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# whoami

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- Ph.D., MS.c., and BS.c., Jordan
- More than 14 years of Technical Background (mainly Linux/Unix and Infosec)
- Technical Instructor for more than 10 years (Infosec, and Linux Courses)
- Hold more than 15 well known Technical Certificates
- Infosec & Linux are my main Interests
Software Exploitation
Shellcode

/* the Aleph One shellcode */
"\x31\xc0\x31\xdb\xb0\x17\xcd\x80\xeb\x1f\x5e\x89"
"\x76\x08\x31\xc0\x88\x46\x07\x89\x46\x0c\xb0\x0b"
"\x89\xf3\x8d\x4e\x08\x8d\x56\x0c\xcd\x80\x31\xdb"
"\x89\xd8\x40\xcd\x80\xe8\xdc\xff\xff\xff/bin/sh";
Outline – Part 3

- Introduction
- System Calls
- Shellcode Basics
- Shellcode Types
- Considerations
- Useful Shellcode Tools
Shellcode?

• AKA bytecode

• Small piece of code used as the payload in the exploitation of a software vulnerability.

• Problems of writing shellcodes:
  – Not easy to write
  – Architecture and OS dependent
  – Must remove all string-delimiting characters
System Calls

• Kernel trap calls used by user-space programs to access kernel-space functions.

• Linux:
  – INT \x80, Sysenter, etc

• Windows
  – INT 0x2e, Sysenter, DLL(s), API(s), etc

• System Call # stored in EAX.
• 1st ARG in EBX, 2nd in ECX, and so on.
Shellcode Basics

- Spawning the process
  - Linux/Unix: execve
  - Windows: CreateProcess
- How child process deals with input and output is very important
- File descriptors (regardless of OS):
  - 0 for Standard Input (stdin)
  - 1 for Standard Output (stdout)
  - 2 for Standard Error (stderr)
Shellcode Types

- Port Binding
- Reverse
- Find Socket
- Command Execution Code
- File Transfer
- Multistage
- System Call Proxy
- Process Injection
- Kernel Space
Port Binding Shellcode

- AKA “bind shell”
- Why/When to use this type of SC?
- What it does:
  - Create TCP socket
  - Bind socket to port (hardcoded and specified by the attacker)
  - Make socket Listen
  - Dup listening socket onto stdin, stdout, and stderr
  - Spawn command shell (bash, cmd.exe, etc)
- Attacker connects to that port to get control
- Problems:
  - Firewalls
  - Not Invisible
  - Can’t distinguish between connections made to it
Port Binding Shellcode
Reverse Shellcode

• AKA ‘callback shellcode”, solves bind shell problems
• Why connect to the target, were we can make the target connect to us?

• What it does:
  – Create TCP socket
  – Make socket connect back to the attacker on IP+Port (hardcoded and specified by the attacker)
  – Connect to the IP and port
  – Dup the socket onto stdin, stdout, and stderr
  – Spawn command shell (bash, cmd.exe, etc)

• Problems
  – Outbound Filtering
  – Attacker must be listening on the specified port
  – Attacker behind NAT
  – Target behind some proxy
  – Not invisible too
Reverse Shellcode
Find Socket Shellcode

- Search for the file descriptor that represents attackers connection.
  - POSIX (file descriptors)
  - Windows (File Handlers)
- Query each descriptor to find which is remotely connected to the attackers computer.
- Hardcode the outbound port into the shellcode, makes find much easier on target.
- No new network connection (hard to detect)!
Find Socket Shellcode - 2

• Steps:
  – Find file descriptor for the network connection.
  – Duplicate the socket onto stdin, stdout, and stderr.
  – Spawn a new command shell process (will use original socket for I/O).

