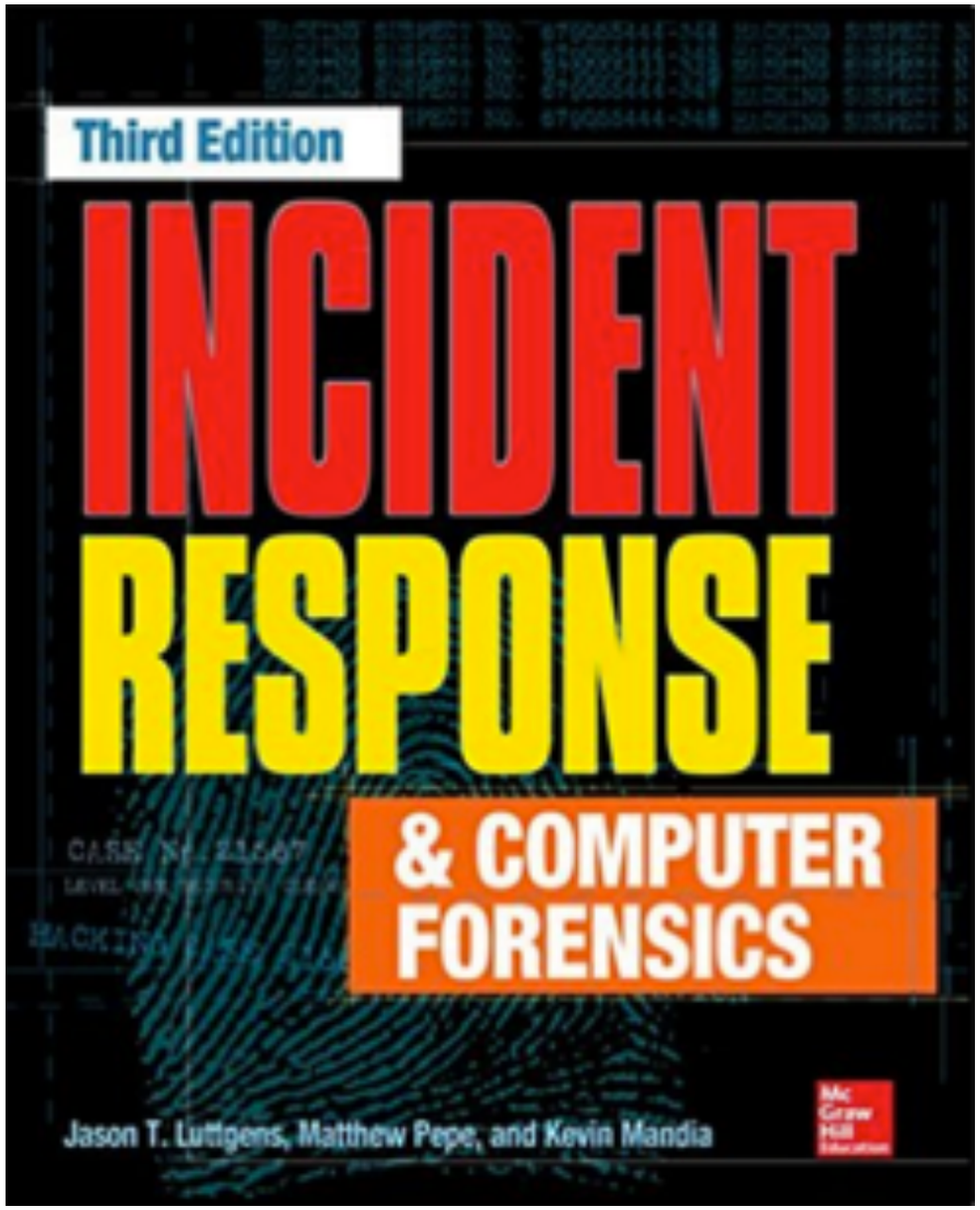
CNIT 121: Computer Forensics



12 Investigating Windows Systems (Part 3)

- Other artifacts of interactive sessions
- Memory forensics
- Alternative persistence mechanisms

Other Artifacts of Interactive Sessions

Interactive Sessions

- **For the purposes of this section, includes**
  - **Login with user at the console**
  - **Remote Desktop sessions**
  - **Screen sharing (via VNC or similar software)**

LNK Files

- **Shortcuts to files**
- **Serve as extensions to Windows Explorer**
- **Windows automatically creates LNKs for every opened file**
  - **To populate "Recent Files"**
- **Separate list in each user profile**

Where the LNK Files Are

- C:\Documents and Settings\%USERNAME%\Recent\
- C:\Documents and Settings\%USERNAME%\Application Data\Microsoft\Office\Recent\

