Zero Day Malware Cleaning with the Sysinternals Tools

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About Me

- Technical Fellow, Windows Azure, Microsoft
- Cofounder and chief software architect of Winternals Software
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  - With Dave Solomon
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About this Talk

- Learn about Sysinternals tools and techniques for analyzing and cleaning malware
  - Professional antimalware analysis requires
  - But even for professionals, Sysinternals tools can prove useful
- Analyzing:
  - Understanding the impact of malware
  - Can be used to understand malware operation
  - Generates road map for cleaning infestations
- Cleaning:
  - Removing an infestation of a compromised system
  - Attempting a clean can also reveal more information about malware's operation

Malware Cleaning Steps

- Disconnect from network
- Identify malicious processes and drivers
- Suspend and terminate identified processes
- Identify and delete malware autostarts
- Delete malware files
- Reboot and repeat

Identifying Malware Processes

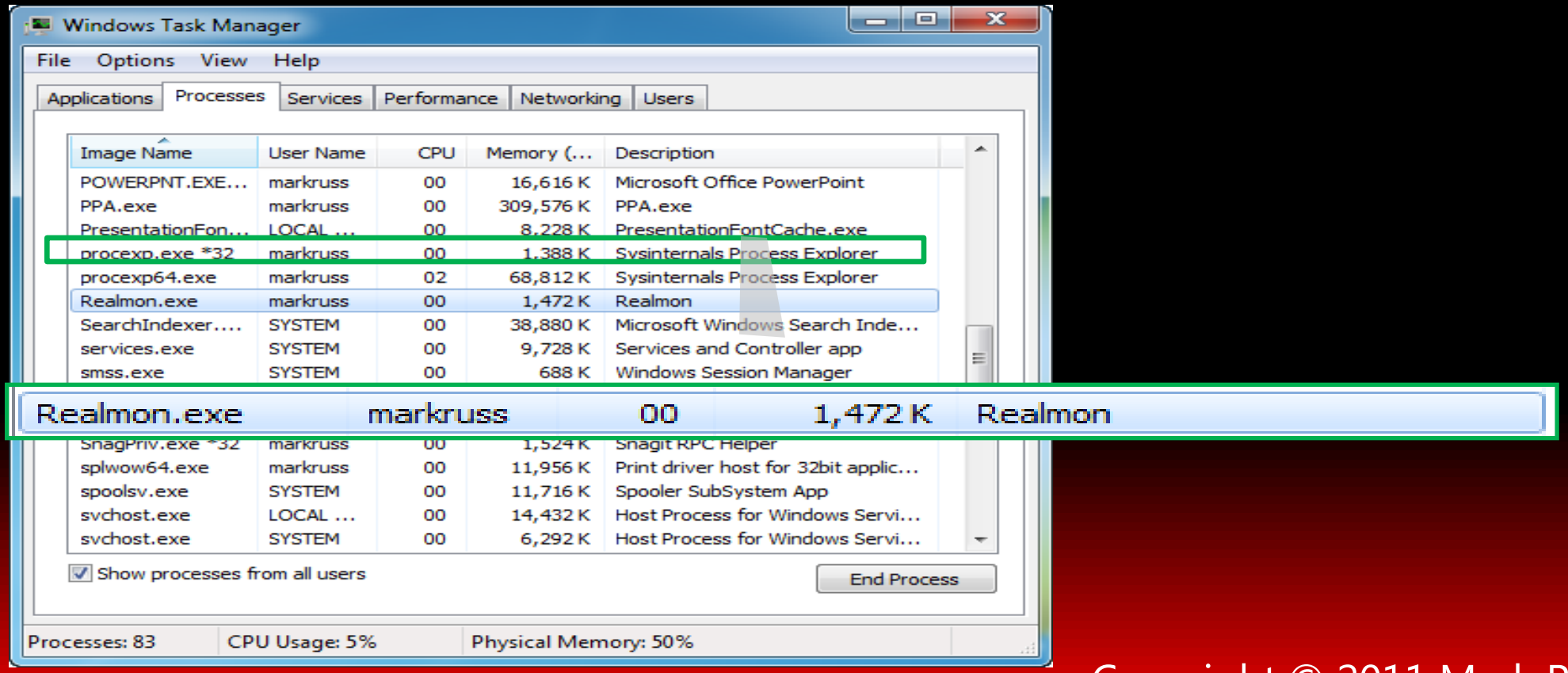
What Are You Looking For?

Investigate processes that…

- …have no icon
- …have no description or company name
- …unsigned Microsoft images
- …live in Windows directory or user profile
- …are packed
- …include strange URLs in their strings
- …have open TCP/IP endpoints
- …host suspicious DLLs or services

What About Task Manager?

- Task Manager provides little information about images that are running

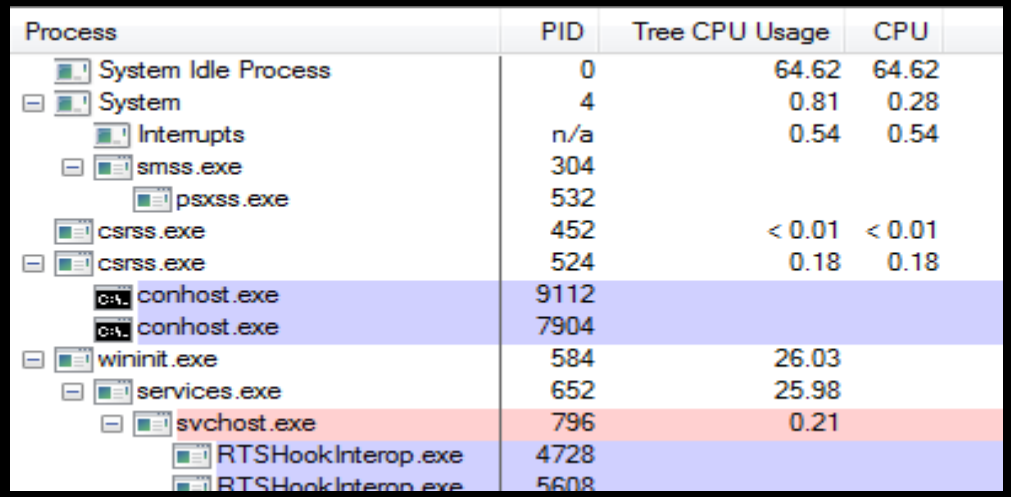


Process Explorer

- Process Explorer is “Super Task Manager”
- Has lots of general troubleshooting capabilities:
  - DLL versioning problems
  - Handle leaks and locked files
  - Performance troubleshooting
  - Hung processes
- We’re going to focus on its malware cleaning capabilities

