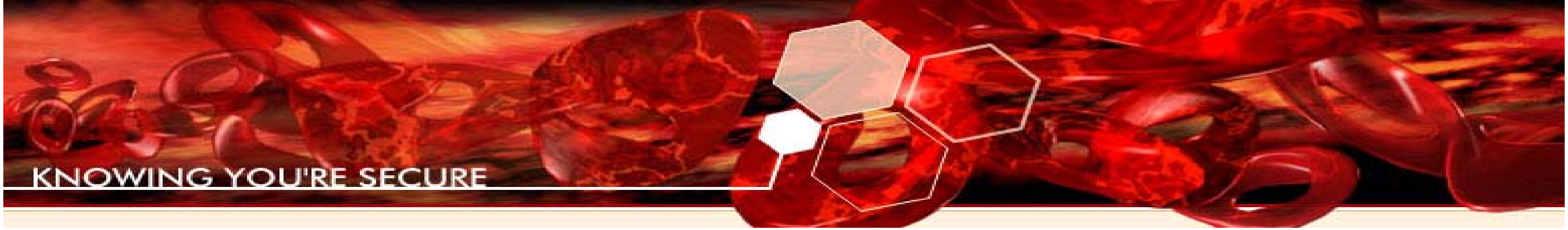

Using Immunity Debugger to Write Exploits

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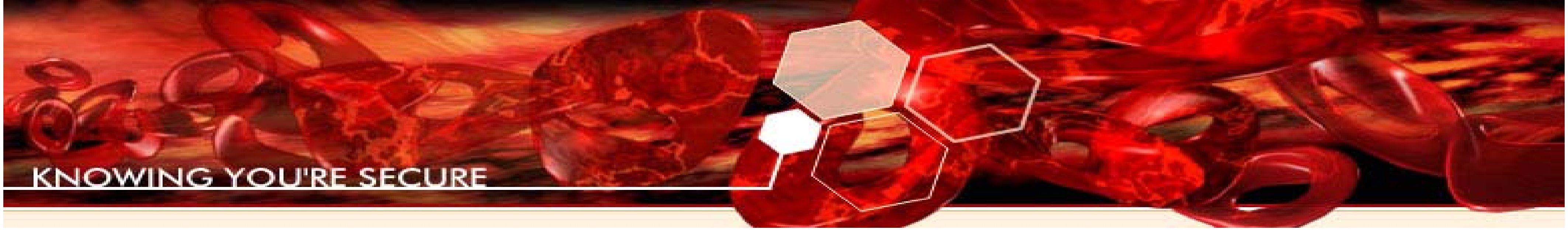
IMMUNITY Security Research

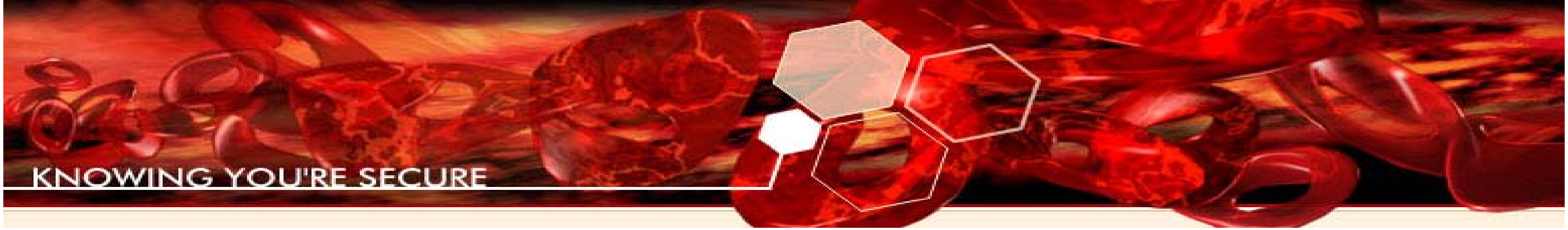


Who am I?

- CTO, Immunity Inc.
- Responsible for new product development
  - Immunity Debugger
  - SILICA
  - Immunity CANVAS

Software companies now understand the value of security

- Over the past few years regular users have become more aware of security problems
- As a result 'security' has become a valuable and marketable asset
- Recognizing this, the computer industry has invested in both hardware and software security improvements



Immunity Debugger is a strategic answer to defensive advances

- ASLR, NX, /gS and high levels of automated and manual code auditing have raised the bar significantly
- Attackers operate at a distinct disadvantage
  - No source code or internal documentation on structures and protocols
  - Vulnerabilities must be created into reliable exploits

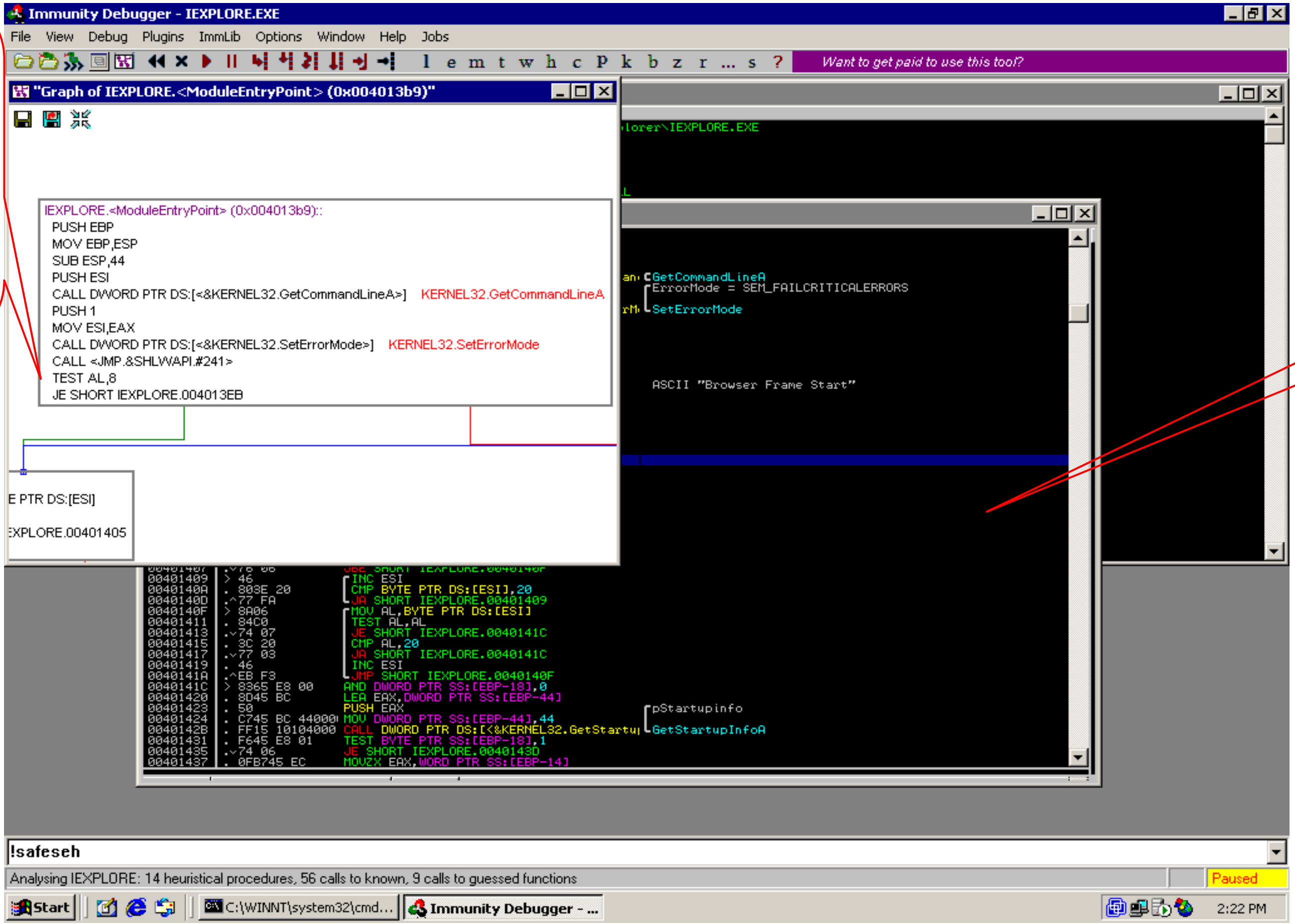
But attackers have their own resources

- Used to working in small teams
- Broad range of knowledge (Unix hackers that know Win32, etc)
- Exploit development knowledge is often not fed back to defensive teams, allowing for knowledge leadership over a long time period
  - i.e. new bug classes and attack surfaces

Attackers will defeat the current generation through profound and rapid tool innovation

- Interfaces
- Analysis engines
- Integration into existing tool-sets
- Teamwork and coordination

Better interfaces save valuable time



```
IEXPLORE.<ModuleEntryPoint> (0x004013b9)::
 PUSH EBP
 MOV EBP,ESP
 SUB ESP,44
 PUSH ESI
 CALL DWORD PTR DS:[<&KERNEL32.GetCommandLineA>]   KERNEL32.GetCommandLineA
 PUSH 1
 MOV ESI,EAX
 CALL DWORD PTR DS:[<&KERNEL32.SetErrorMode>]   KERNEL32.SetErrorMode
 CALL <JMP.&SHLWAPI.#241>
 TEST AL,8
 JE SHORT IEXPLORE.004013EB
```

```
E PTR DS:[ESI]
XPLORE.00401405
```

```
lorer\IEXPLORE.EXE
```

```
an GetCommandLineA
    ErrorMode = SEM_FAILCRITICALERRORS
rM  SetErrorMode

    ASCII "Browser Frame Start"
```

```
00401409 > 46              INC ESI
0040140A . 803E 20         CMP BYTE PTR DS:[ESI],20
0040140D .^77 FA           JA SHORT IEXPLORE.00401409
0040140F > 8A06            MOV AL,BYTE PTR DS:[ESI]
00401411 . 84C0            TEST AL,AL
00401413 .v74 07           JE SHORT IEXPLORE.0040141C
00401415 . 3C 20           CMP AL,20
00401417 .v77 03           JA SHORT IEXPLORE.0040141C
00401419 . 46              INC ESI
0040141A .^EB F3           JMP SHORT IEXPLORE.0040140F
0040141C > 8365 E8 00      AND DWORD PTR SS:[EBP-18],0
00401420 . 8D45 BC         LEA EAX,DWORD PTR SS:[EBP-44]
00401423 . 50              PUSH EAX                                pStartupinfo
00401424 . C745 BC 44000   MOV DWORD PTR SS:[EBP-44],44
0040142B . FF15 10104000   CALL DWORD PTR DS:[<&KERNEL32.GetStartu  GetStartupInfoA
00401431 . F645 E8 01      TEST BYTE PTR SS:[EBP-18],1
00401435 .v74 06           JE SHORT IEXPLORE.0040143D
00401437 . 0FB745 EC       MOVZX EAX,WORD PTR SS:[EBP-14]
```

```
!safeseh
```

```
Analysing IEXPLORE: 14 heuristical procedures, 56 calls to known, 9 calls to guessed functions
```

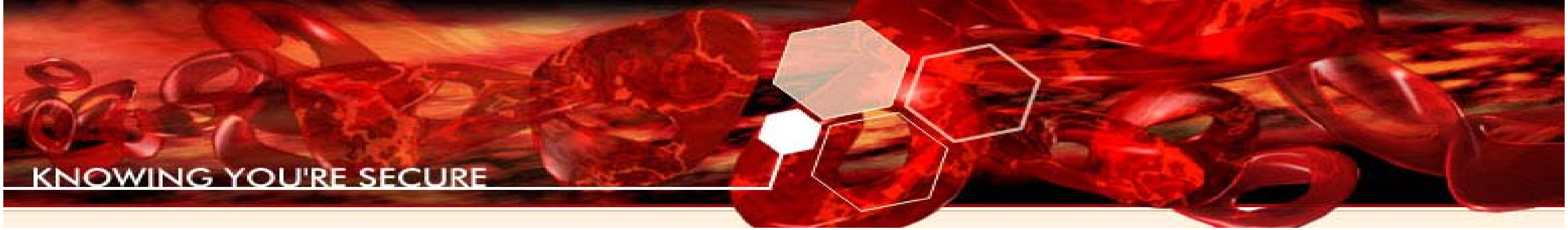
Pure-Python Graphing

Usable GUI

WinDBG-like command line

Python integration offers useful analysis

- safeseh discovery
- stack/heap variable sizing
- most importantly – custom automated binary analysis can be written cheaply and easily!
- Static and runtime analysis



Existing toolsets are also in Python

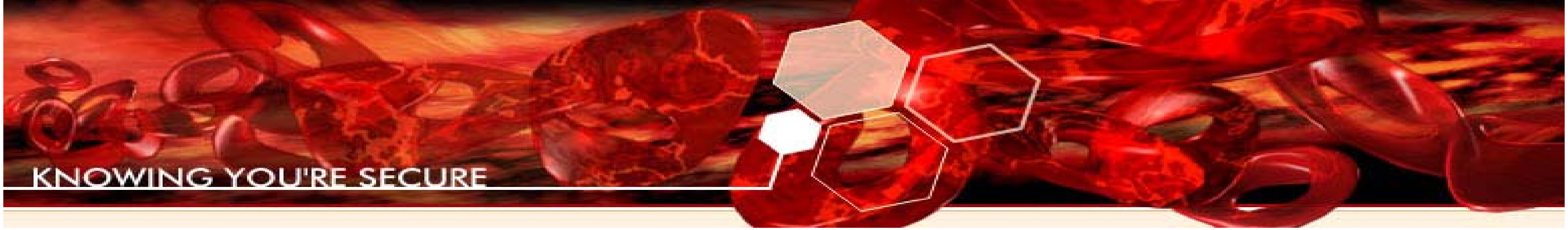
- Python x86 emulators
- Python exploit frameworks
- Python web application analysis
- PEID
- Non-python toolkits can be accessed easily via Sockets or XML-RPC

Hackers already work in teams...

- But their tools don't – yet
- Ongoing efforts include
  - SVN + Debugger
  - Portable function fingerprints
  - Global RE database
- While previous efforts have broken ground in team binary analysis, in a year, this will be the default mode of operation

Two examples of how Immunity Debugger changes assessment and exploitation

- File Include/SQL Injection bugs
- Heap Overflows



SQL Injection/File Include

- Traditionally web applications are looked at via code review or remote blind assessment
  - But complexity is rising and closed source modules are common
- With ID's sql_hooker.py and sqllistener.py
  - All SQL Queries get sent to the attacker via XML-RPC
  - Python lets you filter on only interesting results at server side

Heap overflows are dead, long live heap overflows

- Common technique for reliable exploitation of heap overflows is the write4 primitive

- OS Vendors are well aware of this

And so… heap protection has been introduced

- Windows XP SP2, Windows 2003 SP1 and Vista introduced different heap validity checks to prevent unlink() write4 primitives
- Similar technologies are in place in glibc in Linux
- There are no generic ways to bypass the new heap protection mechanisms
  - The current approaches have a lot of requirements: **How do we meet these requirements?**

XP SP2 makes our work hard

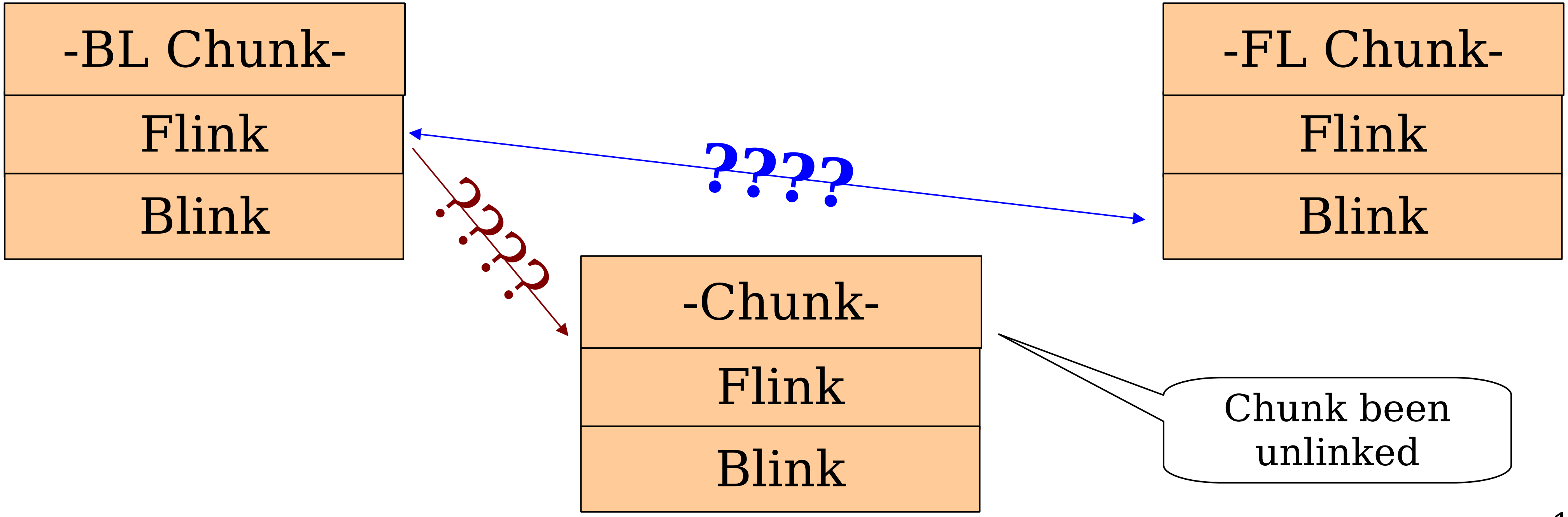
- Windows XP SP2 introduced the first obvious protection mechanism
  - unlinking checks:

```
blink = chunk->blink
flink = chunk->flink

if blink->flink == flink->blink
 and blink->flink == chunk
```

and harder...