Evidence in LNK Files

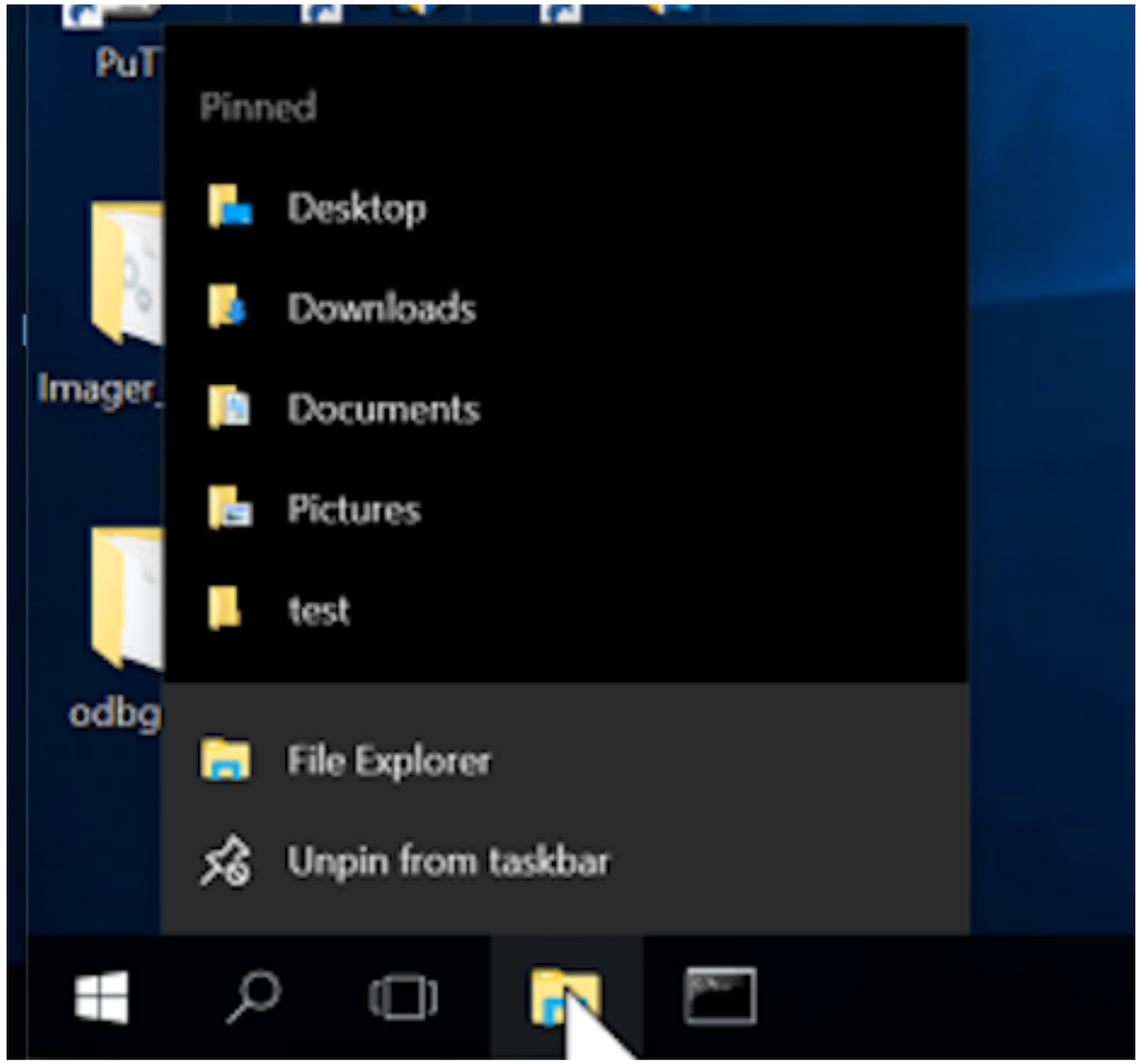
- Full file path (at the time the link was created)
- Network share name (if target file originated from such a source)
- Serial number for the source volume
- Attributes and logical size
- Standard Information Modified, Accessed, and Created timestamps for the referenced file at the time it was last opened
- A unique object identifier (ObjectID), also stored in the target file's MFT record and used by the Distributed Link Tracking service

Timeline

- **LNK files can show just what a user did**
- **Which files were accessed, and in what order**

Jump Lists

- **Right-click a taskbar icon to show recently used items**
- **Word shows recent Word files, etc.**



Where Jump Lists are Stored

C:\Users\%USERNAME%\AppData\Roaming\Microsoft\Windows\Recent\AutomaticDestinations

C:\Users\%USERNAME%\AppData\Roaming\Microsoft\Windows\Recent\CustomDestinations

- **Not human-readable, you need tools**
  - **JumpLister for Windows 7-8**
  - **JLECmd for Windows 10 (link Ch 12t)**

The Recycle Bin

- **Located in \$Recycle.Bin**
- **Contains files deleted from the hard disk**
  - **But not if deleted from removable drives**
  - **Or from the Command Prompt**
  - **Or with Shift+Delete**

Rifiuti2 Tool

```
C:\Users\Admin2\Desktop\rifiuti2-0.6.1-win\x86>rifiuti-vista.exe --output=out --xml --localtime
c:\$Recycle.Bin\S-1-5-21-1005188163-155271582-4242795456-1001
```

C:\Users\Admin2\Deskt

file:///C:/Users/Admin2/Desktop/out.xml


```
<?xml version="1.0" encoding="UTF-8"?>
- <recyclebin version="2" format="dir">
    <filename>c:\$Recycle.Bin\S-1-5-21-1005188163-155271582-4242795456-1001</filename>
  - <record size="111758507" time="2016-03-21T11:31:42-0700" index="$IAQKSS6.wmv">
      <path>C:\Users\student\Desktop\ATM Security Risk.wmv</path>
    </record>
  - <record size="1456128" time="2016-03-21T11:31:45-0700" index="$I856UJ5.exe">
      <path>C:\Users\student\Desktop\x81.exe</path>
    </record>
  - <record size="13767776" time="2016-03-21T11:34:09-0700" index="$I0BT6JN.exe">
      <path>C:\Users\student\Desktop\vc_redist.x86.exe</path>
    </record>
  - <record size="872029" time="2016-03-21T11:34:09-0700" index="$I1A10AB.zip">
      <path>C:\Users\student\Desktop\HxDSetupEN.zip</path>
    </record>
  - <record size="16374114" time="2016-03-21T12:03:09-0700" index="$IZ0RIK0.exe">
      <path>C:\Users\student\Desktop\idafree50.exe</path>
    </record>
```


- **Link Ch 12u**

Memory Forensics

Evidence in RAM

- Running processes and the system objects/resources with which they interact
- Active network connections
- Loaded drivers
- User credentials (which may be hashed, obfuscated, or even appear in clear text)
- Portions of nonvolatile sources of evidence such as the registry, event log, and Master File Table
- Remnants of previously executed console commands
- Remnants of clear-text data that is otherwise encrypted on disk
- Important data structures within the kernel that provide insight into process accounting, behavior, and execution