Process Explorer 2010 Updates

- Versions 12 and 14 included many enhancements, big and small:
  - Network and disk activity
  - Multi-tab system information
  - Tree CPU usage
  - Improved DLL scanning algorithm
  - Command-lines in process tooltips
  - Svchost information
  - Service threads
  - .NET assembly information
  - Support for > 64

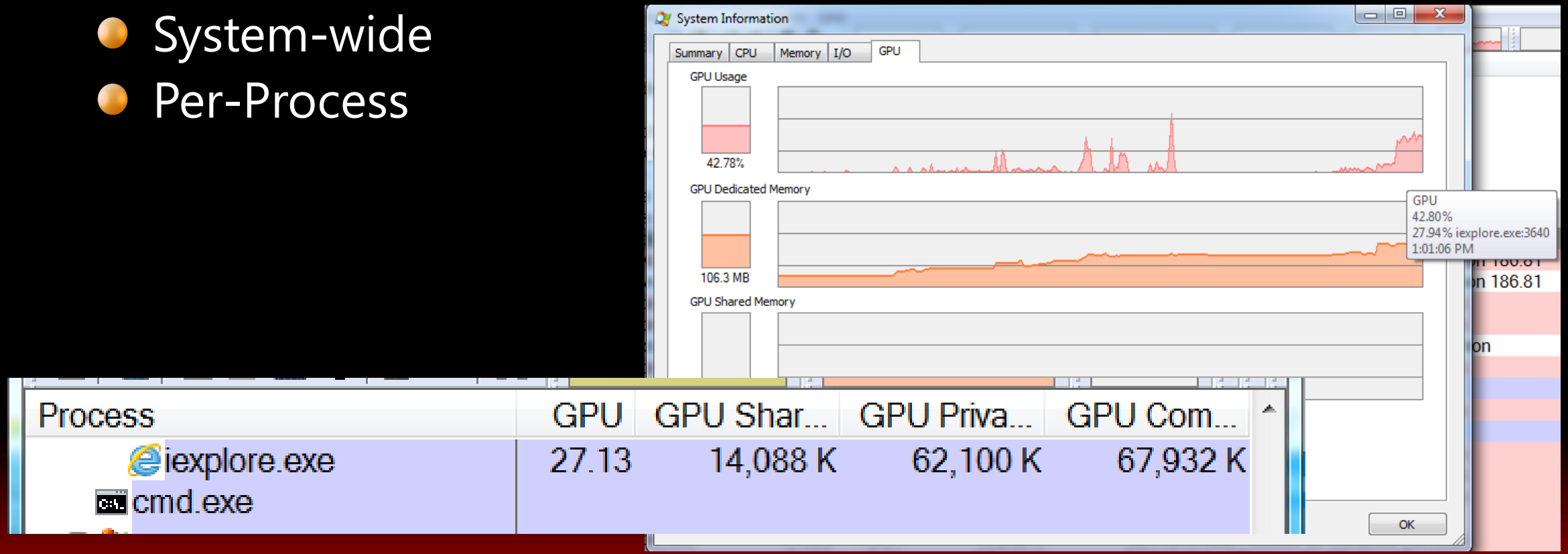


More precise CPU accounting

- Task Manager, Resource Monitor and older Process Explorer versions use time-slice accounting
  - Whatever thread is executing at a timer tick (typically 15.6ms) is charged for the entire time slice
  - Charge is kernel mode if thread is in kernel mode, user mode for user mode
- Process Explorer v14.1 uses cycle counts
  - Full cycle count usage on Win7/Server 2008 R2 because of new API
  - On Vista uses cycle counts to detect < time slice
  - On XP, uses context switches to detect < time slice
- Sub 0.01 usage is shown as < 0.01

Process Explorer v15: GPU Monitoring

- Captures GPU utilization and memory usage
  - System-wide
  - Per-Process



The Process View

- The process tree sort shows parent-child relationships
- Icon, description, and company name are pulled from image version information
  - Most malware doesn't have version information
  - What about malware pretending to be from Microsoft?
    - We'll deal with that shortly…
- Use the Window Finder (in the toolbar) to associate a window with its owning process
- Use the Search Online menu entry to lookup unknown processes
  - But malware often uses totally random or pseudo-random names

Refresh Highlighting

- Refresh highlighting highlights changes
  - Red: process exited
  - Green: new process
- Change duration (default 1 second) in Options
- Press space bar to pause and F5 to refresh
- Cause display to scroll to make new processes visible with Show New Processes option
- We'll see how to spot short-lived processes later…