- Windows XP SP2 introduced the first obvious protection mechanism
  - unlinking checks:



XP SP2 (and Vista) introduced more heap protections

- Low Fragmentation Heap Chunks:

  metadata semi-encryption

```
subsegment  = chunk->subsegmentcode
subsegment ^= RtlpLFHKey
subsegment ^= Heap
subsegment ^= chunk >> 3
```

Vista heap algorithm changes make unlink() unlikely

- Vista Heap Chunks:

metadata semi-encryption and integrity check

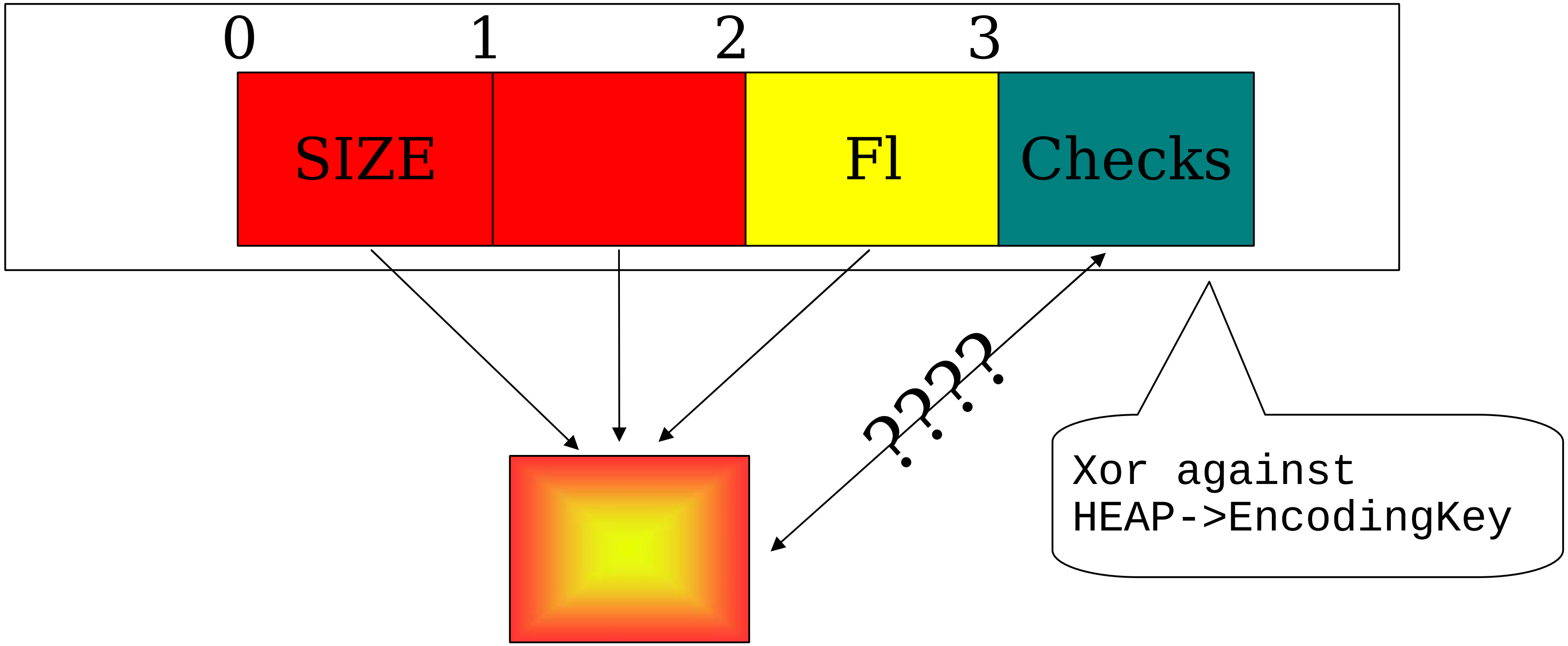
```
*(chunk)    ^=   HEAP->EncodingKey
checksum     =   (char) *( chunk + 1)
checksum    ^=   (char) *( chunk )
checksum    ^=   (char) *(chunk + 2)

if checksum == chunk->Checksum
```

Checksum makes it hard to predict and control the header

- Vista Heap Chunks:

metadata semi-encryption and integrity check



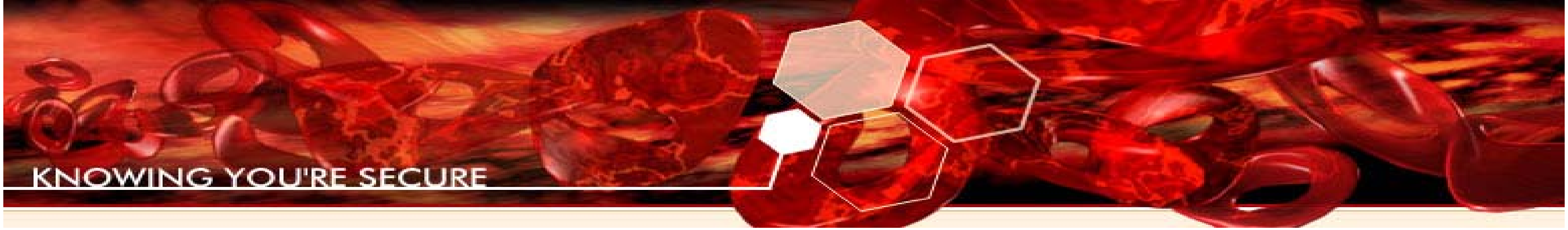
Xor against HEAP->EncodingKey

Other protections in Vista are not heap specific

- Other protection mechanisms:
    - ASLR of pages
    - DEP (Hardware NX)
    - Safe Pointers
    - SafeSEH (stack)
    - etc.

A lot of excellent work has been done to bypass heap protections

- Taking advantage of Freelist[0] split mechanism (*“Exploiting Freelist[0] on XP SP2”* by Brett Moore)
- Taking advantage of Single Linked List unlink on the Lookaside (Oded Horovitz and Matt Connover)
- Heap Feng Shui in Javascript (Alexander Sotirov)



We no longer use heap algorithms to get write4 primitives

- Generic heap exploitation approaches are obsolete. There is no more easy write4.
  - Sinan: "*I can make a strawberry pudding with so many prerequisites*"
- Application specific techniques are needed
  - We use a methodology based on understanding and controlling the algorithm to position data carefully on the heap

We have been working on this methodology for years

- All good heap overflow exploits have been in careful control of the heap for years to reach the maximum amount of reliability
- We now also attack not the heap metadata, but the heap data itself
  - Because our technique is specific to each program, generic heap protections can not prevent it
- Immunity Debugger contains powerful new tools to aid this process

Previous exploits already carefully crafted the heap

- Spooler Exploit:
  - Multiple Write4 with a combination of the Lookaside and the FreeList
- MS05_025:
  - Softmemleaks to craft the proper layout for two Write4 in a row
- Any other reliable heap overflow
- These still used write4s from the heap algorithms themselves!

To establish deterministic control over the Heap you need

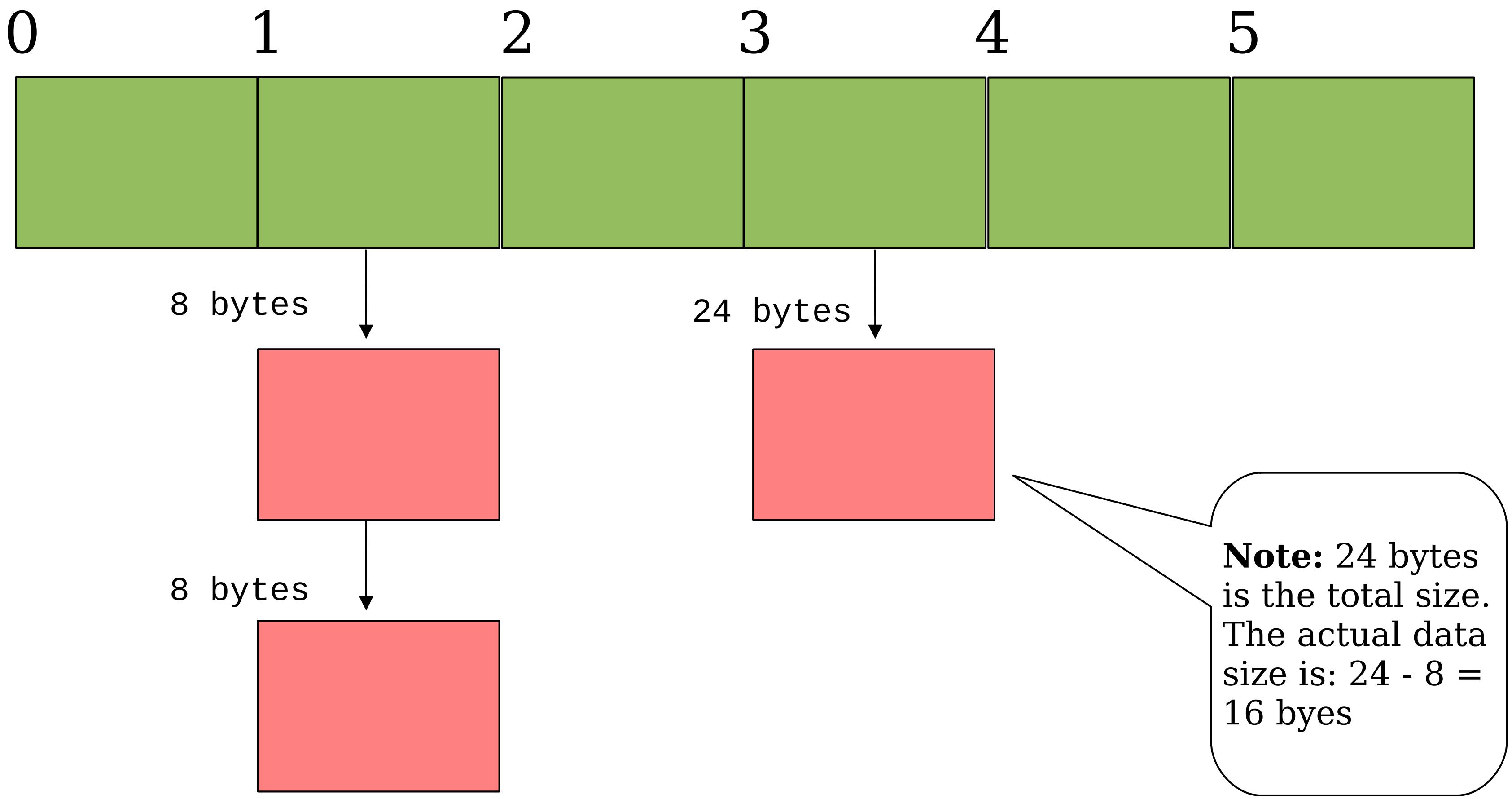
- Understanding of the allocation algorithm
- Understanding of the layout you are exploiting
- A methodology to control the layout
- The proper tools to understand and control the allocation pattern of a process

The heap, piece by piece

- Understanding the algorithm
  - Structures where chunks are held:
    - Lookaside
    - FreeList
- Understanding Chunk Behaviour
  - Coalescing of Chunks
  - Splitting of Chunks

A quick look at the lookaside

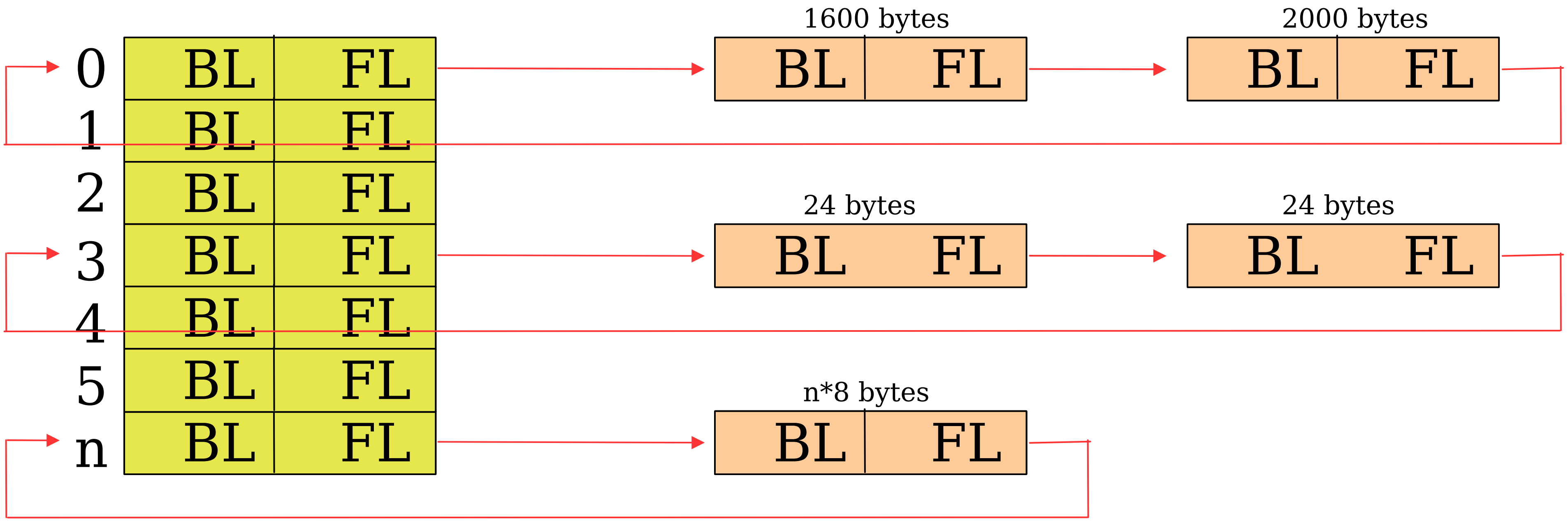
- Lookaside



Note: 24 bytes is the total size. The actual data size is: 24 - 8 = 16 byes

A quick look at the FreeList data structure

- FreeList



0 BL FL
1 BL FL
2 BL FL
3 BL FL
4 BL FL
5 BL FL
n BL FL

1600 bytes
BL FL

2000 bytes
BL FL

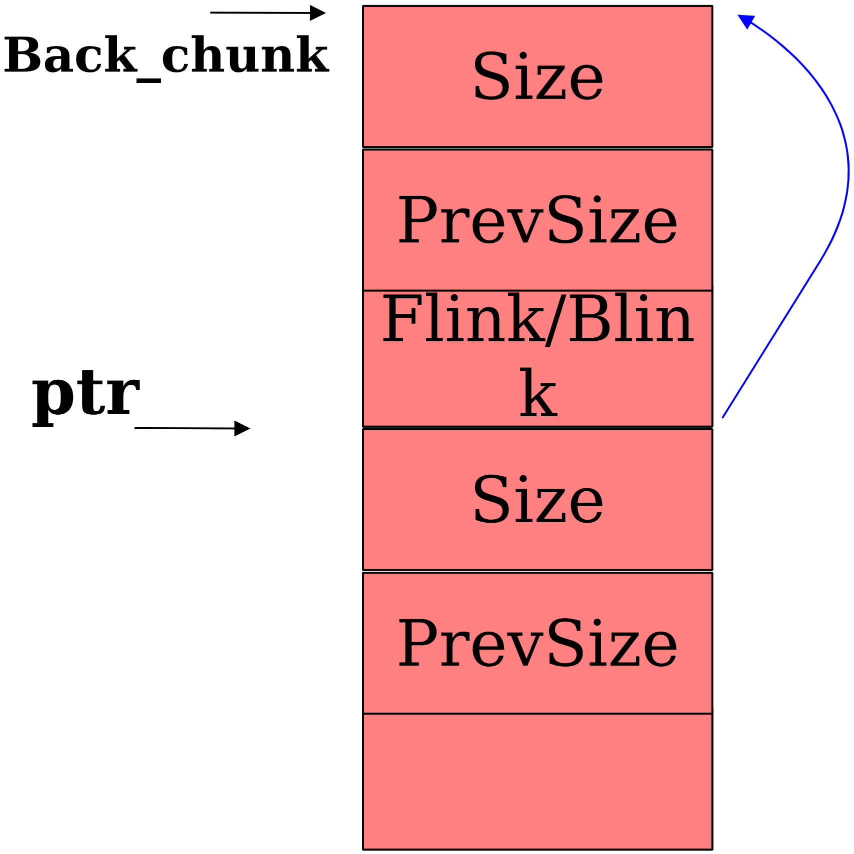
24 bytes
BL FL

24 bytes
BL FL

n*8 bytes
BL FL

Where n < 128

Chunk coalescing: contiguous free chunks are joined to minimize fragmentation



Back_chunk

ptr

Size

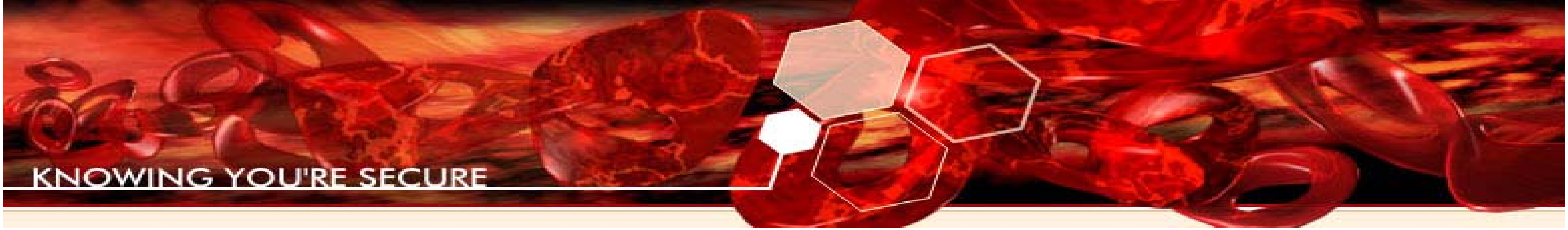
PrevSize

Flink/Blink

Size

PrevSize

```
PSize= *(ptr+2)
Back_chunk = ptr-(PSize*8)
if Back_chunk is not BUSY:
    unlink(Back_chunk)
```



