just return the status back to your Visual Basic or other non-Fortran main program and let it decide what to do.

- Try to write your DLL code so unexpected program exceptions cannot occur, but devise a strategy for dealing with unexpected exceptions if they do happen. The most effective alternative for dealing with an exception is to use Win32 Structured Exception Handling support to gain control when an exception happens. Wrap all your DLL routine calls in C try/except constructs and have the except() filter expression call a routine you define which determines how to respond.

Enabling Floating-Point Traps in Fortran DLL's

Before you can worry about how you will handle a floating-point trap condition occurring in a DLL, you have to consider the problem of unmasking those traps so they can occur. If you are compiling /fpe:3 and polling the floating-point status word to check for exceptions, you do not have to worry about the problem of unmasking traps. You do not want traps unmasked in that case.

However, if your strategy is to compile /fpe:0 and allow traps on floating-point exceptions, you need to take action to unmask the traps in the floating-point control word because most other languages mask traps by default.

Recall that a Fortran Console or Fortran QuickWin (or Standard Graphics) application would have unmasked traps for you automatically because the Fortran run-time system provides the main program and calls your MAIN__ which executes some prolog code before the actual application code starts. You do not have that in a Fortran DLL called by some other language. Different languages establish different initial environments. You must provide the desired initial environment yourself. The samples discussed below and in the discussion of Fortran Windows applications give some ideas on how and when to do this.

Sample Program VBVF1

The following discussion refers to the Visual Fortran sample program VBVF1 provided in the `...\SAMPLES\EXCEPTIONHANDLING` folder. VBVF1 shows how you might incorporate structured exception handling and standard Fortran I/O error handling techniques to protect a Visual BASIC GUI from exceptions and errors occurring in a Fortran DLL called by the GUI. The error handling techniques are general in nature and could be used in other situations as well. For example, a C main program calling a Fortran DLL could also use the ideas presented here.

Sample application VBVF1 attempts to contain the effects of unexpected errors and exceptions occurring in a Fortran DLL by turning the unexpected events into user defined status conditions which the Visual Basic code can deal with gracefully.

The GUI has six buttons each of which generates a particular error condition in the Fortran DLL. A seventh button allows you to clear the error status displayed in the GUI. There are three text boxes in the GUI. One box displays a message associated with the last error. Another box displays an error number for the last error and the third box displays the Visual Basic source file where the error occurred.

Two of the buttons, "Test Integer Divide By Zero Response" and "Test Floating Point Overflow Response," are coded to show the use of a Visual Basic handler to deal with an error occurring in the Fortran DLL. While Visual Basic error handling works for these two specific cases to some extent, it is not a very robust solution for dealing with the more general case. If you are not familiar with Visual Basic error handling, this simple example should begin to give you an idea of what can be done. Refer to Visual Basic documentation for more complete information.

Each of the four remaining buttons causes a call to routine Fortran_Test in the Fortran DLL. See source file gen_errs.f90. Routine Fortran_Test generates the selected error. The Visual Basic code does not call Fortran_Test directly however. All Visual Basic calls to Fortran_Test go through a wrapper routine, Fortran_Test_Wrapper. Fortran_Test_Wrapper (source file wrappers.c) wraps a C try-except construct around calls into the DLL and acts as a control point for containing exceptions and errors that may unexpectedly occur in the DLL. Fortran_Test_Wrapper always returns a user defined application specific status to the Visual Basic calling routine. The Visual Basic code then reacts to the status value by displaying some appropriate message to the user.

The implementation of this scheme depends on two things:

1. The solid programming practice of always requesting and checking I/O status in Fortran I/O statements
2. The use of the try-except construct in the wrapper routine.

In the __try block of the wrapper routine, a call is made to Fortran_Test, which expects a Fortran defined status value to be returned. For the test cases that generate an I/O error, the code in Fortran_Test captures the I/O status and returns it to Fortran_Test_Wrapper. Fortran_Test_Wrapper then calls another DLL routine, TRANSLATE_TO_MY_APP_CODES, which does a table look up to translate the Fortran defined status code to a user defined status code. Execution continues with the return statement following the __except block. The Visual Basic code gets the user defined status value and puts up the appropriate display.

If an exception occurs during the execution of Fortran_Test, control transfers to the operating system. The operating system examines its list of exception handlers and finds the exception filter associated with Fortran_Test_Wrapper. It evaluates the __except expression to see if the exception will be handled here. The __except expression calls another DLL routine, CHECK_EXCEPTION_INFO, passing it the operating system supplied information about the exception. CHECK_EXCEPTION_INFO determines what the exception condition was, generates traceback information with an appropriate message specific to the event and returns EXCEPTION_EXECUTE_HANDLER.

Returning EXCEPTION_EXECUTE_HANDLER tells the operating system to resume execution in the handler block associated with the __except construct in Fortran_Test_Wrapper. The code in the handler block calls TRANSLATE_TO_MY_APP_CODES, which again does a table look up, but to a second table, to translate the Windows defined status code to a user defined status code. Execution continues with the return statement following the __except block. The Visual Basic code gets the user defined status value and puts up the appropriate display.

In this sample, the Fortran code is compiled /fpe:0 and intentionally creates floating point exceptions. It expects traps due to those exceptions. By default, Visual Basic masks all floating point traps so the application must take action to unmask traps. For this sample, two routines are provided in the DLL, Fortran_FP_Trap_Enable and Fortran_FP_Trap_Disable, that are called from the Visual Basic code. In procedure cmdFltOvf_Click, source file frmVBVF1.frm, there is a call to DLL routine Fortran_FP_Trap_Enable to unmask traps before the call to DLL routine Fortran_FltOvf which generates the exception.

Fortran_FP_Trap_Enable uses GETCONTROLFPQQ and SETCONTROLFPQQ to unmask traps in the floating-point control word. In the Visual Basic handler code for this routine at label My_VB_FltOvf_Handler, DLL routine Fortran_FP_Trap_Disable is called to revert to Visual Basic default exception settings. The timing of when and how to unmask or mask floating-point traps is an application design issue. The sample just shows one way you can do it.

Custom Handlers for Fortran Windows Applications

Fortran Windows applications are not hooked up to the Fortran default exception handling processing facilities. Fortran Windows applications are considered to be an area devoted to full customization, and the Fortran run-time system tries to "stay out of the way," so you can do whatever you want in your code.

The following discussion refers to the sample program WINEXCP1 provided with the Visual Fortran kit in the `...\SAMPLES\EXCEPTIONHANDLING` folder. WINEXCP1 extends the GENERIC sample to show how you might incorporate structured exception handling and standard I/O error handling techniques to protect a Fortran message processing routine.

If you build and run this application, the main window will be displayed and you will see a menu labeled "Run Error Simulator." On the error simulator menu you can choose from six different error generating test cases. Selecting any one of the test cases sends a specific message which is interpreted in function MainWndProc in source file generic.f90. For each message, MainWndProc effectively calls the message processing routine ERROR_SIMULATOR to generate the selected condition. But MainWndProc does not call ERROR_SIMULATOR directly. Instead, it calls a wrapper routine, ERROR_SIMULATOR_WRAPPER in source file wrapper.c, which wraps a try-except construct around the call to ERROR_SIMULATOR. Also notice that MainWndProc expects to get a status value returned from ERROR_SIMULATOR_WRAPPER. If ERROR_SIMULATOR_WRAPPER returns a zero, all is well. If a non-zero status is returned, MainWndProc displays a message box indicating the error simulator had an error.

The important point to notice is that errors in the simulator routine are contained and turned into status codes that can be acted upon rather than allowing the program to abort when something unexpected occurs. To achieve this behavior, the code must do two things:

1. The simulator must always ask for and test the completion status on Fortran I/O statements. If the I/O status is not FOR$IOS_SUCCESS, the simulator takes appropriate action and returns the non-zero status to MainWndProc.

2. Exceptions must be caught and dealt with. The __except construct in ERROR_SIMULATOR_WRAPPER allows this to happen. When an exception occurs in ERROR_SIMULATOR, the operating system will evaluate the __except filter expression to see if we want to handle the exception. The filter expression is a call to CHECK_EXCEPTION_INFO in generic1.f90. A pointer to the operating system supplied exception information is passed to CHECK_EXCEPTION_INFO.

   If CHECK_EXCEPTION_INFO returns EXCEPTION_EXECUTE_HANDLER, the code in the __except handler block is executed. The handler block sets the return status to a non-zero value. Execution then continues with the return statement following the handler block and returns to MainWndProc. CHECK_EXCEPTION_INFO takes whatever error handling action is appropriate for the situation. In this sample program, it will clear the floating point exception status for floating point exceptions and in all cases, it will generate a traceback output with a message specific to the exception which occurred.

If CHECK_EXCEPTION_INFO returns EXCEPTION_CONTINUE_SEARCH, the operating system looks for any other handlers on its handler list. In this case it would find the C run-time system default __except filter which calls the C run-time routine _XcptFilter. _XcptFilter would return EXCEPTION_EXECUTE_HANDLER, which would call the C run-time _exit routine to abort the process.

Finally, recall that the Fortran run-time system does not supply a C main routine for a Fortran Windows application as in a Fortran Console or Fortran QuickWin application. In those cases, main would have called MAIN__, which would have executed a few compiler generated Fortran run-time system calls to do some additional initialization work. This application compiles with the /fpe:0 option so that floating-point traps can be demonstrated. The application must unmask these traps since the Fortran run-time system will not be called to do it automatically. For this sample, the traps are unmasked at the beginning of ERROR_SIMULATOR using GETCONTROLFPQQ and SETCONTROLFPQQ. The traps would have been masked by default.

In some situations, you may want a separate initialization routine to unmask traps for the entire duration of your application. In other cases, you may want to mask or unmask traps at selective points during program execution. If you selectively mask and unmask traps, keep in mind that your code may set floating point exception status bits even through you may have traps masked. The floating-point status bits are "sticky," so before you unmask traps again, you should clear the floating point status bits so you do not generate a false trap later in your code.

Using SIGNALQQ and How SIGNALQQ Works

For light-weight exception handling requirements, a handler established with SIGNALQQ may meet your needs. This section describes how signal handling with **SIGNALQQ** works in detail and also how **GETEXCEPTIONPTRSQQ** works.

Reference is made to C run-time sources provided with Microsoft Visual C++. The discussion is worth reviewing even if you do not have Visual C++ available though. The following topics are discussed:

- C-Style Signal Handling Overview
- Signal is Really SEH Again
- How GETEXCEPTIONPTRSQQ Works

C-Style Signal Handling Overview

Many Fortran applications were developed on U*X systems where C-style signal handling was the usual way of dealing with exceptions. When ported to Windows, these applications can continue to use the C signal interface. SIGNALQQ will work with any application type using pure Fortran or mixed Fortran and C code. It does not work well, for example, in a VB-VF application.

SIGNALQQ is just a Fortran jacket to the C run-time signal() function. When you call **SIGNALQQ**, you are actually registering your signal handler (or action) for a particular signal with the C run-time system. The C run-time system simply stores your handler (or action) in an internal exception action table or variable where it associates your handler with the desired signal. The operating system has no knowledge of this association.

If you have Visual C++ available, you can look at the code for the C run-time signal routine in `...\MICROSOFT VISUAL STUDIO\VC98\CRT\WINSIG.C` and see how the table is managed. The table itself is defined and initialized in source file WINXFLTR.C, available in the same folder. When a signal occurs, the C run-time system checks its internal table to see if you have registered a handler for the particular signal. It calls your routine if you have assigned a handler.

Signal is Really SEH Again

Notice that it is the C run-time system that calls your handler when a signal occurs, not the operating system. So how did the C run-time get the exception delivered to it? Recall that the entry point of your image is either mainCRTStartup or WinMainCRTStartup, depending on the application type. Refer back to the section Structure of a Visual Fortran Application and look at these entry points (or look at source file Crt0.c in the C run-time sources). Notice that they wrap a try-except construct around a call to either main() or WinMain() and that the filter expression associated with the __except construct calls a function _XcptFilter. _XcptFilter is passed two arguments which are the operating system supplied exception information.

When an exception occurs, the operating system looks at the list of exception filters and, starting with the inner most nested try-except construct, evaluates except filter expressions until it finds one which does not return EXCEPTION_CONTINUE_SEARCH. If your application type includes main from the Fortran run-time system and thus the except construct associated with main, the Fortran run-time filter will be evaluated before the C run-time filter. The Fortran filter expression will check to see if you have established your own handler with SIGNALQQ. If it finds there is such a handler, or if you have set the environment variable FOR_IGNORE_EXCEPTIONS, it will return EXCEPTION_CONTINUE_SEARCH to allow the C run-time exception filter the opportunity to deal with the exception and find your handler. If you have not established your own handler or set the environment variable, the Fortran run-time will perform its default exception handling processing.

The C filter function, _XcptFilter, compares the exception code from the operating system with its mapping of operating system exceptions to C signal codes. If it finds a match in the table, it uses the exception action entry in the table corresponding to the signal code. This is the same table where your **SIGNALQQ** handler is recorded as the action for the requested signal code. If you have established a handler, it will be called from _XcptFilter. Before your handler is called, _XcptFilter resets the specified action for the signal to SIG_DFL in the exception action table. If you try to continue from the exception and you want your handler invoked on the next occurrence of the signal, you must call **SIGNALQQ** again to reestablish your handler as the action for that signal. When your handler routine is finished executing and returns to _XcptFilter, the value EXCEPTION_CONTINUE_EXECUTION is returned to the operating system by _XcptFilter. The operating system will then resume execution at the point of the exception. If you do not want to continue execution, your handler should take appropriate action to shut down the application.

Not every operating system exception code maps to a C signal code. You can see the mapping in source WINXFLTR.C if you have it. Here is the list if you do not have WINXFLTR.C (as of Visual C++ version 6.0):

Operating System Exception Code	**C Signal Number**
STATUS_ACCESS_VIOLATION	SIGSEGV
STATUS_ILLEGAL_INSTRUCTION	SIGILL
STATUS_PRIVILEGED_INSTRUCTION	SIGILL
STATUS_FLOAT_DENORMAL_OPERAND	SIGFPE
STATUS_FLOAT_DIVIDE_BY_ZERO	SIGFPE
STATUS_FLOAT_INEXACT_RESULT	SIGFPE
STATUS_FLOAT_INVALID_OPERATION	SIGFPE
STATUS_FLOAT_OVERFLOW	SIGFPE
STATUS_FLOAT_STACK_CHECK	SIGFPE
STATUS_FLOAT_UNDERFLOW	SIGFPE

How GETEXCEPTIONPTRSQQ Works

When the C run-time exception filter function _XcptFilter calls your handler that you established with SIGNALQQ, the only argument passed to your handler is the C signal number. The C run-time system also saves a pointer to the exception information supplied by the operating system. This pointer is named _pxcptinfoptrs and you can retrieve it through the Fortran run-time routine GETEXCEPTIONPTRSQQ. See C header file signal.h for the public definition of _pxcptinfoptrs.

The value returned by **GETEXCEPTIONPTRSQQ** can be used in your handler routine to generate a traceback with **TRACEBACKQQ**. **GETEXCEPTIONPTRSQQ** just returns _pxcptinfoptrs. This pointer is only valid while you are executing within the evaluation of the C run-time filter function _XcptFilter because the exception information is on the program stack, so do not use **GETEXCEPTIONPTRSQQ** in any other context.

See the sample program `...\SAMPLES\EXCEPTIONHANDLING\GETEPTRS` for a working example of using GETEXCEPTIONPTRSQQ.

Suggestions for Console Event Handlers

Control-C event handling is basically not reliable due to the threaded nature of processes executing on the Windows operating systems. Depending on what is happening at the instant a user types the Control-C, an event handler may or may not get the opportunity to execute. In any case, there are two ways to establish a handler if you want to do so. You can use the Win32 routine SetConsoleCtrlHandler directly or you can use SIGNALQQ to establish a handler for the C SIGINT or SIGBREAK signals.

The Fortran run-time system establishes a console event handler through a call to SetConsoleCtrlHandler as part of its run-time initialization processing. See the section Default Console Event Handling for a description of this handler's behavior.

If you call SetConsoleCtrlHandler to establish your own event handler, your handler will be called first on console events.

If you establish a handler through **SIGNALQQ** with SIGINT or SIGBREAK, the C run-time system will establish its own internal handler for console events through a call to SetConsoleCtrlHandler, and it will record your routine as the desired action to take upon occurrence of an event. When an event is delivered to the C run-time handler, it will reset the action for the signal to SIG_DFL and then call your handler routine.

You must call **SIGNALQQ** again to reset the action to your routine if you want to continue from the control event. Your handler is called with the signal code (either SIGINT or SIGBREAK) as the argument. After your routine returns to the C run-time event handler, the C handler will return the value TRUE to the operating system indicating the event has been handled.

Converting Unformatted Numeric Data

This section describes how you can use Visual Fortran to read and write nonnative unformatted numeric data, including Compaq Fortran for OpenVMS systems numeric data.

The following topics are discussed:

Supported Native and Nonnative Numeric Formats

Visual Fortran supports the following little endian floating-point formats in memory:

Floating-Point Size	Format in Memory
REAL(KIND=4), COMPLEX(KIND=4)	IEEE S_floating
REAL(KIND=8), COMPLEX(KIND=8)	IEEE T_floating

If your program needs to read or write unformatted data files containing a floating-point format that differs from the format in memory for that data size, you can request that the unformatted data be converted.

Data storage in different computers uses a convention of either little endian or big endian storage. The storage convention generally applies to numeric values that span multiple bytes, as follows:

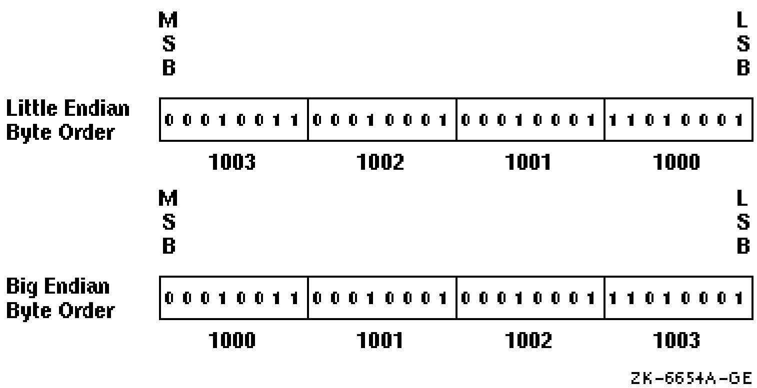
- Little endian storage occurs when:
  - The least significant bit (LSB) value is in the byte with the lowest address.
  - The most significant bit (MSB) value is in the byte with the highest address.
  - The address of the numeric value is the byte containing the LSB.

Subsequent bytes with higher addresses contain more significant bits.

- Big endian storage occurs when:
  - The least significant bit (LSB) value is in the byte with the highest address.
  - The most significant bit (MSB) value is in the byte with the lowest address.
  - The address of the numeric value is the byte containing the MSB. Subsequent bytes with higher addresses contain less significant bits.

The following figure shows the difference between the two byte-ordering schemes.

Little and Big Endian Storage of an INTEGER Value



Moving unformatted data files between big endian and little endian computers requires that the data be converted.

Visual Fortran provides the capability for programs to read and write unformatted data (originally written using unformatted I/O statements) in several nonnative floating-point formats and in big endian INTEGER or floating-point format. Supported nonnative floating-point formats include Compaq VAX little endian floating-point formats supported by VAX FORTRAN, standard IEEE big endian floating-point format found on most Sun Microsystems™ systems and IBM RISC System/6000 systems, IBM floating-point formats (associated with the IBM's System/370 and similar systems), and CRAY floating-point formats.

Converting unformatted data instead of formatted data is generally faster and is less likely to lose precision of floating-point numbers.

The native memory format includes little endian integers and little endian IEEE floating-point formats, S_float for REAL(KIND=4) and COMPLEX(KIND=4) declarations and T_float for REAL(KIND=8) and COMPLEX(KIND=8) declarations.

The keywords for supported nonnative unformatted file formats and their data types are listed in the following table:

Nonnative Numeric Formats, Keywords, and Supported Data Types

Keyword	Description
BIG_ENDIAN	Big endian integer data of the appropriate size (one, two, or four bytes) and big endian IEEE floating-point (REAL (KIND=4), REAL(KIND=8), COMPLEX(KIND=4), COMPLEX (KIND=8)) formats of the appropriate size for either real or complex numbers. INTEGER(KIND=1) data is the same for little endian and big endian.
CRAY	Big endian integer data of the appropriate size (one, two, four, or eight bytes) and big endian CRAY proprietary floating-point format of size REAL(KIND=8) or COMPLEX (KIND=8).
FDX	Little endian integer data of the appropriate size (one, two, four, or eight bytes) and Compaq VAX floating-point data of format F_floating for REAL(KIND=4) or COMPLEX(KIND=4), and D_Floating for REAL(KIND=8) or COMPLEX(KIND=8).
FGX	Little endian integer data of the appropriate size (one, two, four, or eight bytes) and Compaq VAX floating-point data of format F_floating for REAL(KIND=4) or COMPLEX(KIND=4), and G_Floating for REAL(KIND=8) or COMPLEX(KIND=8).
IBM	Big endian integer data of the appropriate size (one, two, or four bytes) and big endian IBM proprietary floating-point format of size REAL(KIND=4) or COMPLEX(KIND=4) or size REAL(KIND=8) or COMPLEX(KIND=8).
LITTLE_ENDIAN	Native little endian integers of the appropriate size (one, two, four, or eight bytes) and native little endian IEEE floating-point data of the appropriate size and type (REAL (KIND=4), REAL(KIND=8), COMPLEX(KIND=4), COMPLEX (KIND=8)). These are the same formats as stored in memory. For additional information on supported ranges for these data types, see Native IEEE Floating-Point Representations.
NATIVE	No conversion occurs between memory and disk. This is the default for unformatted files.

VAXD	Little endian integers of the appropriate size (one, two, four, or eight bytes) and Compaq VAX floating-point format F_floating for size REAL(KIND=4) or COMPLEX(KIND=4), and D_floating for size REAL(KIND=8) or COMPLEX (KIND=8).
VAXG	Little endian integers of the appropriate size (one, two, four, or eight bytes) and Compaq VAX floating-point format F_floating for size REAL(KIND=4) or COMPLEX(KIND=4), and G_floating for size REAL(KIND=8) or COMPLEX (KIND=8).

When reading a nonnative format, the nonnative format on disk is converted to native format in memory. If a converted nonnative value is outside the range of the native data type, a run-time message is displayed.

Limitations of Numeric Conversion

The Visual Fortran floating-point conversion solution is not expected to fulfill all floating-point conversion needs.

For instance, data fields in record structure variables (specified in a **STRUCTURE** statement) and data components of derived types (**TYPE** statement) are not converted. When they are later examined as separate fields by the program, they will remain in the binary format they were stored in on disk, unless the program is modified. With **EQUIVALENCE** statements, the data type of the variable named in the I/O statement is used.

If a program reads an I/O record containing multiple format floating-point fields into a single variable (such as an array) instead of their respective variables, the fields will not be converted. When they are later examined as separate fields by the program, they will remain in the binary format they were stored in on disk, unless the program is modified.

Conversions of the following file structure types are *not* supported:

- Binary data (FORM='BINARY')
- Formatted data (FORM='FORMATTED')
- Unformatted data (FORM='UNFORMATTED') written by Microsoft Fortran PowerStation or by Visual Fortran with the /fpscomp:ioformat compiler option in effect.

Methods of Specifying the Data Format

There are five methods of specifying a nonnative numeric format for unformatted data. If none of these methods are specified, the native LITTLE_ENDIAN format is assumed (no conversion occurs between disk and memory).

Any keyword listed in Supported Native and Nonnative Numeric Formats can be used with any of these methods.