Process-type Highlights

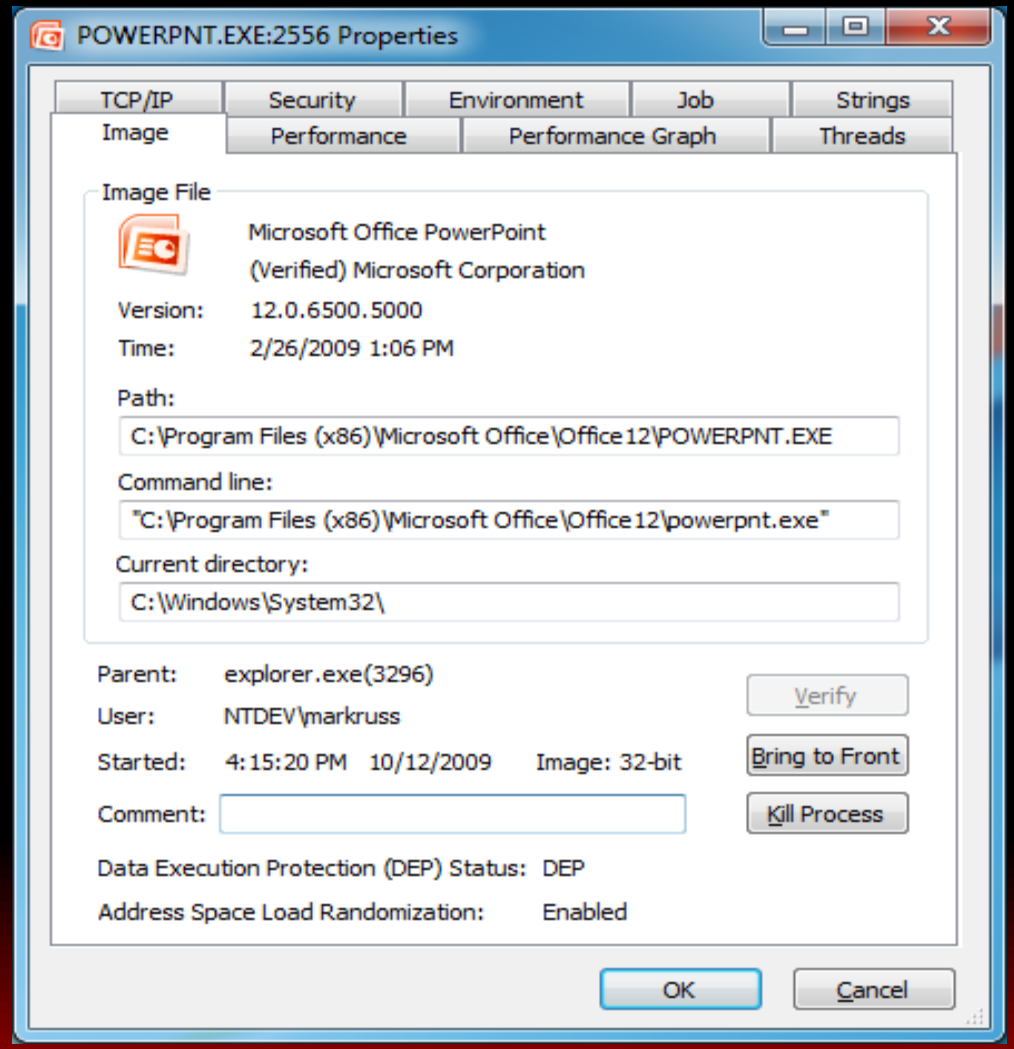
- Blue processes are running in the same security context as Process Explorer
- Pink processes host Windows services (we'll look at services shortly)
- Purple highlighting indicates an image is "packed"
  - Packed can mean compressed or encrypted
  - Malware commonly uses packing (e.g. UPX) to make antivirus signature matching more difficult
  - Packing and encryption also hides strings from view
- There are a few other colors, but they're not important for malware hunting

Tooltips

- Process tooltips show the full path to the process image
- Malware more often hides behind Svchost, Rundll32 and Dllhost
  - Tooltip for Rundll32 processes shows hosted DLL
  - Dllhost tooltip shows hosted COM server
  - Tooltip for service processes shows hosted services
    - Services covered in detail shortly…

Detailed Process Information

- Double-click on a process to see detailed information
- Image tab:
  - Description, company name, version (from .EXE)
  - Full image path
  - Command line used to start process
  - Current directory
  - Parent process
  - User name
  - Start time



Windows Services

- Services can start when the system boots and run independently of the logged-on user
  - Examples include IIS, Themes, Server, Workstation, …
  - Can run as their own process or as a service DLL inside a Svchost.exe
- The services tab shows detailed service information:
  - Registry name (HKLM\System\CurrentControlSet\Services\…)
  - Display name
  - Description (optional)
  - DLL path (for Svchost DLLs)

Image Verification

- All (well, most) Microsoft code is digitally signed
  - Hash of file is signed with Microsoft's private key
  - Signature is checked by decrypting signed hash with the public key
- You can selectively check for signatures with the Verify button on the process image tab
  - Select the Verify Image Signatures option to check all
  - Add the Verified Signer column to see all
- Note that verification will connect to the Internet to check Certificate Revocation List (CRL) servers

Sigcheck and ListDlls

- Scan the system for suspicious executable images

```
sigcheck -e -u -s c:\
```

- Look for same characteristics as suspicious processes
  - Be especially wary of items in the \Windows directory
  - Investigate all unsigned images
- ListDlls will scan running processes for unisigned DLLs

```
listdlls -u
```

Strings

- On-disk and in-memory process strings are visible on the Strings tab
  - There's only a difference if the image is compressed or encrypted
- Strings can help provide clues about unknown processes
  - Look for URLs, names and debug strings
- You can also dump strings with the command-line Strings utility from Sysinternals

```
strings <file>
```

The DLL View

- Malware can hide as a DLL inside a legitimate process
  - We've already seen this with Rundll32 and Svchost
  - Typically loads via an autostart
  - Can load through "dll injection"
  - Packing highlight shows in DLL view as well
- Open the DLL view by clicking on the DLL icon in the toolbar
  - Shows more than just loaded DLLs
  - Includes .EXE and any "memory mapped files"
- Can search for a DLL with the Find dialog
- DLL strings are also viewable from the DLL menu

Loaded Drivers

- There are several tools for viewing configured drivers:
  - Start->Run->Msinfo32
  - Builtin SC command: sc query type= driver
  - Device Manager with View->Show Hidden Devices
- Process Explorer DLL view for the System process shows loaded drivers
  - Even drivers that delete their image files
  - Same path and version info as standard DLL view
- Usually they're not stoppable
  - Delete their files and autostart settings later