Chunks are split into two chunks when necessary

- Chunk splitting happens when a chunk of a specific size is requested and only larger chunks are available
- After a chunk is split, part of the chunk is returned to the process and part is inserted back into the FreeList

The life-cycle of a heap overflow

- There are four distinct segments in a heap exploit's life that you need to understand and control:
  - Before the overflow
  - Between the overflow and a “Write4”
  - Between the “Write4” and the function pointer trigger
  - Hitting payload and onward (surviving)

} Might be the same

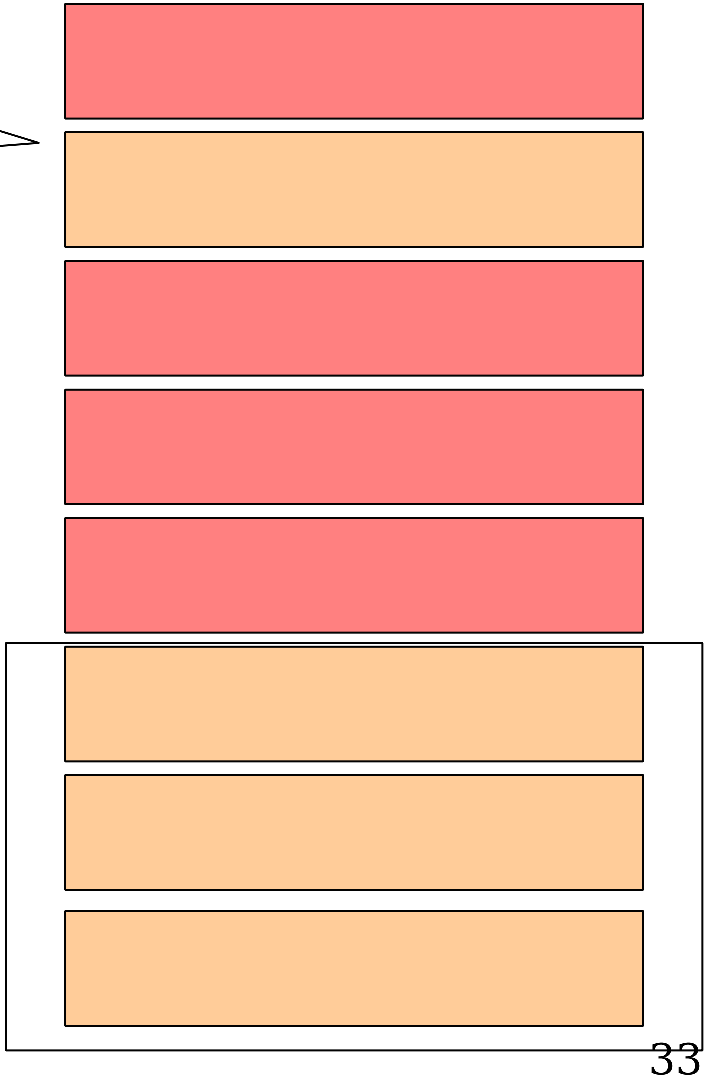
Heaps do not all start in the same layout

- With heap overflows it is not always easy to control how an overwritten chunk will affect the operation of the heap algorithm
- Understanding how the allocation algorithm works, it becomes apparent that doing three allocations in a row does not mean it will return three bordering chunks
- Typically this problem is because of “Heap Holes”

Heap Holes

- Assume

Chunk is part of the FreeList[97]



```
Vulnerable(function)

  A = Allocate(0x300);
  B = Allocate(0x300);
  [...]
  Overwrite(A);
  fn_ptr = B[4];
  fn_ptr("hello world");
```

Heap Holes

- Assuming

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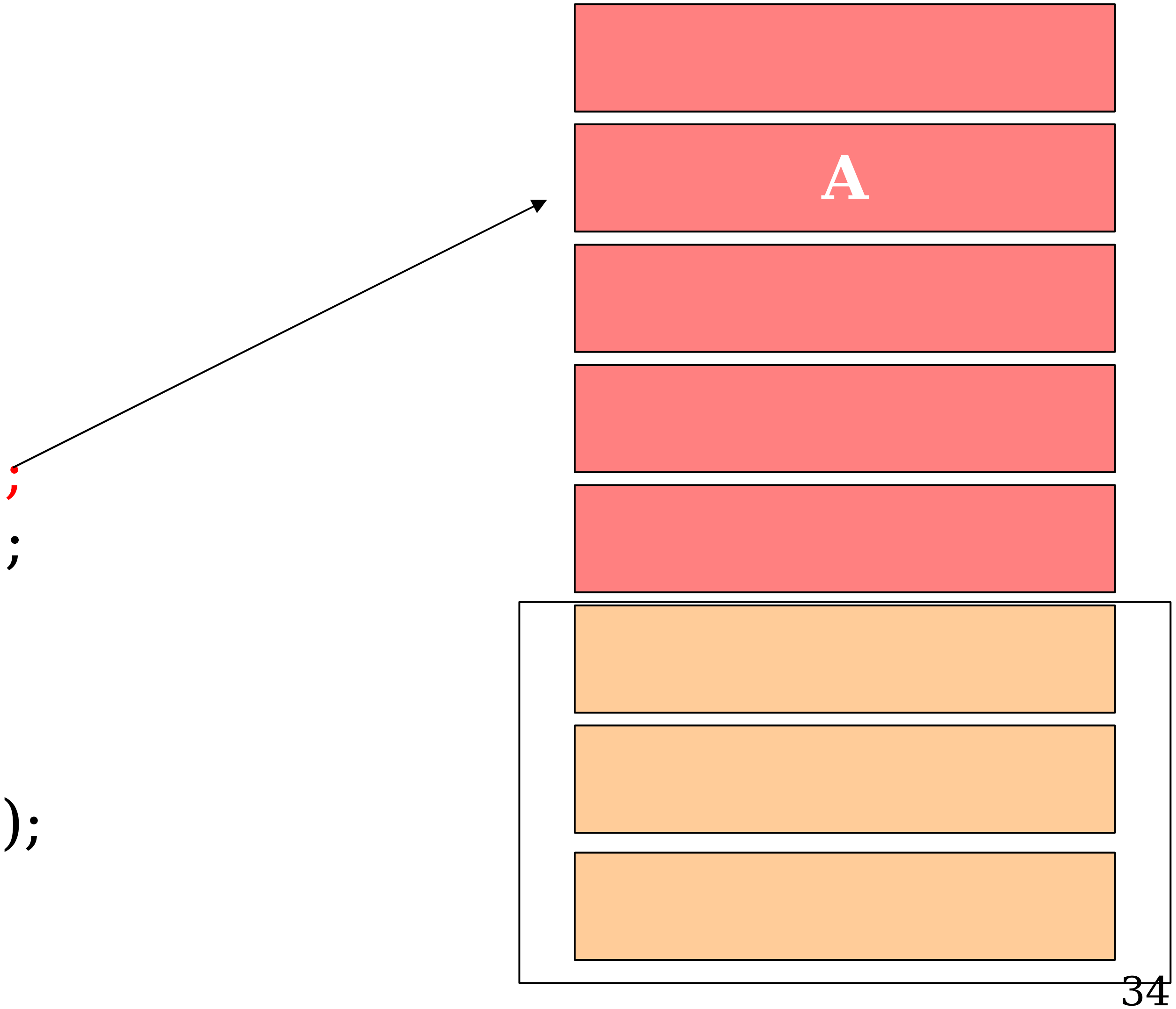

Heap Holes

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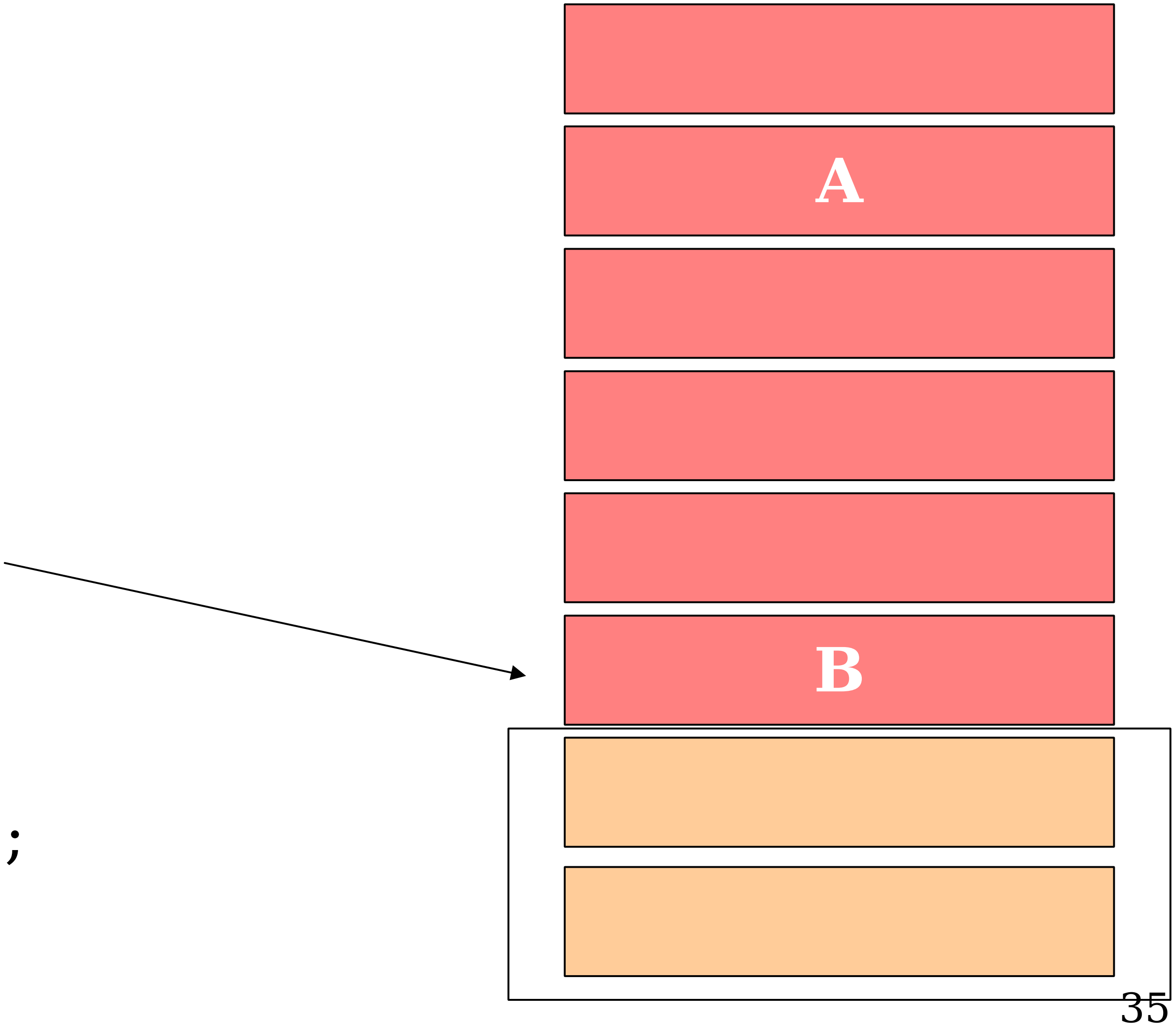

Heap Holes

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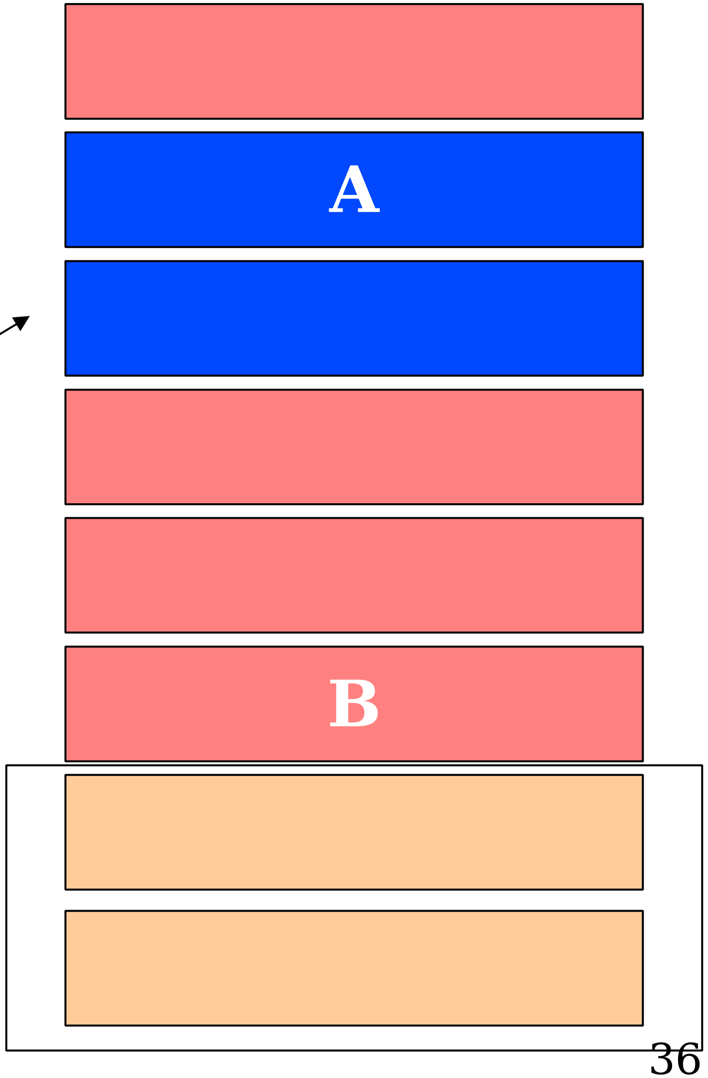