The five methods you can use to specify the type of nonnative (or native) format are as follows:

1. Setting an environment variable for a specific unit number before the file is opened. The environment variable is named FORT_CONVERT*n*, where *n* is the unit number.
2. Setting an environment variable for a specific file name extension before the file is opened. The environment variable is named FORT_CONVERT.*ext* or FORT_CONVERT_*ext*, where *ext* is the file name extension (suffix).
3. Compiling the program with an **OPTIONS** statement that specifies the /CONVERT=*keyword* qualifier. This method affects all unit numbers using unformatted data specified by the program.
4. Specifying the CONVERT keyword in the **OPEN** statement for a specific unit number.
5. Compiling the program with the appropriate compiler option (DF command /convert: *keyword* or visual development environment equivalent), which affects all unit numbers that use unformatted data specified by the program.

If you specify more than one method, the order of precedence when you open a file with unformatted data is to:

1. Check for an environment variable (FORT_CONVERT*n*) for the specified unit number (applies to any file opened on a particular unit).
2. Check for an environment variable (FORT_CONVERT.*ext* is checked before FORT_CONVERT_*ext*) for the specified file name extension (applies to all files opened with the specified file name extension).
3. Check the **OPEN** statement CONVERT specifier.
4. Check whether an **OPTIONS** statement with a /CONVERT=*keyword* qualifier was present when the program was compiled.
5. Check whether the compiler option /convert:*keyword* was present when the program was compiled.

The following sections describe each method:

- Environment Variable FORT_CONVERT*n* Method
- Environment Variable FORT_CONVERT.*xxx* or FORT_CONVERT_*xxx* Method
- OPEN Statement CONVERT= Method
- OPTIONS Statement Method
- Compiler Option /convert Method

Environment Variable FORT_CONVERTn Method

You can use this method to specify a non-native numeric format for each specified unit number. You specify the numeric format at run time by setting the appropriate environment variable before an implicit or explicit **OPEN** to that unit number.

When the appropriate environment variable is set when you open the file, the environment variable is always used because this method takes precedence over the other methods. For instance, you might use this method to specify that a unit number will use a particular format instead of the format specified in the program (perhaps for a one-time file conversion).

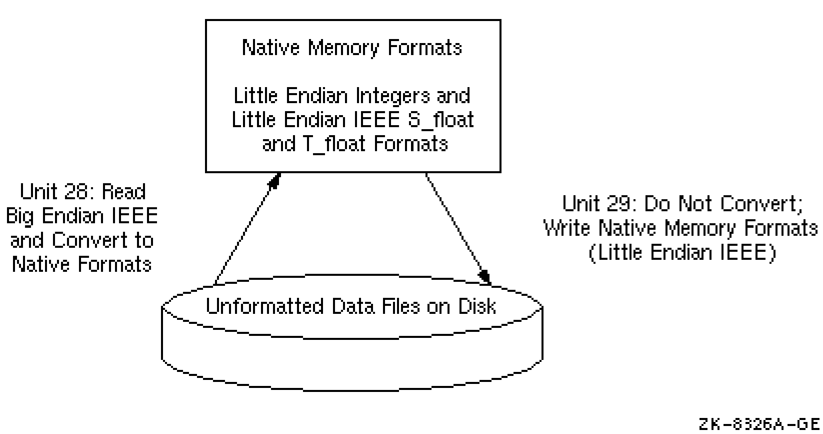
For example, assume you have a previously compiled program that reads numeric data from unit 28 and writes it to unit 29 using unformatted I/O statements. You want the program to read nonnative big endian (IEEE floating-point) format from unit 28 and write that data in native little endian format to unit 29. In this case, the data is converted from big endian IEEE format to native little endian IEEE memory format when read from unit 28, and then written without conversion in native little endian IEEE format to unit 29.

Without requiring source code modification or recompilation of this program, the following command sequence sets the appropriate environment variables before running the program (c:\users\leslie\convieee.exe):

```
set FORT_CONVERT28=BIG_ENDIAN
set FORT_CONVERT29=NATIVE
c:\users\leslie\convieee.exe
```

The following figure shows the data formats used on disk and in memory when the example file c:\users\leslie\convieee.exe is run after the environment variables are set.

Sample Unformatted File Conversion



This method takes precedence over other methods.

Environment Variable FORT_CONVERT.ext or FORT_CONVERT_ext Method

You can use this method to specify a non-native numeric format for each specified file name extension (suffix). You specify the numeric format at run time by setting the appropriate environment variable before an implicit or explicit **OPEN** to one or more unformatted files. You can use the format FORT_CONVERT.*ext* or FORT_CONVERT_*ext* (where *ext* is the file extension or suffix). The FORT_CONVERT.*ext* environment variable is checked before FORT_CONVERT_*ext* environment variable (if *ext* is the same).

For example, assume you have a previously compiled program that reads numeric data from one file and writes to another file using unformatted I/O statements. You want the program to read nonnative big endian (IEEE floating-point) format from a file with a .dat file extension extension and write that data in native little endian format to a file with a extension of .data. In this case, the data is converted from big endian IEEE format to native little endian IEEE memory format (S_float and T_float) when read from file.dat, and then written without conversion in native little endian IEEE format to the file with a suffix of .data, assuming that environment variables FORT_CONVERT.DATA and FORT_CONVERT*n* (for that unit number) are not defined.

Without requiring source code modification or recompilation of this program, the following command sequence sets the appropriate environment variables before running the program (c:\proj2\cvbigend.exe):

```
set FORT_CONVERT.DAT=BIG_ENDIAN
c:\proj2\cvbigend.exe
```

The FORT_CONVERT*n* method takes precedence over this method. When the appropriate environment variable is set when you open the file, the FORT_CONVERT.*ext* or FORT_CONVERT_*ext* environment variable is used if a FORT_CONVERT*n* environment variable is not set for the unit number.

The FORT_CONVERT*n* and the FORT_CONVERT.*ext* or FORT_CONVERT_*ext* environment variable methods take precedence over the other methods. For instance, you might use this method to specify that a unit number will use a particular format instead of the format specified in the program (perhaps for a one-time file conversion).

You can set the appropriate environment variable using the format FORT_CONVERT.*ext* or FORT_CONVERT_*ext*. If you also use Compaq Fortran on U*X systems, consider using the FORT_CONVERT_*ext* form, because a dot (.) cannot be used for environment variable names on certain U*X command shells.

If you do define both FORT_CONVERT.*ext* and FORT_CONVERT_*ext* for the same extension (*ext*), the file defined by FORT_CONVERT.*ext* is used.

On Windows systems, the file name extension (suffix) is not case-sensitive. The extension must be part of the file name (not the directory path).

OPEN Statement CONVERT Method

You can use this method to specify a non-native numeric format for each specified unit number. This method requires an explicit file OPEN statement to specify the numeric format of the file for that unit number.

This method takes precedence over the **OPTIONS** statement and the compiler option /convert:*keyword* method, but has a lower precedence than the environment variable methods.

For example, the following source code shows how the **OPEN** statement would be coded to read unformatted VAXD numeric data from unit 15, which might be processed and possibly written in native little endian format to unit 20 (the absence of the CONVERT keyword or environment variables FORT_CONVERT20, FORT_CONVERT.dat, or FORT_CONVERT_dat indicates native little endian data for unit 20):

```
OPEN (CONVERT='VAXD', FILE='graph3.dat', FORM='UNFORMATTED', UNIT=15)
   .
   .
   .
OPEN (FILE='graph3_t.dat', FORM='UNFORMATTED', UNIT=20)
```

A hard-coded OPEN statement CONVERT keyword value cannot be changed after compile time. However, to allow selection of a particular format at run time, equate the CONVERT keyword to a variable and provide the user with a menu that allows selection of the appropriate format (menu choice sets the variable) before the **OPEN** occurs. You can also select a particular format at run time for a unit number by using one of the environment variable methods (FORT_CONVERT*n*, FORT_CONVERT.*ext*, or FORT_CONVERT_*ext*), which take precedence over the **OPEN** statement CONVERT keyword method.

OPTIONS Statement Method

You can only specify one numeric file format for all unformatted file unit numbers using this method unless you also use one of the environment variable methods or **OPEN** statement CONVERT keyword method.

You specify the numeric format at compile time and must compile all routines under the same OPTIONS statement /CONVERT=*keyword* qualifier. You could use one source program and compile it using different DF commands to create multiple executable programs that each read a certain format.

The FORT_CONVERT*n* environment variable method, FORT_CONVERT.*ext* or FORT_CONVERT_*ext* environment variable method, and the **OPEN** statement CONVERT keyword method take precedence over this method. For instance, you might use the FORT_CONVERT*n* environment variable or **OPEN** CONVERT keyword method to specify each unit number that will use a format other than that specified using the DF option method. This method takes precedence over the DF /convert:*keyword* compiler option method.

You can use **OPTIONS** statements to specify the appropriate floating-point formats (in memory and in unformatted files) instead of using the corresponding DF command qualifiers. For example, to use VAX F_floating and G_floating as the unformatted file format, specify the following **OPTIONS** statement:

```
OPTIONS /CONVERT=VAXG
```

Because this method affects all unit numbers, you cannot read data in one format and write it in another format, unless you use it in combination with one of the environment variable methods or the **OPEN** statement CONVERT keyword method to specify a different format for a particular unit number.

For more information, see the OPTIONS statement.

Compiler Option /convert Method

You can only specify one numeric format for all unformatted file unit numbers using the compiler option /convert method unless you also use one (or more) of the previous methods. You specify the numeric format at compile time and must compile all routines under the same /convert:*keyword* compiler option, which is listed under the Compatibility category in the visual development environment, Fortran tab. You could use the same source program and compile it using different DF commands (or the equivalent in the visual development environment) to create multiple executable programs that each read a certain format.

If you specify other methods, they take precedence over this method. For instance, you might use the environment variable or **OPEN** statement CONVERT keyword method to specify each unit number that will use a format different than that specified using the DF /convert:*keyword* compiler option method for all other unit numbers.

For example, the following command compiles program file.for to use VAX D_floating (and F_floating) floating-point data for all unit numbers (unless superseded by one of the other methods). Data is converted between the file format and the little endian memory format (little endian integers, S_float and T_float little endian IEEE floating-point format). The created file, vconvert.exe, can then be run:

```
DF file.for /convert:vaxd /link /out:vconvert.exe
```

Because this method affects all unformatted file unit numbers, you cannot read data in one format and write it in another file format using the /convert:*keyword* compiler option method alone. You can if you use it in combination with the environment variable methods or the **OPEN** statement CONVERT keyword method to specify a different format for a particular unit number.

Additional Notes on Nonnative Data

The following notes apply to porting nonnative data:

- When porting source code along with the unformatted data, vendors might use different units for specifying the record length (RECL specifier) of unformatted files. While formatted files are specified in units of characters (bytes), unformatted files are specified in longword units for Compaq Fortran (default) and some other vendors.

  To allow you to specify the RECL units (bytes or longwords) for unformatted files without source file modification, use the /assume:byterecl compiler option (in the visual development environment, this is available in the Project menu Settings item, Fortran tab, Fortran Data category).

  The Fortran 90 standard (American National Standard Fortran 90, ANSI X3.198-1991, and International Standards Organization standard ISO/IEC 1539:1991), in Section 9.3.4.5, states: "If the file is being connected for unformatted input/output, the length is measured in processor-dependent units."

- Certain vendors apply different **OPEN** statement defaults to determine the record type. The default record type (RECORDTYPE) with Compaq Fortran depends on the values for the ACCESS and FORM specifiers for the OPEN statement (also described in the *Compaq Fortran Language Reference Manual*).
- Certain vendors use a different identifier for the logical data types, such as hex FF instead of 01 to denote "true."
- Source code being ported may be coded specifically for big endian use.

Hexadecimal-Binary-Octal-Decimal Conversions

The following table lists hexadecimal, binary, octal, and decimal conversion:

Hexadecimal, Binary, Octal, and Decimal Conversion

Hex Number	Binary Number	Octal Number	Decimal Number
0	0000	00	0
1	0001	01	1
2	0010	02	2
3	0011	03	3
4	0100	04	4
5	0101	05	5
6	0110	06	6
7	0111	07	7
8	1000	10	8
9	1001	11	9
A	1010	12	10
B	1011	13	11
C	1100	14	12
D	1101	15	13
E	1110	16	14
F	1111	17	15

Using the IMSL Mathematical and Statistical Libraries

The Professional and Enterprise Editions of Visual Fortran include the IMSL libraries, a collection of nearly 1,000 mathematical and statistical functions easily accessible from the visual development environment.

The IMSL libraries are installed with Visual Fortran, as described in *Compaq Visual Fortran Installation and Getting Started*.

You can view the IMSL `readme` file and online help using the Compaq Visual Fortran program folder. The online documentation included with the IMSL Libraries includes an ASCII readable file and PDF files:

- `README.TXT`

  This ASCII readable file contains the Release Notes for the IMSL Libraries. It also includes information on accessing the IMSL libraries.

- On-line PDF documentation

  The IMSL online Adobe Acrobat PDF documentation lets you quickly find details on the purpose and use of any IMSL Library routine. You can access the following topics through the online IMSL Routines Reference (PDF version):

  - IMSL Mathematical Library Subroutines
  - IMSL Mathematical Library Special Functions
  - IMSL Statistical Library Subroutines, Volumes 1 and 2
  - IMSL Fortran 90 MP Library Subroutines

  Click on any of the libraries to see a submenu of items grouped by subject. Within each category (for example, Linear Systems, Eigensystem Analysis, and so on), click on a routine for more information.

IMSL libraries (and IMSL online documentation files) are included with the Professional and Enterprise Editions of Visual Fortran (*not* the Standard Edition).

When calling the IMSL library routines from a multi-threaded application, be aware that the IMSL routines are intended only for single-thread use.

This section provides information on the following topics:

- Using the IMSL Libraries from Visual Fortran
- Library Naming Conventions

- Using IMSL Libraries in a Mixed-Language Environment

Using the IMSL Libraries from Visual Fortran

To use the IMSL libraries, you need to:

1. Set the necessary IMSL environment variables for your development environment by executing the DFVARS.BAT file (see Using the Compiler and Linker from the Command Line). This sets the INCLUDE path and library (linker) search paths.

   Within the Fortran Command Prompt (command-line window) in the Compaq Visual Fortran program folder, the DFVARS.BAT file is already executed. Within the visual development environment, the equivalent of DFVARS.BAT file (as installed by Visual Fortran) is executed. You can view these directory paths within the visual development environment by:

   a. In the Tools menu, click Options.
   b. Click the Directory tab.
   c. In the drop-down list for Show Directories, select Library files and view the library paths.
   d. In the drop-down list for Show Directories, select Include files and view the include file paths.
   e. Click OK if you have changed any information.

2. The easiest way to pass IMSL libraries to the Linker is to specify the /imsl compiler option.

   Alternatively, if you wish to explicitly include the IMSL libraries, do the following in the visual development environment:

   a. If not already open, open your Project Workspace (File menu, Open Workspace).
   b. In the Project menu, click on Settings.
   c. Click on the Link tab and add the IMSL library names (explained in Library Naming Conventions) to the Project Options box as follows:

      ```
      imsl.lib imsls_err.lib imslmpistub.lib
      ```

   d. Click OK if you have changed any information.

3. Make IMSL routines and their interfaces available to your program:

   - When calling Mathematics and Statistical library routines from a Fortran program, you should use the numerical_libraries module to provide interface blocks and parameter definitions for the routines.

Including the following **USE** statement in your calling program will verify the correct usage of the IMSL routines at compile time:

```
USE numerical_libraries
```

When you add the `USE numerical_libraries` line to your program, you should *not* declare the called routines as external with the **EXTERNAL** statement.

For more details, see the IMSL `readme` file in the Visual Fortran program folder.

When calling Mathematics and Statistical library routines, you do not need to declare the functions or subroutines separately.

- When also calling Fortran 90 MP library routines, you should instead use the imslf90 module to provide interface blocks and parameter definitions for all the Fortran 90 MP routines and the MATH and STAT library routines. Including the following **USE** statement in your calling program will verify the correct usage of the IMSL routines at compile time:

```
USE IMSLF90
```

For more information about calling the Fortran 90 MP routines, see the IMSL Libraries online PDF file.

The free-form Fortran 95/90 example program below invokes the function AMACH and the subroutine UMACH from the IMSL Libraries. The AMACH function retrieves real machine constants that define the computer's real arithmetic. A value for positive machine infinity is returned (`Infinity`). The subprogram UMACH retrieves the output unit number.

```
!  This free-form example demonstrates how to call
!  IMSL routines from Visual Fortran.
!
! The module numerical_libraries includes the Math and
! Stat libraries; these contain the type declarations
! and interface statements for the library routines.

  PROGRAM SHOWIMSL

  USE NUMERICAL_LIBRARIES
  INTEGER NOUT
  REAL RINFP

! The AMACH function and UMACH subroutine are
! declared in the numerical_libraries module

  CALL UMACH(2,NOUT)
  RINFP = AMACH(7)
```

```
WRITE(NOUT,*) 'REAL POSITIVE MACHINE INFINITY = ',RINFP
END PROGRAM
```

For information on compiling and linking with the visual development environment, see Building Programs and Libraries.

Note: IMSL routines are in general not multithread safe. In a multithread environment, you should take care that no two IMSL routines are active at the same time. To insure this, use multithread control techniques. For further information, see Creating Multithread Applications.

Library Naming Conventions

The IMSL Numerical Libraries use the following library names:

File Name	Library Description
IMSL	IMSL Static Library, contains FORTRAN 77 and Fortran 90 routines
IMSLS_ERR	IMSL Error Handler Library
IMSLMPISTUB	Stub Library for MPI Routines used in IMSL

The IMSL Numerical Libraries are for applications in general applied mathematics and for analyzing and presenting statistical data in scientific and business applications.

For command-line window development, executing the DFVARS.BAT file (see Using the Compiler and Linker from the Command Line) sets environment variables required by Visual Fortran.

For more information on the IMSL libraries, see:

- The IMSL `readme` file provided in the Visual Fortran program folder.
- The IMSL online documentation PDF files provided in the Compaq Visual Fortran program folder for the IMSL Routines Reference.
- Product information about IMSL at the following Internet URL:
  http://www.vni.com

Using IMSL Libraries in a Mixed-Language Environment

This section explains how to use the IMSL Libraries in a mixed-language development environment with Visual Fortran and Microsoft Visual C++.

Messages that IMSL routines write to standard output or to error output in a mixed-language application or an application for Windows can be awkward if they are written to the screen. You can avoid this by calling UMACH from a Fortran routine to remap the output and error units to a file instead of to the screen. For example, the following free-form program writes the standard output from VHSTP to the file STD.TXT, and the error message from AMACH to the file ERR.TXT:

```
  PROGRAM fileout
!       This program demonstrates how to use the UMACH routine to
!       redirect the standard output and error output from IMSL
!       routines to files instead of to the screen. The routines
!       AMACH and UMACH are declared in the numerical_libraries module
!
   USE numerical_libraries
   INTEGER STDU, ERRU
   REAL x, frq(10)/3.0,1.0,4.0,1.0,5.0,9.0,2.0,6.0,5.0,3.0/
!
!       Redirect IMSL standard output to STD.TXT at unit 8
!
   CALL umach(-2, STDU)
   OPEN (unit=STDU, file='std.txt')
   CALL vhstp(10,frq,1,'Histogram Plot')
   CLOSE(8)
!
!       Redirect IMSL error output to ERR.TXT at unit 9
!
   CALL umach(-3, ERRU)
   OPEN (unit=ERRU, file='err.txt')
   x = amach(0)   ! Illegal parameter error
   CLOSE(9)
   END
```

The standard output from IMSL routine VHSTP written to STD.TXT is:

```
1
           Histogram Plot
 Frequency-------------------------
    9  *            I           *
    8  *            I           *
    7  *            I           *
    6  *            I   I       *
    5  *          I I   I I     *
    4  *      I   I I   I I     *
    3  *  I   I   I I   I I I   *
    2  *  I   I   I I I I I I   *
    1  *  I I I I I I I I I I   *
 ----------------------------------
 Class            5        10
```

The error output from IMSL routine AMACH written to ERR.TXT is:

```
 *** TERMINAL ERROR 5 from AMACH. The argument must be between 1 and 8
 ***          inclusive. N = 0
```

Consider the following simple Fortran example that uses the IMSL library:

```
USE numerical_libraries
real rinfp
rinfp = AMACH(7)
write(*,*) 'Real positive machine infinity = ',rinfp
end
```

The output is:

```
Real positive machine infinity = Infinity
```

The corresponding C example is:

```
/* FILE CSAMP0.C */
#include <stdio.h>
#include <stdlib.h>

extern float _stdcall AMACH(long *);

main()
{
   long n;
   float rinfp;

   n = 7;
   rinfp = AMACH(&n);
   printf("Real positive machine infinity = %16E\n", rinfp);

   fflush(stdout);
   _exit(0);
}
```

This C language example demonstrates the use of:

- The _stdcall modifier in the function prototype needed when calling the IMSL libraries.
- The & address operator passes the address of the variable to the subprogram (IMSL libraries expect arguments passed by reference).

The C example can be compiled by the `cl` command to create an object file that can be linked using the DF command.

For more information on mixed-language programming, see Programming with Mixed Languages.

Using the Compaq Extended Math Library (CXML)

The Compaq Extended Math Library (CXML, formerly DXML) provides a comprehensive set of mathematical library routines intended to be called from Fortran. CXML contains a set of over 1500 high-performance mathematical subprograms designed for use in many different types of scientific and engineering applications.

CXML subprograms are easily accessible from the Microsoft visual development environment or the command line interface. They are installed with Visual Fortran, using the "Custom" installation option, as described in "Using Setup to Install Visual Fortran and Related Software" in *Compaq Visual Fortran Installing and Getting Started*.

When you install CXML, you should also install the CXML online documentation, which enables you to quickly find details on the purpose and use of any library routine. You should also view the CXML `readme` file provided in the Compaq Visual Fortran program folder.

You can access CXML topics in the *Compaq Extended Math Library Reference Guide* (PDF version) through Adobe Acrobat. Click on any of the topics to see a submenu of items grouped by subject. For example, to view a description of each routine:

1. Click the topic "CXML Subprogram Reference"
2. Click a category name
3. Click a routine name

Further information about CXML is provided in the following sections:

- CXML Routine Groups
- Using CXML from Visual Fortran

CXML Routine Groups

CXML covers the areas of Basic Linear Algebra (BLAS), Linear Algebra Routines (LAPACK), sparse linear system solvers, sorting routines, random number generation, and signal processing functions:

Name	Description
Basic Linear Algebra	The Basic Linear Algebra Subprograms (BLAS) library includes the industry-standard Basic Linear Algebra Subprograms for Level 1 (vector-vector, BLAS1), Level 2 (matrix-vector, BLAS2), and Level 3 (matrix-matrix, BLAS3). Also included are subprograms for BLAS Level 1 Extensions, and Sparse BLAS Level 1.
Signal Processing	The Signal Processing library provides a basic set of signal processing functions. Included are one-, two-, and three-dimensional Fast Fourier Transforms (FFT), group FFTs, Cosine/Sine Transforms (FCT/FST), Convolution, Correlation, and Digital Filters.
Sparse Linear System	The Sparse Linear System library provides both direct and iterative sparse linear system solvers. The direct solver package supports both symmetric and nonsymmetric sparse matrices. The iterative solver package contains a basic set of storage schemes, preconditioners, and iterative solvers.
LAPACK	LAPACK is an industry-standard subprogram package offering an extensive set of linear system and eigenproblem solvers. LAPACK uses blocked algorithms that are better suited to most modern architectures, particularly ones with memory hierarchies.
Utility subprograms	Utility subprograms include random number generation, vector math functions, and sorting subprograms.