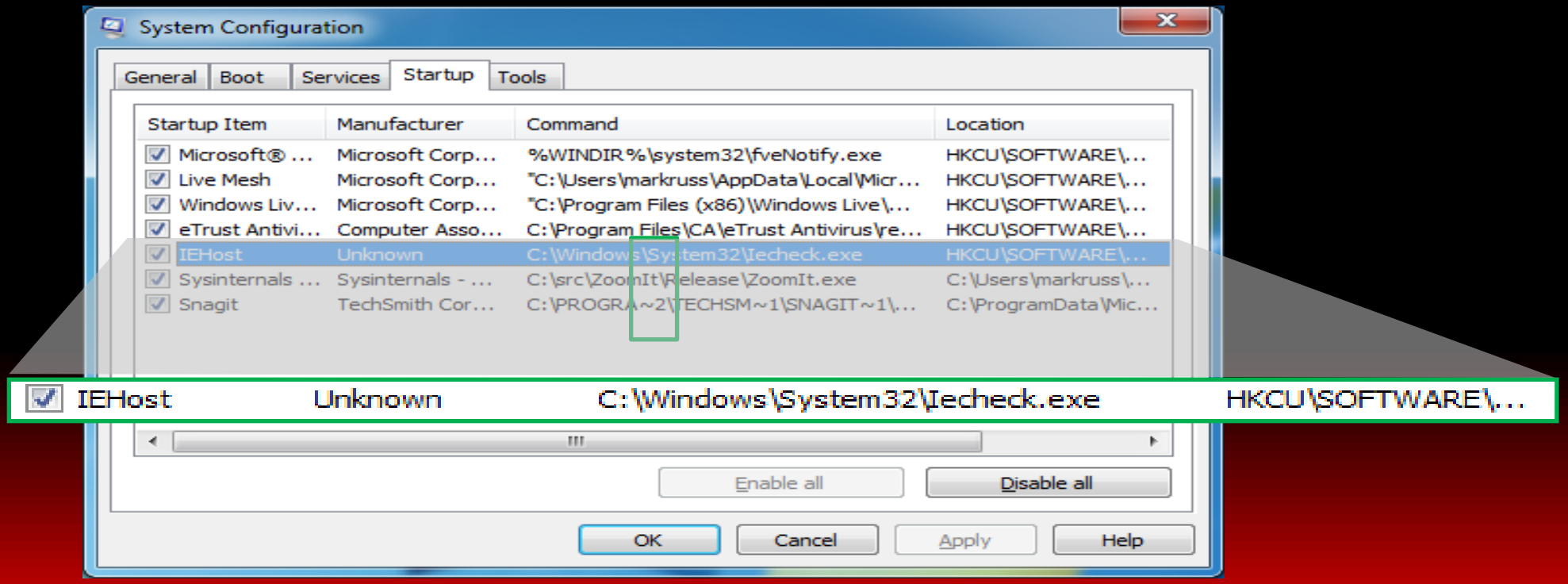
Terminating Malicious Processes

- Don’t kill the processes
  - Malware processes are often restarted by watchdogs
- Instead, suspend them
  - Note that this might cause a system hang for Svchost processes
  - Record the full path to each malicious EXE and DLL
- After they are all asleep then kill them
  - Watch for restarts with new names…

Cleaning Autostarts

Investigating Autostarts

- Windows XP Msconfig (Start->Run->Msconfig) falls short when it comes to identifying autostarting applications
  - It knows about few locations
  - It provides little information

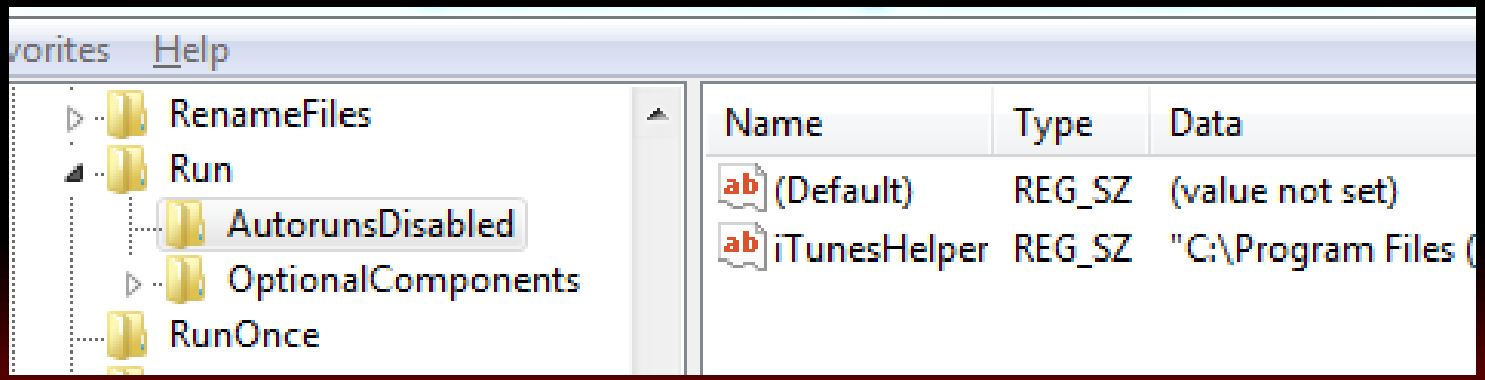


Autoruns

- Shows standard system extension points
  - Standard Run keys and Startup folders
  - Shell, userinit
  - Services and drivers
  - Tasks
  - Winlogon notifications
  - Explorer and IE addins (toolbars, Browser Helper Objects, …)
  - More and ever growing…
- Each startup category has its own tab and all items display on the Everything tab
  - Startup name, image description, company and path

How Autoruns Works

- Many different formats and rules for extension points
  - Shared scan routine for common types
- Disabling moves an entry to a subkey or folder named AutorunsDisabled