Heap Holes

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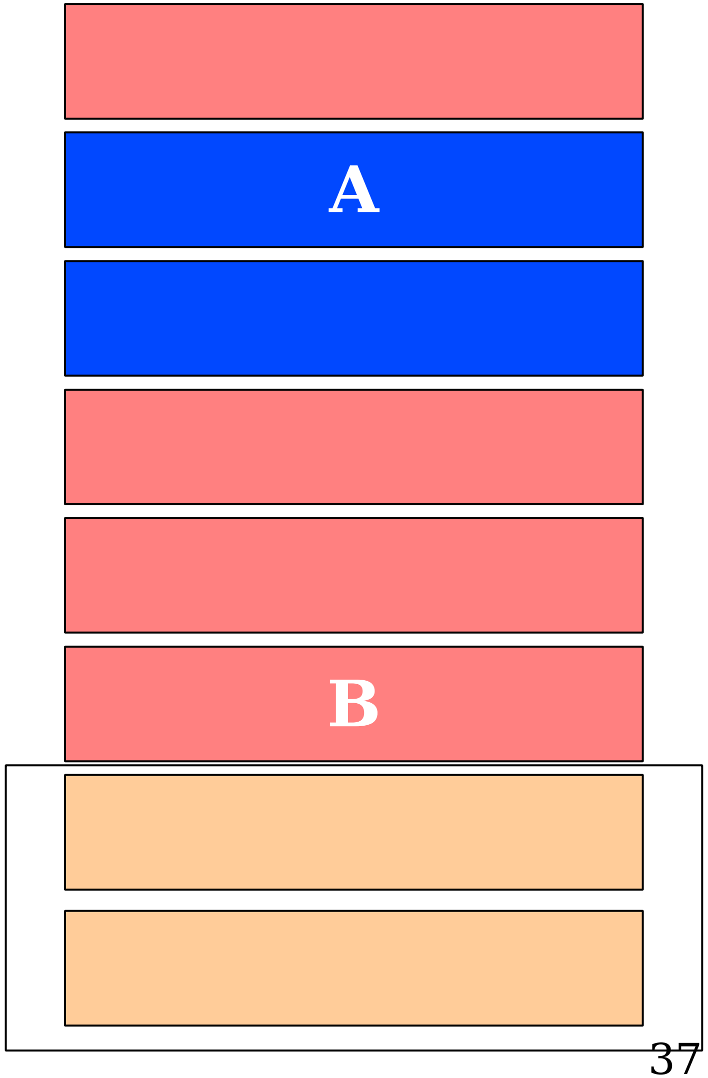
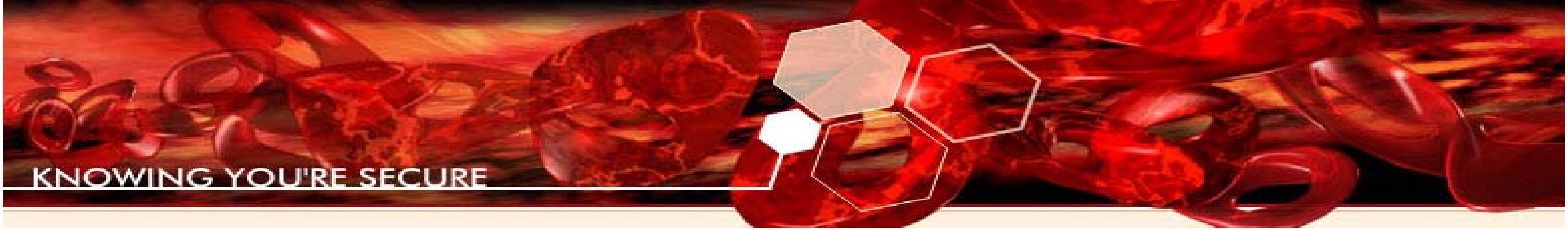
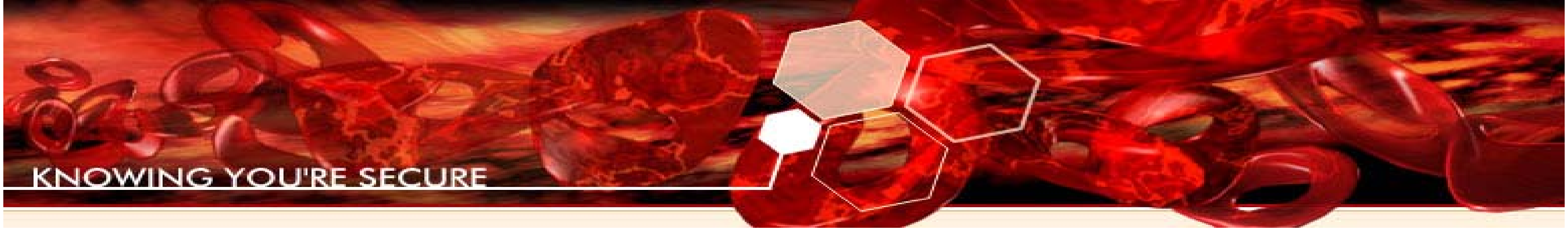




Two types of memory leaks are used in heap exploitation

- A memleak is a portion of memory that is **allocated** but **not deallocated** throughout the life of the target
- There are two types of memleaks:
  - Hard: Memleaks that remain allocated throughout the entire life of the target
  - Soft: Memleaks that remain allocated only for a set period of time (e.g. a memleak based on one connection)



Several bad coding practises lead to hard memleaks

- Allocations within a try-except block that forget to free in the except block
- Use of RaiseException() within a function before freeing locally bound allocations (RPC services do this a lot)
- Losing track of a pointer to the allocated chunk or overwriting the pointer. No sane reference is left behind for a free
- A certain code flow might return without freeing the locally bound allocation

Soft memory leaks are almost as useful to exploit writers

- Soft Memleaks are much easier to find:
  - Every connection to a server that is not disconnected, allocates memory
  - Variables that are set by a command and remain so until they are unset
  - Ex:

    X-LINK2STATE CHUNK=A allocates 0x400 bytes.

    X-LINK2STATE LAST CHUNK=A free that chunk.

We correct our heap layout with memory leaks

- In summary, memleaks will help us do different things:
  - Empty the Lookaside
  - Empty the FreeList
  - Leaving Holes for a specific purpose

} Both have the same objective: to allow us to have consecutive chunks

Heap Rule #1: Force and control the layout

- Assume again

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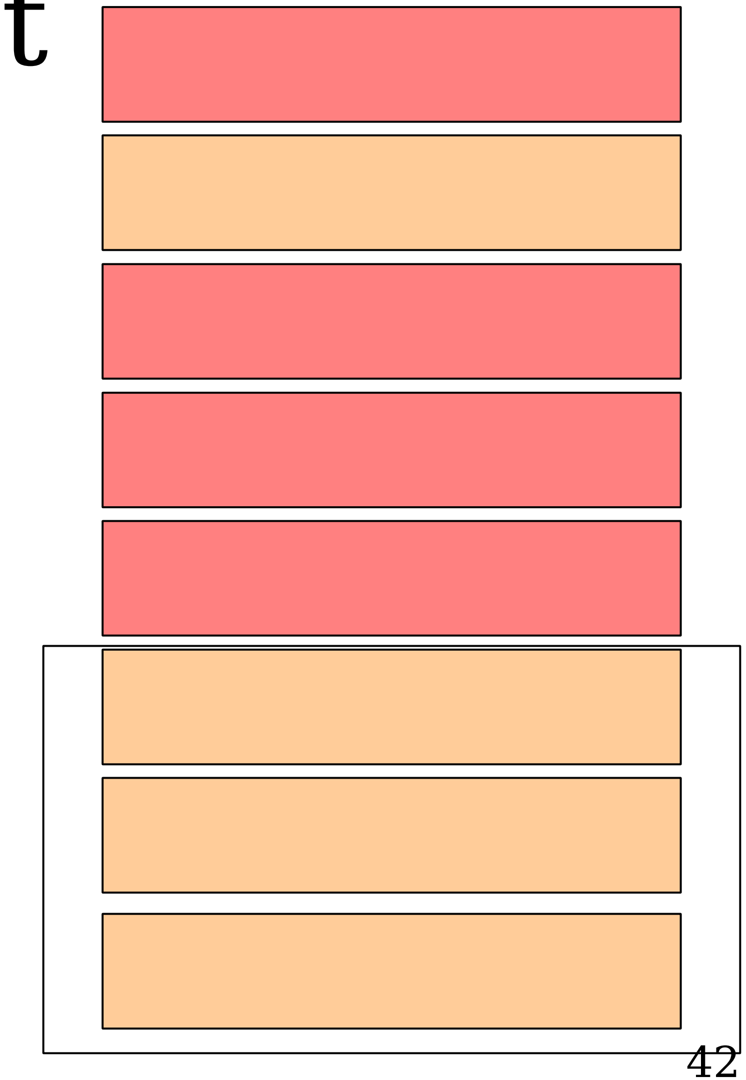
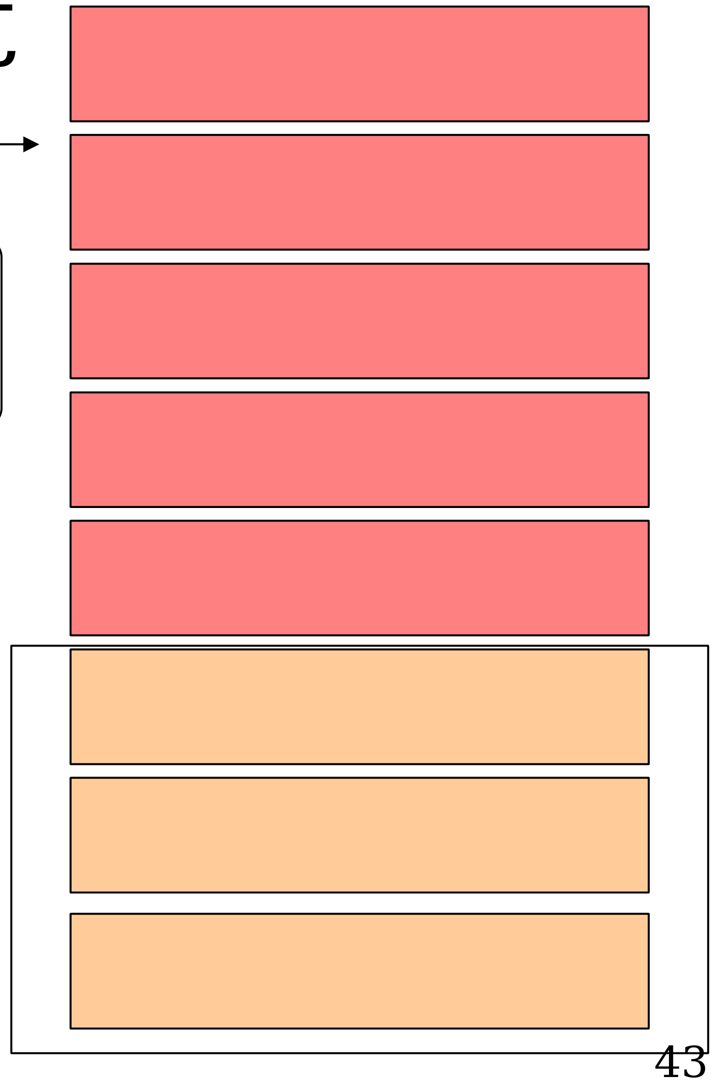


Heap Rule #1: Force and control the layout

- memleak(768)



Calculating size:
768 + 8 = 776
776/8 = **entry 97**

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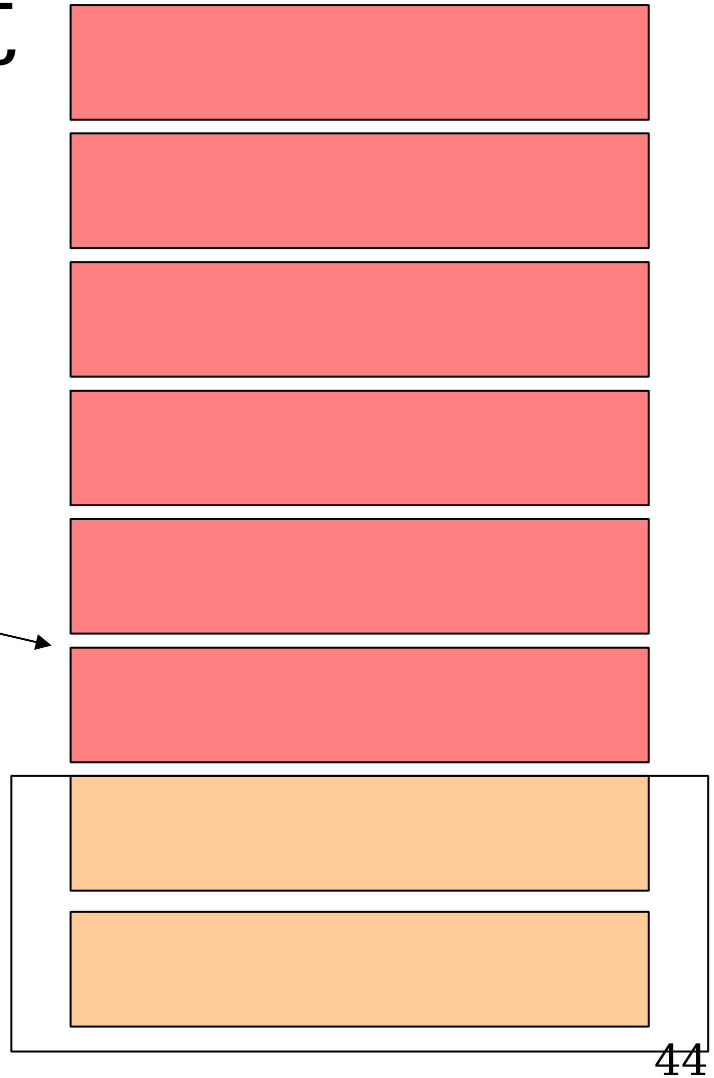

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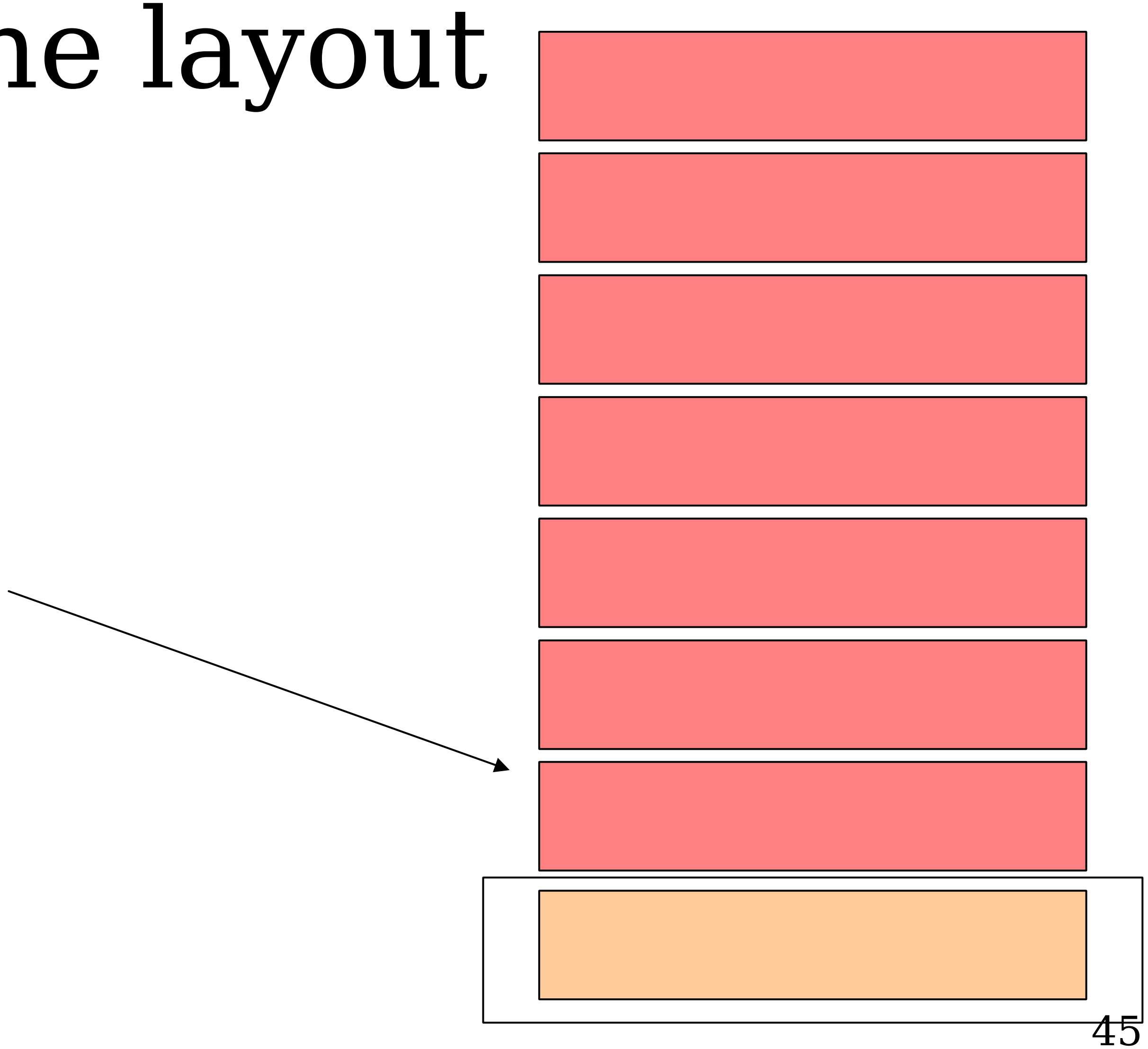