Where appropriate, each subprogram has a version to support each combination of real or complex and single or double precision arithmetic.

For command-line window development, executing the DFVARS.BAT file (see Using the Compiler and Linker from the Command Line) sets Visual Fortran environment variables as well as CXML environment variables (see Environment Variables Used with the DF Command). If you have problems during linking related to CXML routines, please see the online release notes.

For information on compiling and linking with the visual development environment, see Building Programs and Libraries.

For more information on CXML, refer to:

- Using CXML from Visual Fortran.

- The CXML `readme` file provided in the Compaq Visual Fortran program folder.
- The *CXML Reference Guide*, available in PDF format.
- The CXML Samples, installed in `...\Df98\CXML\Samples`.
- The *Compaq Visual Fortran Installing and Getting Started* guide.

Using CXML from Visual Fortran

To use CXML, you need to make the CXML routines and their interfaces available to your program. When calling CXML library routines from a Fortran 95/90 program, you include the file CXML_INCLUDE.F90 as the first statement (after the statement that introduces the program unit). Use the following INCLUDE statement:

```
INCLUDE 'CXML_INCLUDE.F90'
```

An example of the **INCLUDE** statement appears in the following example program.

CXML Program Example

The free-form Fortran example program below invokes the function SAXPY from the BLAS portion of the CXML Libraries. The SAXPY function computes `a*x+y`.

```
 PROGRAM example
  !
  ! This free-form example demonstrates how to call
  ! CXML routines from Visual Fortran.
  !
  ! The include file CXML_INCLUDE.F90 contains interface statements for
  ! the CXML library routines and causes the linker to search the CXML
  ! library.  It must be the first statement following the statement
  ! that introduces the program unit.
  !
   INCLUDE 'CXML_INCLUDE.F90'
   REAL(KIND=4) :: a(10)
   REAL(KIND=4) :: b(10)
   REAL(KIND=4) :: alpha
   INTEGER(KIND=4) :: n
   INTEGER(KIND=4) :: incx
   INTEGER(KIND=4) :: incy
   n = 5 ; incx = 1 ; incy = 1 ; alpha = 3.0
   DO i = 1,n
      a(i) = FLOAT(i)
      b(i) = FLOAT(2*i)
   ENDDO
   PRINT 98, (a(i),i=1,n)
   PRINT 98, (b(i),i=1,n)
98 FORMAT(' Input = ',10F7.3)
   CALL saxpy( n, alpha, a, incx, b, incy )
   PRINT 99, (b(i),I=1,n)
99  FORMAT(/,' Result = ',10F7.3)
   STOP
 END PROGRAM example
```

Compatibility Information

Visual Fortran uses the same Compaq Fortran compiler available on Tru64 UNIX (formerly DIGITAL UNIX) Alpha, Linux Alpha, and OpenVMS Alpha systems. Compaq Visual Fortran supports extensions to the ISO and ANSI standards, including a number of extensions defined by:

- Compaq Fortran for the various Compaq Fortran Alpha platforms
- Microsoft Fortran PowerStation 4.0

Many language extensions associated with Microsoft Fortran PowerStation Version 4 have been added to Visual Fortran; most of these extensions have been added to different releases of Compaq Fortran on Alpha platforms.

The following sections describe Visual Fortran compatibility information:

Compatibility with Compaq Fortran on Other Platforms

Compaq Visual Fortran supports extensions to the Fortran 95 and 90 ISO and ANSI standards, including a number of extensions defined by:

- Compaq Fortran (formerly Digital Fortran)

  Compaq Fortran (including Compaq Visual Fortran) provides many of the language extensions provided by Compaq Fortran 77 for OpenVMS VAX Systems (formerly DEC Fortran 77 and VAX FORTRAN).

- Microsoft Fortran PowerStation 4.0

  For information about Microsoft Fortran PowerStation 4.0, see Compatibility with Microsoft Fortran PowerStation.

This section discusses the following topics:

Summary of Language Compatibility

Compaq Visual Fortran (CVF) uses the same robust, highly efficient Fortran 95/90 compiler used by Compaq Fortran for the following Alpha operating systems:

- Compaq Tru64 UNIX Alpha systems
- Linux Alpha systems
- Compaq OpenVMS Alpha systems

The following table summarizes the compatibility of Compaq Visual Fortran with Compaq Fortran for Alpha systems and Compaq Fortran 77 (CF77) for OpenVMS VAX systems:

Summary of Language Compatibility

	Compaq Fortran (CF) OS/Architecture Platform				
Language Feature	**CVF Windows**	**CF UNIX Alpha**	**CF Linux Alpha**	**CF OpenVMS Alpha**	**CF77 OpenVMS VAX**
Linking against static and shared libraries	X	X	X	X	X
Create code for shared libraries	X	X	X	X	X
Recursive code support	X	X	X	X	X
AUTOMATIC and STATIC statements	X	X	X	X	X
STRUCTURE and RECORD declarations	X	X	X	X	X
INTEGER*1, *2, *4	X	X	X	X	X
LOGICAL*1, *2, *4	X	X	X	X	X
INTEGER*8 and LOGICAL*8	X	X	X	X	
REAL*4, *8	X	X	X	X	X
REAL*16[1]		X	X	X	X
COMPLEX*8, *16	X	X	X	X	X
COMPLEX*32[2]		X	X	X	

POINTER (CRAY-style)	X	X	X	X	X
INCLUDE statement	X	X	X	X	X
IMPLICIT NONE statement	X	X	X	X	X
Data initialization in type declarations	X	X	X	X	X
Automatic arrays	X	X	X	X	
VOLATILE statements	X	X	X	X	X
NAMELIST-directed I/O	X	X	X	X	X
31-character names including $ and _	X	X	X	X	X
Source listing with machine code	X	X	X	X	X
Debug statements in source	X	X	X	X	X
Bit constants to initialize data and use in arithmetic	X	X	X	X	X
DO WHILE and END DO statements	X	X	X	X	X
Built-in functions %LOC, %REF, %VAL	X	X	X	X	X
SELECT CASE construct	X	X	X	X	
EXIT and CYCLE statements	X	X	X	X	
Variable FORMAT expressions (VFEs)	X	X	X	X	X
! marks end-of-line comment	X	X	X	X	X
Optional run-time bounds checking for arrays and substrings	X	X	X	X	X

Binary (unformatted) I/O in IEEE big endian, IEEE little endian, VAX, IBM, and CRAY floating-point formats	X	X	X	X	X
Fortran 95/90 standards checking	X	X	X	X	
FORTRAN-77 standards checking					X
IEEE exception handling	X	X	X	X	
VAX floating data type in memory				X	X
IEEE floating data type in memory	X	X	X	X	
CDD/Repository DICTIONARY support					X
KEYED access and INDEXED files				X	X
Parallel decomposition	[4]	X[3,4]		[4]	X
OpenMP parallel directives		X			
Conditional compilation using IF...DEF constructs	X	X	X	X	
Vector code support					X
Direct inlining of Basic Linear Algebra Subroutines (BLAS)	[5]	[5]	[5]	[5]	X
DATE_AND_TIME returns 4-digit year	X	X	X	X	X
FORALL statement and construct	X	X	X	X	
Automatic deallocation of ALLOCATABLE arrays	X	X	X	X	
Dim argument to MAXLOC and MINLOC	X	X	X	X	

PURE user-defined subprograms	X	X	X	X	
ELEMENTAL user-defined subprograms	X	X	X	X	
Pointer initialization (initial value)	X	X	X	X	
The NULL intrinsic to nullify a pointer	X	X	X	X	
Derived-type structure initialization	X	X	X	X	
CPU_TIME intrinsic subroutine	X	X	X	X	
Kind argument to CEILING and FLOOR intrinsics	X	X	X	X	
Nested WHERE constructs, masked ELSEWHERE statement, and named WHERE constructs	X	X	X	X	
Comments allowed in namelist input	X	X	X	X	
Generic identifier in END INTERFACE statements	X	X	X	X	
Minimal FORMAT edit descriptor field width	X	X	X	X	
Detection of Obsolescent and/or Deleted features[6]	X	X	X	X	

Footnotes to preceding table:

1 For REAL*16 data, OpenVMS VAX systems use H_float format, and Alpha systems use IEEE style X_float format.

2 For COMPLEX*32 data, Alpha systems use IEEE style X_float format for both REAL*16 parts.

3 For parallel processing with Compaq Fortran for Compaq Tru64 UNIX Systems, you can use the OpenMP or Compaq Fortran directives on shared memory multiprocessor systems or MPI software for using High Performance Fortran (HPF) constructs across multiple systems.

4 For parallel processing, you can use the optional KAP performance preprocessor for a shared memory multiprocessor system.

5 BLAS and other routines are available with the Compaq Extended Mathematical Library (CXML) software provided with Compaq Visual Fortran and Compaq Fortran for Alpha systems (for download information, see http://www.compaq.com/math).

6 Compaq Fortran flags these deleted and obsolescent features, but fully supports them.

Common Language Extensions

To simplify porting applications between Compaq Fortran 77 Alpha systems and Compaq Fortran (including Compaq Visual Fortran), Compaq Visual Fortran supports the following Compaq Fortran 77 extensions that are not part of the Fortran 95/90 standards:

- Record structures (**STRUCTURE** and **RECORD** statements)
- I/O statements, including **PRINT**, **ACCEPT**, **TYPE**, **DELETE**, and **UNLOCK**
- I/O statement specifiers, such as the **INQUIRE** statement specifiers CARRIAGECONTROL, CONVERT, ORGANIZATION, and RECORDTYPE
- Multiple INTEGER and REAL kinds
- Size specifiers for data declaration statements, such as INTEGER*4, in addition to the **KIND** type parameter
- IEEE floating-point data types in memory
- The **POINTER** statement and its associated data type (integer pointers or CRAY pointers).
- The typeless **PARAMETER** statement
- The **VOLATILE** statement
- The **AUTOMATIC** and **STATIC** statements
- Built-in functions used in argument lists, such as **%REF**, **%VAL**, and **%LOC**
- Hollerith constants
- Variable-format expressions (VFEs)
- Certain intrinsic functions
- The tab source form (a variation of fixed-source form)
- I/O formatting descriptors
- USEROPEN routines for user-defined open routines
- Additional language features, including the **DEFINE FILE**, **ENCODE**, **DECODE**, and **VIRTUAL** statements

In addition to language extensions, Compaq Visual Fortran also supports the following Compaq Fortran 77 features:

- Compaq Fortran 77 compilation control statements and directives, including:
  - **INCLUDE** statement forms using /LIST and /NOLIST (requires compiling with the /vms compiler option)
  - OPTIONS statement to override or set compiler command-line options
  - General cDEC$ directives, including:
    - cDEC$ ALIAS
    - cDEC$ IDENT
    - cDEC$ OPTIONS
    - cDEC$ PSECT
    - cDEC$ TITLE
    - cDEC$ SUBTITLE
  - foriosdef.for symbolic parameter definitions for use with run-time (IOSTAT) error handling.

  Compaq Visual Fortran includes the following features and enhancements also found on other Compaq Fortran platforms:

  - Support for linking against static libraries
  - Support for linking against dynamically linked libraries (DLL)
  - Support for creating code to be put into a dynamically linked library (DLL)
  - Support for stack-based storage
  - Support for dynamic memory allocation
  - Support for reading and writing binary data files in nonnative formats, including IEEE (little-endian and big-endian), VAX, IBM System\360, and CRAY integer and floating point formats
  - User control over IEEE floating point exception handling, reporting, and resulting values
  - Control for memory boundary alignment of items in **COMMON** and fields in structures and warnings for misaligned data
  - Directives to control listing page titles and subtitles, object file identification field, **COMMON** and record field alignment, and some attributes of **COMMON** blocks
  - Ability to CALL an external function subprogram
  - 7200 character statement length
  - Free form unlimited line length
  - Composite data declarations using **STRUCTURE**, **END STRUCTURE**, and **RECORD** statements, and access to record components through field references
  - Explicit specification of storage allocation units for data types such as:
    - INTEGER*4
    - LOGICAL*4

        - REAL*4
        - REAL*8
        - COMPLEX*8
    - Support for 64-bit signed integers using INTEGER*8 and LOGICAL*8
    - Support for 128-bit floating-point data using REAL*16 and COMPLEX*32 (on Alpha platforms only)
    - A set of data types:
        - BYTE
        - LOGICAL*1, LOGICAL*2, LOGICAL*4, LOGICAL*8
        - INTEGER*1, INTEGER*2, INTEGER*4, INTEGER*8
        - REAL*4, REAL*8
        - COMPLEX*8, COMPLEX*16, DOUBLE COMPLEX
    - Compaq Fortran **POINTER** statement (CRAY style)
    - Data statement style initialization in type declaration statements
    - **AUTOMATIC** and **STATIC** statements
    - Bit constants to initialize LOGICAL, REAL, and INTEGER values and participate in arithmetic and logical expressions
    - Built-in functions **%LOC**, **%REF**, and **%VAL**
    - **VOLATILE** statement
    - Bit manipulation functions
    - Binary, hexadecimal, and octal constants and Z and O format edit descriptors applicable to all data types
    - I/O unit numbers that can be any nonnegative INTEGER*4 value
    - Variable amounts of data can be read from and written to "STREAM" files, which contain no record delimiters
    - **ENCODE** and **DECODE** statements
    - **ACCEPT**, **TYPE**, and **REWRITE** input/output statements
    - **DEFINE FILE**, **UNLOCK**, and **DELETE** statements
    - **USEROPEN** subroutine invocation at file **OPEN**
    - Support for reading nondelimited character strings as input for character **NAMELIST** items
    - Debug statements in source
    - Generation of a source listing file with optional machine code representation of the executable source
    - Variable format expressions in a **FORMAT** statement
    - Optional run-time bounds checking of array subscripts and character substrings
    - 31-character identifiers that can include dollar sign ($) and underscore (_)
    - Support for the supercomputer intrinsics **POPCNT**, **POPPAR**, **LEADZ**, and **TRAILZ**
    - Language elements that support the various extended range and extended precision floating point architectural features:
        - 32-bit IEEE S_floating data type, with an 8-bit exponent and 24-bit mantissa and a precision of typically 7 decimal digits
        - 64-bit IEEE T_floating data type, with an 11-bit exponent and 53-bit mantissa and a precision of typically 15 decimal digits

- Command line control for:
  - The size of default **INTEGER**, **REAL**, and **DOUBLE PRECISION** data items
  - The levels and types of optimization to be applied to the program
  - The directories to search for **INCLUDE** and module files
  - Inclusion or suppression of various compile-time warnings
  - Inclusion or suppression of run-time checking for various I/O and computational errors
  - Control over whether compilation terminates after a specific number of errors has been found
  - Choosing whether executing code will be thread-reentrant
  - Internal procedures can be passed as actual arguments to procedures
- Kind types for all of the hardware-supported data types:
  - For 1-, 2-, 4-, and 8-byte **LOGICAL** data: LOGICAL (KIND=1), LOGICAL (KIND=2), LOGICAL (KIND=4), LOGICAL (KIND=8)
  - For 1-, 2-, 4-, and 8-byte **INTEGER** data: INTEGER (KIND=1), INTEGER (KIND=2), INTEGER (KIND=4), INTEGER (KIND=8)
  - For 4- and 8-byte **REAL** data: REAL (KIND=4), REAL (KIND=8)
  - For single precision and double precision **COMPLEX** data: COMPLEX (KIND=4), COMPLEX (KIND=8)

Major Changes to the Fortran Language Standards

Major additions and improvements to the FORTRAN 77 standard introduced by the Fortran 90 standard include:

- Array operations and features
- Modules
- Free-form source
- Improved facilities for numeric computation
- Parameterized intrinsic data types
- User-defined (derived) data types and operators
- Generic user-defined procedures
- Interface blocks
- Pointers (Fortran 90 pointers)
- The concept of language evolution
- Additional features for source text
- Optional procedure arguments
- Additional input/output features
- Additional control constructs
- Additional intrinsic procedures
- Additional specification statements
- Additional way to specify attributes
- Scope and Association

In addition, the Fortran 90 standard includes the following industry-accepted extensions to the FORTRAN 77 standard:

- Support for recursive subprograms
- **IMPLICIT NONE** statements
- **INCLUDE** statement
- **NAMELIST**-directed I/O
- **DO WHILE** and **ENDDO** statements
- Use of exclamation point (!) for end of line comments
- Support for automatic arrays
- Support for the following **SELECT CASE** – **CASE** – **CASE DEFAULT** – **END SELECT** statements
- Support for the **EXIT** and **CYCLE** statements and for construct names on **DO** – **END DO** statements

Major changes and improvements to the Fortran 90 standard introduced by the Fortran 95 standard include:

- The **FORALL** statement and construct
- **PURE** user-defined procedures
- **ELEMENTAL** user-defined procedures
- **CPU_TIME** intrinsic subroutine
- **NULL** intrinsic function
- Derived-type structure default initialization
- Pointer initialization
- Automatic deallocation of allocatable arrays
- Enhanced intrinsic functions, including **CEILING**, **FLOOR**, **MAXLOC**, **MINLOC**, and **SIGN**
- Printing of -0.0
- Enhanced **WHERE** construct
- Generic identifier allowed in **END INTERFACE** statement
- Minimum-length formats
- Comments allowed in namelist input

For more information:

- See Fortran 95 Features
- See Fortran 90 Features

Platform Porting Notes

When porting code between platforms, be aware that:

- The use of the /stand option during compilation can help identify source code that uses language extensions during compilation. On U*X Alpha systems, specify the -std option. On OpenVMS systems, specify the /STANDARD qualifier. The online Visual Fortran Language Reference and the printed *Compaq Fortran Language Reference Manual* identify

language extensions with a green-blue color.
- The use of certain platform-specific procedures (such as library routines) provided by the operating system need to be located and likely changed. Whenever possible, use Fortran standard language calls (such as to intrinsic procedures) instead of platform-specific routines. For example, if you attempt to link source files and the linker returns unresolved references/symbols, be aware that the routine names may be platform-specific:
  - When porting code from a U*X system, identify code that uses system calls (section 2 in reference pages) and certain other library routines not found on Windows systems. Visual Fortran provides the portability library that includes many U*X Fortran library routines (section 3f in reference pages) found on U*X systems. The Compaq Extended Math Library (CXML) routines supported on Alpha systems are provided with Visual Fortran. For more details about the U*X Alpha programming environment, see the appropriate sections in the *Compaq Fortran User Manual for Tru64 UNIX and Linux Systems*.
  - When porting an application from an OpenVMS system, identify code that calls system services (SYS$ prefix) or RTL routines (such prefixes as LIB$, CVT$, DTK$, MATH$, OTS$, PPL$, SMG$, and STR$). The Compaq Extended Math Library (CXML) routines supported on Alpha systems are provided with Visual Fortran.

    Character arguments on OpenVMS systems may be passed by character descriptors not found on other platforms.

    For more details about the OpenVMS Alpha programming environment, see the appropriate sections in the *Compaq Fortran User Manual for OpenVMS Alpha Systems*.

  - When porting an application from Visual Fortran to an Alpha system, non-graphical applications are usually easier to port. The nature of Visual Fortran applications is usually defined by the chosen project type (such as Fortran Console applications). For example, applications that use many platform-specific graphical system calls are usually difficult to port to other platforms.

    Certain platform-specific Fortran routine names either have QQ appended at the end of the name or use the Win32 naming conventions (see Calling Win32 Routines). Certain groups of routines require different **USE** statements. You can use the HTML Help viewer's index and search facility to locate descriptions of Visual Fortran or Win32 routines.

    The online Visual Fortran Language Reference and the printed *Compaq Fortran Language Reference Manual* identify language elements that are supported only on certain Compaq Fortran platforms.

- Certain math library routines provided by Visual Fortran are available on other platforms:
  - The IMSL Math and Statistical routines provided with the Visual Fortran Professional or Enterprise Editions are also available for many other platforms (including Compaq Alpha systems) from Visual Numerics, Inc. (see http://www.vni.com).
  - The Compaq Extended Math Library (CXML) routines provided with all Visual Fortran Editions are also provided with Compaq Fortran on Alpha systems. CXML routines are available separately for Compaq Alpha systems (see http://www.compaq.com/math).

- Certain application code may make assumptions about the numeric data format stored in memory. Compaq Fortran and Visual Fortran store numeric data in memory in little endian format, while some vendors use big endian formats. Also, certain platforms support different sized intrinsic data types.

- Certain application code may make assumptions about the size of Compaq Fortran (integer) pointers. For example, on an U*X Alpha system, the size of an address is 64 bits. On Windows ia32 systems, the size of an address is 32 bits. On Windows ia64 systems, the size of an address is 64 bits. Whenever possible, use the standard-conforming Fortran 95/90 pointers instead of Compaq Fortran pointers.

- Certain platforms use different name decoration conventions, such as appending an extra character to symbol names. Use of the appropriate cDEC$ **ATTRIBUTES** directives can help overcome this problem (see Adjusting Naming Conventions in Mixed-Language Programming.

- Porting data files used by an application from one platform to another. Consider using `ftp` for binary file transfers to preserve file integrity. Visual Fortran provides the capability to convert unformatted data files in various formats, including big endian formats (see Supported Native and Nonnative Numeric Formats). It is also important to select compatible cross-platform record types.

  When porting data files between Windows systems running Compaq Visual Fortran and Alpha systems running Compaq Fortran:

  1. For formatted data files, use the stream_LF record type.
  2. For unformatted files, use the segmented record type. Unformatted files ported from Compaq Fortran OpenVMS systems may use a non-IEEE floating-point format. For example, Compaq Fortran for OpenVMS Alpha systems allows the user to specify either IEEE and or VAX formats during compilation (see Supported Native and Nonnative Numeric Formats).

One suggested way to port an unformatted file from an OpenVMS system follows:

1. From the OpenVMS system type the following DCL command for the file (*file.dat*):

   ```
   $ SET FILE /ATTR=(RFM=FIX,LRL=512) file.dat
   ```

   For information on porting unformatted data files, see the Compaq Fortran Knowledge Base at http://www.compaq.com/fortran/kb. Examples of record type conversion programs are available at http://www.compaq.com/fortran/examples.
2. Copy the file to your Windows system as a binary (image) copy (perhaps using ftp).
3. Modify the source code to **OPEN** the file with `RECORDTYPE='SEGMEMTED'`.
4. If the file uses a VAX floating-point format, specify the appropriate VAX format by using one of the methods described in Converting Unformatted Numeric Data.

- Be aware that Fortran-only programs are usually easier to port than mixed-language programs.

For more information:

- See the Compatibility appendix and other sections of the appropriate Compaq Fortran for Alpha systems user manual (*Compaq Fortran User Manual for Tru64 UNIX and Linux Systems* or the *Compaq Fortran User Manual for OpenVMS Alpha Systems*).

Compatibility with Microsoft Fortran PowerStation

Visual Fortran recognizes the FL32 command and many of the command-line options provided by the Microsoft Fortran PowerStation Version 4 compiler. For more information on command-line compatibility, see Microsoft Fortran PowerStation Command-Line Compatibility.