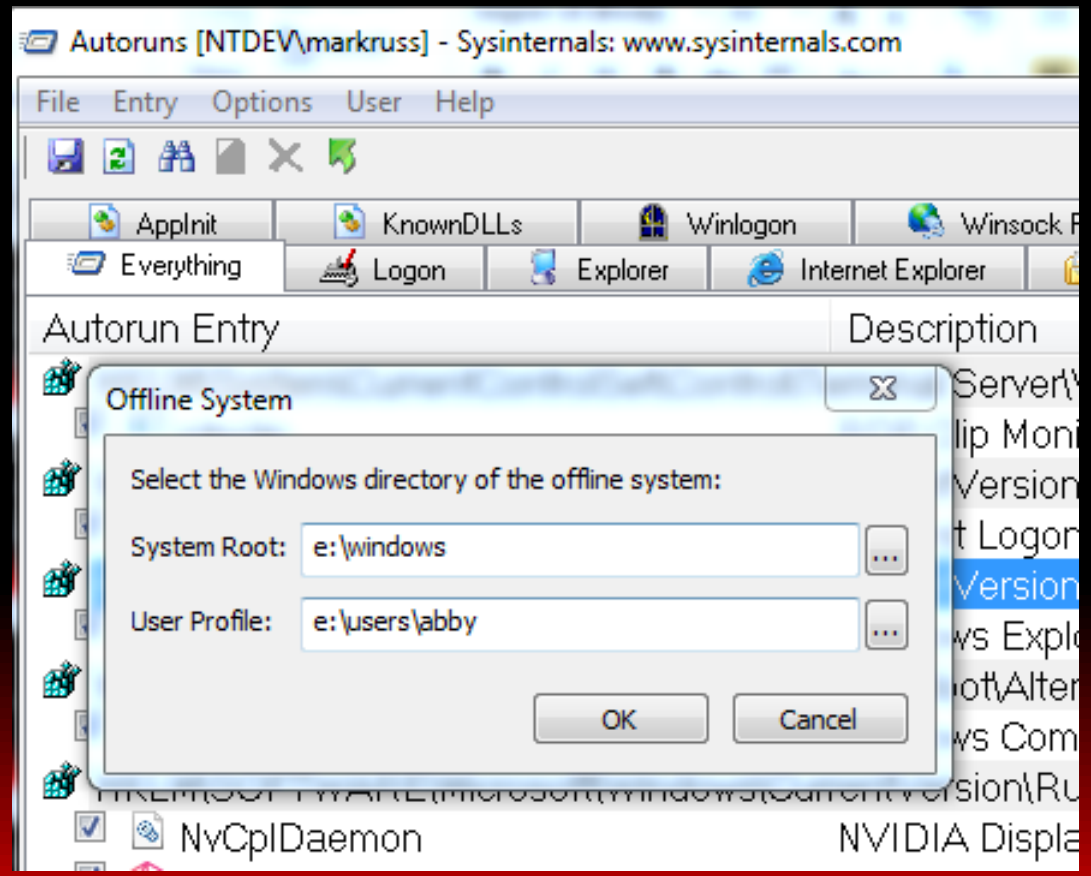


Identifying Malware Autostarts

- Zoom-in on add-ons (including malware) by selecting these options:
  - Verify Code Signatures
  - Hide Microsoft Entries
- Select an item to see more in the lower window
  - Online search unknown images
  - Double-click on an item to look at where its configured in the Registry or file system
- Has other features:
  - Can display other profiles
  - Can also show empty locations (informational only)
  - Includes compare functionality
  - Includes equivalent command-line version, Autorunsc.exe

Analyzing Offline Systems

- Autoruns includes support for scanning offline systems



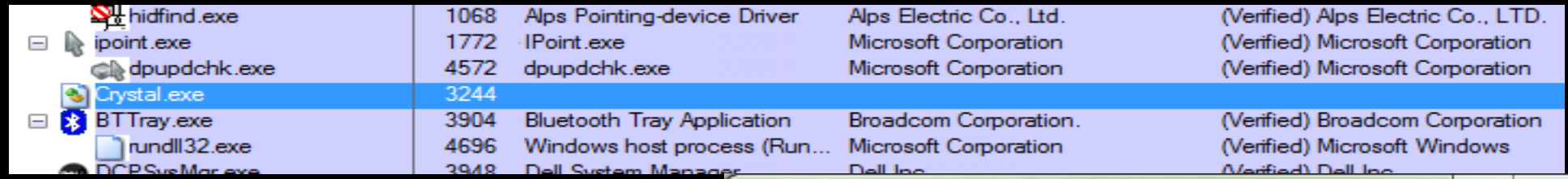
The Case of the Son's Adware

- Web page automatically opened on logon after father got laptop back from son
  - http://www.e-markettop.com/

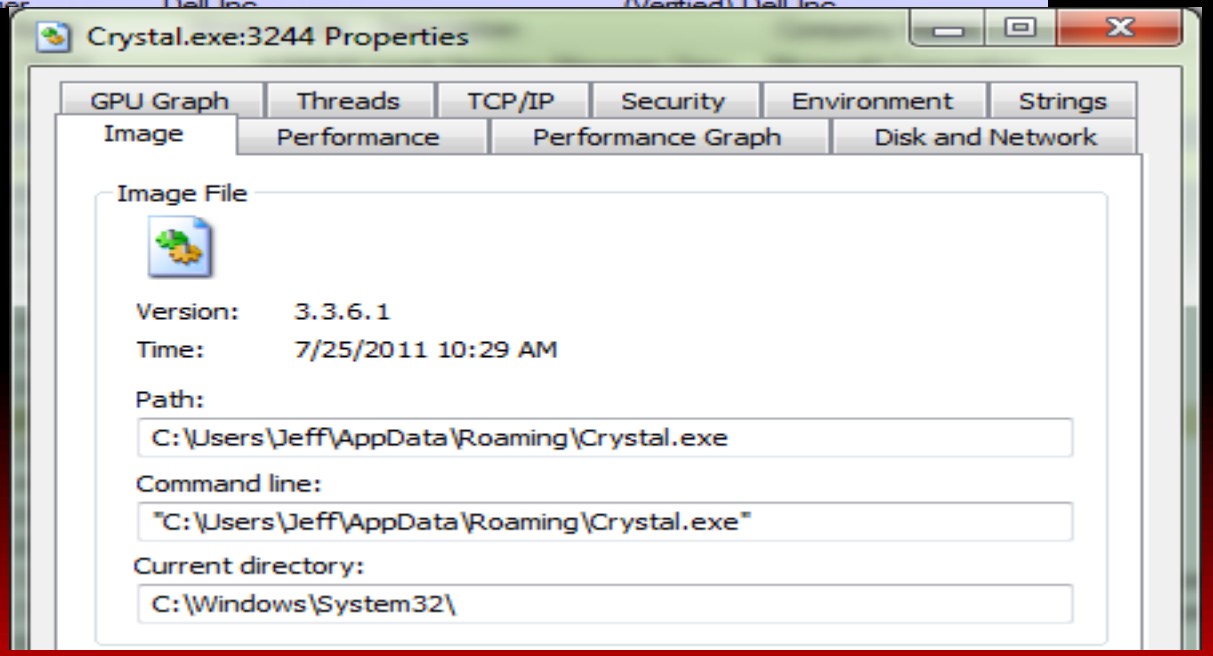
- Tried running Malwarebytes, but it would immediately close

The Case of the Son's Adware (Cont)

- Process Explorer showed one unsigned process, Crystal.exe:

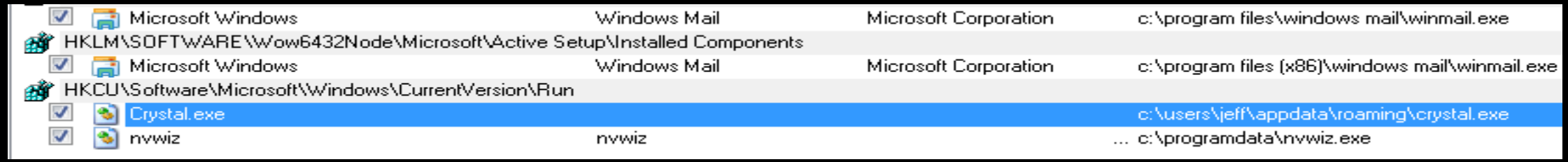


- After suspending Crystal, Malwarebytes ran to completion
  - No malware reported
  - McAfee didn't report any malware, either