Types of Memory

- **Physical (RAM chips)**
- **Page file**
  - **Data moved out of RAM onto the hard disk**
  - **%SYSTEMDRIVE%\pagefile.sys**

Crash Dumps

- **Can be produced when Windows crashes with the "Blue-Screen of Death"**
- **Three levels**
  - **Kernel Memory Dump (default)**
  - **Small Memory Dump (Minidump)**
  - **Complete Memory Dump**

Crash Dump Storage

- **%LOCALAPPDATA%\Crashdumps**
- **Complete Memory Dump is most useful type**
- **But it's rarely turned on**

Hibernation Files

- **Saves the full contents of RAM on disk**
  - **%SYSTEMDRIVE%\Hiberfil.sys**
- **It's compressed and includes metadata**
  - **Link Ch 8t**
- **Volatility can parse it**

Running Processes

- **Volatility can recover**
  - **Process ID (PID)** A unique numeric identifier assigned upon process startup
  - **Parent PID** The ID of the process that was responsible for executing the current process
  - **Process name** The executable file's name
  - **Process path** The fully qualified path to the executable file
  - **Process command line** Any argument parameters supplied in the executable's command line
  - **Process start and exit times** If applicable
  - **Number of threads and handles**

```
root@kali:/usr/share/volatility# python vol.py pslist --profile=Win2008SP1x86 -f /root/Desktop/memdump.mem
Volatility Foundation Volatility Framework 2.3.1
*** Failed to import volatility.plugins.addrspaces.legacyintel (AttributeError: 'module' object has no attri
Offset(V)  Name                    PID   PPID   Thds     Hnds   Sess  Wow64 Start                          E
---------- -------------------- ------ ------ ------ -------- ------ ------ ------------------------------ -
0x82db0910 System                    4      0    100      541 ------      0 2014-01-08 02:17:35 UTC+0000
0x8454c118 smss.exe                404      4      4       28 ------      0 2014-01-08 02:17:35 UTC+0000
0x84561968 csrss.exe               472    460     11      466      0      0 2014-01-08 02:17:35 UTC+0000
0x84450770 csrss.exe               516    508     10      305      1      0 2014-01-08 02:17:36 UTC+0000
0x84453770 wininit.exe             524    460      3       98      0      0 2014-01-08 02:17:36 UTC+0000
0x84465770 winlogon.exe            552    508      3      116      1      0 2014-01-08 02:17:36 UTC+0000
0x83632170 services.exe            604    524      6      250      0      0 2014-01-08 02:17:36 UTC+0000
0x844bf770 lsass.exe               616    524     13      610      0      0 2014-01-08 02:17:36 UTC+0000
0x844c2680 lsm.exe                 624    524     10      208      0      0 2014-01-08 02:17:36 UTC+0000
0x84866d50 svchost.exe             788    604      6      298      0      0 2014-01-08 02:17:42 UTC+0000
0x845f37a8 svchost.exe             848    604      8      280      0      0 2014-01-08 02:17:42 UTC+0000
0x848fa118 svchost.exe             884    604     15      274      0      0 2014-01-08 02:17:42 UTC+0000
0x84914d90 svchost.exe             976    604      6      152      0      0 2014-01-08 02:17:42 UTC+0000
0x8491bd90 svchost.exe            1000    604     45     2072      0      0 2014-01-08 02:17:42 UTC+0000
0x8492a6d0 SLsvc.exe              1056    604      4       96      0      0 2014-01-08 02:17:42 UTC+0000
0x84937d90 svchost.exe            1088    604     17      567      0      0 2014-01-08 02:17:42 UTC+0000
0x84941d90 svchost.exe            1160    604     20      265      0      0 2014-01-08 02:17:42 UTC+0000
0x84945c30 svchost.exe            1188    604     22      596      0      0 2014-01-08 02:17:42 UTC+0000
0x8496e9f0 svchost.exe            1308    604     17      265      0      0 2014-01-08 02:17:43 UTC+0000
0x849c18a8 spoolsv.exe            1424    604     17      291      0      0 2014-01-08 02:17:49 UTC+0000
0x849d7610 armsvc.exe             1460    604      2       56      0      0 2014-01-08 02:17:49 UTC+0000
0x849dcd90 dns.exe                1480    604     10      164      0      0 2014-01-08 02:17:49 UTC+0000
0x849e1cc0 ftpbasicsvr.exe        1508    604      2       52      0      0 2014-01-08 02:17:49 UTC+0000
0x849f5888 svchost.exe            1576    604      5      124      0      0 2014-01-08 02:17:49 UTC+0000
0x849faad8 svchost.exe            1604    604      3       73      0      0 2014-01-08 02:17:49 UTC+0000
```

Handles

- **Used to access files, devices, and more from software**
- **Can help when analyzing malware**
- **Mutants or Mutexes are used for inter-process communication**
  - **To lock a resource so no other process changes it while it's in use**
  - **Used by malware to prevent re-infection**