Visual Fortran supports many of the language extensions to the Fortran 90 Standard supported by Microsoft Fortran PowerStation Version 4. Certain extensions may require the /fpscomp compiler option (also see Categories of Compiler Options). These extensions to the Fortran 90 Standard (and Fortran 95 Standard) include the following:

- .f, .for, .f90 source file types
- # Constants – constants using other than base 10

- C strings – NULL terminated strings
- MBCS characters in comments
- MBCS characters in string literals
- Conditional compilation and metacommand (directive) expressions ($DEFINE, $UNDEFINE, $IF, $ELSEIF, $ELSE, $ENDIF)
- !MS$ directive form (see Compiler Directives: table)
- $FREEFORM, $NOFREEFORM, $FIXEDFORM – source file format
- $OBJCOMMENT – place library-search record in object file
- $INTEGER, $REAL – selects size
- $FIXEDFORMLINESIZE – line length for fixed-form source
- $STRICT, $NOSTRICT – F90 conformance
- $ATTRIBUTES, identifier attributes (C, STDCALL, REFERENCE, VALUE, DLLIMPORT, DLLEXPORT, EXTERN, ALIAS, VARYING)
- $PACK – structure packing
- Kind numbers match bytes – kind parameters
- AUTOMATIC attribute – automatic storage class
- Integer Pointers (Cray pointers)
- VAX Structures equivalent to Fortran 90 sequence derived types
- Mixing logicals and numerics – logicals used with arithmetic operators and variables
- Argument matching for procedure calls
- Mixing integer kinds to intrinsics
- Byte data type equivalent to INTEGER*1
- $ATTRIBUTES [ ] Form
- $ATTRIBUTES ALIAS – external name for a subprogram
- $ATTRIBUTES C, STDCALL – calling and naming conventions
- $ATTRIBUTES VALUE, REFERENCE – argument passing calling conventions
- $ATTRIBUTES DLLIMPORT, DLLEXPORT – import from/export to DLL
- Character and non-character equivalence
- Double complex data type
- .XOR. – exclusive disjunction
- Integer arguments in logical expressions
- OPEN statement specifier options:
    - BLOCKSIZE= internal buffer size used in I/O
    - CARRIAGECONTROL= controls the output of formatted files
    - MODE= controls access to files on networked systems
    - TITLE= affects and IOFOCUS= controls QuickWin child windows
    - SHARE= controls simultaneous access to files on networked systems
- Default carriage control
- Implicit open – prompt user for filenames
- Special device names for FILE in **OPEN** statements
- FORM=BINARY in **INQUIRE/OPEN** statements
- Unformatted sequential file form
- Q edit descriptor – number of characters remaining in the input record
- \ descriptor– prevents writing an end-of-record mark
- $ edit descriptor – suppresses the carriage return at the end of a record
- X edit descriptor default – 1

- Ew.dDe and Gw.dDe edit descriptors – similar to Ew.dEe and Gw.dEe
- Variable Format Expressions (VFEs) – integer expression in **FORMAT** statement
- Expanded missing ,'s in **FORMAT** statements – optional commas
- Expanded namelist start/end sequences
- All path names, including driver, compiler, and **INCLUDE** statements are MBCS enabled [not on Windows 95]
- UNC pathnames
- Long filenames
- 7200 character statement length
- Free form infinite line length
- $DECLARE and $NODECLARE like **IMPLICIT NONE**
- Logical truth: 0 = false, non-zero = true
- $ATTRIBUTES EXTERN – variable allocated in another source file
- $ATTRIBUTES VARYING – variable number of arguments
- Alternate **PARAMETER** syntax – no parenthesis
- $ in identifiers
- INTERFACE TO – subroutine/function prototype, however global scoping is not supported
- Argument passing modifiers – **%VAL**, **%REF**
- Argument passing modifiers – **%DESCR** (treated as **%REF**)
- CRAY pointer support for procedure names (for COM/OLE support)
- $ATTRIBUTES ALLOCATABLE – allocatable array
- Mixing subroutines/functions in generic interfaces
- $MESSAGE – output message during compilation
- Listing directives – $TITLE, $SUBTITLE
- STATIC attribute – static storage class
- **EOF** checks for end of file
- **LOC** equivalent to **%LOC**
- **HFIX**converts to short integer
- **INT1** converts to one byte integer by truncating
- **INT2** converts to two byte integer by truncating
- **INT4** converts to four byte integer by truncating
- **JFIX** same as **INT4**
- **MALLOC** allocates a memory block of the specified number of bytes and returns an integer pointer to the block
- **FREE** frees the memory block specified by the integer pointer
- **COTAN** returns cotangent
- **DCOTAN** returns double precision cotangent
- **IMAG** returns the imaginary part of complex number
- **IBCHNG** reverses value of bit
- **ISHA** shifts arithmetically left or right
- **ISHC** performs a circular shift
- **ISHL** shifts logically left or right

The following known source incompatibilities exist between Microsoft Fortran PowerStation Version 4 and Visual Fortran:

- **DATA** statement style initialization in attribute style declaration (not supported)
- Debug lines (other than D) (not supported)
- $OPTIMIZE – change optimization options (not supported)
- Listing directives – $PAGE, $PAGESIZE, $LINESIZE, $[NO]LIST, $INCLUDE (not supported)
- $DEBUG, $NODEBUG – additional run-time checking (not supported)
- $LINE = C's #line (not supported)
- Internal files can be any type (not supported)
- Negative I/O unit numbers (not supported)
- Interface blocks using INTERFACE [TO] at the beginning of a source file to provide global scoping for subsequent program units (not supported) Visual Fortran uses standard Fortran 90 semantic rules about interface block placement and use.
- Tab continuation lines that start with characters other than digits 1 through 9 (not supported)

Using Visual Fortran Tools

This section summarizes the available Visual Fortran tools and describes how to use tools from the Console command line:

Overview of Visual Fortran Tools

The following tools are available in Visual Fortran:

Tool	Description
Integrated Tools in the Visual Development Environment	
Editor	Provides general editing functionality. It recognizes Fortran syntax and can be customized. For more information, see "Text Editor" in the *Visual C++ User's Guide*.
Debugger	Provides general debug functionality. For more information, see Debugging Fortran Programs
Format Editor (FRMTEDIT)	Presents format code with resulting data layout. For more information, see Editing Format Descriptors with the Format Editor.
Module Wizard (MODWIZ)	Simplifies the use of Component Object Model (COM) and Automation (OLE Automation) objects with Fortran. For more information, see Using COM and Automation Objects.

Profiler (PROFILE, PLAITS, and PREP)	Determines unexecuted code or indicates where an application is spending most of its time. For more information, see Profiling Code from the Command Line.
Resource Editors	Develops user-interface components for projects; for example, to build a dialog box. For more information, see Using Dialogs and see "Resource Editors" in the *Visual C++ User's Guide*.
Source Browser (BSCMAKE)	Creates an information file with details about the symbols in your program. The browse window displays this information and lets you move among instances of the symbols in your source code. For more information, see Source Browser Information for a Configuration.
Additional Tools[1]	
Linker (LINK)	Lets you link object files and libraries, creating 32-bit executable images or DLLs. For more information, see Using the Compiler and Linker from the Command Line and Compiler and Linker Options.
Librarian (LIB)	Lets you manage object libraries, create import libraries to reference exported symbol definitions used when you build Dynamic Link Libraries (DLLs), and extract library members. For more information, see Managing Libraries with LIB.
Microsoft Binary File Dumper (DUMPBIN)	Displays various information from .obj, .exe, and .libs files. For more information, see Examining Files with DUMPBIN.
Microsoft Binary File Editor (EDITBIN)	Lets you modify execution characteristics of a program. For more information, see Editing Files with EDITBIN.
BitViewer (BITVIEW)	Lets you view the binary representation of real numbers in single and double format. For more information, see Viewing Floating-Point Representations with BitViewer.
CVTRES	Lets you convert binary resource files (.res) to linkable object (.obj) files. For more information, see CVTRES below.
DDESpy (DDESPY)	Lets you monitor Dynamic Data Exchange (DDE) activity between processes. For more information, see "Windows Utilities" in the *Visual C++ User's Guide*.

FPP	Lets you preprocess Fortran files; similar to the C preprocessor (CPP). For more information, see /fpp.
FPR	Lets you transform files formatted according to Fortran's carriage control conventions into files formatted according to line printer conventions. For more information, see Fortran Tools: FSPLIT and FPR.
FSPLIT and FSPLIT90	Lets you split a multi-routine Fortran file into individual files. FSPLIT works on FORTRAN 77 files, while FSPLIT90 works on Fortran 90 files. For more information, see Fortran Tools: FSPLIT and FPR.
Microsoft Program Maintenance Utility (NMAKE)	Lets you build projects based on commands contained in a description (makefile) file. For more information, see Building Projects with NMAKE.
OLE Object Viewer (OLEVIEW)	Lets you browse, configure, test, and activate any COM class on your system; also called the OLEViewer. For more information, see OLE Object Viewer below.
PView (PVIEW)	Lets you examine and modify processes and threads running on your system. For more information, see "Windows Utilities" in the *Visual C++ User's Guide*.
Resource Compiler (RC)	Compiles various resources so they can be included in an image. For more information, see Resource Compiler Command Line.
Running Object Table Viewer (IROTVIEW)	Lets you view the contents of the OLE Running Object Table. For more information, see Running Object Table Viewer below.
Spy++ (SPYXX)	Lets you monitor windows messages. For more information, see "Windows Utilities" in the *Visual C++ User's Guide*.
WinDiff (WINDIFF)	Lets you graphically compare the contents of two files or two directories. For more information, see "Windows Utilities" in the *Visual C++ User's Guide*.
ZoomIn (ZOOMIN)	Lets you capture and enlarge an area of the Windows desktop. For more information, see "Windows Utilities" in the *Visual C++ User's Guide*.

---

[1] To access these tools from a command window, the Visual Fortran environment must be initialized, as described in "Using the Command-Line

Interface" in *Compaq Visual Fortran Installing and Getting Started*.

Miscellaneous Tool Information

This section briefly describes tools that are not described in detail elsewhere in the documentation.

CVTRES

Binary resource files (.res) cannot be linked. CVTRES lets you convert a binary resource file into a linkable object file (.obj). For example:

```
cvtres /out:test.obj test.res
```

Running Object Table Viewer (IROTVIEW)

The Running Object Table Viewer lets you view the contents of the OLE Running Object Table (ROT). This table contains information about ActiveX and OLE objects currently existing in memory.

OLE Object Viewer (OLEVIEW)

The OLE/COM Object Viewer (OLEViewer) lets you do the following:

- Browse, in a structured way, all of the Component Object Model (COM) classes installed on your machine.
- See the registry entries for each class in an easy-to-read format.
- Configure any COM class (including Java™-based classes) on your system. This includes Distributed COM activation and security settings.
- Configure system-wide COM settings, including enabling or disabling Distributed COM.
- Test any COM class by double-clicking its name. The list of interfaces that class supports will be displayed. Double-clicking an interface entry allows you to invoke a viewer that will "exercise" that interface.
- Activate COM classes locally or remotely. Use this to test Distributed COM setups.
- View type library contents. Use this to figure out what methods, properties, and events an ActiveX Control supports.
- Copy a properly formatted OBJECT tag to the clipboard for inserting into an HTML document.

The OLEViewer supports plug-in interface viewers. The code for the interface viewers is included in OLEView (in IVIEWERS.DLL).

Using Tools from the Command Line

Although Visual Fortran comes with an integrated Windows-based development environment called Microsoft visual development environment, you can still use many software tools directly from the command line.

If you prefer to use a text-based environment, you can build your programs or libraries in the console (such as the Fortran Command Prompt in the Compaq Visual Fortran program folder), a command-line operating environment similar to MS-DOS provided by your Windows operating system. However, to get the benefit of components that you cannot use from the command line, you may want to do some of your work from the console, and some of it in the visual development environment.

When you run an application for Windows (such as the Format Statement Editor) from the command line, Windows recognizes that the program does not execute within the command window and acts accordingly.

You can tell Windows to run a program with its own resources by using the START command. For example, to run the Library Manager as a separate task, the command is:

```
START LIB.EXE
```

Visual Fortran contains an extensive electronic reference you view with the HTML Help Viewer. This includes the Visual Fortran online documentation and a search engine.

To access HTML Help Viewer books from outside the visual development environment, click on the Online Documentation item in the Visual Fortran program folder. If you want to use Visual Fortran from the command line, you can still use the visual development environment to display HTML Help Viewer, and task switch between it and the console.

The following related sections discuss command-line tools:

- Setting Up the Command Console
- Fortran Compiler and Linker
- MS-DOS Editor
- Building Projects with NMAKE
- Resource Compiler Options
- Managing Libraries with LIB
- Editing Files with EDITBIN
- Examining Files with DUMPBIN
- Editing Format Descriptors with the Format Editor
- Profiling Code from the Command Line
- Fortran Tools: FSPLIT and FPR

For a summary of all Visual Fortran tools, see Overview of Visual Fortran Tools.

Setting Up the Command Console

Visual Fortran provides a command window with the appropriate environment variables already set for Visual Fortran program development. To start the Visual Fortran command window:

1. Click Start
2. Open the Programs submenu
3. Open the Compaq Visual Fortran program folder
4. Click Fortran Command Prompt

The console window provides a similar working environment to that provided by running a version of MS-DOS® instead of the Windows operating system. You can use any command recognized by MS-DOS in the Windows NT 4 or Windows 2000 console, plus some additional commands.

Because the command console runs within the context of Windows, you get the additional benefit that you can easily switch between the command console and other applications for Windows. If you want, you can even have multiple instances of the command console open at once.

When you are finished working in a command console window, use the EXIT command to close the window and end the session.

To start the command console window provided by your operating system, open the Start menu and select MS-DOS Prompt from the Programs submenu.

For more information:

- Configuring the Command Console Window
- Setting Search Paths in the Console

Configuring the Command Console Window

When you start a session in the command console, a window containing the command interpreter opens. The resources available, as well as the size and behavior of the window, are initially set by the operating system, but you can change these properties, including:

- Whether the command console takes over the entire screen or is presented in a window
- The typeface and type size used to display text in the command console
- The size of the command console text buffer and the position of the command console window if it is presented in a window
- The colors used to display text in the command console

- The size of the command history buffer used to store commands that scroll out of view
- The amount of each type of memory that is available to programs running in the command console
- Special configuration files to be run when the console session begins

The controls that you use to make these adjustments depend upon which version of Windows you are using. The operating system provides a way to specify configuration settings for all subsequent sessions with the command console.

On Windows NT 4 and Windows 2000 systems, use the Control Panel.

On Windows 98, Windows Me, and Windows 95 systems, use the Properties dialog box to set all of the initial and operating conditions for the command console. With the command window open, do the following:

1. Click the right mouse button at the top of the window. A pop-up menu appears.
2. Click Properties.
3. From the Properties dialog, set up the console display as you like.

Setting Search Paths in the Console

When the command console session begins, the search paths for libraries, module files, and so forth are those set for your user account on the PC. On Windows 98, Windows Me, and Windows 95 systems, these paths are initially specified in the AUTOEXEC.BAT file that is read when the computer is booted.

By default, Windows NT 4 and Windows 2000 systems use a file called AUTOEXEC.NT to perform initialization of console sessions, but you can specify your own initialization file for the command console with the PIF Editor. (See your operating system manual for more details about the PIF Editor.)

You can use the SET command to change these search paths manually within the console session, but your changes will only be in effect during that session. If you need to specify certain path changes each time you begin a console session, you can put the SET commands into a batch file and run it when you begin a session. The Setup program provides a batch file called DFVARS.BAT for this purpose. You can add your SET commands to this file and run it at the start of each session.

You can run DFVARS.BAT:

- Each time you begin a session on Windows 98 or Windows 95 systems, by specifying it in the Program tab of the Properties dialog box for the console icon.

- On Windows NT 4 and Windows 2000 systems, you can specify it as the initialization file with the PIF Editor.

The instructions specify the PATH, INCLUDE, and LIB environment variables. For example, the lines in the batch file that sets the INCLUDE environment variable include:

```
set LIB=%DFcdrom%\DF98\LIB;%DFcdrom%\VC98\LIB;%LIB%
```

The batch file inserts the directories used by Visual Fortran at the beginning of the existing paths. Because these directories appear first, they are searched before any directories in the path lists provided by Windows. This is especially important if the existing path includes directories with files having the same names as those needed by Visual Fortran.

As described in "Using the Command-Line Interface" in *Compaq Visual Fortran Installing and Getting Started*, the Fortran Command Prompt window sets these variables for you automatically. To activate this command window, select the Fortran Command Prompt icon in the Compaq Visual Fortran program folder.

Fortran Compiler and Linker

The DF (or FL32) command is the driver for running the compiler and linker. You can either compile and link your projects in one step with DF, or compile them with DF and then link them with LINK. You can also use LINK to build libraries of object modules. Each of these commands provides syntax instructions at the command line if you request it with the /? or /help option. For more information about the DF and LINK commands, see:

- Using the Compiler and Linker from the Command Line
- Compiler and Linker Options

MS-DOS Editor

You can use the MS-DOS Editor (EDIT.EXE) or any text editor to create your source programs, but you will not be able to perform the specialized functions built into the visual development environment such as multi-file searches, and your source code will not be displayed with syntax coloring.

You invoke the MS-DOS Editor by typing EDIT followed by the name of the file you want to edit. For example:

```
EDIT test.f90
```

Building Projects with NMAKE

Some projects require an extensive set of build instructions to ensure that each component is built with the appropriate options. With the Microsoft visual development environment, you can specify build instructions by source file, and you can have separate sets of instructions for the debug and release builds of a project. In the visual development environment, you select these options in a set of dialog boxes. For information on creating (exporting) a makefile from the visual development environment, see The Project Makefile.

When you build projects from the command line, you can put your build instructions into a special build file, and run the build process with NMAKE, the Microsoft Program Maintenance Utility. Other command-line building methods include using indirect command files (see DF Indirect Command File Use) and .BAT files.

The Microsoft Program Maintenance Utility (NMAKE.EXE) is a 32-bit tool that builds projects based on commands contained in a description file. This section discusses the following:

- Running NMAKE
- Contents of a Makefile
- Description Blocks
- Commands in a Makefile
- Inline Files in a Makefile
- Macros and NMAKE
- NMAKE Inference Rules
- Dot Directives
- Makefile Preprocessing

Running NMAKE

The syntax for NMAKE is:

NMAKE [*option*...] [*macros*...] [*targets*...] [@*commandfile*...]

NMAKE builds only specified *targets* or, if none is specified, the first target in the makefile is used. The first makefile target can be a pseudotarget (a label used in place of a filename in a dependency line) that builds other targets. NMAKE uses makefiles specified with the /F option. If /F is not specified, it uses the MAKEFILE file in the current directory. If no makefile is specified, it uses inference rules to build command-line *targets*.

The *commandfile* text file contains command-line input. Other input can precede or follow @*commandfile*. A path is permitted. In *commandfile*, line breaks are treated as spaces. Enclose macro definitions in quotation marks if they contain spaces.

For more information:

- On targets, see Description Blocks
- On macros, see Macros and NMAKE
- On options, see NMAKE Options

NMAKE Options

NMAKE options are described in the following sections. Options are preceded by either a slash (/) or a dash (-) and are not case sensitive. Use !CMDSWITCHES (described in Makefile Preprocessing Directives) to change option settings in a makefile or in TOOLS.INI.

This section describes the following topics:

- NMAKE Option Descriptions
- TOOLS.INI and NMAKE
- Exit Codes from NMAKE

NMAKE Option Descriptions

Option	Description
/A	Forces build of all evaluated targets, even if not out-of-date with respect to dependents. Does not force build of unrelated targets.
/B	Forces build even if timestamps are equal. Recommended for very fast systems (resolution of two seconds or less).
/C	Suppresses default output, including nonfatal NMAKE errors or warnings, timestamps, and NMAKE copyright message. Suppresses warnings issued by the /K option.
/D	Displays timestamps of each evaluated target and dependent and a message when a target does not exist. Useful with the /P option for debugging a makefile. Use !CMDSWITCHES (described in Makefile Preprocessing Directives) to set or clear the /D option for part of a makefile.
/E	Causes environment variables to override makefile macro definitions.

/F *filename*	The option /F *filename* specifies *filename* as a makefile. Spaces or tabs can precede *filename*. Specify the /F option once for each makefile. To supply a makefile from standard input, specify a dash (-) for *filename*. End keyboard input with either F6 or Ctrl+Z.
/HELP, /?	The option /HELP or /? displays a brief summary of NMAKE command-line syntax.
/I	Ignores exit codes from all commands. To set or clear the /I option for part of a makefile, use !CMDSWITCHES (described in Makefile Preprocessing Directives). To ignore exit codes for part of a makefile, use a dash (-) command modifier or .IGNORE. Overrides the /K option if both are specified.
/K	Continues building unrelated dependencies if a command returns an error; also issues a warning and returns an exit code of 1. By default, NMAKE halts if any command returns a nonzero exit code. Warnings from the /K option are suppressed by the /C option; the /I option overrides the /K option if both are specified.
/N	Displays but does not execute commands; preprocessing commands are executed. Does not display commands in recursive NMAKE calls. Useful for debugging makefiles and checking timestamps. To set or clear the /N option for part of a makefile, use !CMDSWITCHES (described in Makefile Preprocessing Directives).
/NOLOGO	Suppresses the NMAKE copyright message.
/P	Displays information (macro definitions, inference rules, targets, .SUFFIXES list) to standard output, then runs the build. If no makefile or command-line target exists, it displays information only. Use with the /D option to debug a makefile.
/Q	Checks timestamps of targets; does not run the build. Returns a zero exit code if all are up-to-date and a nonzero exit code if any target is not. Preprocessing commands are executed. Useful when running NMAKE from a batch file.
/R	Clears the .SUFFIXES list and ignores inference rules and macros that are defined in the TOOLS.INI file or that are predefined.
/S	Suppresses display of executed commands. To suppress display in part of a makefile, use the @ command modifier or .SILENT. To set or clear the /S option for part of a makefile, use !CMDSWITCHES (described in Makefile Preprocessing Directives).

/T	Updates timestamps of command-line targets (or first makefile target) and executes preprocessing commands but does not run the build.
/X *filename*	The option /X *filename* sends NMAKE error output to *filename* instead of standard error. Spaces or tabs can precede *filename*. To send error output to standard output, specify a dash (-) for *filename*. Does not affect output from commands to standard error.
/Y	Disables batch-mode inference rules. When this option is selected, all batch-mode inference rules are treated as regular inference rules.

TOOLS.INI and NMAKE

NMAKE reads TOOLS.INI before it reads makefiles, unless the /R option is used. It looks for TOOLS.INI first in the current directory and then in the directory specified by the INIT environment variable. The section for NMAKE settings in the initialization file begins with [NMAKE] and can contain any makefile information. Specify a comment on a separate line beginning with a semicolon (;) or a number sign (#).

Exit Codes from NMAKE

By default, NMAKE halts if any command returns a nonzero exit code. The /I option causes NMAKE to ignore exit codes. Warnings from the /K option are suppressed by the /C option; the /I option overrides the /K option if both are specified. The following table lists the exit codes.

Code	Meaning
0	No error (possibly a warning)
1	Incomplete build (issued only when the /K option is used)
2	Program error, possibly due to one of the following: • A syntax error in the makefile • An error or exit code from a command • An interruption by the user
4	System error – out of memory
255	Target is not up-to-date (issued only when the /Q option is used)

Contents of a Makefile

A makefile contains:

- Description blocks
- Commands
- Macros
- Inference Rules
- Dot Directives
- Preprocessing Directives

Other features of a makefile include wildcards, long filenames, comments, and special characters.

Wildcards and NMAKE

NMAKE expands filename wildcards (* and ?) in dependency lines. A wildcard specified in a command is passed to the command; NMAKE does not expand it.