The Case of the Son's Adware (Cont)

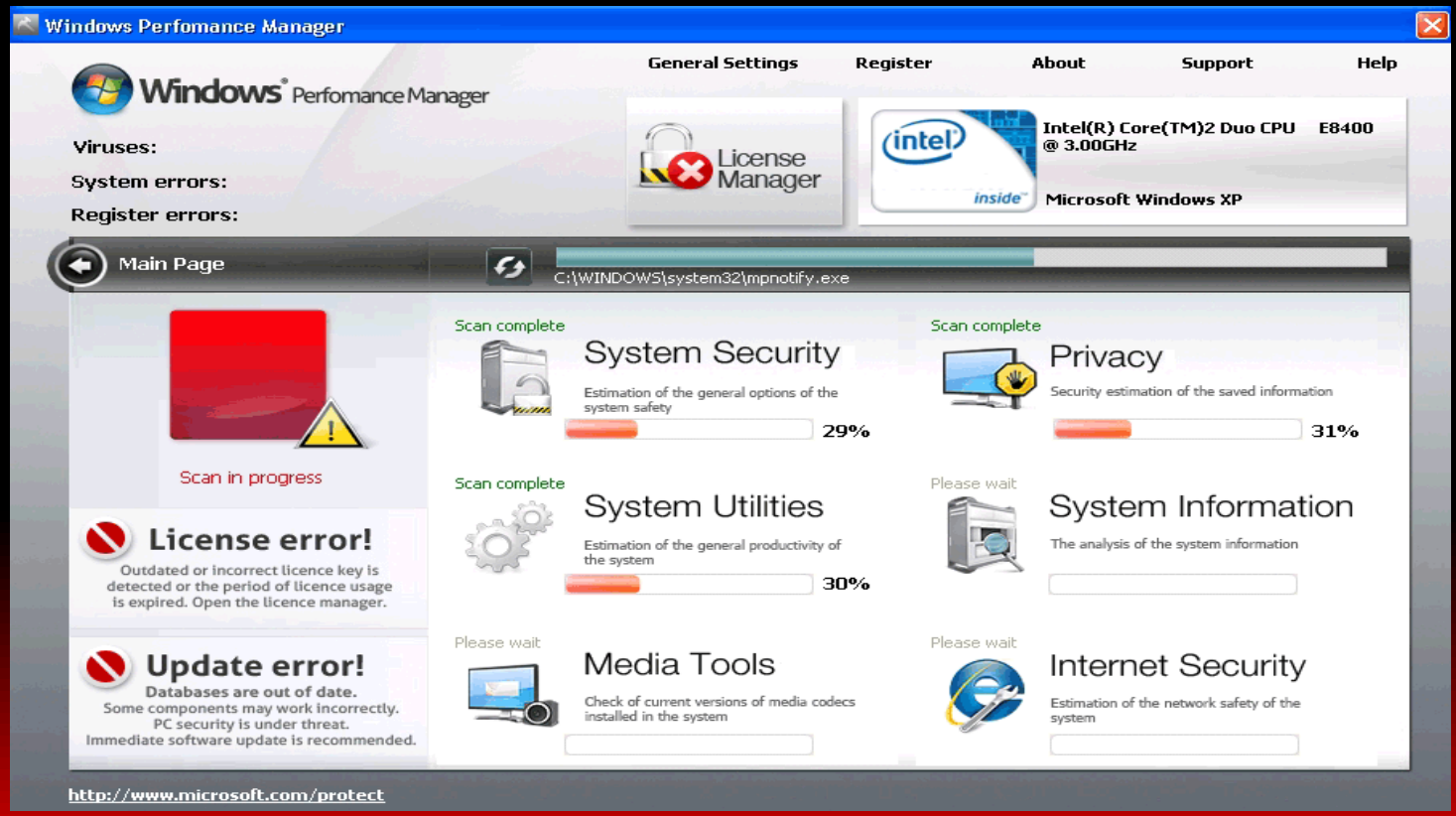
- Ran Autoruns and found Crystal in the Run key:



- Disabled it, rebooted and system operated normally: problem solved
  - Web search revealed that it was the Bifrost trojan: http://comprolive.com/remove/trojan/bifrost/crystal-exe-usb-exe-cleaner-exe