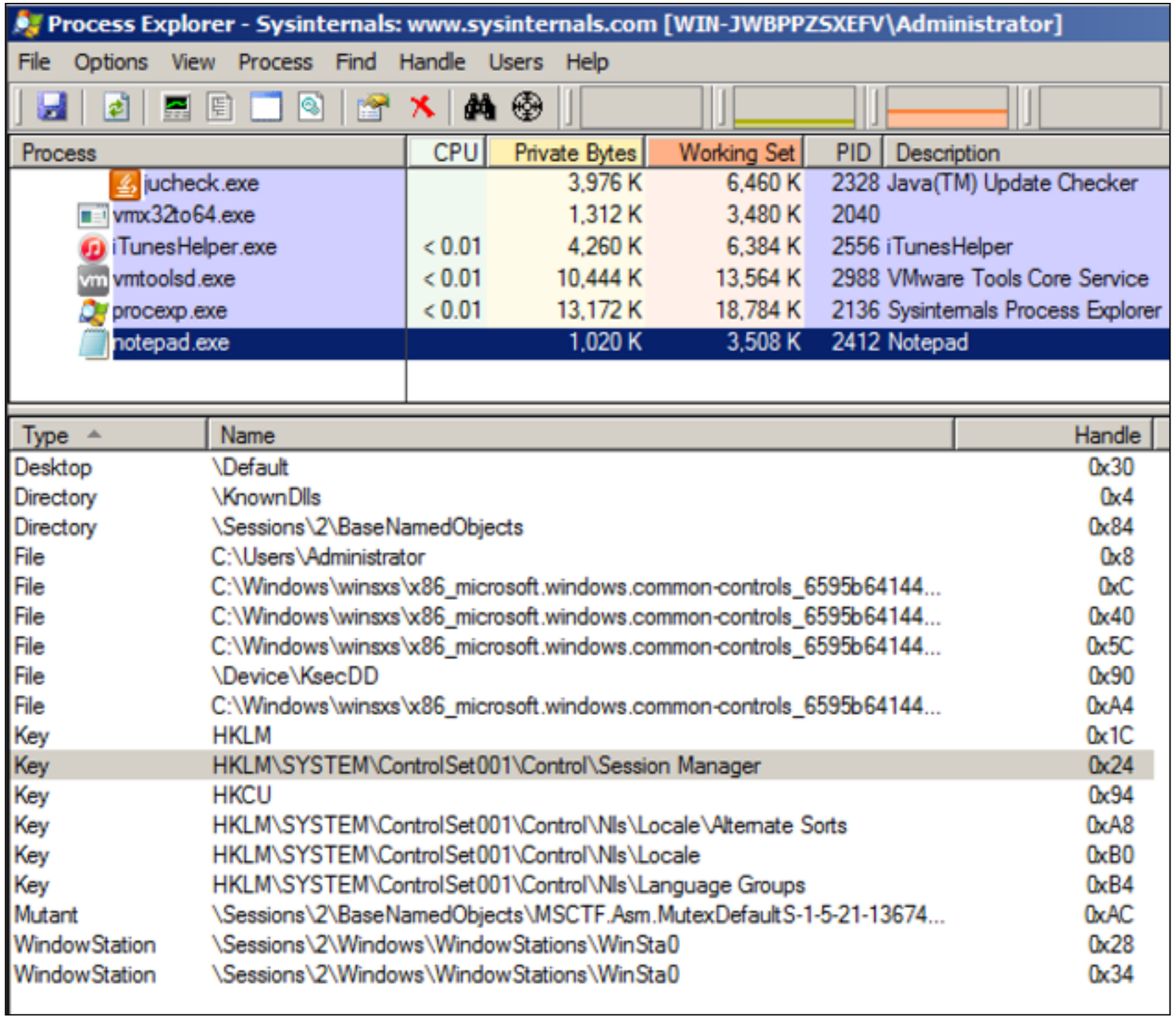
Handles for Zeus

```
$python vol.py -f ~/zeus.vmem handles -p 856 >> ~/zeusfiles/pid-856-
handles.txt
```

```
0xff21b438    856      0x430   0x1f0003 Event
0xff1398c0    856      0x434   0x12019f File            \Device\NamedPipe\_AVIRA_2108
0xff2a0e98    856      0x438   0x1f0003 Event
0xff27b7e8    856      0x43c   0x1f0001 Mutant          _AVIRA_2108
0xff1b8638    856      0x440   0x1f03ff Thread          TID 2004 PID 856
0xff23d020    856      0x444   0x1f03ff Thread          TID 2000 PID 856
0x80f19200    856      0x450   0x1f0001 Mutant
0xff1db540    856      0x454   0x100020 File            \Device\HarddiskVolume1\WINDOWS
indows.Common-Controls_6595b64144ccf1df_6.0.2600.2180_x-ww_a84f1ff9
```

