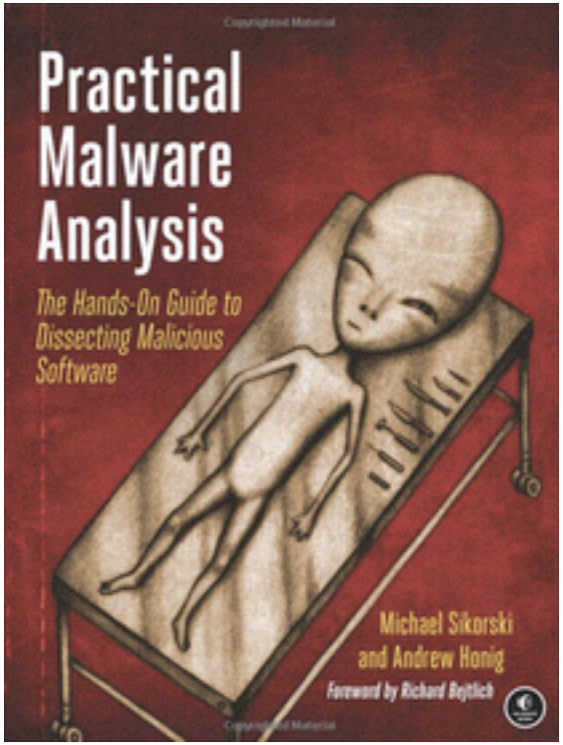
Practical Malware Analysis

Ch 12: Covert Malware Launching



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Hiding Malware

- Malware used to be visible in Windows Task Manager
  - But users often know how to look there
- So malware authors now try to blend their malware into the normal Windows landscape
- Covert lanching techniques

Launchers

Purpose of a Launcher

- Sets itself or another piece of malware
  - For immediate or future covert execution
- Conceals malicious behavior from the user
- Usually contain the malware they're loading
  - An executable or DLL in its own resource section
- Normal items in the resource section
  - Icons, images, menus, strings
  - Not considered part of the executable

Encryption or Compression

- The resource section may be encrypted or compressed
- Resource extraction will use APIs like
  - **`FindResource`**
  - **`LoadResource`**
  - **`SizeofResource`**
- Malware also often contains privilege escalation code

Process Injection

Process Injection

- The most popular covert launching technique
  - Two types: DLL Injection and Direct Injection
- Injects code into a running process
- Conceals malicious behavior
- May bypass firewalls and other process-specific security mechanisms
- Common API calls:
  - **`VirtualAllocEx`** to allocate space in another process's memory
  - **`WriteProcessMemory`** to write to it

DLL Injection

- The most commonly used covert launching technique
- Inject code into a remote process that calls **`LoadLibrary`**
- Forces the DLL to load in the context of that process
- On load, the OS automatically calls **`DLLMain`** which contains the malicious code

Example

- Launcher wants Internet access
  - To download more code
- But a process-specific firewall won't let the launcher's process access the Internet
- Solution: inject malicious code into Internet Explorer process
  - Which already has Internet access