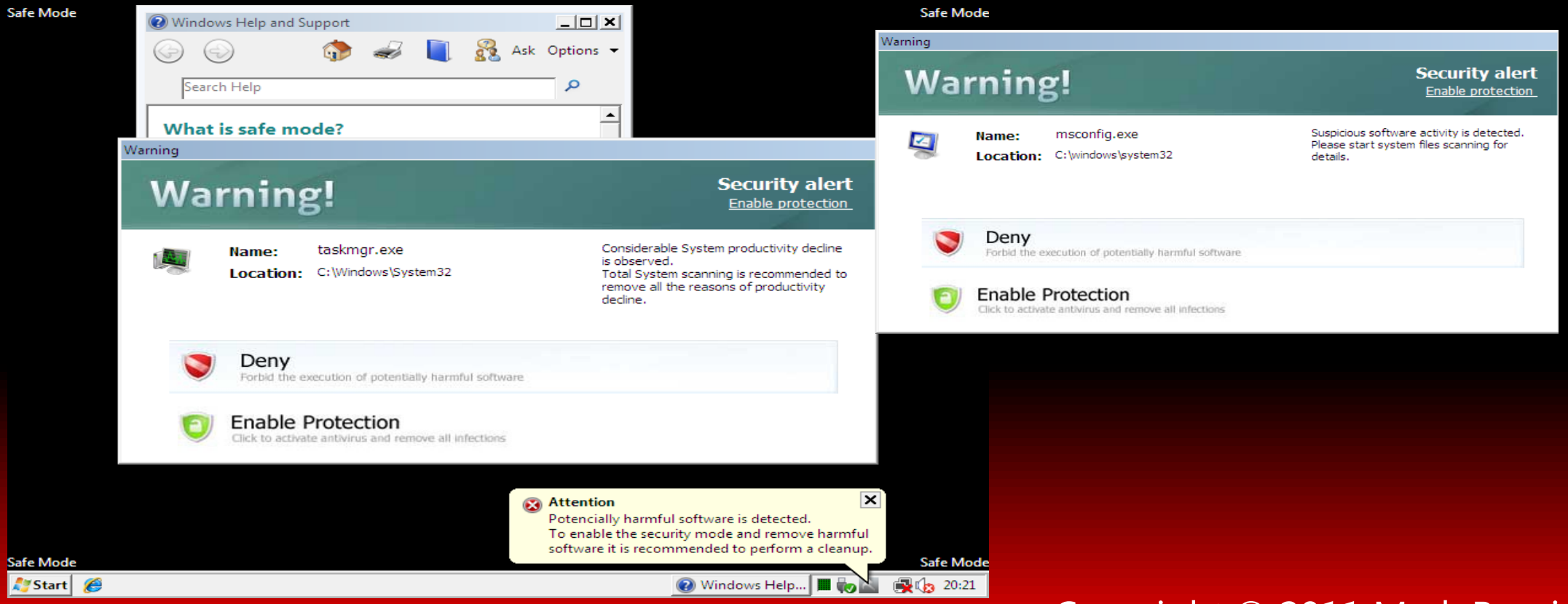
The Case of the Scareware

- A user's father-in-law complained that there was an application that wouldn't exit:



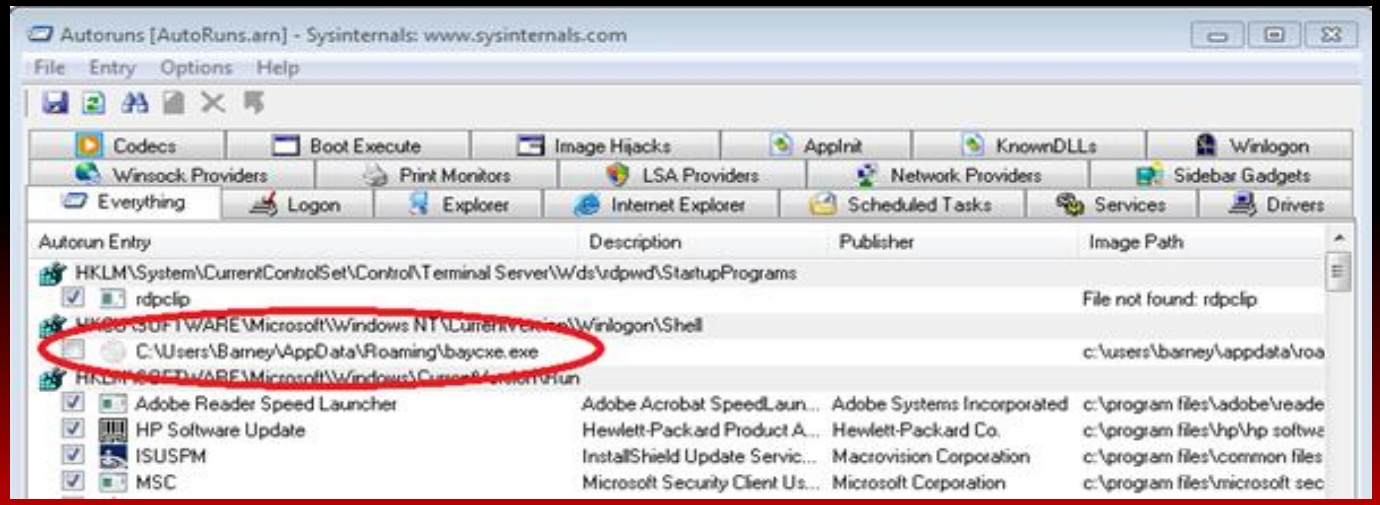
The Case of the Scareware (Cont)

- When a user tries to run Task Manager or MsConfig, they get errors, even in Safe Mode:



The Case of the Scareware: Solved

- Ran Autoruns and one entry stood out as suspicious
  - No company name or description
  - Installed in user's profile
  - Replaces shell
- Right-clicked and "jumped" to the Shell registry entry
  - Replaced malware name with "Explorer"
  - Rebooted
- Problem solved



The Case of the Unusable System

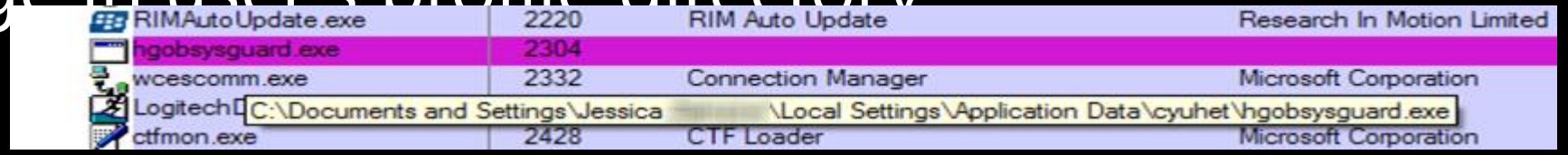
http://blogs.technet.com/b/markrussinovich/archive/2011/03/14/3412374.aspx

- Friend's of a friend's computer became infected with malware
- It was unable to run anything:

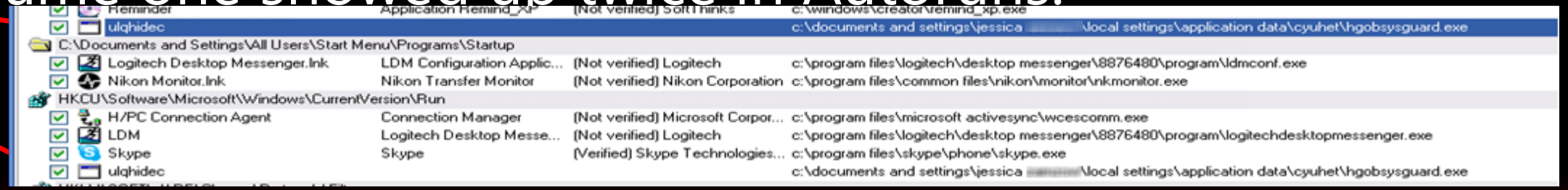
- Could have used Safemode, but wanted to see if I could run something at logon before malware activated
  - Logged off and back on
  - Was able to run Process Explorer and Autoruns

The Case of the Unusable System: Solved

- Process Explorer had one unsigned, random-name, packed image in user's profile directory:



- Same one showed up twice in Autoruns:



- Used Sigcheck to look for other suspicious files: none
- Killed process, deleted autostarts: system clean