• Problem:
  – Attacker behind NAT device, can’t control the outbound port from which his connection originated (P.S. won’t know what file descriptor is used for his connection!)
Command Execution
Shellcode

• Why create a network session when all needed to do is run a command?
  – ssh-copy-id to target
  – Adding/modifying a user account
  – Modify configuration file

• Steps:
  – Assemble command name
  – Assemble arguments required (if any!)
  – Invoke system call to execute the command

• Often very small
File Transfer Shellcode

• Very simple, all needed is to upload a file to the target

• Steps:
  – Open new file on target
  – Read data from the network connection, and write it to the opened file (Note: connection obtained using previous discussed network shellcodes)
  – Repeat RW until file successfully transferred.
  – Close the open file

• Can be combined with a CE Shellcode
Multistage Shellcode

• Vulnerability contains un-sufficient space for injecting shellcode
• Consist of 2 or more shellcode stages
• Steps:
  – Stage1:
    • read more shellcode,
    • pass control to Stage2 shellcode
  – Stage2: accomplish the functionality required
System Call Proxy Shellcode

- AKA Syscall Proxy
- Technique first introduced by Maximiliano Caceres (CORE Impact creators) which can provide a real remote interface to the target's kernel
- Local process running has no idea it is running remotely!
- Syscall proxy payload can continue to run in the context of the exploited process.
System Call Proxy – Cont.

- Use many tools without installing anything on the target machine
- Memory resident
- Kernel Interface
- Request Local, Execute Remote
- Remote Debugging
- Others? use your own imagination!
Process Injection Shellcode

• Loading libraries of code running under a separate thread of execution within the context of an existing process on the target.
• Host process can be:
  – Process exploited.
  – Migrate to a complete different process.
• Injected library might never get written to the hard drive and harness in memory (hard even for forensics to discover)!
• Ex: Metasploit’s Meterpreter (next week).
Important Stuff

• Disassemble
  – Maybe running a backdoor!

• Encoding
  – Bad char(s) is chasing you!

• Others?
  – Please add ...
Assignments – Choose 2

• What is a Kernel Space Shellcode?
• Can we categories Metasploit’s Meterpreter as a Multi-Stage Shellcode?
• How can we debug a shellcode?
Debugging a Shellcode

char shellcode[] =
"Insert shellcode/bytecode here";

int main(int argc, char **argv)
{
    int (*func)();
    func = (int (*)(())) code;
    (int)(*func)();
}
Useful Tools

- GCC: gcc -c shellcode.s
- Objdump: objdump -d shellcode.o
- LD: ld binary.o -o binary
- NASM: nasm -f elf64 shellcode.asm
- strace: trace system calls and signals
- Corelan’s pveWritebin.pl and pveReadbin.pl
- BETA3 --decode
- Ndisasm
- Immunity Debugger
- GDB
Summary

• What Shellcodes are, and problems that face shellcode developers,
• Types of Shellcodes,
• Why it’s important to disassemble a shellcode you didn’t write,
• Why sometimes you need to encode your shellcode,
• List of useful tools related to shellcode development.
References (1)

- Papers/Presentations/Links:
  - ShellCode, [http://www.blackhatlibrary.net/Shellcode](http://www.blackhatlibrary.net/Shellcode)
  - Unix Assembly Codes Development, [http://pentest.cryptocity.net/files/exploitation/asmcodes-1.0.2.pdf](http://pentest.cryptocity.net/files/exploitation/asmcodes-1.0.2.pdf)
  - Win32 Assembly Components, [http://pentest.cryptocity.net/files/exploitation/winasm-1.0.1.pdf](http://pentest.cryptocity.net/files/exploitation/winasm-1.0.1.pdf)
References (2)

• Papers/Presentations/Links:
  – Understanding Windows’s Shellcode (Matt Miller’s, aka skape)
  – Metasploit’s Meterpreter (Matt Miller, aka skape)
  – Syscall Proxying fun and applications, csk @ uberwall.org
  – X86 Opcode and Instruction Reference, http://ref.x86asm.net/
References (3)

• Books:
  – The Shellcoders Handbook,
  – The Art of Exploitation, 2nd Edition,

• Shellcode Repositories:
  – Exploit-DB: http://www.exploit-db.com/shellcodes/
  – Shell Storm: http://www.shell-storm.org/shellcode/

• Tools:
  – X86 Opcode and Instruction Reference, http://ref.x86asm.net/