Gaining Privileges

- Malware code has the same privileges as the code it is injected into

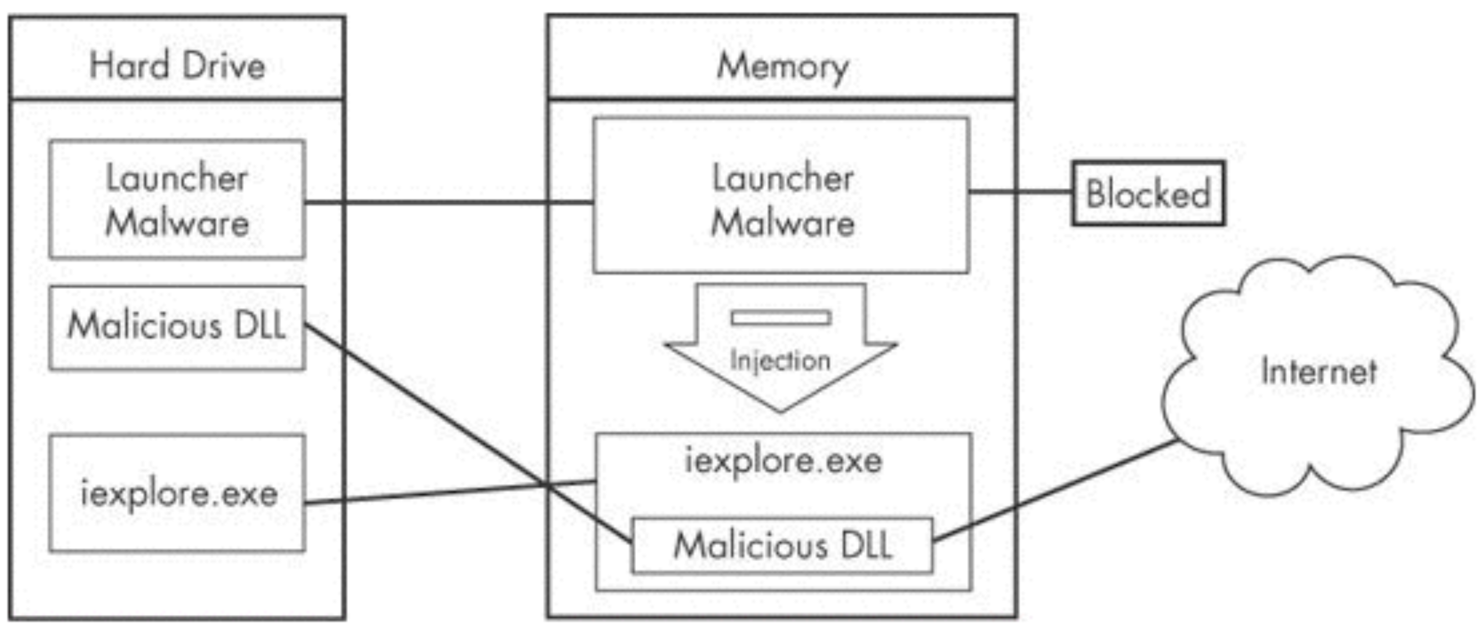

Figure 13-1. DLL injection—the launcher malware cannot access the Internet until it injects into iexplore.exe.

Example 13-1. C Pseudocode for DLL injection

```
hVictimProcess = OpenProcess(PROCESS_ALL_ACCESS, 0, victimProcessID 1);

pNameInVictimProcess = VirtualAllocEx(hVictimProcess,...,sizeof(maliciousLibraryName),...,...);
WriteProcessMemory(hVictimProcess,...,maliciousLibraryName, sizeof(maliciousLibraryName),...);
GetModuleHandle("Kernel32.dll");
GetProcAddress(...,"LoadLibraryA");
2 CreateRemoteThread(hVictimProcess,...,...,LoadLibraryAddress,pNameInVictimProcess,...,...);
```

- **`CreateRemoteThread`** uses 3 parameters
  - Process handle **`hProcess`**
  - Starting point **`lpStartAddress`** (LoadLibrary)
  - Argument **`lpParameter`** Malicious DLL name

Figure 13-2. DLL injection debugger view

Analyzing DLL Injection

- Once you find DLL injection activity in disassembly
  - Look for strings containing the name of the malicious DLL and the victim process
  - Or put a breakpoint in the injection code and examine the stack to find them

Direct Injection

- Injects code directly into the remote process
- Without using a DLL
- More flexible than DLL injection
- Requires a lot of customized code
  - To run without negatively impacting the host process
- Difficult to write

Process Replacement

Process Replacement

- Overwrites the memory space of a running object with malicious code
- Disguises malware as a legitimate process
- Avoids risk of crashing a process with process injection
- Malware gains the privileges of the process it replaces
- Commonly replaces *svchost.exe*