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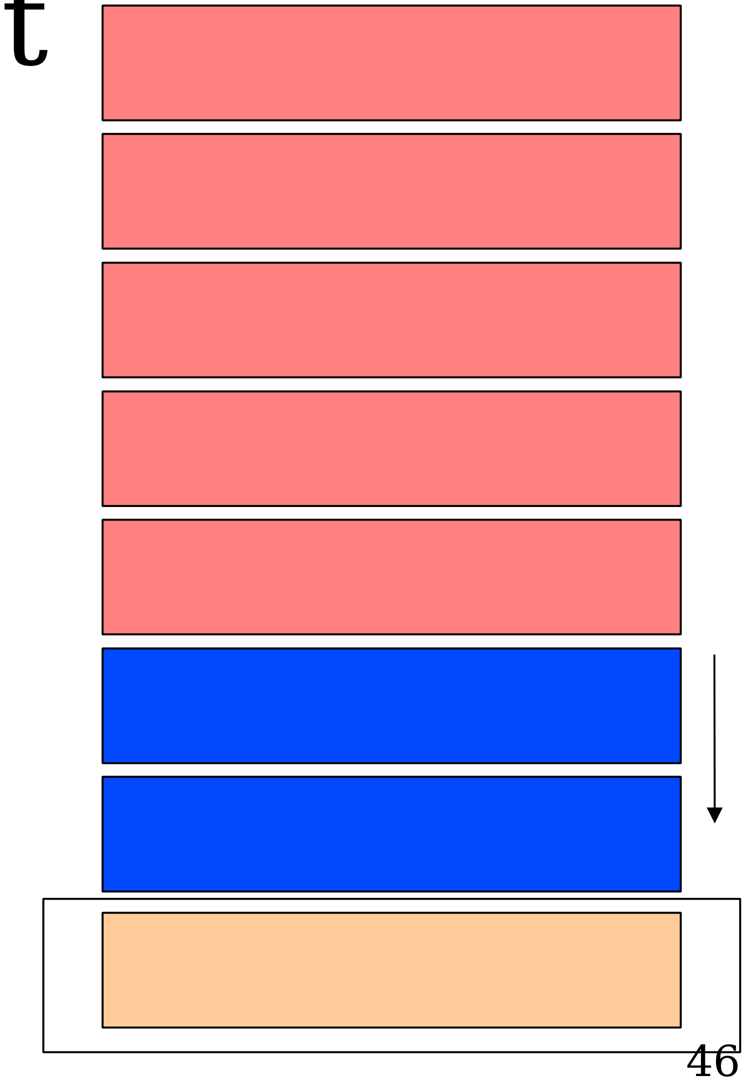

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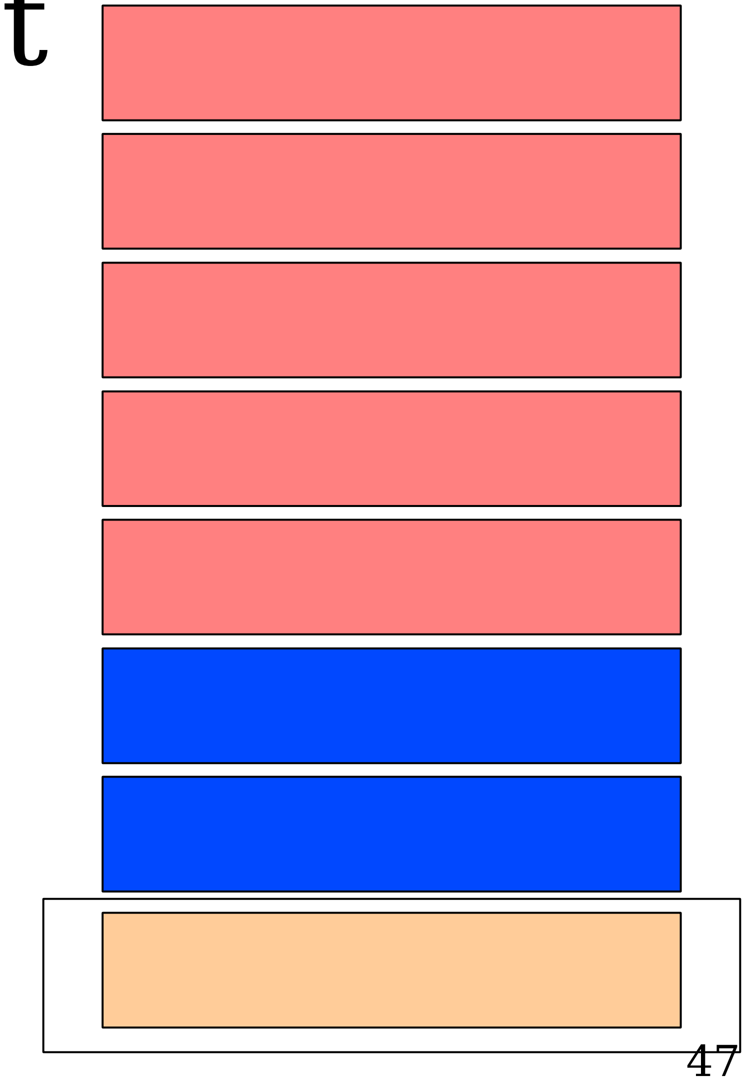
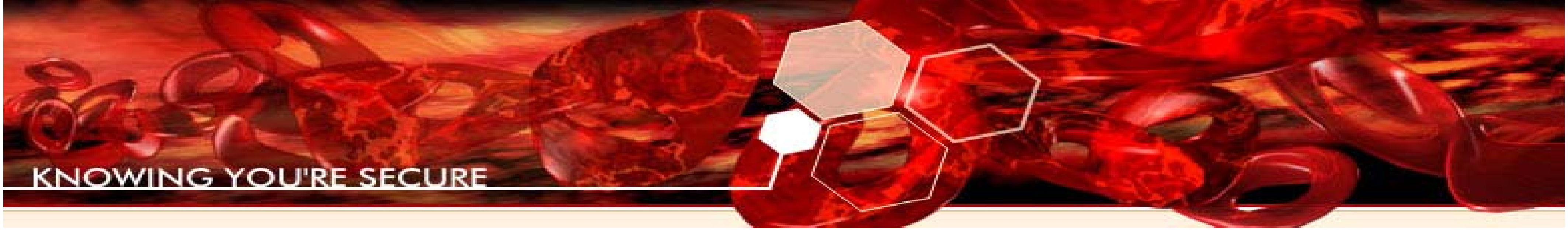


Good exploits are the result of Intelligent Debugging

- With the new requirements for maximum deterministic control over the algorithm, exploiting the Win32 heap relies on intelligent debugging
- The need for a debugger that will fill these requirements arises



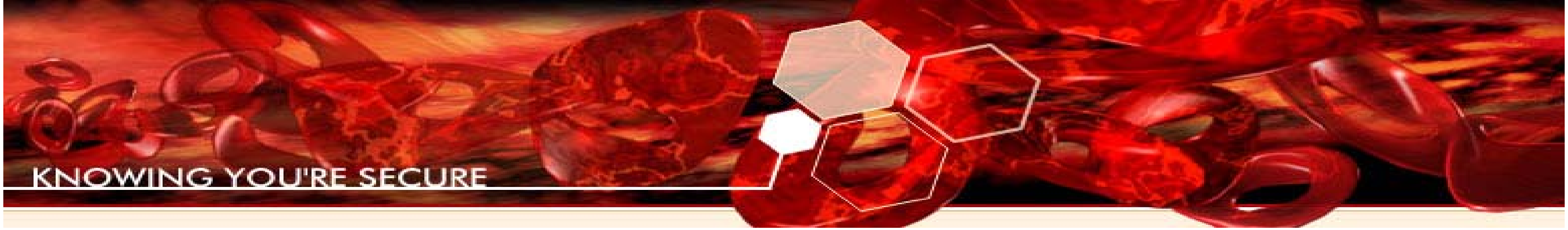
Immunity Debugger is the first debugger specifically for vulnerability development

- Powerful GUI
- WinDBG compatible commandline
- Powerful Python based scripting engine

Immunity Debugger's specialized heap analysis tools

- A series of scripts offering everything needed for modern Win32 Heap exploitation

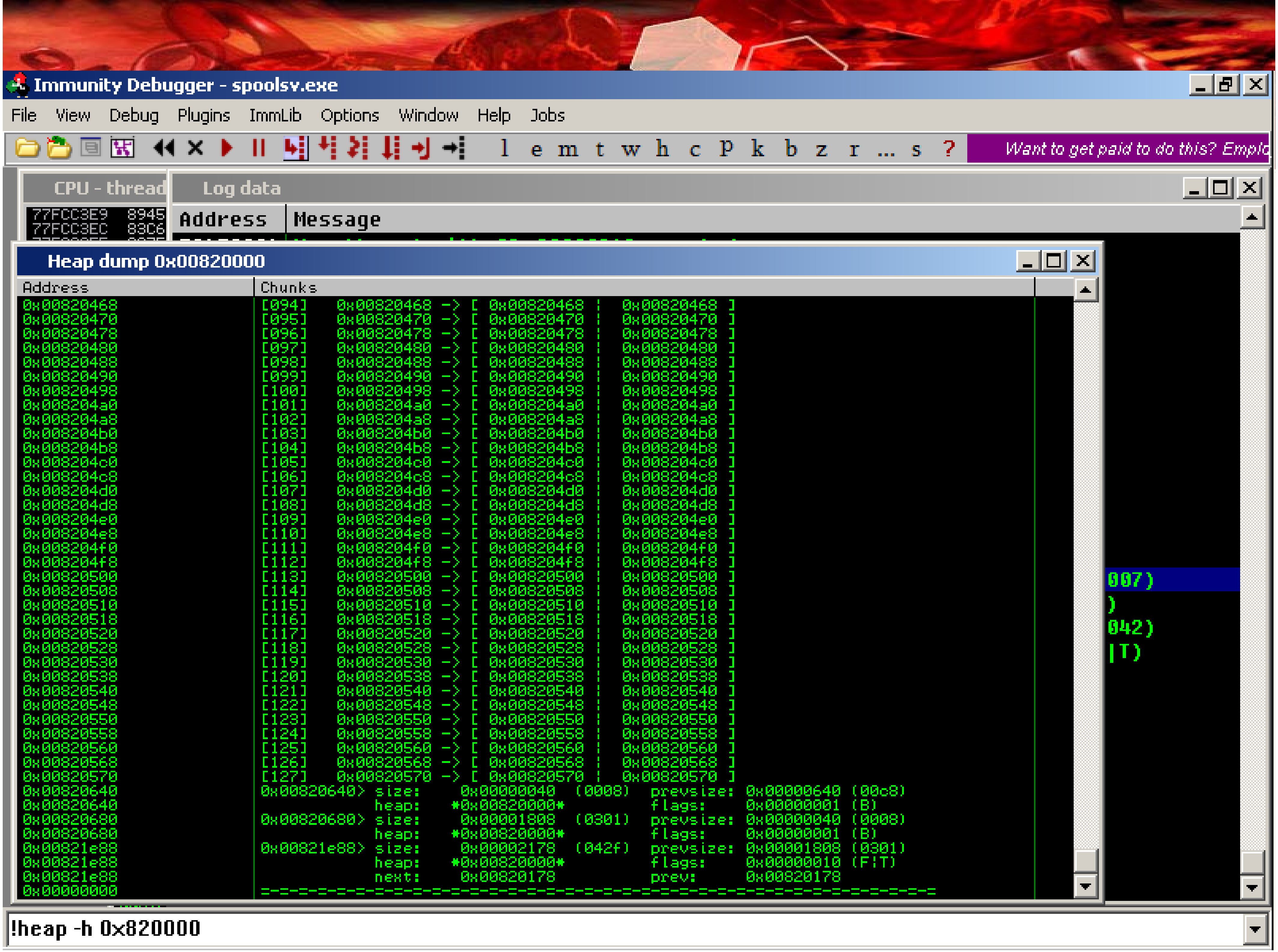
  !heap
  !funsniff
  !hippie
  !searchheap
  !heap_analyze_chunk
  !modptr



Immunity Debugger

- Dumping the Heap:
  - !heap -h ADDRESS
- Scripting example:

```
pheap = imm.getHeap( heap )
for chunk in pheap.chunks:
  chunk.printchunk()
```



```
Address      Chunks
0x00820468   [094]   0x00820468 -> [ 0x00820468 ¦  0x00820468 ]
0x00820470   [095]   0x00820470 -> [ 0x00820470 ¦  0x00820470 ]
0x00820478   [096]   0x00820478 -> [ 0x00820478 ¦  0x00820478 ]
0x00820480   [097]   0x00820480 -> [ 0x00820480 ¦  0x00820480 ]
0x00820488   [098]   0x00820488 -> [ 0x00820488 ¦  0x00820488 ]
0x00820490   [099]   0x00820490 -> [ 0x00820490 ¦  0x00820490 ]
0x00820498   [100]   0x00820498 -> [ 0x00820498 ¦  0x00820498 ]
0x008204a0   [101]   0x008204a0 -> [ 0x008204a0 ¦  0x008204a0 ]
0x008204a8   [102]   0x008204a8 -> [ 0x008204a8 ¦  0x008204a8 ]
0x008204b0   [103]   0x008204b0 -> [ 0x008204b0 ¦  0x008204b0 ]
0x008204b8   [104]   0x008204b8 -> [ 0x008204b8 ¦  0x008204b8 ]
0x008204c0   [105]   0x008204c0 -> [ 0x008204c0 ¦  0x008204c0 ]
0x008204c8   [106]   0x008204c8 -> [ 0x008204c8 ¦  0x008204c8 ]
0x008204d0   [107]   0x008204d0 -> [ 0x008204d0 ¦  0x008204d0 ]
0x008204d8   [108]   0x008204d8 -> [ 0x008204d8 ¦  0x008204d8 ]
0x008204e0   [109]   0x008204e0 -> [ 0x008204e0 ¦  0x008204e0 ]
0x008204e8   [110]   0x008204e8 -> [ 0x008204e8 ¦  0x008204e8 ]
0x008204f0   [111]   0x008204f0 -> [ 0x008204f0 ¦  0x008204f0 ]
0x008204f8   [112]   0x008204f8 -> [ 0x008204f8 ¦  0x008204f8 ]
0x00820500   [113]   0x00820500 -> [ 0x00820500 ¦  0x00820500 ]
0x00820508   [114]   0x00820508 -> [ 0x00820508 ¦  0x00820508 ]
0x00820510   [115]   0x00820510 -> [ 0x00820510 ¦  0x00820510 ]
0x00820518   [116]   0x00820518 -> [ 0x00820518 ¦  0x00820518 ]
0x00820520   [117]   0x00820520 -> [ 0x00820520 ¦  0x00820520 ]
0x00820528   [118]   0x00820528 -> [ 0x00820528 ¦  0x00820528 ]
0x00820530   [119]   0x00820530 -> [ 0x00820530 ¦  0x00820530 ]
0x00820538   [120]   0x00820538 -> [ 0x00820538 ¦  0x00820538 ]
0x00820540   [121]   0x00820540 -> [ 0x00820540 ¦  0x00820540 ]
0x00820548   [122]   0x00820548 -> [ 0x00820548 ¦  0x00820548 ]
0x00820550   [123]   0x00820550 -> [ 0x00820550 ¦  0x00820550 ]
0x00820558   [124]   0x00820558 -> [ 0x00820558 ¦  0x00820558 ]
0x00820560   [125]   0x00820560 -> [ 0x00820560 ¦  0x00820560 ]
0x00820568   [126]   0x00820568 -> [ 0x00820568 ¦  0x00820568 ]
0x00820570   [127]   0x00820570 -> [ 0x00820570 ¦  0x00820570 ]
0x00820640   0x00820640> size:    0x00000040  (0008)  prevsize: 0x00000640 (00c8)
0x00820640               heap:   *0x00820000*         flags:    0x00000001 (B)
0x00820680   0x00820680> size:    0x00001808  (0301)  prevsize: 0x00000040 (0008)
0x00820680               heap:   *0x00820000*         flags:    0x00000001 (B)
0x00821e88   0x00821e88> size:    0x00002178  (042f)  prevsize: 0x00001808 (0301)
0x00821e88               heap:   *0x00820000*         flags:    0x00000010 (F¦T)
0x00821e88               next:    0x00820178          prev:     0x00820178
0x00000000   ====================================================================
```

```
!heap -h 0x820000
```

Searching the heap using Immlib

- Search the heap
  - !searchheap

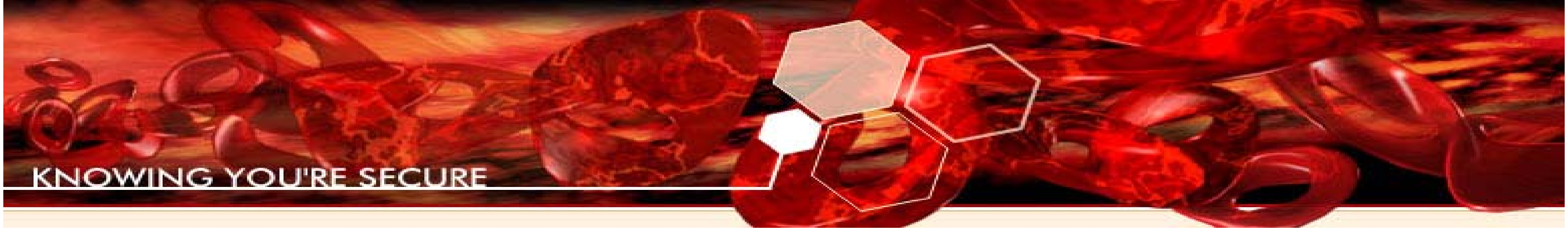
```
 what   (size,usize,psize,upsize,flags,address,next,prev)

action (=,>,<,>=,<=,&,not,!=)

value  (value to search for)

heap   (optional: filter the search by heap)
```