Long Filenames in a Makefile

Enclose long filenames in double quotation marks, as follows:

```
  all : "VeryLongFileName.exe"
```

Comments in a Makefile

Precede a comment with a number sign (#). NMAKE ignores text from the number sign to the next newline character. The following are examples of comments:

```
# Comment on line by itself
OPTIONS = /MAP # Comment on macro definition line

all.exe : one.obj two.obj # Comment on dependency line
    link one.obj two.obj
# Comment in commands block
#   copy *.obj \objects # Command turned into comment
    copy one.exe \release

.obj.exe: # Comment on inference rule line
    link $<

 my.exe : my.obj ; link my.obj # Error: cannot comment this
  # Error: # must be the first character
.obj.exe: ; link $< # Error: cannot comment this
```

To specify a literal number sign, precede it with a caret (^), as follows:

```
DEF = ^#define #Macro representing a Fortran compiler directive
```

Special Characters in a Makefile

To use an NMAKE special character as a literal character, place a caret (^) in front of it. NMAKE ignores carets that precede other characters. The special characters are:

: ; # ( ) $ ^ \ { } ! @ -

A caret within a quoted string is treated as a literal caret character. A caret at the end of a line inserts a literal newline character in a string or macro.

In macros, a backslash followed by a newline character is replaced by a space.

In commands, a percent symbol (%) is a file specifier. To represent a percent symbol (%) literally in a command, specify a double percent sign (%%) in place of a single one. In other situations, NMAKE interprets a single % literally, but it always interprets a double %% as a single %. Therefore, to represent a literal %%, specify either three percent signs, %%%, or four percent signs, %%%%.

To use the dollar sign ($) as a literal character in a command, specify two dollar signs ($$); this method can also be used in other situations where ^$ also works.

Description Blocks

A description block is a dependency line optionally followed by a commands block:

```
targets... : dependents...
       commands...
```

A dependency line specifies one or more targets and zero or more dependents. A target must be at the start of the line. Separate targets from dependents by a colon (:); spaces or tabs are allowed. To split the line, use a backslash (\ ) after a target or dependent. If a target does not exist, has an earlier timestamp than a dependent, or is a pseudotarget, NMAKE executes the commands. If a dependent is a target elsewhere and does not exist or is out-of-date with respect to its own dependents, NMAKE updates the dependent before updating the current dependency.

For more information:

- Targets
- Pseudotargets
- Multiple Targets
- Cumulative Dependencies

- Targets in Multiple Description Blocks
- Dependents

Targets

In a dependency line, specify one or more targets, using any valid filename or pseudotarget. Separate multiple targets with one or more spaces or tabs. Targets are not case sensitive. Paths are permitted with filenames. A target cannot exceed 256 characters. If the target preceding the colon is a single character, use a separating space; otherwise, NMAKE interprets the letter-colon combination as a drive specifier.

Pseudotargets

A pseudotarget is a label used in place of a filename in a dependency line. It is interpreted as a file that does not exist and so is out-of-date. NMAKE assumes a pseudotarget's timestamp is the most recent of all its dependents; if it has no dependents, the current time is assumed. If a pseudotarget is used as a target, its commands are always executed.

A pseudotarget used as a dependent must also appear as a target in another dependency; however, that dependency does not need to have a commands block.

Pseudotarget names follow the filename syntax rules for targets. However, if the name does not have an extension (that is, does not contain a period), it can exceed the 8-character limit for filenames and can be up to 256 characters long.

Multiple Targets

NMAKE evaluates multiple targets in a single dependency as if each were specified in a separate description block as follows:

This...	...is evaluated as this

`bounce.exe leap.exe : jump.obj`
`   echo Building...`
	`bounce.exe : jump.obj`
	`   echo Building...`
	`leap.exe : jump.obj`
	`   echo Building...`

Cumulative Dependencies

Dependencies are cumulative in a description block if a target is repeated as follows:

This...	...is evaluated as this

`bounce.exe : jump.obj`
`bounce.exe : up.obj`
`   echo Building`
`bounce.exe...`
	`bounce.exe : jump.obj`
	`up.obj`
	`   echo Building`
	`bounce.exe...`

Multiple targets in multiple dependency lines in a single description block are evaluated as if each were specified in a separate description block, but targets that are not in the last dependency line do not use the commands block as follows:

This...	...is evaluated as this

`bounce.exe leap.exe :`
`jump.obj`
`bounce.exe climb.exe :`
`up.obj`
`   echo Building...`
	`bounce.exe : jump.obj`
	`up.obj`
	`   echo Building`
	`bounce.exe...`
	`climb.exe : up.obj`
	`   echo Building`
	`climb.exe...`
	`leap.exe : jump.obj`
	`# invokes an inference rule`

Targets in Multiple Description Blocks

To update a target in more than one description block using different commands, specify two consecutive colons (::) between targets and dependents. For example:

```
target.lib :: one.f90 two.f90 three.f90
    df one.f90 two.f90 three.f90
    lib target one.obj two.obj three.obj
target.lib :: four.c five.c
    df /c four.for five.for
    lib target four.obj five.obj
```

Dependency Side Effects

If a target is specified with a colon (:) in two dependency lines in different locations, and if commands appear after only one of the lines, NMAKE interprets the dependencies as if adjacent or combined. It does not invoke an inference rule for the dependency that has no commands, but instead assumes that the dependencies belong to one description block and executes the commands specified with the other dependency as follows:

This...	...is evaluated as this

`bounce.exe : jump.obj`
`   echo Building bounce.exe...`
`bounce.exe : up.obj`
	`bounce.exe : jump.obj up.obj`
	`   echo Building bounce.exe...`

This effect does not occur if :: is used as follows:

This...	...is evaluated as this

`bounce.exe :: jump.obj`
`   echo Building bounce.exe...`
 	
`bounce.exe :: up.obj`
	`bounce.exe : jump.obj`
	`   echo Building bounce.exe...`
	
	`bounce.exe : up.obj`
	`# invokes an inference rule`

Dependents

In a dependency line, specify zero or more dependents after the colon (:) or double colon (::) using any valid filename or pseudotarget. Separate multiple dependents with one or more spaces or tabs. Dependents are not case sensitive. Paths are permitted with filenames.

Inferred Dependents

An inferred dependent is derived from an inference rule and is evaluated before explicit dependents. If an inferred dependent is out-of-date with respect to its target, NMAKE invokes the commands block for the dependency. If an inferred dependent does not exist or is out-of-date with respect to its own dependents, NMAKE first updates the inferred dependent. For more information, see NMAKE Inference Rules.

Search Paths for Dependents

Each dependent has an optional search path, specified as follows:

{*directory*[;*directory...*]}*dependent*

NMAKE looks for a dependent first in the current directory, and then in directories in the order specified. A macro can specify part or all of a search path. Enclose directory names in braces ({ }); separate multiple directories with a semicolon (;). No spaces or tabs are allowed.

Commands in a Makefile

A description block or inference rule specifies a block of commands to run if the dependency is out-of-date. NMAKE displays each command before running it, unless the /S option, .SILENT, !CMDSWITCHES, or @ is used. NMAKE looks for a matching inference rule if a description block is not followed by a commands block.

A commands block contains one or more commands, each on its own line. No blank line can appear between the dependency or rule and the commands block. However, a line containing only spaces or tabs can appear; this line is interpreted as a null command and no error occurs. Blank lines are permitted between command lines.

A command line begins with one or more spaces or tabs. A backslash (\ ) followed by a newline character is interpreted as a space in the command; use a backslash at the end of a line to continue a command onto the next line. NMAKE interprets the backslash literally if any other character, including a space or tab, follows the backslash.

A command preceded by a semicolon (;) can appear on a dependency line or inference rule, whether or not a commands block follows:

```
project.obj : project.f90 ; df /c project.f90
```

For more information:

- Command Modifiers in NMAKE
- Filename-Parts Syntax in NMAKE

Command Modifiers in NMAKE

You can specify one or more command modifiers preceding a command, optionally separated by spaces or tabs. As with commands, modifiers must be indented. The following table lists the command modifiers:

Modifier	Action
@command	Prevents display of the command. Display by commands is not suppressed. By default, NMAKE echoes all executed commands. Use the /S option to suppress display for the entire makefile; use .SILENT to suppress display for part of the makefile.

-[*number*] *command*	Turns off error checking for *command*. By default, NMAKE halts when a command returns a nonzero exit code. If -*number* is used, NMAKE stops if the exit code exceeds *number*. Spaces or tabs cannot appear between the dash and *number*; at least one space or tab must appear between *number* and *command*. Use the /I option to turn off error checking for the entire makefile; use .IGNORE to turn off error checking for part of the makefile.
!*command*	Executes *command* for each dependent file if *command* uses $** (all dependent files in the dependency) or $? (all dependent files in the dependency with a later timestamp than the target).

Filename-Parts Syntax in NMAKE

Filename-parts syntax in commands represents components of the first dependent filename (which may be an implied dependent). Filename components are the file's drive, path, base name, and extension as specified, not as it exists on disk.

Use %s to represent the complete filename.

Use %|[*parts*]F to represent parts of the filename, where *parts* can be zero or more of the following letters, in any order:

Letter	**Description**
No letter	Complete name (same as %s)
d	Drive
p	Path
f	File base name
e	File extension

Inline Files in a Makefile

An inline file contains text you specify in the makefile. Its name can be used in commands as input (for example, a LINK command file), or it can pass commands to the operating system. The file is created on disk when a command that creates the file is run.

For more information:

Specifying an Inline File in Makefiles

The syntax for specifying an inline file in a command is:

<<[*filename*]

Specify two angle brackets (<<) in the command where the filename is to appear. The angle brackets cannot be a macro expansion. When the command is run, the angle brackets are replaced by *filename*, if specified, or by a unique NMAKE-generated name. If specified, *filename* must follow the angle brackets without a space or tab. A path is permitted. No extension is required or assumed.

If *filename* is specified, the file is created in the current or specified directory, overwriting any existing file by that name; otherwise, it is created in the TMP directory (or the current directory, if the TMP environment variable is not defined). If a previous *filename* is reused, NMAKE overwrites the previous file.

Creating Inline File Text in Makefiles

The syntax to create the content of an inline file is:

inlinetext
.
.
.
<<[KEEP | NOKEEP]

Specify *inlinetext* on the first line after the command. Mark the end with double brackets at the beginning of a separate line. The file contains all *inlinetext* before the delimiting brackets. The *inlinetext* can have macro expansions and substitutions, but not directives or makefile comments. Spaces, tabs, and newline characters are treated literally.

Inline files are temporary or permanent. A temporary file exists for the duration of the session and can be reused by other commands. Specify KEEP after the closing angle brackets to retain the file after the NMAKE session; an unnamed file is preserved on disk with the generated filename. Specify NOKEEP or nothing for a temporary file. KEEP and NOKEEP are not case sensitive.

Reusing Inline Files in Makefiles

To reuse an inline file, specify <<*filename* where the file is defined and first used, then reuse *filename* without the angle brackets (<<) later in the same or another command. The command to create the inline file must run before all commands that use the file.

Multiple Inline Files

A command can create more than one inline file. The syntax to do this is:

command << <<
inlinetext
<<[KEEP | NOKEEP]
inlinetext
<<[KEEP | NOKEEP]

For each file, specify one or more lines of inline text followed by a closing line containing the delimiter. Begin the second file's text on the line following the delimiting line for the first file.

Macros and NMAKE

Macros replace a particular string in the makefile with another string. Using macros, you can create a makefile that can build different projects, specify options for commands, or set environment variables. You can define your own macros or use NMAKE's predefined macros.

For more information:

- Defining an NMAKE Macro
- Special Characters in NMAKE Macros
- Null and Undefined NMAKE Macros
- Where to Define Macros
- Precedence in Macro Definitions
- Using an NMAKE Macro
- Macro Substitution
- Special NMAKE Macros

Defining an NMAKE Macro

Use the following syntax to define a macro:

macroname=string

The *macroname* is a combination of letters, digits, and underscores (_) up to 1024 characters, and is case sensitive. The *macroname* can contain an invoked macro. If *macroname* consists entirely of an invoked macro, the macro being invoked cannot be null or undefined.

The *string* can be any sequence of zero or more characters. A null string contains zero characters or only spaces or tabs. The *string* can contain a macro invocation.

Special Characters in NMAKE Macros

A number sign (#) after a definition specifies a comment. To specify a literal number sign in a macro, use a caret (^), as in ^#.

A dollar sign ($) specifies a macro invocation. To specify a literal $, use $$.

To extend a definition to a new line, end the line with a backslash (\). When the macro is invoked, the backslash plus newline character is replaced with a space. To specify a literal backslash at the end of the line, precede it with a caret (^), or follow it with a comment specifier (#).

To specify a literal newline character, end the line with a caret (^), as in:

```
CMDS = cls^
dir
```

Null and Undefined NMAKE Macros

Both null and undefined macros expand to null strings, but a macro defined as a null string is considered defined in preprocessing expressions. To define a macro as a null string, specify no characters except spaces or tabs after the equal sign (=) in a command line or command file, enclose the null string or definition in double quotation marks (" "). To undefine a macro, use !UNDEF.

Where to Define Macros

You can define macros in a makefile command line, or command file.

In a makefile, each macro definition must appear on a separate line and cannot start with a space or tab. Spaces or tabs around the equal sign (=) are ignored. All *string* characters are literal, including surrounding quotation marks and embedded spaces.

In a command line or command file, spaces and tabs delimit arguments and cannot surround the equal sign. If *string* has embedded spaces or tabs, enclose either the string itself or the entire macro in double quotation marks (" ").

Precedence in Macro Definitions

If a macro is multiply defined, NMAKE uses the highest-precedence definition. The following list shows the order of precedence, from highest to lowest:

1. A macro defined on the command line
2. A macro defined in a makefile or include file
3. An inherited environment-variable macro
4. A predefined macro, such as FOR and RC

Use the /E option to cause macros inherited from environment variables to override makefile macros with the same name. Use !UNDEF to override a command line.

Using an NMAKE Macro

To use a macro, enclose its name in parentheses preceded by a dollar sign ($):

$(*macroname*)

No spaces are allowed. The parentheses are optional if *macroname* is a single character. The definition string replaces $(*macroname*); an undefined macro is replaced by a null string.

Macro Substitution

To substitute text within a macro, use the following syntax:

$(*macroname*:*string1*=*string2*)

When *macroname* is invoked, each occurrence of *string1* in its definition string is replaced by *string2*. Macro substitution is case sensitive and is literal; *string1* and *string2* cannot invoke macros. Substitution does not modify the original definition. You can substitute text in any predefined macro except $$@.

No spaces or tabs precede the colon; any after the colon are interpreted as literal. If *string2* is null, all occurrences of *string1* are deleted from the macro's definition string.

Special NMAKE Macros

NMAKE provides several special macros to represent various filenames and commands. One use for some of these macros is in the predefined inference rules. Like all macros, the macros provided by NMAKE are case sensitive.

This section discusses:

- Filename Macros
- Recursion Macros
- Command Macros and Options Macros
- Environment-Variable Macros

Filename Macros

Filename macros are predefined as filenames specified in the dependency (not full filename specifications on disk). These macros do not need to be enclosed in parentheses when invoked; specify only a $ as shown.

Macro	Meaning
$@	Current target's full name (path, base name, extension), as currently specified.
$$@	Current target's full name (path, base name, extension), as currently specified. Valid only as a dependent in a dependency.
$*	Current target's path and base name minus file extension.
$**	All dependents of the current target.
$?	All dependents with a later timestamp than the current target.
$<	Dependent file with a later timestamp than the current target. Valid only in commands in inference rules.

To specify part of a predefined filename macro, append a macro modifier and enclose the modified macro in parentheses.

Modifier	Resulting Filename Part
D	Drive plus directory
B	Base name
F	Base name plus extension
R	Drive plus directory plus base name

Recursion Macros

Use recursion macros to call NMAKE recursively. Recursive sessions inherit command-line and environment-variable macros. They do not inherit makefile-defined inference rules or .SUFFIXES and .PRECIOUS specifications. To pass macros to a recursive NMAKE session, either set an environment variable with the SET command before the recursive call or define a macro in the command for the recursive call.

Macro	**Definition**
MAKE	Command used originally to invoke NMAKE.
MAKEDIR	Current directory when NMAKE was invoked.
MAKEFLAGS	Options currently in effect. Use as /$(MAKEFLAGS).

Command Macros, Options Macros

Command macros are predefined for Microsoft products. Options macros represent options to these products and are undefined by default. Both are used in predefined inference rules and can be used in description blocks or user-defined inference rules. Command macros can be redefined to represent part or all of a command line, including options. Options macros generate a null string if left undefined.

Product	**Command Macro**	**Defined as:**	**Options Macro**
Macro Assembler	AS	ml	AFLAGS
Basic Compiler	BC	bc	BFLAGS
C Compiler	CC	cl	CFLAGS
COBOL Compiler	COBOL	cobol	COBFLAGS
C++ Compiler	CPP	cl	CPPFLAGS
C++ Compiler	CXX	cl	CXXFLAGS
Compaq Visual Fortran Compiler	FOR	df	FFLAGS
Pascal Compiler	PASCAL	pl	PFLAGS
Resource Compiler	RC	rc	RFLAGS

Environment-Variable Macros

NMAKE inherits macro definitions for environment variables that exist before the start of the session. If a variable was set in the operating-system environment, it is available as an NMAKE macro. Use the /E option to cause macros inherited from environment variables to override any macros with the same name in the makefile.

Environment-variable macros can be redefined in the session, and this changes the corresponding environment variable. You can also change environment variables with the SET command. Using the SET command to change an environment variable in a session does not change the corresponding macro, however.

For example:

```
PATH=$(PATH);\nonesuch

all:
    echo %PATH%
```

In this example, changing PATH changes the corresponding environment variable PATH; it appends \nonesuch to your path.

If an environment variable is defined as a string that would be syntactically incorrect in a makefile, no macro is created and no warning is generated. If a variable's value contains a dollar sign ($), NMAKE interprets it as the beginning of a macro invocation. Using the macro can cause unexpected behavior.

NMAKE Inference Rules

Inference rules supply commands to update targets and to infer dependents for targets. Extensions in an inference rule match a single target and dependent that have the same base name. Inference rules are user-defined or predefined; predefined rules can be redefined.

If an out-of-date dependency has no commands and if .SUFFIXES contains the dependent's extension, NMAKE uses a rule whose extensions match the target and an existing file in the current or specified directory. If more than one rule matches existing files, the .SUFFIXES list determines which to use; list priority descends from left to right.

If a dependent file doesn't exist and is not listed as a target in another description block, an inference rule can create the missing dependent from another file with the same base name. If a description block's target has no dependents or commands, an inference rule can update the target. Inference rules can build a command-line target even if no description block exists.

NMAKE may invoke a rule for an inferred dependent even if an explicit dependent is specified.

For more information:

- Defining an Inference Rule in NMAKE
- Search Paths in Inference Rules
- Batch-Mode Rules
- Predefined Inference Rules
- Inferred Dependents and Rules
- Precedence in NMAKE Inference Rules

Defining an Inference Rule in NMAKE

To define an inference rule, use the following syntax:

> .*fromext*.*toext* :
> *commands*

The *fromext* represents the extension of a dependent file, and *toext* represents the extension of a target file. Extensions are not case sensitive. Macros can be invoked to represent *fromext* and *toext*; the macros are expanded during preprocessing.

The period (.) preceding *fromext* must appear at the beginning of the line. The colon (:) is preceded by zero or more spaces or tabs; it can be followed only by spaces or tabs, a semicolon (;) to specify a command, a number sign (#) to specify a comment, or a newline character. No other spaces are allowed. Commands are specified as in description blocks.

Search Paths in Inference Rules

An inference rule that specifies paths has the following syntax:

> {*frompath*}.*fromext*{*topath*}.*toext*:
> *commands*

An inference rule applies to a dependency only if paths specified in the dependency exactly match the inference-rule paths. Specify the dependent's directory in *frompath* and the target's directory in *topath*; no spaces are allowed. Specify only one path for each extension. A path on one extension requires a path on the other. To specify the current directory, use either a period (.) or empty braces ({ }). Macros can represent *frompath* and *topath*; they are invoked during preprocessing.

Batch-Mode Rules

Batch-mode inference rules provide only one invocation of the inference rule when N commands go through this inference rule. Without batch-mode inference rules, it would require N commands to be invoked. N is the number of dependents that trigger the inference rule.

Makefiles that contain batch-mode inference rules must use NMAKE version 1.62 or higher. To check the NMAKE version, run the _NMAKE_VER macro available with NMAKE version 1.62 or higher. This macro returns an integer representing the NMAKE version. For example, the macro returns 162 for NMAKE version 1.62.

A batch-mode inference rule has the following syntax:

> {*frompath*}.*fromext*{*topath*}.*toext*::
> *commands*

The only syntactical difference from the standard inference rule is that the batch-mode inference rule is terminated with a double colon (::).

> **Note:** The tool being invoked must be able to handle multiple files. The batch-mode inference rule must use $< as the macro to access dependent files.

The batch-mode inference rules can speed up the build process. It is faster to supply files to the compiler in batch, because the compiler driver is invoked only once.

Predefined Inference Rules

Predefined inference rules use NMAKE-supplied command and option macros:

Rule	Command	Default Action
.asm.exe	$(AS) $(AFLAGS) $*.asm	ml $*.asm
.asm.obj	$(AS) $(AFLAGS) /c $*.asm	ml /c $*.asm
.c.exe	$(CC) $(CFLAGS) $*.c	cl $*.c
.c.obj	$(CC) $(CFLAGS) /c $*.c	cl /c $*.c
.cpp.exe	$(CPP) $(CPPFLAGS) $*.cpp	cl $*.cpp
.cpp.obj	$(CPP) $(CPPFLAGS) /c $*.cpp	cl /c $*.cpp
.cxx.exe	$(CXX) $(CXXFLAGS) $*.cxx	cl $*.cxx

.cxx.obj	$(CXX) $(CXXFLAGS) /c $*.cxx	cl /c $*.cxx
.bas.obj	$(BC) $(BFLAGS) $*.bas;	bc $*.bas;
.cbl.exe	$(COBOL) $(COBFLAGS) $*.cbl, $*.exe;	cobol $*.cbl, $*.exe;
.cbl.obj	$(COBOL) $(COBFLAGS) $*.cbl;	cobol $*.cbl;
.for.exe	$(FOR) $(FFLAGS) $*.for	fl32 $*.for
.f90.exe	$(FOR) $(FFLAGS) $*.f90	fl32 $*.f90
.f.exe	$(FOR) $(FFLAGS) $*.f	fl32 $*.f
.for.obj	$(FOR) /c $(FFLAGS) $*.for	fl32 $*.for /c
.f90.obj	$(FOR) /c $(FFLAGS) $*.f90	fl32 $*.f90 /c
.f.obj	$(FOR) /c $(FFLAGS) $*.f	fl32 $*.f /c
.pas.exe	$(PASCAL) $(PFLAGS) $*.pas	pl $*.pas
.pas.obj	$(PASCAL) /c $(PFLAGS) $*.pas	pl /c $*.pas
.rc.res	$(RC) $(RFLAGS) /r $*	rc /r $*

Inferred Dependents and Rules

NMAKE assumes an inferred dependent for a target if an applicable inference rule exists. A rule applies if:

- *toext* matches the target's extension.
- *fromext* matches the extension of a file that has the target's base name and that exists in the current or specified directory.
- *fromext* is in .SUFFIXES; no other *fromext* in a matching rule has a higher .SUFFIXES priority.
- No explicit dependent has a higher .SUFFIXES priority.

Inferred dependents can cause unexpected side effects. If the target's description block contains commands, NMAKE executes those commands and not the commands in the rule.

Precedence in NMAKE Inference Rules

If an inference rule is multiply defined, the highest-precedence definition. The following list shows the order of precedence from highest to lowest:

1. An inference rule defined in a makefile; later definitions have precedence.

2. An inference rule defined in Tools.ini; later definitions have precedence.
3. A predefined inference rule.

Dot Directives in Makefiles

pecify dot directives outside a description block, at the start of a line. Dot directives begin with a period (.) and are followed by a colon (:). Spaces and tabs are allowed. Dot directive names are case sensitive and are uppercase.