Suspended State

- In a *suspended state*, the process is loaded into memory but the primary thread is suspended
  - So malware can overwrite its code before it runs
- This uses the **`CREATE_SUSPENDED`** value
- in the **`dwCreationFlags`** parameter
- In a call to the **`CreateProcess`** function

Example 13-2. Assembly code showing process replacement

```
00401535        push    edi                 ; lpProcessInformation
00401536        push    ecx                 ; lpStartupInfo
00401537        push    ebx                 ; lpCurrentDirectory
00401538        push    ebx                 ; lpEnvironment
00401539        push    CREATE_SUSPENDED ; dwCreationFlags
0040153B        push    ebx                 ; bInheritHandles
0040153C        push    ebx                 ; lpThreadAttributes
0040153D        lea     edx, [esp+94h+CommandLine]
00401541        push    ebx                 ; lpProcessAttributes
00401542        push    edx                 ; lpCommandLine
00401543        push    ebx                 ; lpApplicationName
00401544        mov     [esp+0A0h+StartupInfo.dwFlags], 101h
0040154F        mov     [esp+0A0h+StartupInfo.wShowWindow], bx
00401557        call    ds:CreateProcessA
```

Example 13-3. C pseudocode for process replacement

```
CreateProcess(...,"svchost.exe",...,CREATE_SUSPEND,...);
ZwUnmapViewOfSection(...);
VirtualAllocEx(...,ImageBase,SizeOfImage,...);
WriteProcessMemory(...,headers,...);
for (i=0; i < NumberOfSections; i++) {
  1 WriteProcessMemory(...,section,...);
}
SetThreadContext();
...
ResumeThread();
```

- **`ZwUnmapViewOfSection`** releases all memory pointed to by a section
- **`VirtualAllocEx`** allocates new memory
- **`WriteProcessMemory`** puts malware in it

Example 13-3. C pseudocode for process replacement

```
CreateProcess(...,"svchost.exe",...,CREATE_SUSPEND,...);
ZwUnmapViewOfSection(...);
VirtualAllocEx(...,ImageBase,SizeOfImage,...);
WriteProcessMemory(...,headers,...);
for (i=0; i < NumberOfSections; i++) {
  1 WriteProcessMemory(...,section,...);
}
SetThreadContext();
...
ResumeThread();
```

- **`SetThreadContext`** restores the victim process's environment and sets the entry point
- **`ResumeThread`** runs the malicious code

Hook Injection

Hooks

- Windows hooks intercept messages destined for applications
- Malicious hooks
  - Ensure that malicious code will run whenever a particular message is intercepted
  - Ensure that a DLL will be loaded in a victim process's memory space