- **Mutant _AVIRA_2108 is a fingerprint of Zeus**
- **Link Ch 12u**

Handles for Notepad



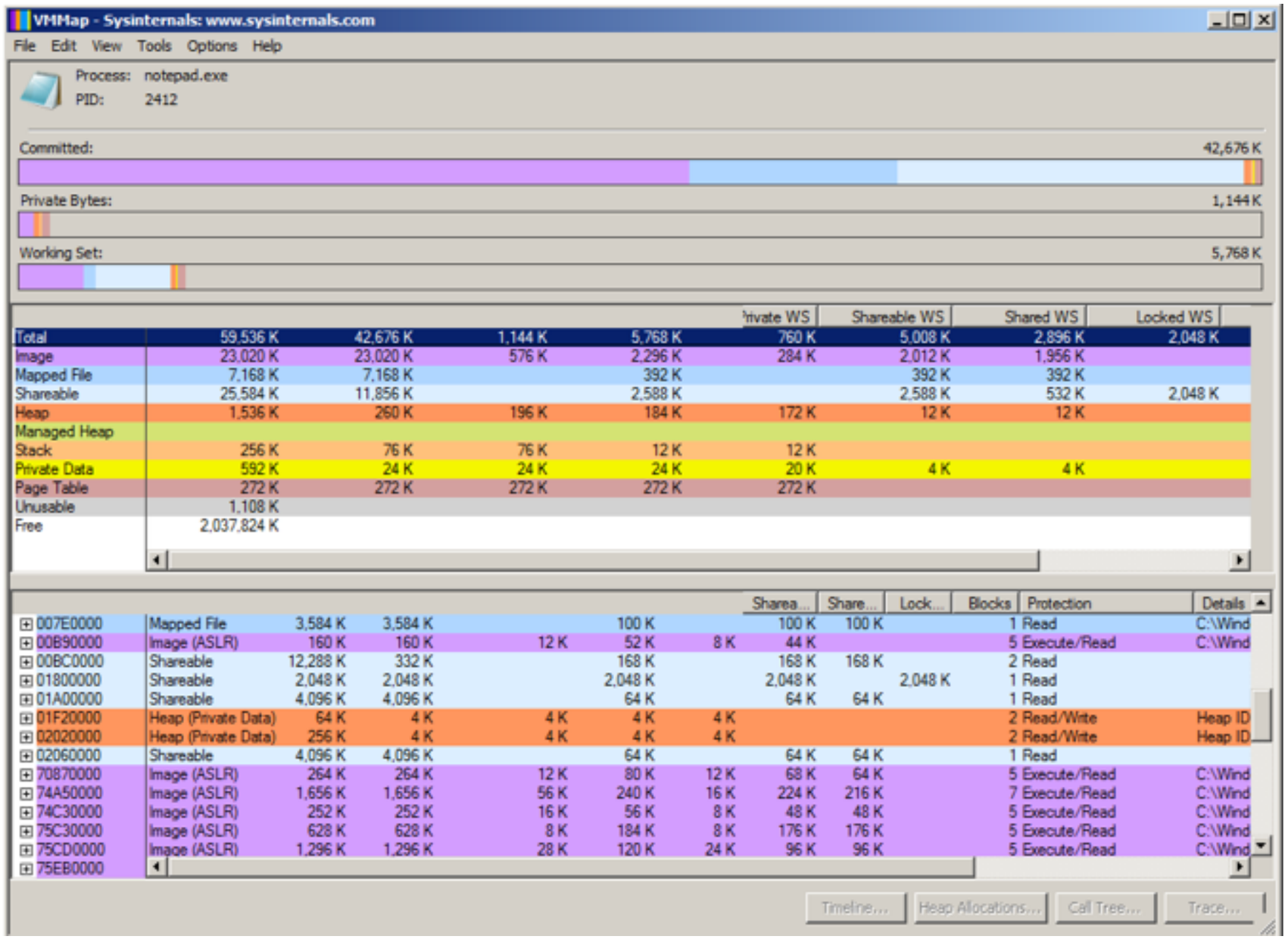
Process	CPU	Private Bytes	Working Set	PID	Description
jucheck.exe		3,976 K	6,460 K	2328	Java(TM) Update Checker
vmx32to64.exe		1,312 K	3,480 K	2040	
iTunesHelper.exe	< 0.01	4,260 K	6,384 K	2556	iTunesHelper
vmtoolsd.exe	< 0.01	10,444 K	13,564 K	2988	VMware Tools Core Service
procexp.exe	< 0.01	13,172 K	18,784 K	2136	Sysinternals Process Explorer
notepad.exe		1,020 K	3,508 K	2412	Notepad

Type	Name	Handle
Desktop	\Default	0x30
Directory	\KnownDlls	0x4
Directory	\Sessions\2\BaseNamedObjects	0x84
File	C:\Users\Administrator	0x8
File	C:\Windows\winsxs\x86_microsoft.windows.common-controls_6595b64144...	0xC
File	C:\Windows\winsxs\x86_microsoft.windows.common-controls_6595b64144...	0x40
File	C:\Windows\winsxs\x86_microsoft.windows.common-controls_6595b64144...	0x5C
File	\Device\KsecDD	0x90
File	C:\Windows\winsxs\x86_microsoft.windows.common-controls_6595b64144...	0xA4
Key	HKLM	0x1C
Key	HKLM\SYSTEM\ControlSet001\Control\Session Manager	0x24
Key	HKCU	0x94
Key	HKLM\SYSTEM\ControlSet001\Control\Nls\Locale\Alternate Sorts	0xA8
Key	HKLM\SYSTEM\ControlSet001\Control\Nls\Locale	0xB0
Key	HKLM\SYSTEM\ControlSet001\Control\Nls\Language Groups	0xB4
Mutant	\Sessions\2\BaseNamedObjects\MSCTF.Asm.MutexDefaultS-1-5-21-13674...	0xAC
WindowStation	\Sessions\2\Windows\WindowStations\WinSta0	0x28
WindowStation	\Sessions\2\Windows\WindowStations\WinSta0	0x34

Sections

- **Each process has a virtual address space**
  - **Including RAM and some disk space in the pagefile**
- **The OS swaps data in and out of physical memory**
- **Virtual Address Descriptor (VAD) tree**
  - **A kernel data structure that shows how memory is used by each process (link Ch 12v)**

Memory Map for Notepad



					Private WS	Shareable WS	Shared WS	Locked WS
Total	59,536 K	42,676 K	1,144 K	5,768 K	760 K	5,008 K	2,896 K	2,048 K
Image	23,020 K	23,020 K	576 K	2,296 K	284 K	2,012 K	1,956 K	
Mapped File	7,168 K	7,168 K		392 K		392 K	392 K	
Shareable	25,584 K	11,856 K		2,588 K		2,588 K	532 K	2,048 K
Heap	1,536 K	260 K	196 K	184 K	172 K	12 K	12 K	
Managed Heap								
Stack	256 K	76 K	76 K	12 K	12 K			
Private Data	592 K	24 K	24 K	24 K	20 K	4 K	4 K	
Page Table	272 K	272 K	272 K	272 K	272 K			
Unusable	1,108 K							
Free	2,037,824 K							

							Sharea...	Share...	Lock...	Blocks	Protection	Details
007E0000	Mapped File	3,584 K	3,584 K		100 K		100 K	100 K		1	Read	C:\Wind
00B90000	Image (ASLR)	160 K	160 K	12 K	52 K	8 K	44 K			5	Execute/Read	C:\Wind
00BC0000	Shareable	12,288 K	332 K		168 K		168 K	168 K		2	Read	
01800000	Shareable	2,048 K	2,048 K		2,048 K		2,048 K		2,048 K	1	Read	
01A00000	Shareable	4,096 K	4,096 K		64 K		64 K	64 K		1	Read	
01F20000	Heap (Private Data)	64 K	4 K	4 K	4 K	4 K				2	Read/Write	Heap ID
02020000	Heap (Private Data)	256 K	4 K	4 K	4 K	4 K				2	Read/Write	Heap ID
02060000	Shareable	4,096 K	4,096 K		64 K		64 K	64 K		1	Read	
70870000	Image (ASLR)	264 K	264 K	12 K	80 K	12 K	68 K	64 K		5	Execute/Read	C:\Wind
74A50000	Image (ASLR)	1,656 K	1,656 K	56 K	240 K	16 K	224 K	216 K		7	Execute/Read	C:\Wind
74C30000	Image (ASLR)	252 K	252 K	16 K	56 K	8 K	48 K	48 K		5	Execute/Read	C:\Wind
75C30000	Image (ASLR)	628 K	628 K	8 K	184 K	8 K	176 K	176 K		5	Execute/Read	C:\Wind
75CD0000	Image (ASLR)	1,296 K	1,296 K	28 K	120 K	24 K	96 K	96 K		5	Execute/Read	C:\Wind
75EB0000												