Directive	Action
.IGNORE :	Ignores nonzero exit codes returned by commands, from the place it is specified to the end of the makefile. By default, NMAKE halts if a command returns a nonzero exit code. To restore error checking, use !CMDSWITCHES (described in Makefile Preprocessing Directives). To ignore the exit code for a single command, use the dash modifier. To ignore exit codes for an entire file, use the /I option.
.PRECIOUS : *targets*	Preserves *targets* on disk if the commands to update them are halted; has no effect if a command handles an interrupt by deleting the file. Separate the target names with one or more spaces or tabs. By default, NMAKE deletes a target if a build is interrupted by Ctrl+C or Ctrl+BREAK. Each use of .PRECIOUS applies to the entire makefile; multiple specifications are cumulative.
.SILENT :	Suppresses display of executed commands, from the place it is specified to the end of the makefile. By default, NMAKE displays the commands it invokes. To restore echoing, use !CMDSWITCHES. To suppress echoing of a single command, use the @ modifier. To suppress echoing for an entire file, use the /S option.
.SUFFIXES : *list*	Lists extensions for inference-rule matching; predefined as: .exe .obj .asm .c .cpp .cxx .bas .cbl .for .pas .res .rc

To change the .SUFFIXES list order or to specify a new list, clear the list and specify a new setting. To clear the list, specify no extensions after the colon:

```
.SUFFIXES :
```

To add additional suffixes to the end of the list, specify:

```
.SUFFIXES : suffixlist
```

where *suffixlist* is a list of the additional suffixes, separated by one or more spaces or tabs. To see the current setting of .SUFFIXES, run NMAKE with the /P option.

Makefile Preprocessing

You can control the NMAKE session by using preprocessing directives and expressions. Preprocessing instructions can be placed in the makefile. Using directives, you can conditionally process your makefile, display error messages, include other makefiles, undefine a macro, and turn certain options on or off.

For more information:

- Makefile Preprocessing Directives
- Expressions in Makefile Preprocessing
- Makefile Preprocessing Operators
- Executing a Program in Preprocessing

Makefile Preprocessing Directives

Preprocessing directives are not case sensitive. The initial exclamation point (!) must appear at the beginning of the line. Zero or more spaces or tabs can appear after the exclamation point, for indentation. The following are preprocessing directives:

- !CMDSWITCHES {+ | -}*option*...

  Turns each *option* listed on or off. Spaces or tabs must appear before the + or - operator; none can appear between the operator and the option letters. Letters are not case sensitive and are specified without a slash (/). To turn some options on and others off, use separate specifications of !CMDSWITCHES.

  Only /D, /I, /N, and /S can be used in a makefile. In Tools.ini, all options are allowed except /F, /HELP, /NOLOGO, /X, and /?. Changes specified in a description block do not take effect until the next description block. This directive updates the MAKEFLAGS recursion macro; changes are inherited during recursion if MAKEFLAGS is specified.

- !ERROR *text*

  Displays *text* in error U1050, then halts NMAKE, even if /K, /I, .IGNORE, !CMDSWITCHES, or the dash (-) command modifier is used. Spaces or tabs before *text* are ignored.

- !MESSAGE *text*

  Displays *text* to standard output. Spaces or tabs before *text* are ignored.

- !INCLUDE [<]*filename*[>]

  Reads *filename* as a makefile, then continues with the current makefile. NMAKE searches for *filename* first in the specified or current directory, then recursively through directories of any parent makefiles, then, if *filename* is enclosed by angle brackets (<>), in directories specified by the INCLUDE macro, which is initially set to the INCLUDE environment variable. Useful to pass .SUFFIXES settings, .PRECIOUS, and inference rules to recursive makefiles.

- !IF *constantexpression*

  Processes statements between !IF and the next !ELSE or !ENDIF if *constantexpression* evaluates to a nonzero value.

- !IFDEF *macroname*

  Processes statements between !IFDEF and the next !ELSE or !ENDIF if *macroname* is defined. A null macro is considered to be defined.

- !IFNDEF *macroname*

  Processes statements between !IFNDEF and the next !ELSE or !ENDIF if *macroname* is not defined.

- !ELSE [IF *constantexpression* | IFDEF *macroname* | IFNDEF *macroname*]

  Processes statements between !ELSE and the next !ENDIF if the prior !IF, !IFDEF, or !IFNDEF statement evaluated to zero. The optional keywords give further control of preprocessing.

- !ELSEIF

  Synonym for !ELSE IF.

- !ELSEIFDEF

  Synonym for !ELSE IFDEF.

- !ELSEIFNDEF

  Synonym for !ELSE IFNDEF.

- !ENDIF

  Marks the end of an !IF, !IFDEF, or !IFNDEF block. Any text after !ENDIF on the same line is ignored.

- !UNDEF *macroname*

  Undefines *macroname*.

Expressions in Makefile Preprocessing

The !IF or !ELSE IF *constantexpression* consists of integer constants (in decimal or C-language notation), string constants, or commands. Use parentheses to group expressions. Expressions use C-style signed long integer arithmetic; numbers are in 32-bit two's-complement form in the range -2147483648 to 2147483647.

Expressions can use operators that act on constant values, exit codes from commands, strings, macros, and file-system paths.

Makefile Preprocessing Operators

The DEFINED operator is a logical operator that acts on a macro name. The expression DEFINED (*macroname*) is true if *macroname* is defined. DEFINED in combination with !IF or !ELSE IF is equivalent to !IFDEF or !ELSE IFDEF. However, unlike these directives, DEFINED can be used in complex expressions using binary logical operators.

The EXIST operator is a logical operator that acts on a file-system path. EXIST (*path*) is true if *path* exists. The result from EXIST can be used in binary expressions. If *path* contains spaces, enclose it in double quotation marks.

Integer constants can use the unary operators for numerical negation (-), one's complement (~), and logical negation (!).

Constant expressions can use the following binary operators:

Operator	**Description**	**Operator**	**Description**
+	Addition	||	Logical OR
-	Subtraction	<<	Left shift
*	Multiplication	>>	Right shift
/	Division	==	Equality
%	Modulus	!=	Inequality
&	Bitwise AND	<	Less than

|	Bitwise OR	>	Greater than
^	Bitwise XOR	<=	Less than or equal to
&&	Logical AND	>=	Greater than or equal to

To compare two strings, use the equality (= =) operator and the inequality (!=) operator. Enclose strings in double quotation marks.

Executing a Program in Preprocessing

To use a command's exit code during preprocessing, specify the command, with any arguments, within brackets ([ ]). Any macros are expanded before the command is executed. NMAKE replaces the command specification with the command's exit code, which can be used in an expression to control preprocessing.

Resource Compiler Options

With Visual Fortran, you can create dialog boxes for an interactive user interface at run-time. For example, you can provide selection lists and scroll bars and the user will not have to type in text strings or numerical control parameters. You can also create custom icons for your Fortran QuickWin and Fortran Windows applications.

The Microsoft visual development environment includes a special dialog editor for creating dialogs and placing the controls within them, and a graphic editor for drawing or importing icons. You must use the dialog editor and graphic editor in the visual development environment to design dialogs and icons. Once you have created a dialog or icon, you can compile it from the command line using the Resource Compiler (RC).

In the visual development environment, you can view the resources in your project in the ResourceView pane (a tab next to the FileView pane). The resource editor in the Microsoft visual development environment offers easy, time-saving alternatives to the traditional hand-coded scripts used to create resources. Resources are built when you build your project.

These visual tools create and manage your project's script – you do not need to hand-code scripts. For more information on the working with resources in the visual development environment, see the Resource Editors section in the *Visual C++ User's Guide*.

For information on creating resource-definition script files and using the RC command from the command line, see:

- Including Resources in an Application
- Creating a Resource Definition File
- Resource Compiler Command Line
- The online *Platform SDK* sections under "Windows Programming Guidelines," "Platform SDK Tools," such as "Compiling" and "Using the Resource Compiler."

Including Resources in an Application

To include resources in your Win32-based application with RC from the command line, do the following:

1. Use the visual development environment dialog editor or graphic editor to create a resource for each dialog or icon in your application. (For more information, see "Resources Editors" in the *Visual C++ User's Guide*.)
2. Create a resource-definition file (also called a script) that describes all resources used by the application.
3. Compile the script into a resource (.RES) file with RC.EXE (RC).
4. Link the compiled resource files into the application's executable file.

You do not use RC to include compiled resources into the executable file or to mark the file as an application. The linker recognizes the compiled resource files and links them to the executable file.

Creating a Resource-Definition File

After creating individual resource files for your application's dialog box and icon resources, you create a resource-definition file, or script. A script is a text file with the extension .RC.

The script lists every resource in your application and describes some types of resources in great detail. For a resource that exists in a separate file, such as an icon or cursor, the script names the resource and the file that contains it. For some resources, such as a menu, the entire definition of the resource exists within the script.

A script file can contain the following information:

- Comments (single-line comments or block line comments)
- Predefined macros
- Preprocessing directives, which instruct RC to perform actions on the script before compiling.
- Preprocessor operators
- Resource definition statements, which name and describe resources. Statements can be single-line or multiline statements.

- Pragmas for changing the code page

The following example shows a script file that defines the resources for an application named Shapes:

```
#include "SHAPES.H"

ShapesCursor CURSOR SHAPES.CUR
ShapesIcon ICON SHAPES.ICO

    BEGIN
        POPUP "&Shape"
            BEGIN
                MENUITEM "&Clear", ID_CLEAR
                MENUITEM "&Rectangle", ID_RECT
                MENUITEM "&Triangle", ID_TRIANGLE
                MENUITEM "&Star", ID_STAR
                MENUITEM "&Ellipse", ID_ELLIPSE
            END
    END
```

The CURSOR statement names the application's cursor resource ShapesCursor and specifies the cursor file SHAPES.CUR, which contains the image for that cursor. Custom cursors are not available in Visual Fortran.

The ICON statement names the application's icon resource ShapesIcon and specifies the icon file SHAPES.ICO, which contains the image for that icon.

The MENU statement defines an application menu named ShapesMenu, a pop-up menu with five menu items.

The menu definition, enclosed by the BEGIN and END keywords, specifies each menu item and the menu identifier that is returned when the user selects that item. For example, the first item on the menu, Clear, returns the menu identifier ID_CLEAR when the user selects it. The menu identifiers are defined in the application header file, SHAPES.H.

Once you create the resource-definition script (RC) file, use the Resource Compiler Command Line to create the RES file.

For details about script files, see the online *Platform SDK* sections under "Windows Programming Guidelines" and "Platform SDK Tools" such as "Using the Resource Compiler."

Resource Compiler Command Line

To start RC, use the following command-line syntax:

RC [*options*] *script-file*

The *script-file* argument specifies the name of the resource-definition script that contains the names, types, filenames, and descriptions of the resources to be compiled.

The *options* argument can include one or more of the following options:

Option	**Description**
/?	Displays a list of RC command-line options.
/d	Defines a symbol for the preprocessor that you can test with #ifdef.
/fo *resname*	Uses *resname* for the name of the .RES file.
/h	Displays a list of RC command-line options.
/i *directory*	Causes RC to search the specified *directory* before searching the directories specified by the INCLUDE environment variable.
/lcodepage	Specifies default language for compilation. For example, -l409 is equivalent to including the following statement at the top of the resource script file: `LANGUAGE LANG_ENGLISH,SUBLANG_ENGLISH_US` Alternatively, you use #pragma code_page(409) in the .RC file.
/n	Null terminates all strings in the string table.
/r	Ignored. Provided for compatibility with existing makefiles.
/u	Undefines a symbol.
/v	Causes a display of messages that report on the progress of the compiler.
/x	Prevents RC from checking the INCLUDE environment variable when searching for header files or resource files.

Options are not case sensitive and a dash (-) can be used in place of a forward slash (/). You can combine single-letter options if they do not require additional arguments. For example, the following commands are equivalent:

```
RC /V /X SAMPLE.RC
rc -vx sample.rc
```

For more information on these options and the resource compiler, see the online

Platform SDK sections under "Windows Programming Guidelines" and "Platform SDK Tools," such as "Using the Resource Compiler."

Managing Libraries with LIB

You may find it useful to create libraries of Common Object File Format (COFF) object files to organize shared components of multiple projects.

In the Microsoft visual development environment, you create and manage object libraries with a variety of dialogs. From the command line, you can use the Microsoft 32-Bit Library Manager (LIB.EXE) to manage COFF object libraries, create export files and import libraries to reference exported symbol definitions when you build Dynamic Link Libraries (DLLs), and extract library members.

You use the standard libraries, import libraries, and export files LIB creates with LINK when building a 32-bit program. (LINK is described in Using the Compiler and Linker from the Command Line and Compiler and Linker Options.) The three LIB modes -- creating standard (COFF) libraries, creating import libraries and export files, and extracting library members -- are mutually exclusive. You can use LIB in only one mode at a time.

You can use LIB to perform the following library-management tasks:

- Add objects to a library

  Specify the filename for the existing library and the filenames for the new objects.

- Combine libraries

  Specify the library filenames. You can add objects and combine libraries in a single LIB command.

- Replace a library member with a new object

  Specify the library containing the member object to be replaced and the filename for the new object (or the library that contains it). When an object that has the same name exists in more than one input file, LIB puts the last object specified in the LIB command into the output library. When you replace a library member, be sure to specify the new object or library after the library that contains the old object.

- Delete a member from a library

  Use the /REMOVE option. LIB processes any specifications of /REMOVE after combining all input objects, regardless of command-line order.

Note: You cannot both delete a member and extract it to a file in the same step. You must first extract the member object using /EXTRACT, then run LIB again using /REMOVE.

This section describes the Microsoft 32-Bit Library Manager (LIB.EXE). The following topics are covered:

- LIB Input/Output
- Running LIB
- LIB Options
- Extracting a Library Member
- Import Libraries and Export Files

LIB Input/Output

LIB expects types of input files and generates types of output files depending on the mode in which it is used. You can also get information about the resulting library with the /LIST option, and you can examine the contents of the library by using DUMPBIN with the /LINKERMEMBER option.

For more information:

- LIB Input Files
- LIB Output Files
- Other LIB Output
- Viewing Contents of a Library

LIB Input Files

The input files expected by LIB depend on the mode in which it is used, as follows:

Mode	Input
Default (building or modifying a library)	COFF object (.OBJ) files, COFF libraries (.LIB), 32-bit OMF object (.OBJ) files
Extracting a member with /EXTRACT	COFF library (.LIB)
Building an export file and import library with /DEF	Module-definition (.DEF) file, COFF object (.OBJ) files, COFF libraries (.LIB), 32-bit OMF object (.OBJ) files

Note: Object Model Format (OMF) libraries created by the 16-bit version of LIB cannot be used as input to the 32-bit LIB.

LIB Output Files

The output files produced by LIB depend on the usage mode as follows:

Mode	Output
Default (building or modifying a library)	COFF library (.LIB)
Extracting a member with /EXTRACT	Object (.OBJ) file
Building an export file and import library with /DEF	Import library (.LIB) and export (.EXP) file

Other LIB Output

In the default mode, you can use the /LIST option to display information about the resulting library. You can redirect this output to a file.

LIB displays a copyright and version message and echoes command files unless the /NOLOGO option is used.

When you type lib with no other input, LIB displays a usage statement that summarizes its options.

Error and warning messages issued by LIB have the form LNK*nnnn*. The LINK, DUMPBIN, and EDITBIN tools also use this range of errors.

Viewing Contents of a Library

A library contains COFF objects. Objects in a library contain functions and data that can be referenced externally by other objects in a program. An object in a library is sometimes referred to as a library member.

You can get additional information about the contents of a library by running the DUMPBIN tool with the /LINKERMEMBER option. For more information, see Examining Files with DUMPBIN.

Running LIB

This section presents information on running LIB in any mode. It describes the LIB command line, discusses the use of command files, and gives general rules for using options.

For more information:

LIB Command Line

To run LIB, type the command LIB followed by the options and filenames for the task you are using LIB to perform. LIB also accepts command-line input in command files. LIB does not use an environment variable.

> **Note:** If you are accustomed to the LINK32.EXE and LIB32.EXE tools provided with the Microsoft Win32 Software Development Kit for Windows NT, you may have been using either the command LINK32 -LIB or the command LIB32 for managing libraries and creating import libraries. Be sure to change your makefiles and batch files to use the LIB command instead.

LIB Command Files

You can pass command-line arguments to LIB in a command file by using the following syntax:

LIB @*commandfile*

The *commandfile* is the name of a text file. No space or tab is allowed between the at sign (@) and the filename. There is no default extension; you must specify the full filename, including any extension. Wildcards cannot be used. You can specify an absolute or relative path with the filename.

In the command file, arguments can be separated by spaces or tabs as they can on the command line, and they can also be separated by newline characters. Use a semicolon (;) to mark a comment. LIB ignores all text from the semicolon to the end of the line.

You can specify either all or part of the command line in a command file, and you can use more than one command file in a LIB command. LIB accepts the command-file input as if it were specified in that location on the command line. Command files cannot be nested. LIB echoes the contents of command files unless the /NOLOGO option is used.

Using LIB Options

An option consists of an option specifier, which is either a dash (-) or a forward slash (/), followed by the name of the option. Option names cannot be abbreviated. Some options take an argument, specified after a colon (:). No spaces or tabs are allowed within an option specification. Use one or more spaces or tabs to separate option specifications on the command line.

Option names and their keyword or filename arguments are not case sensitive, but identifiers used as arguments are case sensitive. LIB processes options in the order specified on the command line and in command files. If an option is repeated with different arguments, the last one to be processed takes precedence.

The following LIB options apply to all modes of LIB:

- /MACHINE

  Specifies the architecture of the library.

- /NOLOGO

  Suppresses display of the LIB copyright message and version number and prevents echoing of command files.

- /VERBOSE

  Displays details about the progress of the session. The information is sent to standard output and can be redirected to a file.

Other options apply only to specific modes of LIB. These options are discussed in the sections describing each mode.

LIB Options

The default mode for LIB is to build or modify a library of COFF objects. LIB runs in this mode when you do not specify /EXTRACT (to copy an object to a file) or /DEF (to build an import library).

To build a library from objects and/or libraries, use the following syntax:

LIB [*options*...] *files*...

The *options* that apply to building and modifying a library are listed in the following table:

Option	**Description**
/CONVERT	Converts an import library to the previous (Visual C++ version 5.0) format.

/LIBPATH:*dir*	Overrides the environment library path. For more information, see the linker option /LIBPATH.
/LIST	Displays information about the output library to standard output. The output can be redirected to a file. You can use /LIST to determine the contents of an existing library without modifying it.
/LINK50COMPAT	Generates an import library in the previous (Visual C++ version 5.0) format for backwards compatibility.
/OUT:*filename*	Overrides the default output filename. By default, the output library has the base name of the first library or object on the command line and the extension .LIB.
/REMOVE:*object*	Omits the specified *object* from the output library. LIB creates an output library by first combining all objects (whether in object files or libraries), then deleting any objects specified with /REMOVE.
/SUBSYSTEM	Tells the operating system how to run a program created by linking to the output library. For more information, see the description of the LINK /SUBSYSTEM option in Compiler and Linker Options.

Other LIB options are described in:

- Building an Import Library and Export File
- Extracting a Library Member
- Using LIB Options

The *files* can be COFF object files, 32-bit OMF object files, and existing COFF libraries. LIB creates one library that contains all objects in the specified files. If an input file is a 32-bit OMF object file, LIB converts it to COFF before building the library. LIB cannot accept a 32-bit OMF object that is in a library created by the 16-bit version of LIB. You must first use the 16-bit LIB to extract the object, then you can use the extracted object file as input to the 32-bit LIB. The 16-bit version of LIB is not provided with Visual Fortran.

By default, LIB names the output file using the base name of the first object or library file and the extension .LIB. If a file already exists with the same name, the output file overwrites the existing file. To preserve an existing library, use the /OUT option to specify a name for the output file.

You can use LIB to perform the following library-management tasks:

- Add objects to a library

Specify the filename for the existing library and the filenames for the new objects.

- Combine libraries

  Specify the library filenames. You can add objects and combine libraries in a single LIB command.

- Replace a library member with a new object

  Specify the library containing the member object to be replaced and the filename for the new object (or the library that contains it). When an object that has the same name exists in more than one input file, LIB puts the last object specified in the LIB command into the output library. When you replace a library member, be sure to specify the new object or library after the library that contains the old object.

- Delete a member from a library

  Use the /REMOVE option. LIB processes any specifications of /REMOVE after combining all input objects, regardless of command-line order.

Note: You cannot both delete a member and extract it to a file in the same step. You must first extract the member object using /EXTRACT, then run LIB again using /REMOVE. This behavior differs from that of the 16-bit LIB (for OMF libraries) provided in some Microsoft products.

Extracting a Library Member

You can use LIB to create an object (.OBJ) file that contains a copy of a member of an existing library. To extract a copy of a member, use the following syntax:

LIB *library* /EXTRACT:*member* /OUT:*objectfile*

This command creates an .OBJ file called *objectfile* that contains a copy of a *member* of a *library*. The *member* name is case sensitive. You can extract only one member in a single command. The /OUT option is required; there is no default output name. If a file called *objectfile* already exists in the specified directory (or current directory, if no directory is specified with *objectfile*), the extracted *objectfile* overwrites the existing file.

Import Libraries and Export Files

You can use LIB with the /DEF option to create an import library and an export file. LINK uses the exports file to build a program that contains exports (usually a DLL), and it uses the import library to resolve references to those exports in other programs.

In most situations, you do not need to use LIB to create your import library. When you link a program (either an executable file or a DLL) that contains exports, LINK automatically creates an import library that describes the exports. Later, when you link a program that references those exports, you specify the import library.

However, when a DLL exports to a program that it also imports from, whether directly or indirectly, you must use LIB to create one of the import libraries. When LIB creates an import library, it also creates an export file. You must use the exports file when linking one of the DLLs.

For more information, see:

- Building an Import Library and Export File
- Using an Import Library and Export File

Building an Import Library and Export File

To build an import library and export file, use the following syntax:

LIB /DEF[:*deffile*] [*options*] [*objfiles*] [*libraries*]

When /DEF is specified, LIB creates the output files from export specifications that are passed in the LIB command. There are three methods for specifying exports, listed in recommended order of use:

- *c***DEC$ ATTRIBUTES** DLLEXPORT in one of the *objfiles* or *libraries*
- A specification of /EXPORT:*name* on the LIB command line
- A definition in an EXPORTS statement in a *deffile*

These are the same methods you use to specify exports when linking an exporting program. A program can use more than one method. You can specify parts of the LIB command (such as multiple *objfiles* or /EXPORT specifications) in a command file in the LIB command, just as you can in a LINK command.

The following options apply to building an import library and export file:

- /DEBUGTYPE:{CV|COFF|BOTH}

  This option sets the format of debugging information. Specify CV for new-style Microsoft Symbolic Debugging Information, required by Visual C++ and Visual Fortran. Specify COFF for Common Object File Format (COFF) debugging information. Specify BOTH for both COFF debugging information and old-style Microsoft debugging information.

- /OUT:*import*

  This option overrides the default output filename for the *import* library being created. When /OUT is not specified, the default name is the base name of the first object file or library in the LIB command and the extension .LIB. The exports file is given the same base name as the import library and the extension .EXP.

- /EXPORT:*entryname*[=*internalname*] [,@*ordinal*[,NONAME]][,DATA]

  This option exports a function from your program to allow other programs to call the function. You can also export data. Exports are usually defined in a DLL.

  The *entryname* is the name of the function or data item as it is to be used by the calling program. You can optionally specify the *internalname* as the function known in the defining program; by default, *internalname* is the same as *entryname*. The *ordinal* specifies an index into the exports table in the range 1 - 65535; if you do not specify *ordinal*, LIB assigns one. The NONAME keyword exports the function only as an ordinal, without an *entryname*.