- Scripting example:

```
SearchHeap(imm, what, action, value, heap = heap)
```

Comparing a heap before and after you break it

- Dumping a Broken Heap:
  - Save state:
    - `!heap -h ADDRESS -s`
  - Restore State:
    - `!heap -h ADDRESS -r`

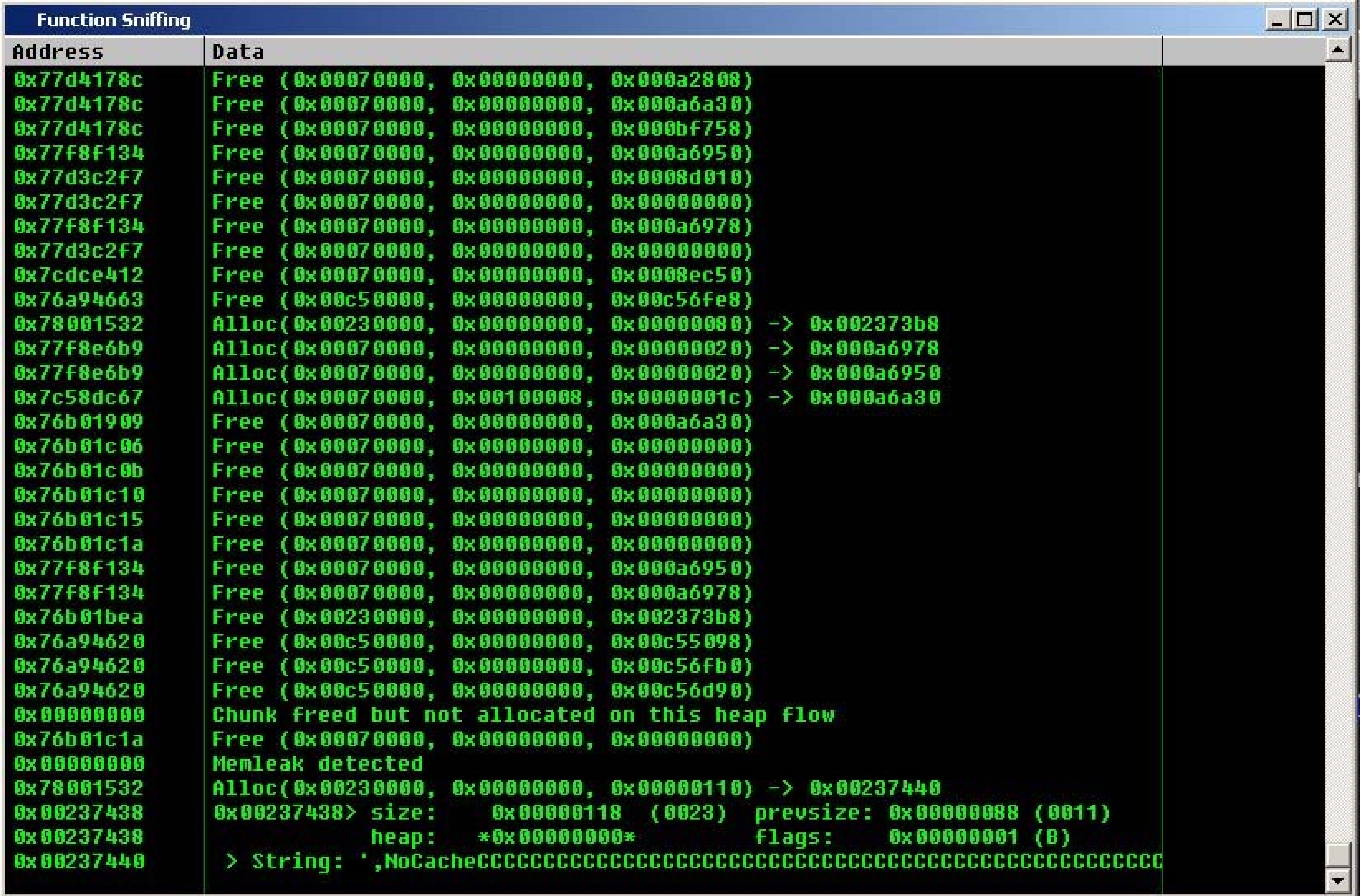


Heap Fingerprinting

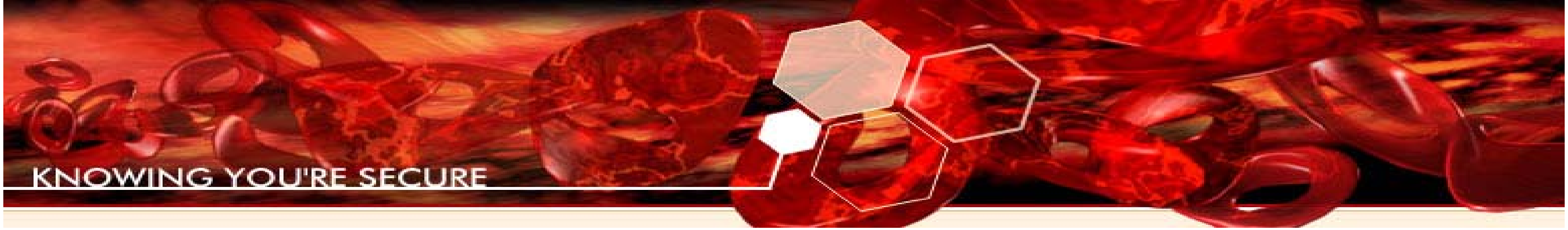
- To craft a correct Heap layout we need a proper understanding of the allocation pattern of different functions in the target process
- This means there is a need for fingerprinting the heap flow of a specific function

Heap Fingerprinting

- !funsniff <address>
  - fingerprint the allocation pattern of the given function
  - find memleaks
  - double free
  - memory freed of a chunk not belonging to our current heap flow (Important for soft memleaks)



```
0x77d4178c   Free (0x00070000, 0x00000000, 0x000a2808)
0x77d4178c   Free (0x00070000, 0x00000000, 0x000a6a30)
0x77d4178c   Free (0x00070000, 0x00000000, 0x000bf758)
0x77f8f134   Free (0x00070000, 0x00000000, 0x000a6950)
0x77d3c2f7   Free (0x00070000, 0x00000000, 0x0008d010)
0x77d3c2f7   Free (0x00070000, 0x00000000, 0x00000000)
0x77f8f134   Free (0x00070000, 0x00000000, 0x000a6978)
0x77d3c2f7   Free (0x00070000, 0x00000000, 0x00000000)
0x7cdce412   Free (0x00070000, 0x00000000, 0x0008ec50)
0x76a94663   Free (0x00c50000, 0x00000000, 0x00c56fe8)
0x78001532   Alloc(0x00230000, 0x00000000, 0x00000080) -> 0x002373b8
0x77f8e6b9   Alloc(0x00070000, 0x00000000, 0x00000020) -> 0x000a6978
0x77f8e6b9   Alloc(0x00070000, 0x00000000, 0x00000020) -> 0x000a6950
0x7c58dc67   Alloc(0x00070000, 0x00100008, 0x0000001c) -> 0x000a6a30
0x76b01909   Free (0x00070000, 0x00000000, 0x000a6a30)
0x76b01c06   Free (0x00070000, 0x00000000, 0x00000000)
0x76b01c0b   Free (0x00070000, 0x00000000, 0x00000000)
0x76b01c10   Free (0x00070000, 0x00000000, 0x00000000)
0x76b01c15   Free (0x00070000, 0x00000000, 0x00000000)
0x76b01c1a   Free (0x00070000, 0x00000000, 0x00000000)
0x77f8f134   Free (0x00070000, 0x00000000, 0x000a6950)
0x77f8f134   Free (0x00070000, 0x00000000, 0x000a6978)
0x76b01bea   Free (0x00230000, 0x00000000, 0x002373b8)
0x76a94620   Free (0x00c50000, 0x00000000, 0x00c55098)
0x76a94620   Free (0x00c50000, 0x00000000, 0x00c56fb0)
0x76a94620   Free (0x00c50000, 0x00000000, 0x00c56d90)
0x00000000   Chunk freed but not allocated on this heap flow
0x76b01c1a   Free (0x00070000, 0x00000000, 0x00000000)
0x00000000   Memleak detected
0x78001532   Alloc(0x00230000, 0x00000000, 0x00000110) -> 0x00237440
0x00237438   0x00237438> size:    0x00000118  (0023)  prevsize: 0x00000088 (0011)
0x00237438               heap:   *0x00000000*         flags:    0x00000001 (8)
0x00237440    > String: ',NoCacheCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
```



Automated data type discovery using Immlib

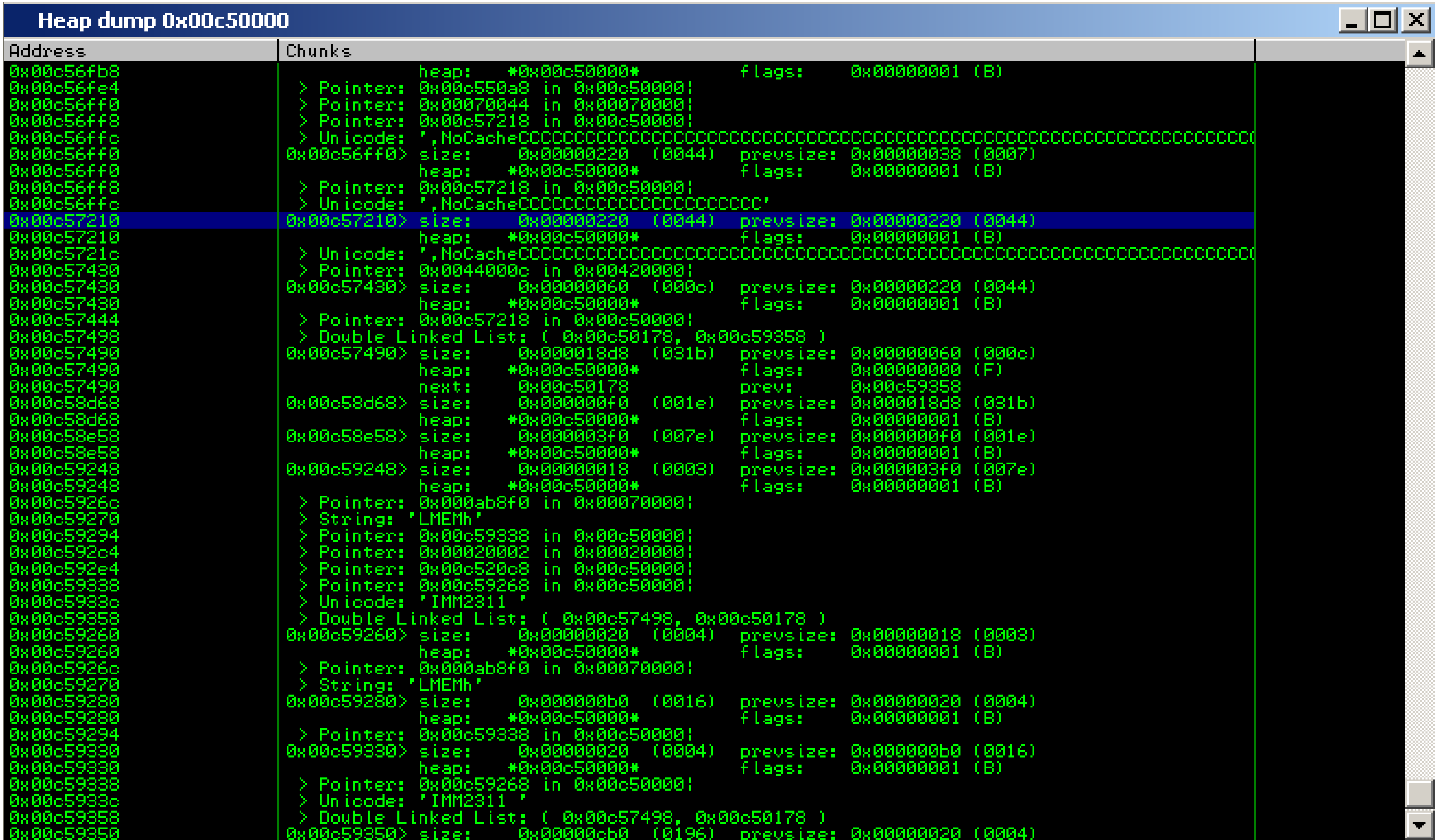
- As we now know overwriting the metadata of chunks to get a unlink primitive is mostly no longer viable
- The next step of heap exploitation is taking advantage of the **content of chunks**
- We need straightforward runtime recognition of chunk content

Immunity Debugger offers simple runtime analysis of heap data to find data types

- String/Unicode
- Pointers (Function Pointer, Data pointer, Stack Pointer)
- Double Linked lists
  - Important because they have their own unlink() write4 primitives!

Data Discovery

- !heap -h HEAP_ADDRESS -d
  - See next slide for awesome screenshot of this in action!



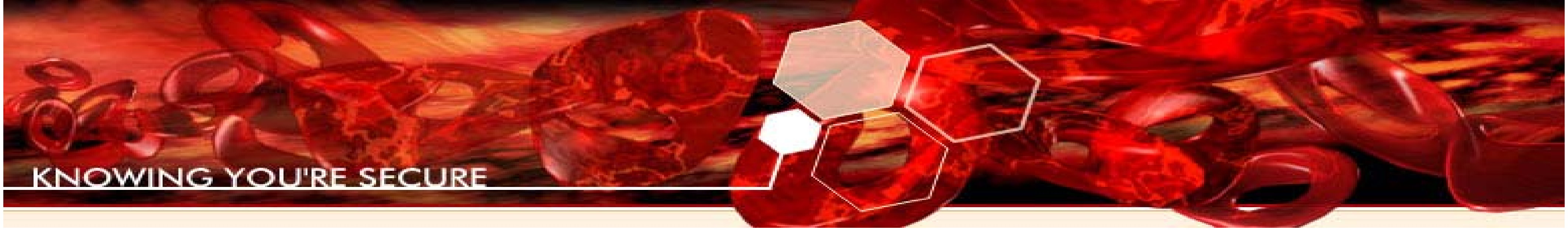
```
Address       Chunks
0x00c56fb8                heap:   *0x00c50000*         flags:    0x00000001 (B)
0x00c56fe4     > Pointer: 0x00c550a8 in 0x00c50000|
0x00c56ff0     > Pointer: 0x00070044 in 0x00070000|
0x00c56ff8     > Pointer: 0x00c57218 in 0x00c50000|
0x00c56ffc     > Unicode: ',NoCacheCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
0x00c56ff0    0x00c56ff0> size:    0x00000220  (0044)  prevsize: 0x00000038 (0007)
0x00c56ff0                heap:   *0x00c50000*         flags:    0x00000001 (B)
0x00c56ff8     > Pointer: 0x00c57218 in 0x00c50000|
0x00c56ffc     > Unicode: ',NoCacheCCCCCCCCCCCCCCCCCCCCCC'
0x00c57210    0x00c57210> size:    0x00000220  (0044)  prevsize: 0x00000220 (0044)
0x00c57210                heap:   *0x00c50000*         flags:    0x00000001 (B)
0x00c5721c     > Unicode: ',NoCacheCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
0x00c57430     > Pointer: 0x0044000c in 0x00420000|
0x00c57430    0x00c57430> size:    0x00000060  (000c)  prevsize: 0x00000220 (0044)
0x00c57430                heap:   *0x00c50000*         flags:    0x00000001 (B)
0x00c57444     > Pointer: 0x00c57218 in 0x00c50000|
0x00c57498     > Double Linked List: ( 0x00c50178, 0x00c59358 )
0x00c57490    0x00c57490> size:    0x000018d8  (031b)  prevsize: 0x00000060 (000c)
0x00c57490                heap:   *0x00c50000*         flags:    0x00000000 (F)
0x00c57490                next:    0x00c50178          prev:     0x00c59358
0x00c58d68    0x00c58d68> size:    0x000000f0  (001e)  prevsize: 0x000018d8 (031b)
0x00c58d68                heap:   *0x00c50000*         flags:    0x00000001 (B)
0x00c58e58    0x00c58e58> size:    0x000003f0  (007e)  prevsize: 0x000000f0 (001e)
0x00c58e58                heap:   *0x00c50000*         flags:    0x00000001 (B)
0x00c59248    0x00c59248> size:    0x00000018  (0003)  prevsize: 0x000003f0 (007e)
0x00c59248                heap:   *0x00c50000*         flags:    0x00000001 (B)
0x00c5926c     > Pointer: 0x000ab8f0 in 0x00070000|
0x00c59270     > String: 'LMEMh'
0x00c59294     > Pointer: 0x00c59338 in 0x00c50000|
0x00c592c4     > Pointer: 0x00020002 in 0x00020000|
0x00c592e4     > Pointer: 0x00c520c8 in 0x00c50000|
0x00c59338     > Pointer: 0x00c59268 in 0x00c50000|
0x00c5933c     > Unicode: 'IMM2311 '
0x00c59358     > Double Linked List: ( 0x00c57498, 0x00c50178 )
0x00c59260    0x00c59260> size:    0x00000020  (0004)  prevsize: 0x00000018 (0003)
0x00c59260                heap:   *0x00c50000*         flags:    0x00000001 (B)
0x00c5926c     > Pointer: 0x000ab8f0 in 0x00070000|
0x00c59270     > String: 'LMEMh'
0x00c59280    0x00c59280> size:    0x000000b0  (0016)  prevsize: 0x00000020 (0004)
0x00c59280                heap:   *0x00c50000*         flags:    0x00000001 (B)
0x00c59294     > Pointer: 0x00c59338 in 0x00c50000|
0x00c59330    0x00c59330> size:    0x00000020  (0004)  prevsize: 0x000000b0 (0016)
0x00c59330                heap:   *0x00c50000*         flags:    0x00000001 (B)
0x00c59338     > Pointer: 0x00c59268 in 0x00c50000|
0x00c5933c     > Unicode: 'IMM2311 '
0x00c59358     > Double Linked List: ( 0x00c57498, 0x00c50178 )
0x00c59350    0x00c59350> size:    0x00000cb0  (0196)  prevsize: 0x00000020 (0004)
```