DLLs for Notepad

Process Explorer - Sysinternals: www.sysinternals.com [WIN-JWBPPZSXEFV\Administrator]

File Options View Process Find DLL Users Help

Process	CPU	Private Bytes	Working Set	PID	Description
jucheck.exe		3,976 K	6,460 K	2328	Java(TM) Update Checker
vmx32to64.exe		1,312 K	3,480 K	2040	
iTunesHelper.exe		4,260 K	6,384 K	2556	iTunesHelper
vmtoolsd.exe	< 0.01	10,444 K	13,560 K	2988	VMware Tools Core Service
procexp.exe	< 0.01	13,264 K	19,580 K	2136	Sysinternals Process Explorer
notepad.exe		1,020 K	3,508 K	2412	Notepad

Name	Description	Company Name	Path
advapi32.dll	Advanced Windows 32 Base API	Microsoft Corporation	C:\Windows\System32\advapi32.dll
comctl32.dll	User Experience Controls Library	Microsoft Corporation	C:\Windows\winsxs\x86_microsoft.win
comdlg32.dll	Common Dialogs DLL	Microsoft Corporation	C:\Windows\System32\comdlg32.dll
gdi32.dll	GDI Client DLL	Microsoft Corporation	C:\Windows\System32\gdi32.dll
imm32.dll	Multi-User Windows IMM32 API Client DLL	Microsoft Corporation	C:\Windows\System32\imm32.dll
kernel32.dll	Windows NT BASE API Client DLL	Microsoft Corporation	C:\Windows\System32\kernel32.dll
loc2008.nls			C:\Windows\System32\loc2008.nls
loc2008.nls			C:\Windows\System32\loc2008.nls
lpk.dll	Language Pack	Microsoft Corporation	C:\Windows\System32\lpk.dll
msctf.dll	MSCTF Server DLL	Microsoft Corporation	C:\Windows\System32\msctf.dll
msvcrt.dll	Windows NT CRT DLL	Microsoft Corporation	C:\Windows\System32\msvcrt.dll
notepad.exe	Notepad	Microsoft Corporation	C:\Windows\System32\notepad.exe
ntdll.dll	NT Layer DLL	Microsoft Corporation	C:\Windows\System32\ntdll.dll
ole32.dll	Microsoft OLE for Windows	Microsoft Corporation	C:\Windows\System32\ole32.dll
oleaut32.dll		Microsoft Corporation	C:\Windows\System32\oleaut32.dll
rpcrt4.dll	Remote Procedure Call Runtime	Microsoft Corporation	C:\Windows\System32\rpcrt4.dll
shell32.dll	Windows Shell Common Dll	Microsoft Corporation	C:\Windows\System32\shell32.dll
shlwapi.dll	Shell Light-weight Utility Library	Microsoft Corporation	C:\Windows\System32\shlwapi.dll
user32.dll	Multi-User Windows USER API Client DLL	Microsoft Corporation	C:\Windows\System32\user32.dll
usp10.dll	Uniscribe Unicode script processor	Microsoft Corporation	C:\Windows\System32\usp10.dll
uxtheme.dll	Microsoft UxTheme Library	Microsoft Corporation	C:\Windows\System32\uxtheme.dll
winspool.drv	Windows Spooler Driver	Microsoft Corporation	C:\Windows\System32\winspool.drv

Detecting Malicious DLLs

- **Check for valid digital signatures**
- **Known-good or -bad hash values**
- **Evidence of process-tampering attacks**
  - **Malware loading a DLL surreptitiously or running code in memory**

Other Memory Artifacts

- **Network connections**
- **Loaded drivers**
  - **Runs in kernel, with elevated privileges**
- **Console command history**
- **Strings in memory**
- **Credentials**

Pagefile Analysis

- **Has no intrinsic structure**
- **Can search for strings**
- **Be careful: antivirus and host-based intrusion detection systems leaves signatures in the pagefile**
  - **Suspicious IP addresses, domain names, and malware filenames**
- **Windows can clear the pagefile on shutdown, but this is not its default setting**

Analyzing Common In-Memory Attacks

- **Process injection**
- **Hooking**

Process Injection

- **A malicious *injecting* process causes a legitimate process (*injected*) to load and execute malicious code**
- **In-memory attack**
  - **Disk files do not change**
- ***Injected* process has no evidence indicating which process was responsible for the injection**