- /INCLUDE:*symbol*

  This option adds the specified symbol to the symbol table. This is useful for forcing the use of a library object that otherwise would not be included.

Using an Import Library and Export File

When a program (either an executable file or a DLL) exports to another program that it also imports from, or if more than two programs both export to and import from each other, the commands to link these programs must accommodate the circular exports.

In a situation without circular exports, when you link a program that uses exports from another program, you must specify the import library for the exporting program. The import library for the exporting program is created when you link that exporting program. This requires that you link the exporting program before the importing program. For example, if TWO.DLL imports from ONE.DLL, you must first link ONE.DLL and get the import library ONE.LIB. You then specify ONE.LIB when you link TWO.DLL. When the linker creates TWO.DLL, it also creates its import library, TWO.LIB. You use TWO.LIB when linking programs that import from TWO.DLL.

However, in a circular export situation, it is not possible to link all of the interdependent programs using import libraries from the other programs. In the example discussed earlier, if TWO.DLL also exports to ONE.DLL, the import library for TWO.DLL won't exist yet when ONE.DLL is linked. When circular exports exist, you must use LIB to create an import library and exports file for one of the programs.

To begin, choose one of the programs on which to run LIB. In the LIB command, list all objects and libraries for the program and specify the /DEF option. If the program uses a .DEF file or /EXPORT specifications, specify these as well.

After you create the import library (.LIB) and the export file (.EXP) for the program, you then use the import library when linking the other program or programs. LINK creates an import library for each exporting program it builds. For example, if you ran LIB on the objects and exports for ONE.DLL, you created ONE.LIB and ONE.EXP. You can now use ONE.LIB when linking TWO.DLL; this step also creates the import library TWO.LIB.

Finally, link the program you began with. In the LINK command, specify the objects and libraries for the program, the .EXP file that LIB created for the program, and the import library or libraries for the exports used by the program. In the continuing example, the LINK command for ONE.DLL contains ONE.EXP and TWO.LIB, as well as the objects and libraries that go into ONE.DLL. Do not specify the .DEF file and /EXPORT specifications in the LINK command; these are not needed because the exports definitions are contained in the .EXP file. When you link using an .EXP file, LINK does not create an import library because it assumes that one was created when the .EXP file was created.

Editing files with EDITBIN

You can specify execution characteristics of a program or library by selecting options in the visual development environment. For example, you might need to specify the base address at which a program is loaded by the operating system. If you work from the command line, you can use the Microsoft Binary File Editor (EDITBIN) to set these types of controls.

This section describes the Microsoft COFF Binary File Editor (EDITBIN.EXE). EDITBIN modifies 32-bit Common Object File Format (COFF) binary files. You can use EDITBIN to modify object files, executable files, and dynamic-link libraries (DLLs).

EDITBIN converts the format of an Object Module Format (OMF) input file to COFF before making other changes to the file. You can use EDITBIN to convert the format of a file to COFF by running EDITBIN with no options.

The following topics are covered in this section:

- EDITBIN Command Line
- EDITBIN Options

EDITBIN Command Line

To run EDITBIN, use the following syntax:

EDITBIN [*options*] *files*...

Specify one or more files for the objects or images to be changed, and one or more *options* for changing the files.

When you type the command EDITBIN without any other command-line input, EDITBIN displays a usage statement that summarizes its options.

EDITBIN Options

An option consists of an option specifier, which is either a dash (-) or a forward slash (/), followed by the name of the option. Option names cannot be abbreviated. Some options take arguments, specified after a colon (:). No spaces or tabs are allowed within an option specification. Use one or more spaces or tabs to separate option specifications on the command line. Option names and their keyword or filename arguments are not case sensitive.

This section discusses the following EDITBIN options:

- /BIND
- /HEAP
- /LARGEADDRESSAWARE
- /NOLOGO
- /REBASE
- /RELEASE
- /SECTION
- /STACK
- /SUBSYSTEM
- /SWAPRUN
- /VERSION
- /WS

EDITBIN Option /BIND

The /BIND option sets the addresses of the entry points in the import address table for an executable file or DLL. Use this option to reduce load time of a program.

The /BIND option has the following form:

/BIND[:PATH=*path*]

Specify the program's executable file and DLLs in the *files* argument on the EDITBIN command line. The optional *path* argument to the /BIND option specifies the location of the DLLs used by the specified files. Separate multiple directories with semicolons (;). If *path* is not specified, EDITBIN searches the directories specified in the PATH environment variable. If *path* is specified, EDITBIN ignores the PATH variable.

By default, the Windows program loader sets the addresses of entry points when it loads a program. The amount of time this takes varies depending on the number of DLLs and the number of entry points referenced in the program.

If a program has been modified with the /BIND option, and if the base addresses for the executable file and its DLLs do not conflict with DLLs that are already loaded, the operating system does not need to set these addresses. In a situation where the files are incorrectly based, the operating system will relocate the program's DLLs and recalculate the entry-point addresses; this adds to the program's load time.

EDITBIN Option /HEAP

The /HEAP option sets the size of the heap in bytes. It has the following form:

/HEAP:*reserve*[,*commit*]

The *reserve* argument specifies the total heap allocation in virtual memory. The default heap size is 1MB. The linker rounds up the specified value to the nearest 4 bytes.

The optional *commit* argument is subject to interpretation by the operating system. It specifies the amount of physical memory to allocate at a time. Committed virtual memory causes space to be reserved in the paging file. A higher *commit* value saves time when the application needs more heap space but increases the memory requirements and possibly startup time.

Specify the *reserve* and *commit* values in decimal or C-language notation.

EDITBIN Option /LARGEADDRESSAWARE

This option edits the image to indicate that the application can handle addresses larger than 2 gigabytes.

EDITBIN Option /NOLOGO

This option suppresses display of the EDITBIN copyright message and version number.

EDITBIN Option /REBASE

The option /REBASE[:*modifiers*] sets the base addresses for the specified files. EDITBIN assigns new base addresses in a contiguous address space according to the size of each file rounded up to the nearest 64K.

Specify the program's executable files and DLLs in the *files* argument on the EDITBIN command line in the order in which they are to be based. You can optionally specify one or more *modifiers*, each separated by a comma (,):

Modifier	**Action**
BASE=*address*	Provides a beginning address for reassigning base addresses to the files. Specify *address* in decimal or C-language notation. If BASE is not specified, the default starting base address is 0x400000. If DOWN is used, BASE must be specified, and *address* sets the end of the range of base addresses.
BASEFILE	Creates a file named COFFBASE.TXT, which is a text file in the format expected by LINK's /BASE option.
DOWN	Tells EDITBIN to reassign base addresses downward from an ending address. The files are reassigned in the order specified, with the first file located in the highest possible address below the end of the address range. BASE must be used with DOWN to ensure sufficient address space for basing the files. To determine the address space needed by the specified files, run EDITBIN with the /REBASE option on the files and add 64K to the displayed total size.

EDITBIN Option /RELEASE

This option sets the checksum in the header of an executable file. The operating system requires the checksum for certain files such as device drivers. It is recommended that you set the checksum for release versions of your programs to ensure compatibility with future operating systems.

EDITBIN Option /SECTION

This option changes the properties of a section, overriding the properties that were set when the object file for the section was compiled or linked. It has the following form:

/SECTION:name[=*newname*][,*properties*][,*alignment*]

After the colon (:), specify the name of the section. To change the section name, follow name with an equal sign (=) and a *newname* for the section.

To set or change the section's properties, specify a comma (,) followed by one or more property characters. To negate a property, precede its character with an exclamation point (!). The following characters specify memory properties:

Property	**Setting**
c	code
d	discardable
e	executable
i	initialized data
k	cached virtual memory
m	link remove
o	link info
p	paged virtual memory
r	read
s	shared
u	uninitialized data
w	write

To control *alignment*, specify the character "a" followed by a character to set the size of alignment in bytes, as follows:

Character	Alignment Size in Bytes
1	1
2	2
4	4
8	8
p	16
t	32
s	64
x	no alignment

Specify the *properties* and *alignment* characters as a string with no white space. The characters are not case sensitive.

EDITBIN Option /STACK

This option sets the size of the stack in bytes and takes arguments in decimal or C-language notation. The /STACK option applies only to an executable file. This option takes the following form:

/STACK:*reserve*[,*commit*]

The *reserve* argument specifies the total stack allocation in virtual memory. EDITBIN rounds up the specified value to the nearest 4 bytes. The optional *commit* argument is subject to interpretation by the operating system. On Windows NT 4 and Windows 2000 systems, *commit* specifies the amount of physical memory to allocate at a time. Committed virtual memory causes space to be reserved in the paging file. A higher *commit* value saves time when the application needs more stack space but increases the memory requirements and possibly startup time.

EDITBIN Option /SUBSYSTEM

Edits the image to indicate which subsystem the operating system must invoke for execution.

For more information, see the description of the LINK /SUBSYSTEM option in Compiler and Linker Options.

EDITBIN Option /SWAPRUN

This option edits the image to tell the operating system to copy the image to a swap file and run it from there. Use this option for images that reside on networks or removable media. It has the following form:

/SWAPRUN:{[!]NET|[!]CD}

You can add or remove the NET or CD qualifiers:

- NET indicates that the image resides on a network.
- CD indicates that the image resides on a CD-ROM or similar removable medium.

Use !NET and !CD to reverse the effects of NET and CD.

EDITBIN Option /VERSION

This option places a version number into the header of the image. It has the following form:

/VERSION:*left*[, *right*]

The whole number part of the version number (the portion to the left of the decimal point) is represented by *left*. The fractional part of the version number (the portion to the right of the decimal point) is represented by *right*.

EDITBIN Option /WS

This option adds the WS_AGGRESSIVE property to your application's image. It has the following form:

/WS:AGGRESSIVE

In Windows NT 4 and Windows 2000, the loader recognizes this property and aggressively trims the working set of the process when the process is inactive. This has the same effect as using the following call throughout your application:

```
SetProcessWorkingSetSize(hThisProcess, -1, -1)
```

Use /WS:AGGRESSIVE for applications such as services and screen savers that must have a low impact on the system's memory pool. If the speed of your application matters, do not use /WS:AGGRESSIVE without testing the resulting performance.

Examining Files with DUMPBIN

There are times when you must examine or change OBJ, EXE, and DLL files. In the visual development environment, you can open any file as a Binary rather than as an ASCII text file and work with both hexadecimal and ASCII versions of the contents. From the command line, you can use the Microsoft Binary File Dumper (DUMPBIN) to edit these types of files.

This section describes the Microsoft COFF Binary File Dumper (DUMPBIN.EXE). DUMPBIN displays information about 32-bit Common Object File Format (COFF) binary files. You can use DUMPBIN to examine COFF object files, standard libraries of COFF objects, executable files, and dynamic-link libraries (DLLs).

The following topics are covered in this section:

- DUMPBIN Command Line
- DUMPBIN Options

DUMPBIN Command Line

The syntax for DUMPBIN is:

> DUMPBIN [*options*] *files*...

Specify one or more binary files, along with any options required to control the information. DUMPBIN displays the information to standard output. You can either redirect it to a file or use the /OUT option to specify a filename for the output.

When you run DUMPBIN on a file without specifying an option, DUMPBIN displays the /SUMMARY output.

When you type the command DUMPBIN without any other command-line input, DUMPBIN displays a usage statement that summarizes its options.

DUMPBIN Options

An option consists of an option specifier, which is either a dash (-) or a forward slash (/), followed by the name of the option. Option names cannot be abbreviated. Some options take arguments, specified after a colon (:). No spaces or tabs are allowed within an option specification. Use one or more spaces or tabs to separate option specifications on the command line. Option names and their keyword or filename arguments are not case sensitive. Most options apply to all binary files; a few apply only to certain types of files.

The DUMPBIN options are as follows:

Option	Description
/ALL	Displays all available information except code disassembly. Use the /DISASM option to display disassembly. You can use /RAWDATA:NONE with the /ALL option to omit the raw binary details of the file.
/ARCHIVEMEMBERS	Displays minimal information about member objects in a library.
/ARCH	Dumps the .arch section of an image.
/DEPENDENTS	Dumps the names of the DLLs from which the image imports functions. Does not dump the names of the imported functions.
/DIRECTIVES	Dumps the compiler-generated .drective section of an image.
/DISASM	Displays disassembly of code sections, using symbols if present in the file.
/EXPORTS	Displays all definitions exported from an executable file or DLL.
/FPO	Displays Frame Pointer Optimization (FPO) records.
/HEADERS	Displays coff header information.
/IMPORTS	Displays all definitions imported to an executable file or DLL. Output resembles the /EXPORTS option.
/LINENUMBERS	Displays COFF line numbers. Line numbers exist in an object file if it was compiled with Program Database (/Zi) or Line Numbers Only (/Zd). An executable file or DLL contains COFF line numbers if it was linked with Generate Debug Info (/DEBUG) and COFF Format (/DEBUGTYPE:COFF).

<table>
<tr><td>/LINKERMEMBER</td><td>The option /LINKERMEMBER[:{1|2}] displays public symbols defined in a library. Specify the 1 argument to display symbols in object order, along with their offsets. Specify the 2 argument to display offsets and index numbers of objects, then list the symbols in alphabetical order along with the object index for each. To get both outputs, specify /LINKERMEMBER without the number argument.</td></tr>
<tr><td>/OUT</td><td>The option /OUT:filename specifies a filename for the output. By default, DUMPBIN displays the information to standard output.</td></tr>
<tr><td>/PDATA</td><td>dumps the exception tables (.pdata) from an image or object.</td></tr>
<tr><td>/RAWDATA</td><td>The option /RAWDATA[:{ BYTES | SHORTS | LONGS | NONE }[, number]] displays the raw contents of each section in the file. The arguments control the format of the display, as follows:
<table>
<tr><th>Argument</th><th>Result</th></tr>
<tr><td>BYTES</td><td>The default. Contents are displayed in hexadecimal bytes, and also as ASCII if they have a printed representation.</td></tr>
<tr><td>SHORTS</td><td>Contents are displayed in hexadecimal words.</td></tr>
<tr><td>LONGS</td><td>Contents are displayed in hexadecimal longwords.</td></tr>
<tr><td>NONE</td><td>Raw data is suppressed. This is useful to control the output of the /ALL option.</td></tr>
<tr><td>number</td><td>Displayed lines are set to a width that holds number values per line.</td></tr>
</table></td></tr>
<tr><td>/RELOCATIONS</td><td>Displays any relocations in the object or image.</td></tr>
<tr><td>/SECTION</td><td>The option /SECTION:section restricts the output to information on the specified section.</td></tr>
<tr><td>/SUMMARY</td><td>Displays minimal information about sections, including total size. This option is the default if no other option is specified.</td></tr>
</table>

/SYMBOLS	Displays the COFF symbol table. Symbol tables exist in all object files. A COFF symbol table appears in an image file only if it is linked with the Generate Debug Info and COFF Format options under Debug Info on the Debug category for the linker (or the /DEBUG and /DEBUGTYPE:COFF options on the command line).

Editing Format Descriptors with the Format Editor

The Format Editor is an application for Windows® that shows you what data formatted to match your edit descriptors will look like, and lets you edit either the descriptor list or the data. You can interactively create and edit Fortran 90 **FORMAT** statements and embedded formatting directives.

You can run the Format Editor either from the Edit menu in the visual development environment or from the command line. The Format Editor program is located in the `...\Common\MSDev98\Bin` directory, and is called FRMTEDIT.EXE. To use it from the command line, you specify the source code file name, line number and column position in the argument list, and the Format Editor operates on the formatting at the indicated location. For example:

```
FRMTEDIT test.f90 5 18
```

If the line specified by the second parameter is empty, a new format statement is created with the words *label FORMAT*.

To use the Format Editor on a multi-line format statement, the argument list must specify the first line of the format statement. In-line comments in a multi-line Format statement are lost when the Format Editor writes the updated format statement and generates new continuation marks. Similarly, the part of a formatted I/O statement that follows the formatting directives is lost when the Format Editor writes the updated directive string back to the file.

When you are finished editing the format statement, the Format Editor rewrites the source file with code for the format you have developed. If the file has the extension .F90, the revised code is written with Fortran 90 free-form syntax rules; otherwise, it is written with Fortran 90 fixed-form syntax rules.

The Format Editor is installed on the Edit menu during Visual Fortran installation. If you have removed it for any reason, and need to reinstall it, you can do so by choosing Customize from the Tools menu. The argument list, which passes the current file name, line number and column position to the Format Editor, is $File $Line $Column. For more information about adding programs to the Tools menu, select the Help button in the Customize dialog.

Starting the Format Editor from the Microsoft Visual Development Environment

The Format Editor presents the format code and a sample of the resulting data layout in a window that works like a dialog box. You can edit either the source code or the data layout, and the Format Editor changes the other to match.

To open the Format Editor:

1. Load a Fortran source file that contains a **FORMAT** statement or an I/O edit descriptor.
2. Place the cursor on the first line of the **FORMAT** statement or on the line containing the edit descriptor.
3. From the Edit menu, choose Format Editor. The Format Editor dialog box opens.

The Format Editor dialog box consists of the following text boxes and buttons:

- The edit descriptors in the upper-left text box
- The sample data display in the lower-left text box
- The New Field, Remove Field, Change Value, OK, Cancel, and Help buttons along the bottom

When you open the Format editor in a line with an edit descriptor, the editor attempts to parse the first opening quote that precedes the cursor position. When you open the editor in a line containing a **FORMAT** statement, the editor attempts to parse the edit descriptors in the statement. If the editor is successful, it displays the edit descriptors in the upper-left box and a sample data display in the lower text box. If the editor cannot parse the descriptor string or **FORMAT** statement, you will get a parse error message.

To insert new I/O edit descriptors into existing formatted I/O statements or FORMAT statements in Microsoft visual development environment:

1. Place the cursor in the existing descriptor or **FORMAT** statement.
2. From the Edit menu, choose Format Editor.
3. Choose New Field from the Format Editor dialog box.
4. Choose the descriptor type (Character, Integer, and so on) and choose whether to insert the descriptor before or after the current descriptor.
5. A default value is used for the descriptor you choose (for example, I5). To change the descriptor value, select the value and type in the new value. (For example, select 5 from I5 and type 8 to get an I8 format.)

To insert a new format statement:

1. Place the cursor on a blank line.
2. From the Edit menu, choose Format Editor.

The Format Editor inserts the words *label FORMAT* into the file at the cursor. You can define the new edit descriptor with the Format Editor.

For a discussion of the features of the Format Editor in Microsoft visual development environment, choose Format Editor from the Edit menu, and click on Help in the Format Editor dialog box.

Profiling Code from the Command Line

The profiler is an analysis tool you can use to examine the run-time behavior of your programs. By profiling, you can find out which sections of your code are working efficiently and which need to be tuned. The profiler can also show areas of code that are not being executed.

Because profiling is a tuning process, you should use the profiler to make your programs run better, not to find bugs. Once your program is fairly stable, you should start profiling to find out where to optimize your code. Use the profiler to determine whether an algorithm is effective, a function is being called frequently (if at all), or if a piece of code is being covered by software testing procedures.

In the Microsoft visual development environment, you can use the Profiler to generate reports that characterize how your program executes. If you work from the command line, you can create a batch command file to run PREP, PROFILE and PLIST, the programs that generate execution profile reports.

If you work from the command line, specify the /profile option to the LINK command to enable profiling. Similarly, when using the visual development environment, you need to enable profiling in the Link tab in the Project Settings dialog box.

For information on using the Profiler from the Microsoft visual development environment and timing your application, see Analyze Program Performance.

This section describes how to use the components of the profiler from the command line. The following topics are covered:

- Profiler Batch Processing
- Profiler Batch Files
- Profiler Command-Line Options
- Exporting Data From the Profiler

Profiler Batch Processing

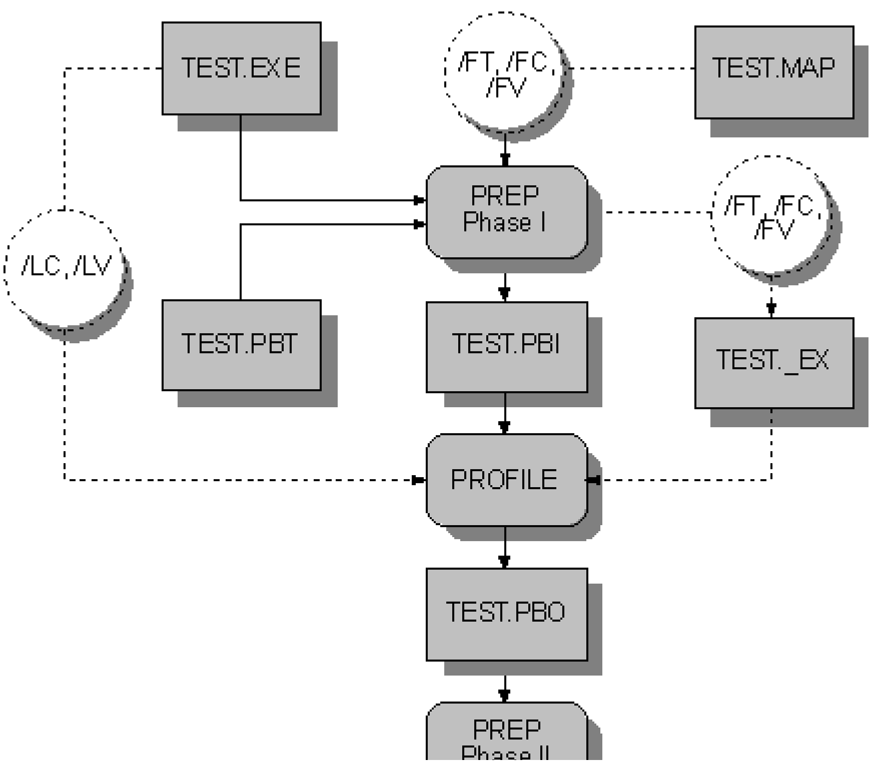
Profiling requires three separate programs: PREP, PROFILE, and PLIST. The visual development environment executes all three of these programs for you automatically. To execute them efficiently from the command line, and to customize the output format or specify function and line count profiling, you must write batch files to invoke PREP, PROFILE, and PLIST. You can redirect the output of the batch file to a designated file by using the redirection character (>).

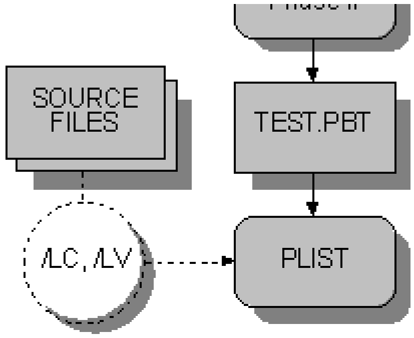
A typical profiler batch file might look like this:

```
PREP /OM /FT /EXC nafxcwd.lib %1
if errorlevel == 1 goto done
PROFILE %1 %2 %3 %4 %5 %6 %7 %8 %9
if errorlevel == 1 goto done
PREP /M %1
if errorlevel == 1 goto done
PLIST /SC %1 >%1.lst
 :done
```

Note that the PREP program is called twice - once before the actual profiling and again afterward. The command-line arguments govern PREP's behavior. Intermediate files with extensions .PBI, .PBO, and .PBT are used to transfer information between profiling steps. The first call to PREP generates a .PBI file which is passed to PROFILER. PROFILER generates a .PBO file which is passed in the second call to PREP. The second call to PREP generates a .PBT file which is passed to PLIST. The profiler data flow is shown in the following figure:

Profiler Data Flow





If the preceding batch file was named FTIME.BAT, and you wanted to profile the program TEST from the command prompt, you would type:

```
FTIME C:\Program Files\DF98\MYDIR\TEST.EXE
```

Profiler Batch Files

Like the linker, all three profiler programs accept response files. The following command line:

```
PREP /OM /FT /EXC nafxcwd.lib %1
```

can be replaced by this line:

```
PREP @opts.rsp %1
```

if you create a file OPTS.RSP that contains this text:

```
/OM /FT /EXC nafxcwd.lib # this is a comment
```

The # character in a response file defines a comment that runs through the end of the line.