Data Discovery can be scripted easily

```
import libdatatype

dt  = libdatatype.DataTypes( imm )

ret = dt.Discover( memory, address, what)
```

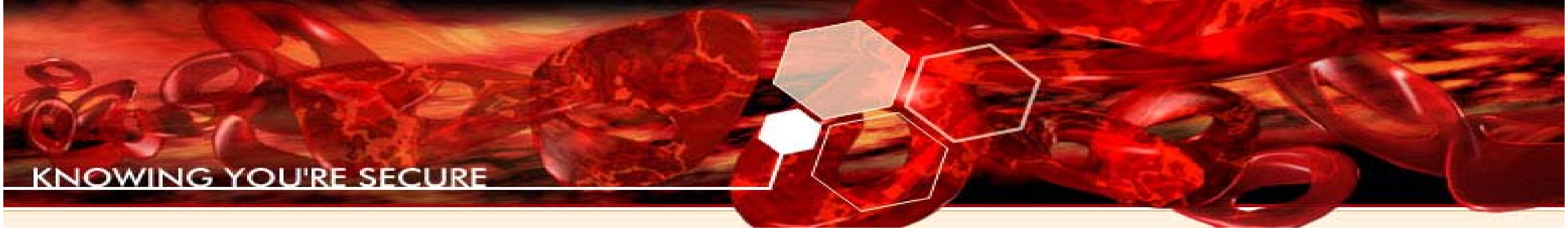
memory	memory to inspect
address	address of the inspected memory
what	(all, pointers, strings, asciistrings, unicodestrings, doublelinkedlists, exploitable)

```
for obj in ret:

    print ret.Print()
```



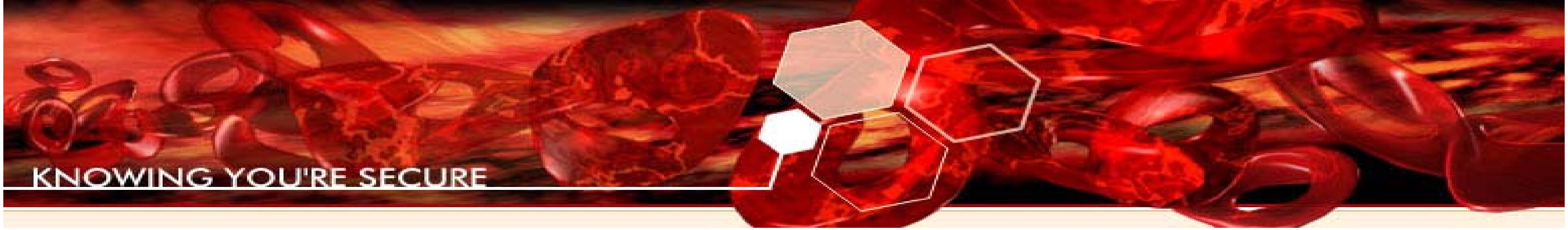
Heap Fuzzing heaps you discover a way to obtain the correct layout

- Sometimes controlling the layout is not as easy as you think, even though it sounds straightforward in theory
- From this the concept of Fuzzing the Heap arises, to help in discovering the correct layout for your process (manually or automatically)



Heap Fuzzing

- !chunkanalizehook
- Get the status of a given chunk at a specific moment. Answers the common questions:
  - What chunks are bordering your chunk?
  - What is the data in those chunks?

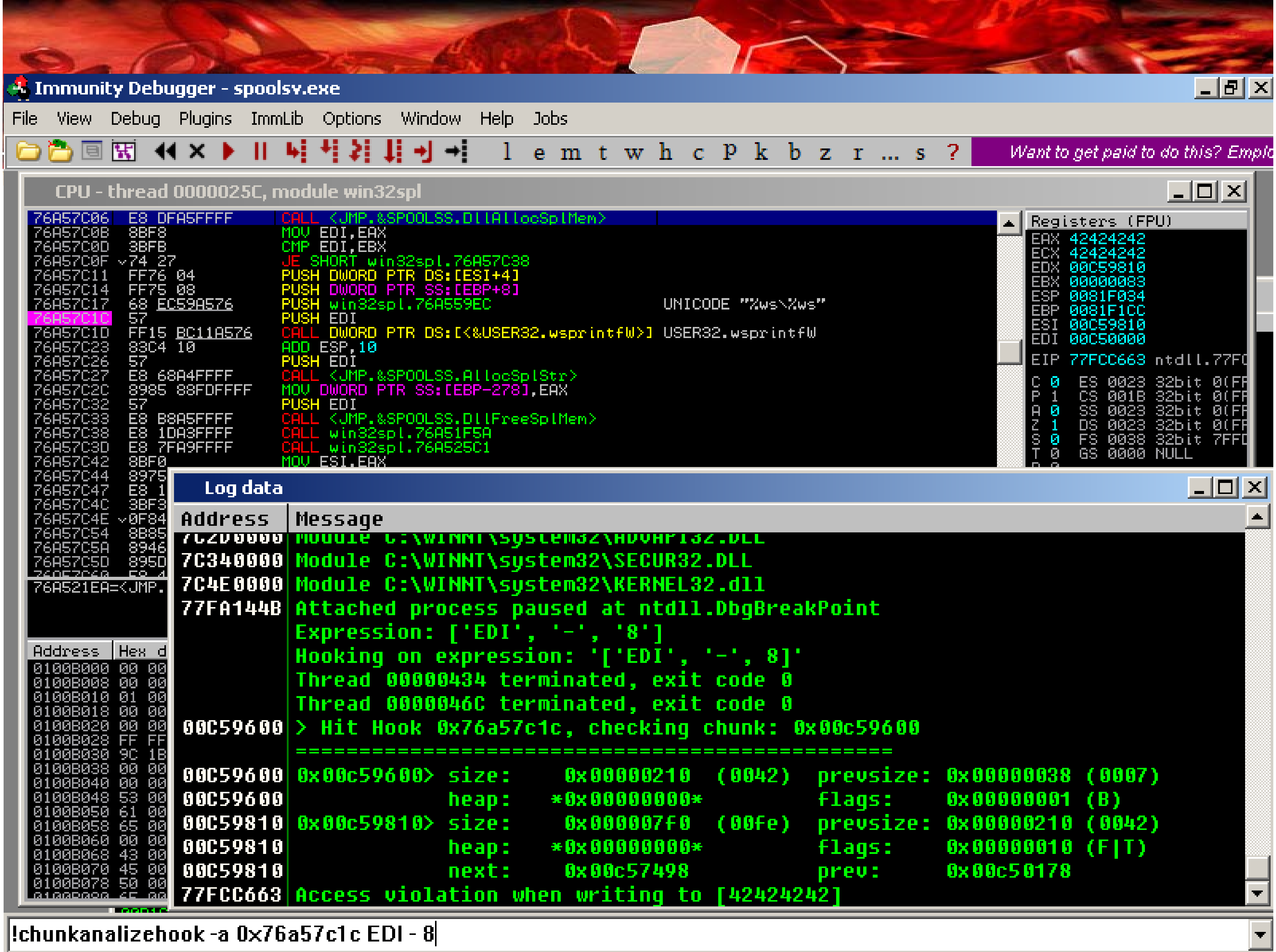


Heap Fuzzing

- *Run the script, Fuzz and get result...*
- usage:

```
 !chunkanalizehook (-d) -a ADDRES <exp>
  -a ADDRESS     address of the hook
  -d             find datatypes
  <exp>          how to find the chunk
```

ex: *!chunkanalizehook -d -a 0x77fcb703 EBX - 8*



```
76A57C06   E8 DFA5FFFF      CALL <JMP.&SPOOLSS.DllAllocSplMem>
76A57C0B   8BF8             MOV EDI,EAX
76A57C0D   3BFB             CMP EDI,EBX
76A57C0F  ˅74 27            JE SHORT win32spl.76A57C38
76A57C11   FF76 04          PUSH DWORD PTR DS:[ESI+4]
76A57C14   FF75 08          PUSH DWORD PTR SS:[EBP+8]
76A57C17   68 EC59A576      PUSH win32spl.76A559EC                 UNICODE "%ws\%ws"
76A57C1C   57               PUSH EDI
76A57C1D   FF15 BC11A576    CALL DWORD PTR DS:[<&USER32.wsprintfW>] USER32.wsprintfW
76A57C23   83C4 10          ADD ESP,10
76A57C26   57               PUSH EDI
76A57C27   E8 68A4FFFF      CALL <JMP.&SPOOLSS.AllocSplStr>
76A57C2C   8985 88FDFFFF    MOV DWORD PTR SS:[EBP-278],EAX
76A57C32   57               PUSH EDI
76A57C33   E8 B8A5FFFF      CALL <JMP.&SPOOLSS.DllFreeSplMem>
76A57C38   E8 1DA3FFFF      CALL win32spl.76A51F5A
76A57C3D   E8 7FA9FFFF      CALL win32spl.76A525C1
76A57C42   8BF0             MOV ESI,EAX
76A57C44   8975
76A57C47   E8 1
76A57C4C   3BF3
76A57C4E  ˅0F84
76A57C54   8B85
76A57C5A   8946
76A57C5D   895D
76A521EA=<JMP.
```

```
EAX 42424242
ECX 42424242
EDX 00C59810
EBX 00000083
ESP 0081F034
EBP 0081F1CC
ESI 00C59810
EDI 00C50000

EIP 77FCC663 ntdll.77FC

C 0  ES 0023 32bit 0(FF
P 1  CS 001B 32bit 0(FF
A 0  SS 0023 32bit 0(FF
Z 1  DS 0023 32bit 0(FF
S 0  FS 0038 32bit 7FFD
T 0  GS 0000 NULL
```

```
Address   Hex d
0100B000  00 00
0100B008  00 00
0100B010  01 00
0100B018  00 00
0100B020  00 00
0100B028  FF FF
0100B030  9C 1B
0100B038  00 00
0100B040  00 00
0100B048  53 00
0100B050  61 00
0100B058  65 00
0100B060  00 00
0100B068  43 00
0100B070  45 00
0100B078  50 00
```

```
Address   Message
7C340000  Module C:\WINNT\system32\SECUR32.DLL
7C4E0000  Module C:\WINNT\system32\KERNEL32.dll
77FA144B  Attached process paused at ntdll.DbgBreakPoint
          Expression: ['EDI', '-', '8']
          Hooking on expression: '['EDI', '-', 8]'
          Thread 00000434 terminated, exit code 0
          Thread 0000046C terminated, exit code 0
00C59600  > Hit Hook 0x76a57c1c, checking chunk: 0x00c59600
          ===============================================
00C59600  0x00c59600> size:     0x00000210  (0042)  prevsize:  0x00000038 (0007)
00C59600                heap:    *0x00000000*         flags:     0x00000001 (B)
00C59810  0x00c59810> size:     0x000007f0  (00fe)  prevsize:  0x00000210 (0042)
00C59810                heap:    *0x00000000*         flags:     0x00000010 (F|T)
00C59810                next:     0x00c57498          prev:      0x00c50178
77FCC663  Access violation when writing to [42424242]
```

```
!chunkanalizehook -a 0x76a57c1c EDI - 8
```

Inject Hook

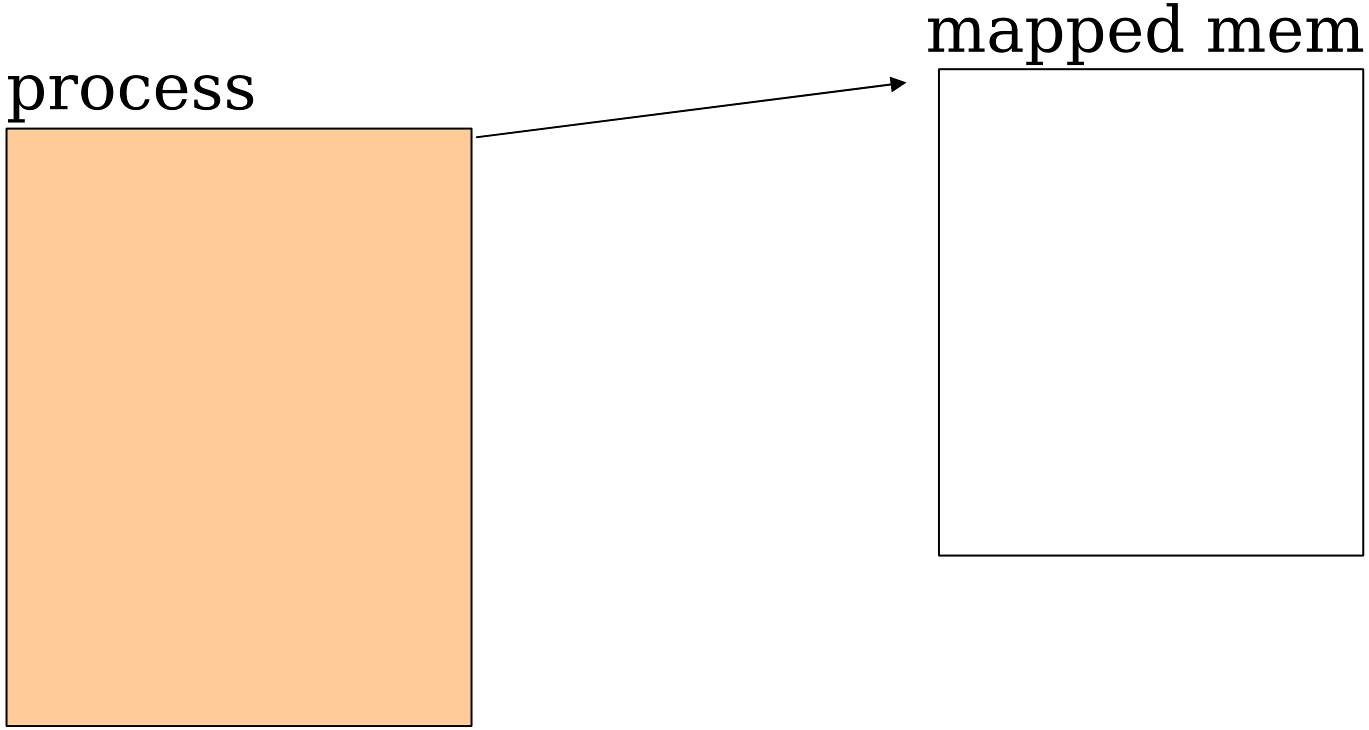
- One of the biggest problems when hooking an allocation function is speed
- Allocations are so frequent in some processes that a hook ends up slowing down the process and as a result changing the natural heap behaviour (thus changing the layout)
  - lsass
  - iexplorer