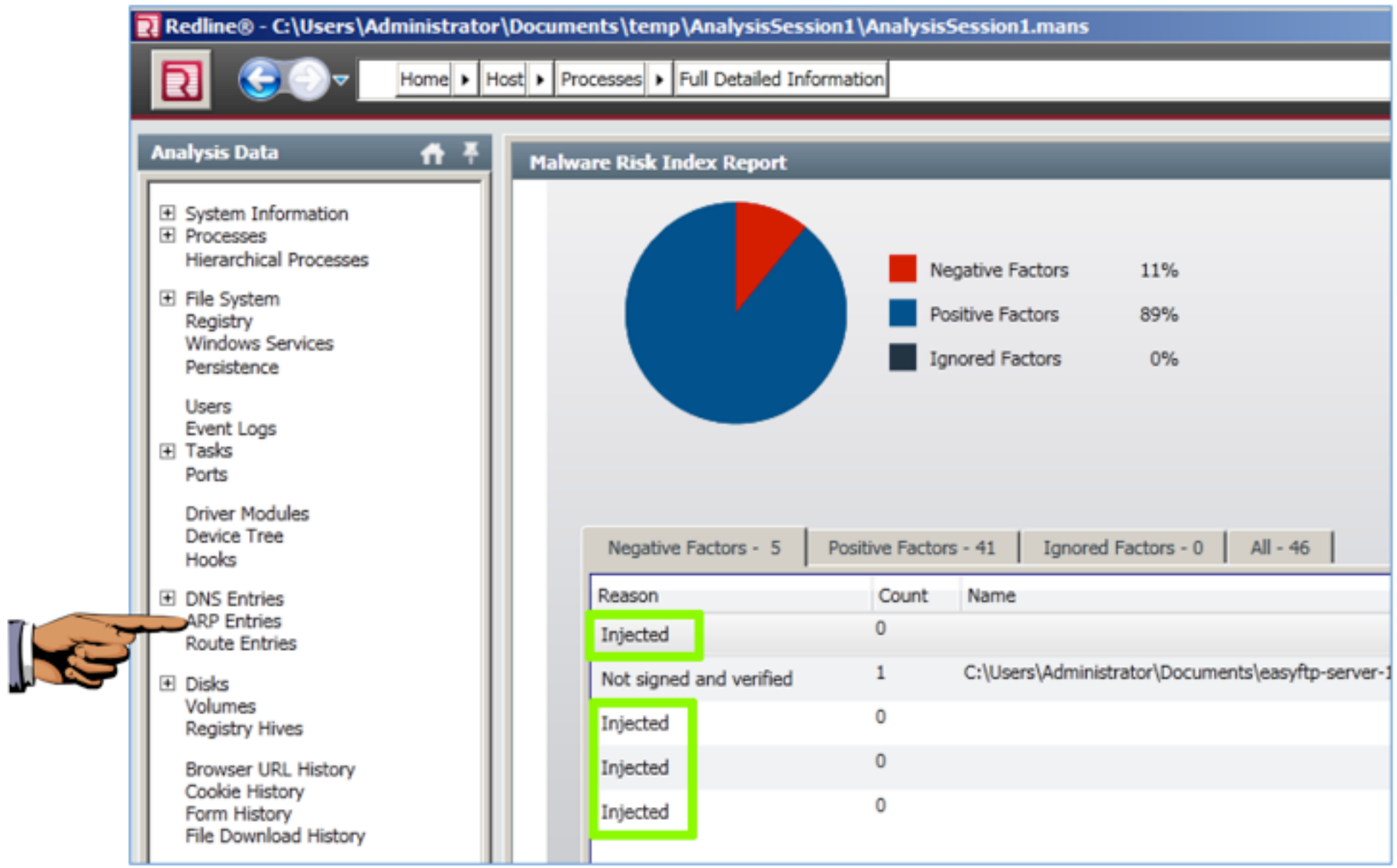
Methods of Process Injection

- **Use Windows APIs (requires Administrator or SYSTEM privileges)**
  - **Force target process to load a malicious DLL from disk**
  - **Directly write malicious code to target process's memory and invoke a remote thread to execute it**

Process Replacement

- **Malware launches a legitimate executable in a suspended state**
- **Then overwrite process memory with malicious code**
- **Unsuspend it to execute**

Redline Detecting Injection



Detecting Malicious Injection

- **Memory sections with Execute, Read and Write permissions**
- **Processes that don't match corresponding disk files**
  - **Links Ch 12w, 12x**

Finding Persistence Mechanisms

- **The *injecting* process needs a persistence mechanism to survive reboots**
- **So it maybe found in**
  - **Auto-run keys, DLL load-order hijacking, etc.**

Hooking

- **Allows code within running processes to intercept, modify, and view events such as function calls and data they return**
- **Windows provides many API mechanisms to do this**
- **Used by legitimate programs**
  - **Antivirus, host-based intrusion detection systems, application inventory software**

Malicious Hooking

- **Rootkits use hooking to hide files, processes, registry keys, or network connections**
- **Keyloggers may use SetWindowsHookEx to cause a malicious DLL function to be called whenever a keyboard event occurs**
- **Or use GetAsyncKeyState to constantly check the up/down state of keys**

Types of Hooks

- **Manipulate a process's Import Address Table**
  - **So it calls malicious functions instead of legitimate system functions**
- **Hook kernel structures such as the Interrupt Descriptor Table (IDT) and System Service Dispatch Table (SSDT)**
  - **Prevented on modern Windows systems by Kernel Patch Protection (KPP)**

Zeus Hook

- **The next slide shows the output of "apihooks" (a Volatility plugin)**
- **On a system infected with Zeus**
- **Shows an inline hook to the HttpSendRequestA function imported from WinInet.dll within the process space of lsass.exe**

Volatility Detecting Hooks

```
C:\Windows\system32\cmd.exe
**************************************************************************
Hook mode: Usermode
Hook type: Inline/Trampoline
Process: 688 (lsass.exe)
Victim module: WININET.dll (0x771b0000 - 0x77256000)
Function: WININET.dll!HttpSendRequestA at 0x771c76b8
Hook address: 0xa27366
Hooking module: <unknown>

Disassembly(0):
0x771c76b8 e9a9fc8589        JMP 0xa27366
0x771c76bd 6a13              PUSH 0x13
0x771c76bf 6a00              PUSH 0x0
0x771c76c1 ff7518            PUSH DWORD [EBP+0x18]
0x771c76c4 ff7514            PUSH DWORD [EBP+0x14]
0x771c76c7 ff7510            PUSH DWORD [EBP+0x10]
0x771c76ca ff750c            PUSH DWORD [EBP+0xc]
0x771c76cd ff7508            PUSH DWORD [EBP+0x8]

Disassembly(1):
0xa27366 55              PUSH EBP
0xa27367 8bec            MOV EBP, ESP
0xa27369 e8cac7feff      CALL 0xa13b38
0xa2736e ff7510          PUSH DWORD [EBP+0x10]
0xa27371 8b4518          MOV EAX, [EBP+0x18]
```