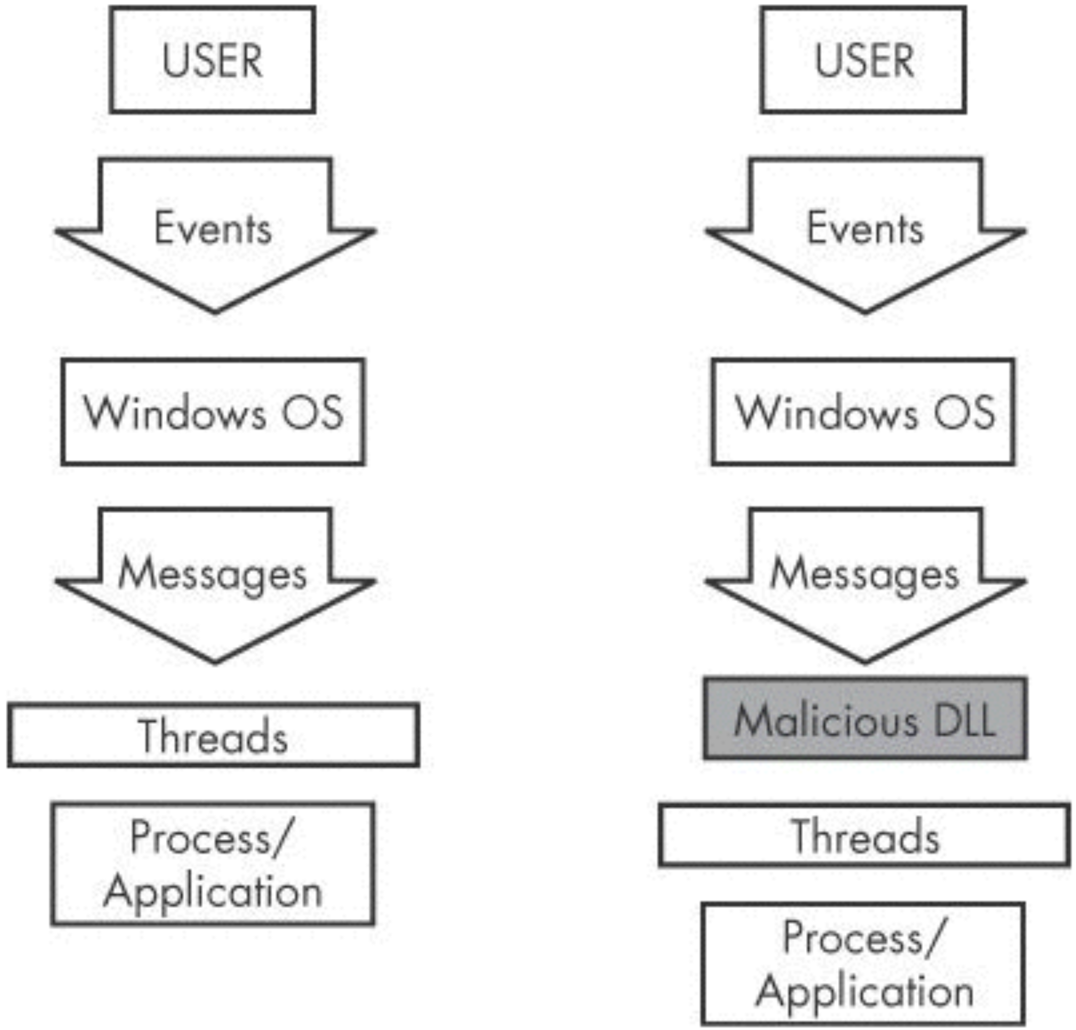

Figure 13-3. Event and message flow in Windows with and without hook injection

Local and Remote Hooks

- *Local hooks* observe or manipulate messages destined for an internal process
- *Remote hooks* observe or manipulate messages destined for a remote process (another process on the computer)

High-Level and Low-Level Remote Hooks

- *High-level remote hooks*
  - Require that the hook procedure is an exported function contained in a DLL
  - Mapped by the OS into the process space of a hooked thread or all threads
- *Low-level remote hooks*
  - Require that the hook procedure be contained in the process that installed the hook

Keyloggers Using Hooks

- Keystrokes can be captured by high-level or low-level hooks using these procedure types
  - **WH_KEYBOARD**
  - or
  - **WH_KEYBOARD_LL**

Using **SetWindowsHookEx** for Remote Windows Hooking

- Parameters
  - **idHook** – type of hook to install
  - **lpfn** – points to hook procedure
  - **hMod** – handle to DLL, or local module, in which the **lpfn** procedure is defined
  - **dwThreadId**– thread to associate the hook with. Zero = all threads
- The hook procedure must call **CallNextHookEx** to pass execution to the next hook procedure so the system continues to run properly

Thread Targeting

- Loading into all threads can degrade system performance
- May also trigger an IPS
- Keyloggers load into all threads, to get all the keystrokes
- Other malware targets a single thread
- Often targets a Windows message that is rarely used, such as **`WH_CBT`** (a computer-based training message)