Inject Hooks into the target process speeds things up

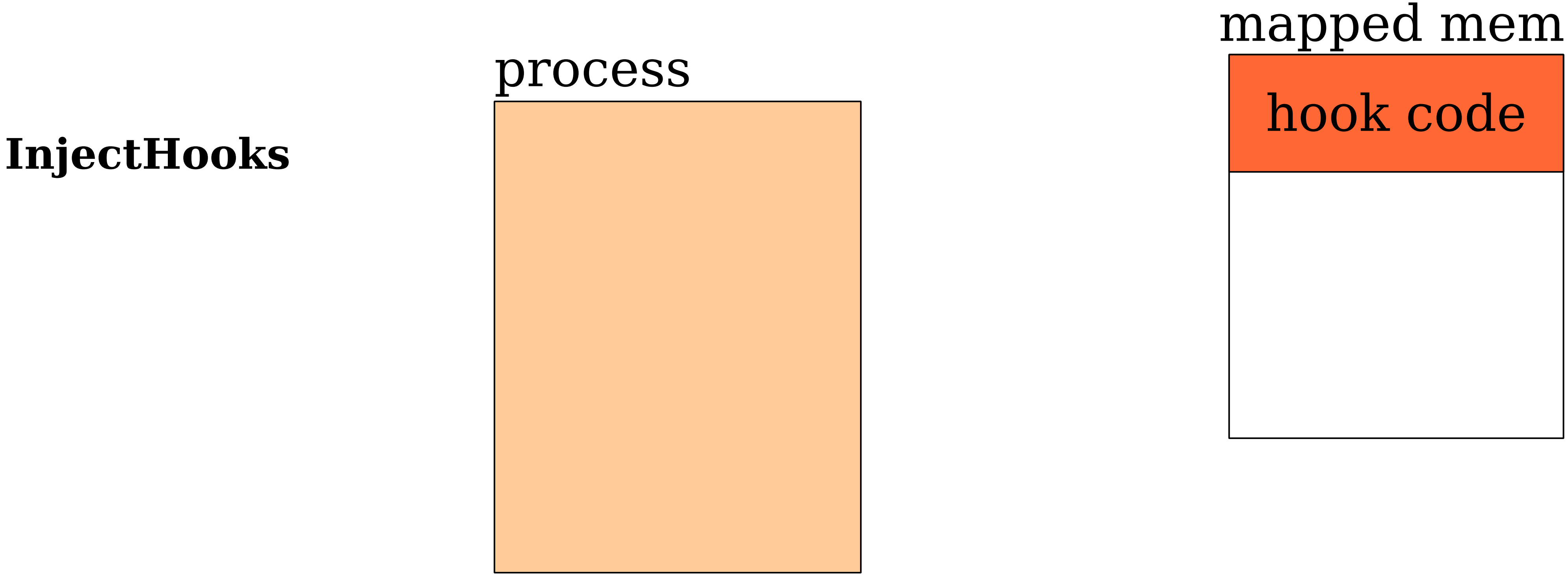
- This means doing function redirection and logging the result in the debugger itself (Avoiding breakpoints, event handling, etc)
- Can be done automatically via Immlib

Inject Hook

VirtualAllocEx



Inject Hook



InjectHooks

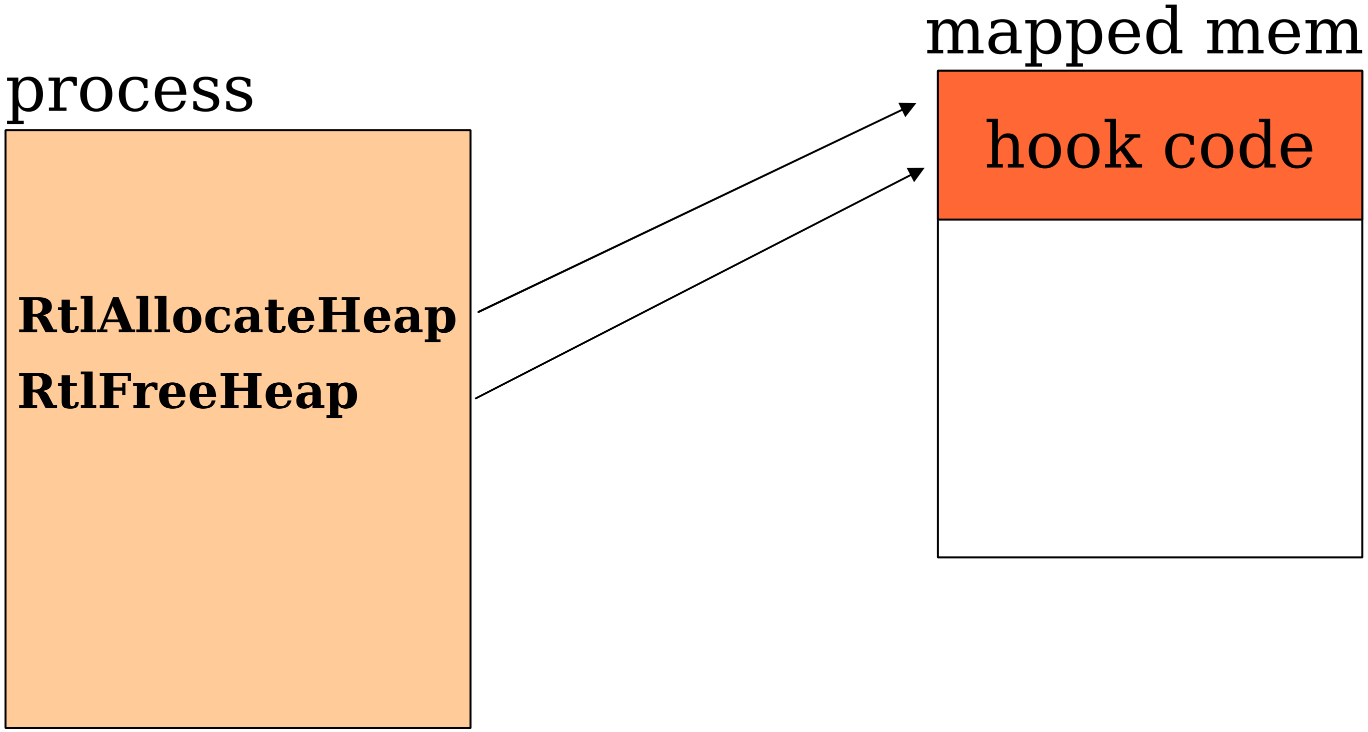
process

mapped mem

hook code

Inject Hook

Redirect Function



process

RtlAllocateHeap

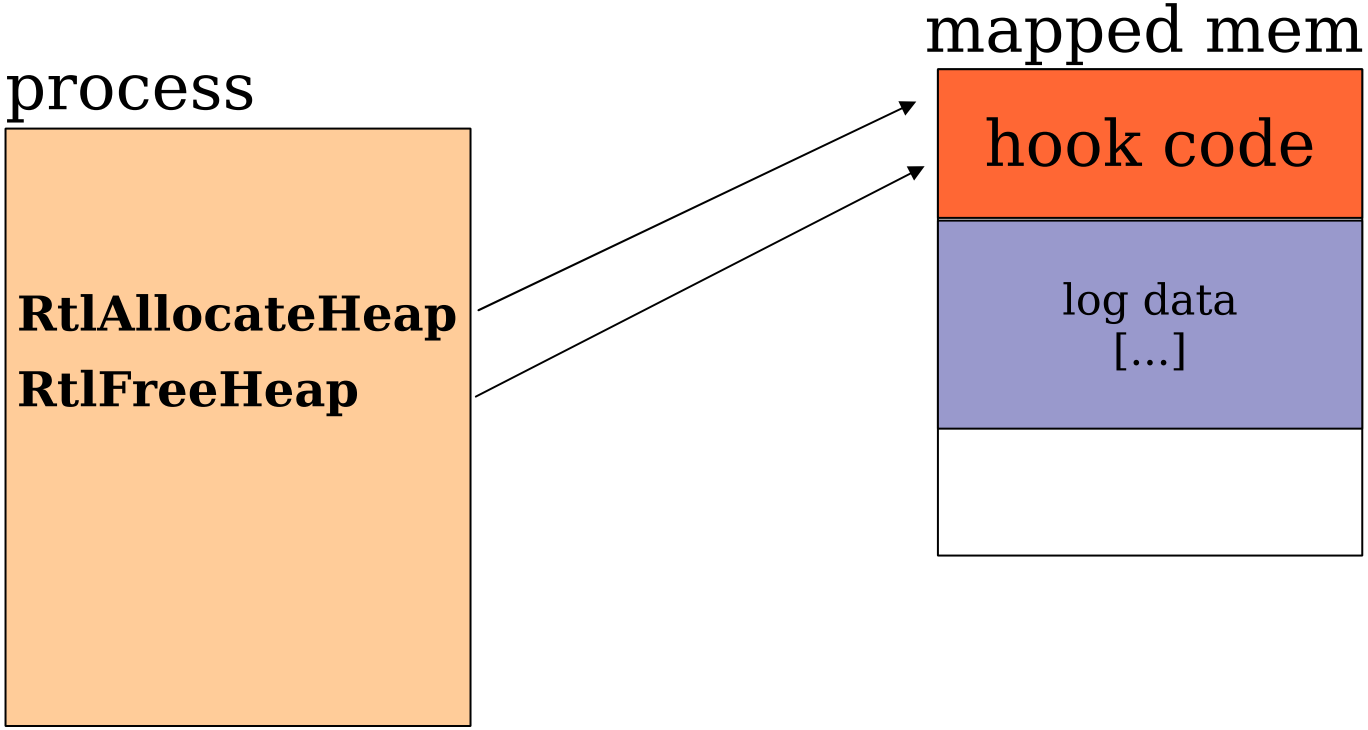
RtlFreeHeap

mapped mem

hook code

Inject Hook

Run the program



process

RtlAllocateHeap

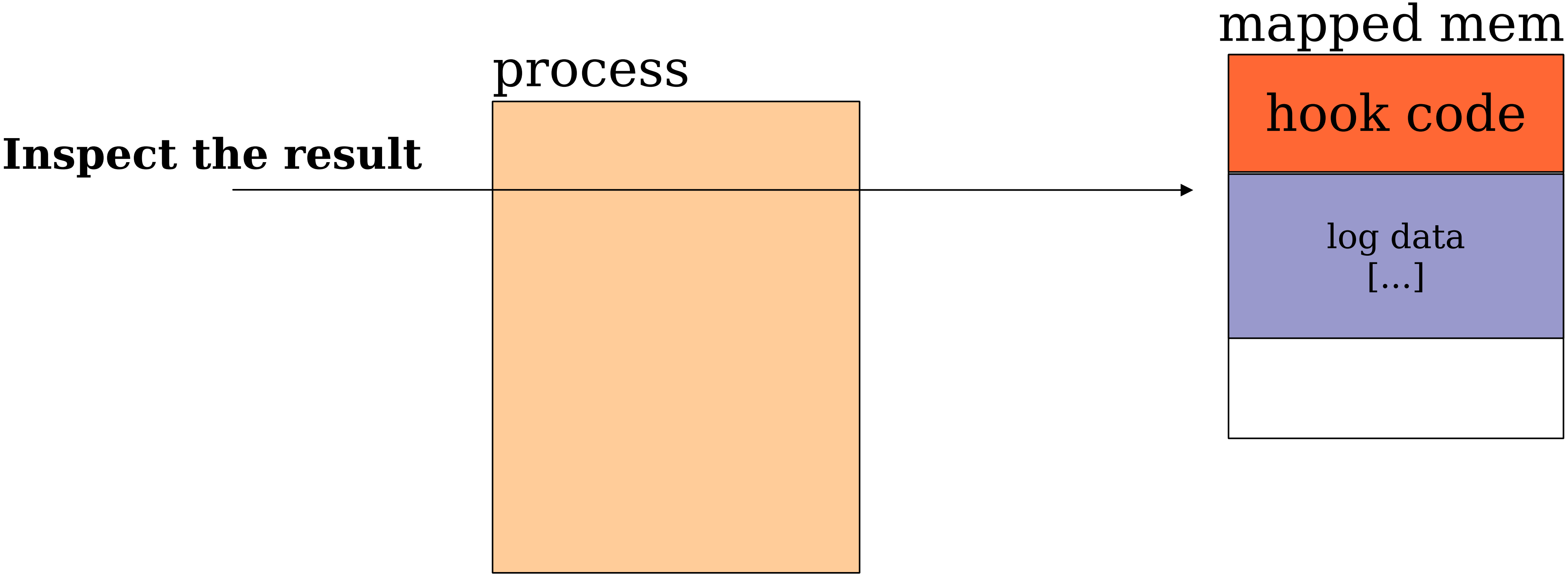
RtlFreeHeap

mapped mem

hook code

log data
[...]

Inject Hook



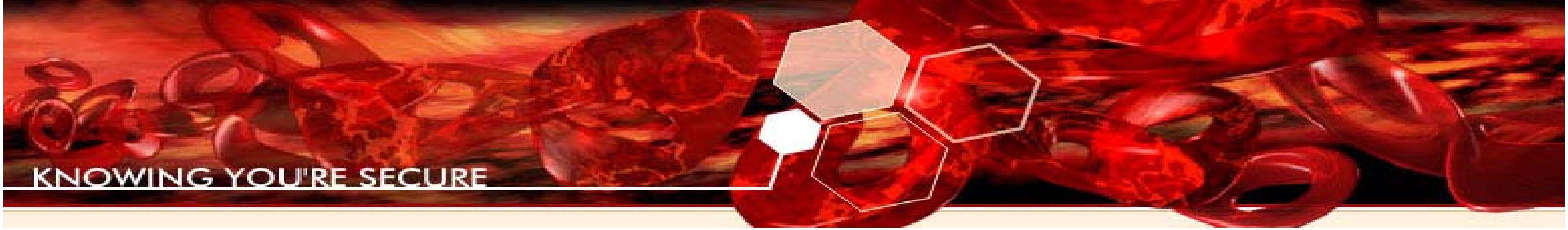
Inspect the result

process

mapped mem

hook code

log data
[...]



Inject Hook

- Hooking redirection:
  - !hippie -af -n tag_name
- Hooking redirection as script:

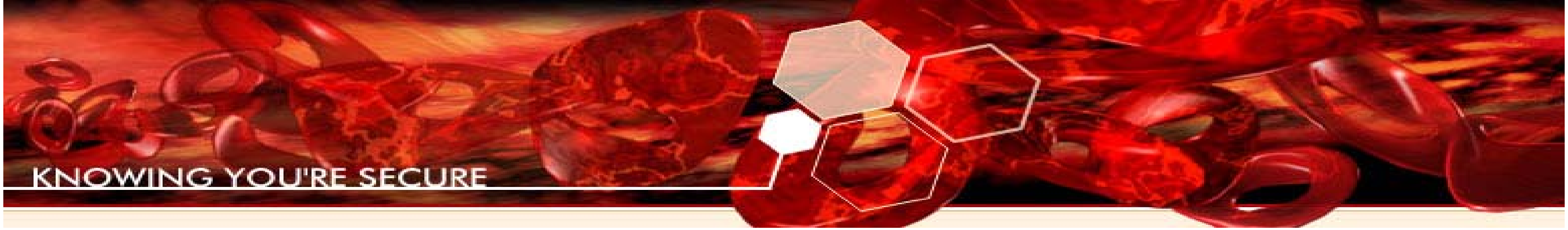
```
 fast = immlib.STDCALLFastLogHook( imm )
fast.logFunction( rtlallocate, 3)
fast.logRegister( "EAX" )
fast.logFunction( rtlfree, 3 )
fast.Hook()
```

The future

- In the near future ID will have a heap simulator that, when fed with heap flow fingerprints, will tell you which function calls are needed to get the correct heap layout for your target process
- Simple modifications to existing scripts can put memory access breakpoints at the end of every chunk to find out exactly when a heap overflow happens
  - This is great for fuzzers

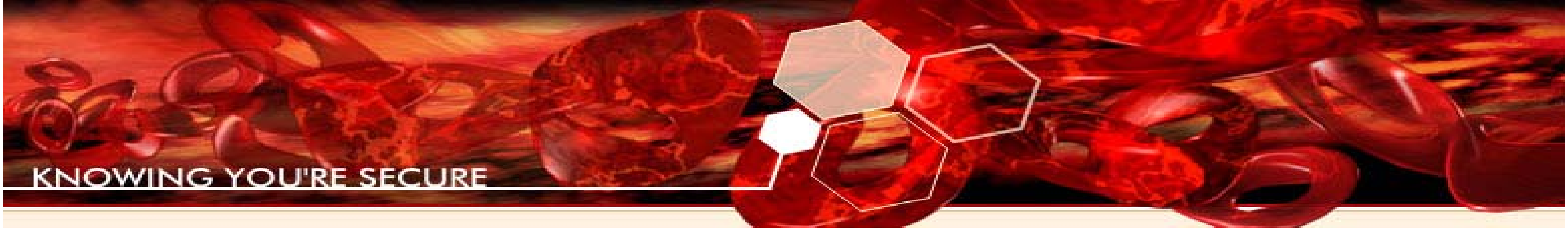
Automating exploitation

- Stack overflows
  - Automation of simple exploitation techniques (bad bytes, etc) will be built into VisualSploit+ID
- Anti-DEP scripts already working!
- Deep protocol analysis and fuzzer integration on its way



Conclusions

- Exploiting heap vulnerabilities has become much more costly
- Immunity Debugger offers tools to drastically reduce the effort needed to write reliable heap overflows
  - On older Windows platforms getting a reliable write4 the traditional way
  - On newer Windows platforms by abusing program-specific data structures



Thank you for your time

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