Figure 12.26 — Output of the Volatility Framework's apihooks plugin on a system

Memory Analysis Tools

- **Acquisition tools**
  - **FTK Imager**
  - **DumpIt**
  - **Memoryze and Redline**
- **Analysis tools**
  - **Memoryze and Redline**
  - **Volatility**

Alternative Persistence Mechanisms

Alternative Persistence Mechanisms

- **Startup folders**
- **Recurring tasks**
- **System binary modification**
- **The sticky keys attack**
- **DLL load-order hijacking**

Startup Folders

- **Any program or shortcut in this folder is launched**
  - **On startup or login**

On Windows Vista and Windows 7, the “all users” Startup folder is located at C:\ProgramData\Microsoft\Windows\Start Menu\Programs\Startup, and the user-specific Startup folder is located at C:\Users\[username]\AppData\Roaming\Microsoft\Windows\Start Menu\Programs\Startup.

Recurring Tasks

- **Use "at" or "schtasks" commands**
- **To make a task that recurs at regular times or days of the week**
- **Future and recurring scheduled tasks persist as .job files in %SYSTEMROOT%\Tasks**

System Binary Modification

- **Modify existing Windows binary**
  - **Typically one automatically loaded on bootup or login**
- **Add malicious code**
- **Time-stomp**
- **Will change MD5 hash and break signature, but not all legitimate binaries are signed**

Careful Modifications

- **Changes that cause Windows to crash or impair user experience will limit the attacker's ability to persist**
- **Attackers are more likely to replace noncritical executables or libraries**

Defenses

- **Windows File Protection in older versions of Windows (XP, 2000)**
  - **Easily bypassed by a local Administrator**
- **Replaced by Windows Resource Protection (WRP) in Windows Vista and later**
  - **Requires TrustedInstaller permissions to alter WFP-governed resources**
  - **More resistant to tampering**

The Sticky Keys Attack

- **Targets sethc.exe**
  - **A file that provides accessibility features**
  - **Replace sethc.exe with cmd.exe**
- **Press Shift key five times before logon**
  - **A command shell opens with SYSTEM privileges**
  - **Even works during a Remote Desktop Protocol session**

The Sticky Keys Attack

- **No longer works on Vista and later versions**
- **But there's another way to get the same result**

An attacker can simply set cmd.exe as the debugger for sethc.exe by adding the registry key HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Image File Execution Options\sethc.exe, creating a value of type REG_SZ named Debugger, and setting the value data to C:\WINDOWS\system32\cmd.exe.

DLL Load-Order Hijacking

- **DLLs are loaded when a program launches**
- **But DLLs might be in many different folders**
- **"KnownDLLs" registry key lists known system DLLs and ensures that they are always loaded from %systemroot%\System32**

Registry Editor

File Edit View Favorites Help

- ServiceProvider
- Session Manager
  - AppCompatCache
  - Configuration Mana
  - DOS Devices
  - Environment
  - Executive
  - FileRenameOperatic
  - I/O System
  - kernel
  - KnownDLLs
  - Memory Manageme
  - Power
  - Quota System
  - SubSystems
  - WPA
- SNMP
- StillImage
- Storage
- SystemInformation
- SystemResources
- Terminal Server
- TimeZoneInformation
- usbflags
- usbstor
- VAN
- Video
- VirtualDeviceDrivers
- Wdf
- WDI
- Windows
- Winlogon
- Winresume

Name	Type	Data
(Default)	REG_SZ	(value not set)
advapi32	REG_SZ	advapi32.dll
clbcatq	REG_SZ	clbcatq.dll
COMDLG32	REG_SZ	COMDLG32.dll
DllDirectory	REG_EXPAND_SZ	%SystemRoot%\system32
gdi32	REG_SZ	gdi32.dll
IERTUTIL	REG_SZ	IERTUTIL.dll
IMAGEHLP	REG_SZ	IMAGEHLP.dll
IMM32	REG_SZ	IMM32.dll
kernel32	REG_SZ	kernel32.dll
LPK	REG_SZ	LPK.dll
MSCTF	REG_SZ	MSCTF.dll
MSVCRT	REG_SZ	MSVCRT.dll
NORMALIZ	REG_SZ	NORMALIZ.dll
NSI	REG_SZ	NSI.dll
ole32	REG_SZ	ole32.dll
OLEAUT32	REG_SZ	OLEAUT32.dll
rpcrt4	REG_SZ	rpcrt4.dll
Setupapi	REG_SZ	Setupapi.dll
SHELL32	REG_SZ	SHELL32.dll
SHLWAPI	REG_SZ	SHLWAPI.dll
URLMON	REG_SZ	URLMON.dll
user32	REG_SZ	user32.dll
USP10	REG_SZ	USP10.dll
WININET	REG_SZ	WININET.dll
WLDAP32	REG_SZ	WLDAP32.dll
WS2_32	REG_SZ	WS2_32.dll

Computer\HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Session Manager\KnownDLLs

Unknown DLL Search Order

SafeDllSearchMode Disabled (0)	**SafeDllSearchMode Enabled (1)**
Directory where the application is loaded	Directory where the application is loaded
Current working directory	%systemroot%\system32
%systemroot%\system32	%systemroot%\system
%systemroot%\system	%systemroot%
%systemroot%	Current working directory
%PATH% environment variable entries	%PATH% environment variable entries

DLL Load-Order Hijacking Works When:

- The legitimate DLL is not specified in KnownDLLs.
- The legitimate DLL is not in the same directory as the application executable file.
- The executable file does not use an absolute path to load the DLL.

- **ntshrui.dll is loaded by Windows Explorer and is vulnerable**

- **A malicious ntshrui.dll in %systemroot% will launch when Explorer does**