Explanation of Next Slide

- Malicious DLL *hook.dll* is loaded
- Malicious hook procedure address **`MalwareProc`** obtained
- The hook procedure calls only **`CallNextHookEx`**
- A **`WH_CBT`** message is sent to a Notepad thread
- Forces *hook.dll* to be loaded by Notepad
- It runs in the Notepad process space

Example 13-4. Hook injection, assembly code

```
00401100        push    esi
00401101        push    edi
00401102        push    offset LibFileName ; "hook.dll"
00401107        call    LoadLibraryA
0040110D        mov     esi, eax
0040110F        push    offset ProcName ; "MalwareProc"
00401114        push    esi                ; hModule
00401115        call    GetProcAddress
0040111B        mov     edi, eax
0040111D        call    GetNotepadThreadId
00401122        push    eax                ; dwThreadId
00401123        push    esi                ; hmod
00401124        push    edi                ; lpfn
00401125        push    WH_CBT   ; idHook
00401127        call    SetWindowsHookExA
```

Detours

A Microsoft Product

- Detours makes it easy for application developers to modify applications and the OS
- Used in malware to add new DLLs to existing binaries on disk
- Modifies the PE structure to create a **`.detour`** section
- Containing original PE header with a new import address table

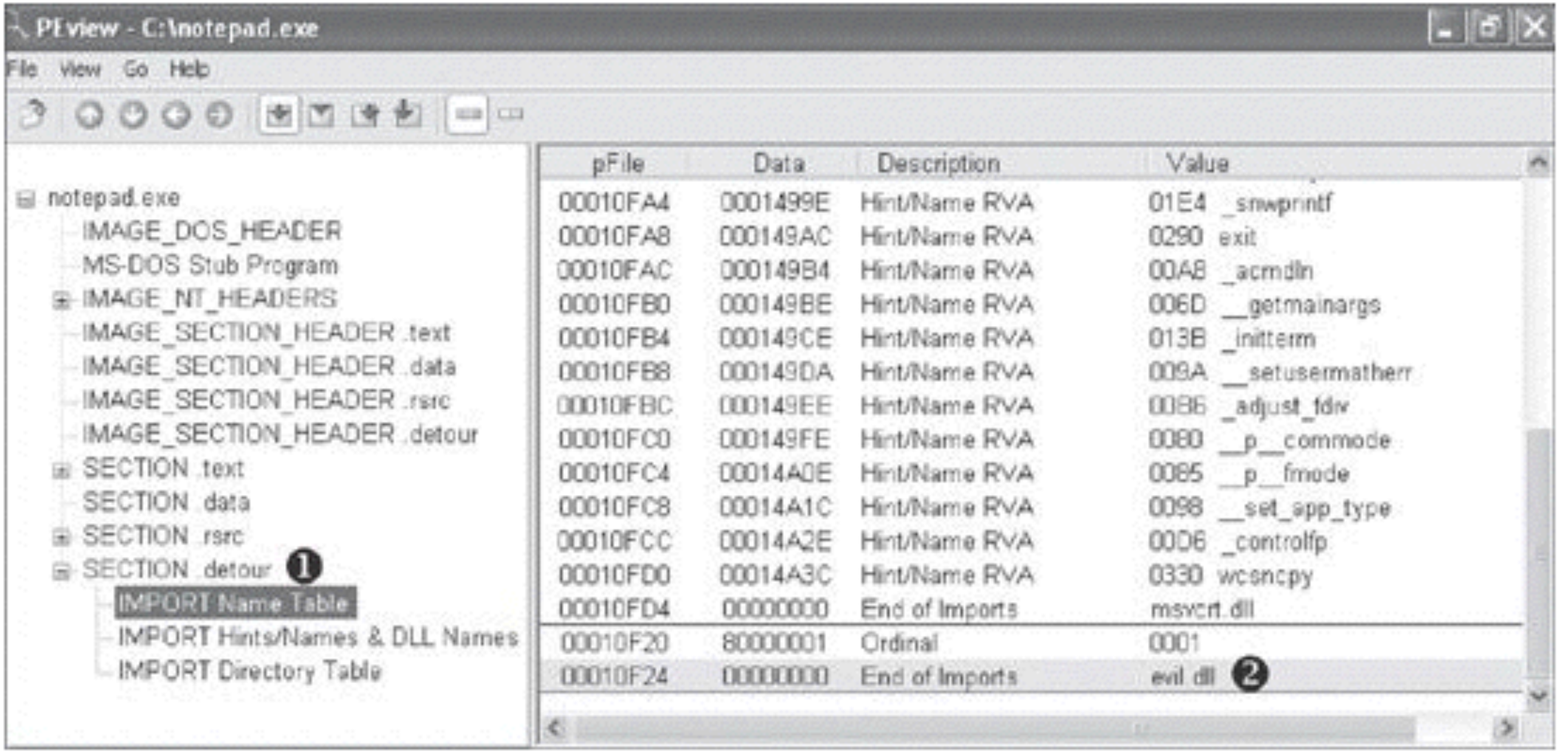

Figure 13-4. A PEview of Detours and the evil.dll

- **`setdll`** is the Microsoft tool used to point the PE to the new import table
- There are other ways to add a **`.detour`** section

APC Injection

Asynchronous Procedure Call (APC)

- Directs a thread to execute other code prior to executing its regular path
- Every thread has a queue of APCs attached to it
- These are processed when the thread is in an alterable state, such as when these functions are called
  - **`WaitForSingleObjectEx`**
  - **`WaitForMultipleObjectsEx`**
  - **`Sleep`**

Two Forms of APCs

- Kernel-Mode APC
  - Generated for the system or a driver
- User-Mode APC
  - Generated for an application
- APC Injection is used in both cases

APC Injection from User Space