Five standard batch files ship with the profiler:

Filename	**Description**
FTIME.BAT	Function timing
FCOUNT.BAT	Function counting
FCOVER.BAT	Function coverage
LCOUNT.BAT	Line counting
LCOVER.BAT	Line coverage

These batch files contain only the minimum parameters for the initial call to

PREP. Use them as prototypes for your own batch files, which should contain selection parameters. If you ran an unmodified LCOVER batch file for a complex Fortran 90 application with a large number of functions, subroutines and modules, the output report could be thousands of lines long.

Profiler Command-Line Options

The following sections describe the command-line options for the three components of the profiler:

- PREP
- PROFILE
- PLIST

PREP

The PREP program runs twice during a normal profiling operation. In Phase I, it reads an .EXE file and then creates .PBI and .PBT files. In Phase II, it reads .PBT and .PBO files and then writes a new .PBT file for PLIST. An 'X' in the following Options table indicates that a PREP command-line option applies to a particular phase.

The syntax for PREP is:

PREP [*options*] [*programname1*] [*programname2*...*programname8*]

PREP reads the command line from left to right, so the rightmost options override contradictory options to the left. None of the options are case sensitive. You must prefix options with a forward slash (/) or a dash (-), and options must be separated by spaces.

Parameter	**Description**
options	Control the kind of profiling, the inclusion and exclusion of code to be profiled, whether to merge profiles, and other profiling features. See the PREP Options table.
programname1	Filename of primary program to profile (.DBG, .EXE, or .DLL). PROFILE adds the .EXE extension if no extension is given. This parameter must be specified in the first call to PREP and not the second call.
programname2 ... *programname8*	Additional programs to profile. These parameters can be specified for the first call to PREP only.

PREP Options

Option	Phase I	Phase II	Description
/AT	X		Collects attribution data for function timing and function counting. Function attribution reports which function called another function. See the /STACK switch later in this list.
/CB	X		Used with function timing, allows you to set the calibrated overhead of profiler calls in the event that your function timing calls have varied because of varied calibrated overhead values. The calibrated overhead is displayed in default (non-tab-delimited) PLIST output.
/EXC	X		Excludes a specified module from the profile (See the Remarks section).
/EXCALL	X		Excludes all modules from the profile (See the Remarks section).
/FC	X		Selects function count profiling.
/FT	X		Selects function timing profiling. This option causes the profiler to generate count information as well.
/FV	X		Selects function coverage profiling.
/INC	X		Includes in profile (See the Remarks section).
/H[ELP]	X	X	Provides a short summary of PREP options.
/IO *filename*		X	Merges an existing .PBO file (the file generated by PROFILER to be passed in the second call to PREP). Up to eight .PBO files can be merged at a time. The default extension is .PBO.
/IT *filename*		X	Merges an existing .PBT file (the file generated by the second call to PREP to be passed to PLIST). Up to eight .PBT files can be merged at a time. You cannot merge .PBT files from different profiling methods. The default extension is .PBT.
/LC	X		Selects line count profiling.

/LV	X		Selects line coverage profiling.
/M *filename*		X	Substitutes for /IT, /IO, and /OT options.
/NOLOGO	X	X	Suppresses the PREP copyright message.
/OI *filename*	X		Creates a .PBI file (the file generated by the first call to PREP). The default extension is .PBI. If /OI is not specified, the output .PBI file is *programname1*.PBI.
/OM	X		Creates a self-profiling file with _XE or _LL extension for function timing, function counting, and function coverage. Without this option, the executable code is stored in the .PBI file. This option speeds up profiling.
/OT *filename*	X	X	Specifies the output .PBT file. The default extension is .PBT. If /OT is not specified, the output .PBT file is *programname1*.PBT.
/SF *function*	X		Starts profiling with *function*. The function name must correspond to an entry in the .MAP file.
/STACK *dpt*	X		When using the /AT switch, you can also set the stack depth (*dpt*) to which functions will have their attribution data recorded.
/?	X	X	Provides a short summary of PREP options.

Environment Variable

The PREP environment variable specifies the default PREP command-line options. If a value for the PREP environment variable is not specified, the default options for PREP are:

```
/FT /OI filename /OT filename
```

where *filename* is set to the *programname1* parameter value.

Remarks

The /INC and /EXC options specify individual .LIB, .OBJ, .FOR and .F90 files. For line counting and line coverage, you can specify line numbers with source files as in:

```
/EXCALL /INC TEST.F90(3-41,50-67)
```

In this example, the /EXCALL option excludes all modules from the profile, and the /INC option supercedes that to include only lines 3 - 41 and lines 50 - 67 from the source file TEST.F90. Note the absence of spaces in the source specification.

To specify all source lines in a particular module, specify the .OBJ file like this:

```
/EXCALL /INC TEST.OBJ
```

or by using the source filename with zero line numbers like this:

```
/EXCALL /INC TEST.F90(0-0)
```

The following statement profiles from line 50 to the end of the file:

```
/EXCALL /INC TEST.F90(50-0)
```

PROFILE

PROFILE profiles an application and generates a .PBO file of the results. Use PROFILE after creating a .PBI file with PREP.

The syntax for PROFILE is:

PROFILE [*options*] *programname* [*programargs*]

PROFILE reads the command line from left to right, so the rightmost options override contradictory options to the left. None of the options are case sensitive. You must prefix options with a forward slash (/) or a dash (-), and options must be separated by spaces.

If you do not specify a .PBO filename on the command line, PROFILE uses the base name of the .PBI file with a .PBO extension. If you do not specify a .PBI or a .PBO file, PROFILE uses the base name of *programname* with the .PBI and .PBO extensions.

Parameter	**Description**
options	Control .PBI input, .PBO output, error printing, and other profiler features. (See the PROFILE Options table).
programname	Filename of program to profile. PROFILE adds the .EXE extension if no extension is given. (See the Remarks section.)
programargs	Optional command-line arguments for *programname*. (See the Remarks section.)

PROFILE Options

Option	Description
/A	Appends any redirected error messages to an existing file. If the /E command-line option is used without the /A option, the file is overwritten. This option is valid only with the /E option.
/E *filename*	Sends profiler-generated error messages to *filename.*
/H[ELP]	Provides a short summary of PROFILE options.
/ I *filename*	Specifies a .PBI file to be read. This file is generated by PREP.
/NOLOGO	Suppresses the PROFILE copyright message.
/O *filename*	Specifies a .PBO file to be generated. Use the PREP utility to merge with other .PBO files or to create a .PBT file for use with PLIST.
/X	Returns the exit code of the program being profiled.
/?	Provides a short summary of PROFILE options.

Environment Variable

The PROFILE environment variable specifies the default command-line options for PROFILE. If the PROFILE environment variable is not specified, there are no defaults.

Remarks

You must specify the filename of the program to profile on the PROFILE command line. PROFILE assumes the .EXE extension, if no extension is given.

You can follow the program name with command-line arguments; these arguments are passed to the profiled program unchanged.

If you are profiling code in a .DLL file, give the name of an executable file that calls it. For example, if you want to profile SAMPLE.DLL, which is called by CALLER.EXE, you can type:

```
PROFILE CALLER.EXE
```

assuming that CALLER.PBI has SAMPLE.DLL selected for profiling.

PLIST

PLIST converts results from the .PBT file generated by the second call to PREP into a formatted text file.

The syntax for PLIST is:

PLIST [*options*] *inputfile*

PLIST reads the command line from left to right, so the rightmost options override contradictory options to the left. None of the options are case sensitive. You must prefix options with a forward slash (/) or a dash (-), and options must be separated by spaces.

PLIST results are sent to STDOUT by default. Use the greater-than (>) redirection

PLIST must be run from the directory in which the profiled program was compiled.

Parameter	**Description**
options	Control the format and organization of profiler output data. (See the PLIST Options table.)
inputfile	The .PBT file to be converted by PLIST.

PLIST Options

Option	**Description**
/C *count*	Specifies the minimum hit count to appear in the listing.
/D *directory*	Specifies an additional directory for PLIST to search for source files. Use multiple /D command-line options to specify multiple directories. Use this option when PLIST cannot find a source file.
/F	Lists full paths in tab-delimited report.
/FLAT	When using function attribution (see PREP /AT), displays function attribution with no indentation.
/H[ELP]	Provides a short summary of PLIST options.

/INDENT	When using function attribution (see PREP /AT), displays function attribution information in indented format. This is the default display for function attribution if neither /FLAT nor /TAB is selected.
/NOLOGO	Suppresses the PLIST copyright message.
/PL *length*	Sets page length (in lines) of output. The length must be 0 or 15-255. A length of 0 suppresses page breaks. The default length is 0.
/PW *width*	Sets page width (in characters) of output. The width must be 1-511. The default width is 511.
/SC	Sorts output by counts, highest first.
/SL	Sorts output in the order that the lines appear in the file. This is the default. This option is available only when profiling by line.
/SLS	Forces line count profile output to be printed in coverage format.
/SN	Sorts output in alphabetical order by function name. This option is available only when profiling by function.
/SNS	Displays function timing or function counting information in function coverage format. Sorts output in alphabetical order by function name.
/ST	Sorts output by time, highest first.
/T	Tab-separated output. Generates a tab-delimited database from the .PBT file for export to other applications. All other options, including sort specifications, are ignored when using this option. For more information, see Exporting Data from the Profiler.
/TAB *indent*	When using function attribution (see PREP /AT), sets tab width for indentation of function information.
/?	Provides a summary of PLIST options.

Environment Variable

The PLIST environment variable specifies the default command-line options for PLIST. If the PLIST environment variable is not specified, the default options for PLIST depend on the profile type as shown:

Profile Type	Sort Option	Hit Count Option
Function timing	/ST	/C 1
Function counting	/SC	/C 1
Function coverage	/SN	/C 0
Line counting	/SL	/C 0
Line coverage	/SLS	/C 0

Exporting Data from the Profiler

In addition to formatted reports, the PLIST report-generation utility can produce a tab-delimited report of profiler output. The following sections describe the data format of the report, steps for analyzing statistics in the report, and a Microsoft Excel macro that uses this report format:

- Tab-Delimited Record Format
- Global Information Records
- Local Information Records
- Steps to Analyze Profiler Statistics
- Processing Profiler Output with Microsoft Excel
- Generating the Tab-Delimite Report
- Using the PROFILER.XLM Macro
- Changing the PROFILER.XLM Selection Criteria

The PLIST /T command-line option causes PLIST to dump the contents of a .PBT file into a tab-delimited format suitable for import into a spreadsheet or database. This format can also be used by user-written programs.

For example, to create a tab-delimited file called MYPROG.TXT from MYPROG.PBT, enter:

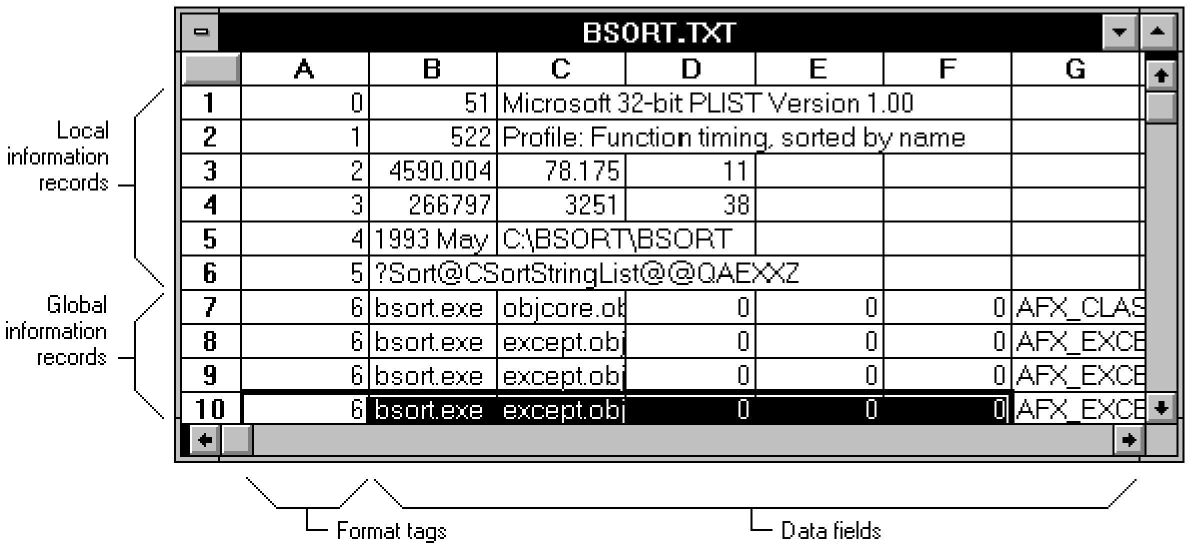
```
PLIST /T MYPROG > MYPROG.TXT
```

The ASCII tab-delimited format was designed to be read by other programs; it was not intended for general reporting.

Tab-Delimited Record Format

Every piece of data stored by the Profiler is available through the tab-delimited report. Because not all aspects of the database are recorded by every profiling method, unused fields within a record may be zero. For example, the total time of the program will be zero if the program was profiled for counts only. Also, all included functions will be listed for function counting and timing profiles, even if those functions were not executed.

The tab-delimited format is arranged with one record per line and two to eight fields per record. The following figure shows how a database looks when loaded into Microsoft Excel. The database was produced using the PLIST /T command-line option.



The first item in each record is a format tag number. These tags range from 0 to 7 and indicate the kind of data given in the other fields of the record. The fields in each record are described in:

- Global Information Records
- Local Information Records

Tab-delimited reports are generated with global information records first, organized in numerical order by format tag. The local information records, containing information about specific lines or functions, are generated last. Local information records are organized by line number.

If the .PBT file contains information from more than one .EXE or .DLL file, the global information will cover them all. Local information records include the EXE field, which specifies the name of the executable file that each record pertains to.

Global Information Records

The global information records contain information about the entire executable file. The format tag numbers for global information records are 0 through 5. The record formats are as follows:

Profiling Banner		
0	Version	Banner

Field	Explanation
0	Format tag number
Version	PLIST version number
Banner	PLIST banner

Profiling Method		
1	Method	Description

Field	Explanation
1	Format tag number
Method	Numeric value that indicates the profiling type (see the following table)
Description	ASCII description of the profiling type given by the method field

The profiling types are listed in the following table:

Profiling Types	
Method	**Description**
321	Profile: Line counting, sorted by line
324	Profile: Line coverage, sorted by line
521	Profile: Function counting, sorted by function name
522	Profile: Function timing, sorted by function name
524	Profile: Function coverage, sorted by function name

Profiling Time and Depth			
2	Total Time	Outside Time	Call Depth

Field	Explanation
2	Format tag number
Total Time	Total amount of time used by the program being profiled. This field is zero for counting and coverage profiles
Outside Time	Amount of time spent before the first profiled function (with function profiling) or line (with line profiling) was executed. This field is zero for counting and coverage profiles
Call Depth	Maximum number of nested functions found while profiling. Only profiled functions are counted. This field is zero for line-level profiling

Profiling Hit Counts			
3	Total Hits	Lines/Funcs	Lines/Funcs Hit

Field	Explanation
3	Format tag number
Total Hits	Total number of times the profiler detected a profiled line or function being executed
Lines/Funcs	Total number of lines or functions marked for profiling
Lines/Funcs Hit	Number of marked lines or functions executed at least once while profiling

Profiling Date/Command Line		
4	Date	Command Line

Field	Explanation
4	Format tag number
Date	The date/time the profile was run (ASCII format)
Command Line	The PLIST command-line arguments

Profiling Starting Function Name	
5	Starting Function Name

Field	Explanation
5	Format tag number
Starting Function Name	The decorated name of the starting function identified by the PREP /SF parameter

Local Information Records

The local information records contain information about specific lines or functions that were profiled. The format tag numbers for local information records are 6 and 7. A report can have only one kind of local information record. The record formats are as follows:

Profiling Function Information						
6	Exe	Source	Count	Time	Child	Func

Field	Explanation
6	Format tag number
Exe	ASCII name of the executable file that contains this function.
Source	ASCII name of the object module (including the .OBJ extension) that contains this function
Count	Number of times this function has been executed
Time	Amount of time spent executing this function in milliseconds. This field is zero with profiling by counting or coverage
Child	Amount of time spent executing the function and any child functions it calls. This field is zero with profiling by counting or coverage
Func	ASCII name of the function

Profiling Line Information				
7	Exe	Source	Line	Count

Field	Explanation
7	Format tag number
Exe	ASCII name of the executable file that contains this function
Source	ASCII name of the source that contains the first line of this function
Line	Line number of this line
Count	Number of times this line has been executed. With coverage, this field is 1 if the line has been executed and 0 otherwise

Profiling Function-Attribution Stacks	
8	Number of stacks

Field	Explanation
8	Format tag number
Number of stacks	Number of stacks for each function call

Profiling Stack Hits and Timing				
9	Stack size	Hit count	Stack time	Child time

Field	Explanation
9	Format tag number
Stack size	Stack size for each function call
Hit count	Hit count for this stack
Stack time	This stack's self-time
Child time	This stack's child-time

Profiling Stack Function Name	
10	Function name

Field	Explanation
10	Format tag number
Function name	Each function's name on the stack. The number of names that appear here will be equal to the stack size field in Profiling Stack Hits and Timing (above).

Steps to Analyze Profiler Statistics

The profiler tab-delimited report format can contain a great deal of information. You can process this data in a spreadsheet, database, or user-written program.

To process the data in the tab-delimited report:

1. Collect the cumulative data from the global information records. These lines begin with the numbers 0 through 5. Each of these lines appears only once, and always in ascending order.
2. Determine the type of database by finding the value of the "Method" field. This field is the second field of record type 1.
3. If the value in the "Method" field is greater than 400, the report comes from function profiling. If it is less than 400, the report comes from line profiling. The type of information in the local information records given later is directly related to this value.
4. In any one report, the local information records are always of the same type, either line information or function information.
5. Process data from the local information records. For example, to calculate the percentage of hits on a given function, divide the value of the "Count" field in record type 6 by the total number of hits from the "Total Hits" field of record type 3.
6. Remember that there can be only one type of local information record (either line or function information) in a report.
7. Send the results to a file or STDOUT.

Processing Profiler Output with Microsoft Excel

PROFILER.XLM is an example Microsoft Excel™ macro that processes a tab-delimited profiler report (generated by PLIST) and creates a graph based on the results. You will find this macro in the `..\vc\bin` directory.

The PROFILER.XLM macro is composed of four sub-macros. The first two macros, in columns A and B, are helper macros that copy and preprocess the data for use by the second pair of macros in columns C and D. The macro in column C, labeled CreateColumnChart, creates a graph showing the number of times that each function or line was executed. The final macro, in column D, is CreateColumnTimeChart; it works like CreateColumnChart, but operates on timing information.

Generating the Tab-Delimited Report

To generate the tab-delimited report, use the PLIST /T option. This can be done after the normal profile run has been completed; PLIST will read the profile data from the last profiler execution. The output of PLIST /T should be redirected to a file, preferably with the .XLS extension for easy loading into Excel (Excel will interpret the tab-delimited file correctly as a text file even with the .XLS extension).

Using the PROFILER.XLM Macro

To run the macro, follow these steps from within Microsoft Excel:

1. Open PROFILER.XLM by choosing Open from the File menu.
2. Open the tab-delimited report that was created by PLIST by choosing Open from the File menu.
3. If you have several open worksheets, activate the one containing the profiler data by selecting it with the mouse or by choosing its title from the Windows menu.
4. Run the macro:
   - Press Ctrl+C for a chart based on hit counts.
   - Press Ctrl+T for a chart based on timing.

You cannot get a timing chart if the report contains only counting or coverage information.

The macro typically takes only a few seconds to execute. When it is complete, Microsoft Excel displays a 3-D bar chart based on the results in the report. You can change the chart type by using the Gallery menu.

This macro copies the data in the report to another worksheet before processing it. The original tab-delimited report is left untouched.

Changing the PROFILER.XLM Selection Criteria

The standard PROFILER.XLM macro displays hit counts greater than 0 (for Ctrl+C) and times greater than .01 millisecond (for Ctrl+T). If you need to narrow the selections without analyzing the macro, edit the formulas in cells C10 and D10.

Fortran Tools: FSPLIT and FPR

This section describes the following Fortran command-line tools:

- FSPLIT (includes FSPLIT90)
- FPR

FSPLIT and FSPLIT90

The FSPLIT and FSPLIT90 tools split a multi-routine Fortran file into individual files. These tools are useful if you have a large Fortran program.

Use FSPLIT90 when your program uses free-form source or Fortran 95/90 constructs. Use FSPLIT for FORTRAN 77 code. The FSPLIT and FSPLIT90 commands have the same form:

FSPLIT [*options*] [*input-file*...]

FSPLIT90 [*options*] [*input-file*...]

options
Is one of the keywords listed in the following table. If more than one option is specified, separate each with a space. The command options are:

Option	Description
`-e:`*name*	Processes only the program unit name. You can specify more than one -e *name* on a command line.
`-extend_source`	Treats the statement field of each source line as ending in column 132, instead of column 72.
`-help, ?`	Displays information about the FSPLIT command.
`-nologo`	Suppresses the copyright notice that is displayed when FSPLIT or FSPLIT90 is run.
`-silent`	Suppresses display of the name of each file opened (input and output files).
input-file	A Fortran source file to be split. You can specify more than one file by using a list of files. If *input-file* is omitted the FSPLIT or FSPLIT90 Utility reads from standard input.

input-file
A Fortran source file to be split. You can specify more than one file by using a list of files. If *input-file* is omitted the FSPLIT or FSPLIT90 Utility reads from standard input.

FSPLIT or FSPLIT90 splits multi-routine Fortran files into separate routine files of the form *filename*.for, where *filename* is the name of the program unit (for example: a function, subroutine, block data, or program). The name for unnamed block data subprograms has the form `blkdta`*nnn*`.for`, where *nnn* is a 3-digit code. For unnamed main programs, the name has the form `main`*nnn*`.for`.

If there is an error in classifying a program unit, or if *filename*.for already exists, the program unit is put in a file named `zzz`*nnn*`.for`, where *nnn* is a 3-digit code.

Normally each subprogram unit is split into a separate file.

Avoid using the `-e` option for unnamed main programs and block data subprograms since you must predict the created file name.

If FSPLIT or FSPLIT90 cannot find the names specified by the `-e` option, an error message is written to standard error device.

The following command example splits the subprogram units `readit` and `doit` into separate files:

```
FSPLIT -e readit -e doit prog.for
```

FPR

The FPR tool transforms files formatted according to Fortran's carriage control conventions into files formatted according to line printer conventions. The FPR command has the following form:

FPR [-f *record-size*] [*filename*]

record-size
Specifies a fixed-length record as input. The *record-size* must be a decimal integer.

filename
Specifies the data file to be transformed.

FPR copies the input *filename* onto itself, replacing the carriage control characters with characters that will produce the intended effects when printed using the PRINT command. The first character of each line determines the vertical spacing as follows:

Character	Vertical Space Before Printing
Blank	One line
0	Two lines
1	To first line of next page
+	No advance
$ or ASCII NUL	One line; no return after printing

FPR interprets the first character of every line of input, even if that character is not a recognizable control character. Control characters that are not recognized are treated as blanks and result in a single line advance.

FPR handles stream and fixed-length files. Input to FPR is assumed to be a stream (Stream_LF) file, unless you specify the `-f` option.

No diagnostic message is issued when FPR encounters an unrecognized control character.