- Uses API function **`QueueUserAPC`**
- Thread must be in an alterable state
- **`WaitForSingleObjectEx`** is the most common call in the Windows API
- Many threads are usually in the alterable state

`QueueUserAPC` Parameters

- **`hThread`** handle to thread
- **`pfnAPC`** defines the function to run
- **`dwData`** parameter for function

Example 13-5. APC injection from a user-mode application

```
00401DA9        push    [esp+4+dwThreadId]      ; dwThreadId
00401DAD        push    0                       ; bInheritHandle
00401DAF        push    10h                     ; dwDesiredAccess
00401DB1        call    ds:OpenThread 1
00401DB7        mov     esi, eax
00401DB9        test    esi, esi
00401DBB        jz      short loc_401DCE
00401DBD        push    [esp+4+dwData]          ; dwData = dbnet.dll
00401DC1        push    esi                     ; hThread
00401DC2        push    ds:LoadLibraryA 2      ; pfnAPC
00401DC8        call    ds:QueueUserAPC
```

- 1: Opens a handle to the thread
- 2: **QueueUserAPC** is called with **pfnAPC** set to **LoadLibraryA** (loads a DLL)
- **dwData** contains the DLL name (*dbnet.dll*)
- *Svchost.exe* is often targeted for APC injection

APC Injection from Kernel Space

- Malware drivers and rootkits often want to execute code in user space
- This is difficult to do
- One method is APC injection to get to user space
- Most often to *svchost.exe*
- Functions used:
  - **`KeInitializeApc`**
  - **`KeInsertQueueApc`**

Example 13-6. User-mode APC injection from kernel space

```
000119BD        push    ebx
000119BE        push    1 1
000119C0        push    [ebp+arg_4] 2
000119C3        push    ebx
000119C4        push    offset sub_11964
000119C9        push    2
000119CB        push    [ebp+arg_0] 3
000119CE        push    esi
000119CF        call    ds:KeInitializeApc
000119D5        cmp     edi, ebx
000119D7        jz      short loc_119EA
000119D9        push    ebx
000119DA        push    [ebp+arg_C]
000119DD        push    [ebp+arg_8]
000119E0        push    esi
000119E1        call    edi         ;KeInsertQueueApc
```