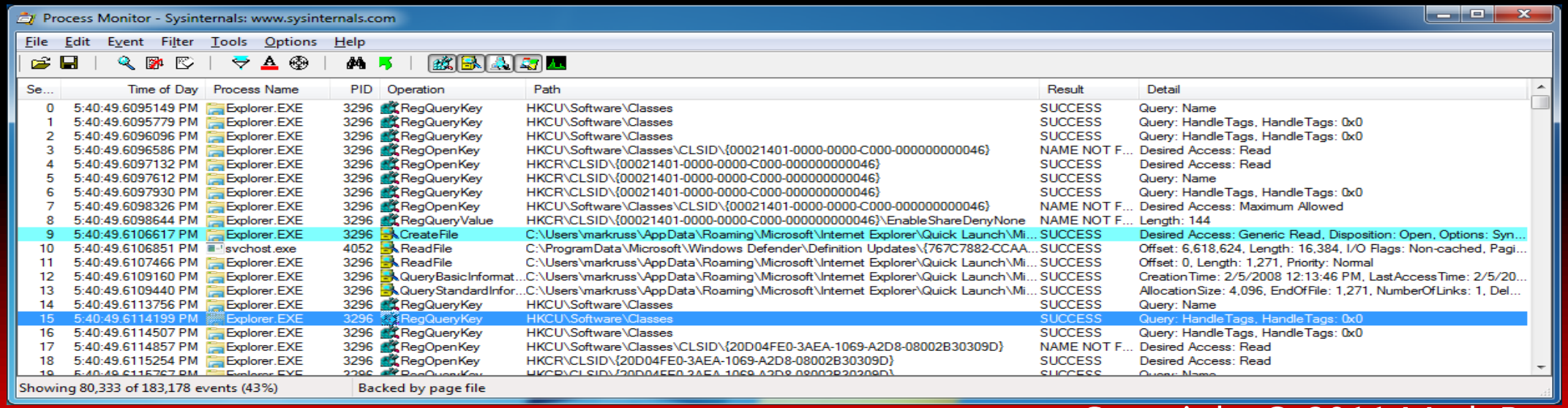
Deleting Autostarts

- Disable suspicious autostarts
  - First rule of troubleshooting: make reversible changes
- After you're done do a full refresh
- If they come back, run Process Monitor to see who's putting them back
  - You might have misidentified a malware process
  - It might be a hidden, system, or legitimate process

Tracing Malware Activity

Tracing Malware

- Tracing activity can reveal the system impact of malware
  - Tracing shows initial infection, before cloaking is applied
  - Can reveal the internals of "buddy system" and other infection-protection mechanisms
- Process Monitor makes tracing easy
  - A simple filter can identify all system modifications
  - Investigating stacks can distinguish legitimate activity from malicious activity



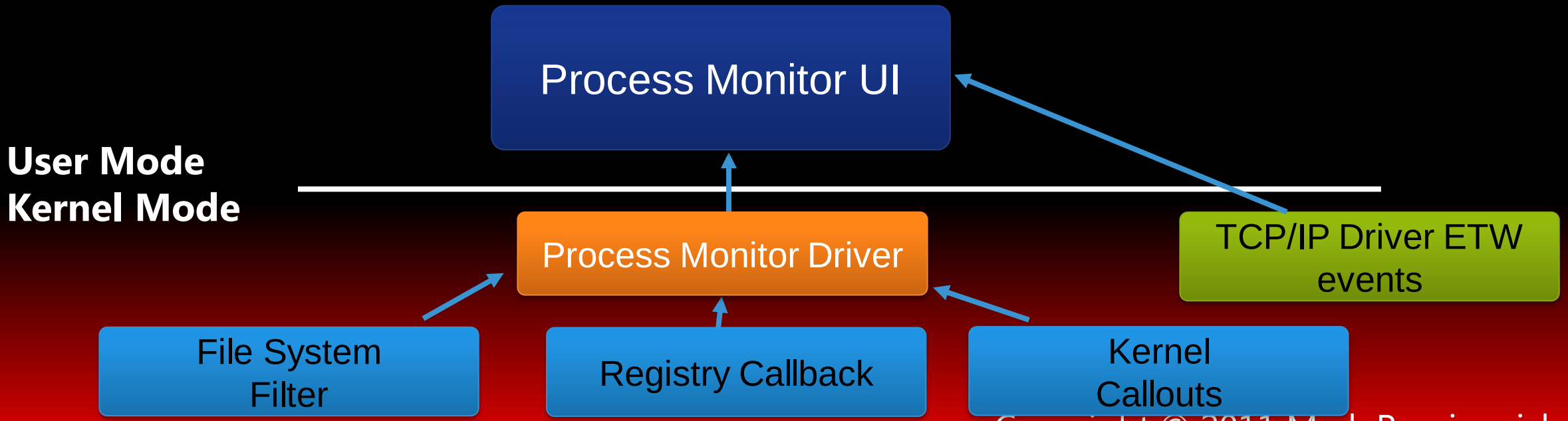
Se...	Time of Day	Process Name	PID	Operation	Path	Result	Detail
0	5:40:49.6095149 PM	Explorer.EXE	3296	RegQueryKey	HKCU\Software\Classes	SUCCESS	Query: Name
1	5:40:49.6095779 PM	Explorer.EXE	3296	RegQueryKey	HKCU\Software\Classes	SUCCESS	Query: HandleTags, HandleTags: 0x0
2	5:40:49.6096096 PM	Explorer.EXE	3296	RegQueryKey	HKCU\Software\Classes	SUCCESS	Query: HandleTags, HandleTags: 0x0
3	5:40:49.6096586 PM	Explorer.EXE	3296	RegOpenKey	HKCU\Software\Classes\CLSID\{00021401-0000-0000-C000-000000000046}	NAME NOT F...	Desired Access: Read
4	5:40:49.6097132 PM	Explorer.EXE	3296	RegOpenKey	HKCR\CLSID\{00021401-0000-0000-C000-000000000046}	SUCCESS	Desired Access: Read
5	5:40:49.6097612 PM	Explorer.EXE	3296	RegQueryKey	HKCR\CLSID\{00021401-0000-0000-C000-000000000046}	SUCCESS	Query: Name
6	5:40:49.6097930 PM	Explorer.EXE	3296	RegQueryKey	HKCR\CLSID\{00021401-0000-0000-C000-000000000046}	SUCCESS	Query: HandleTags, HandleTags: 0x0
7	5:40:49.6098326 PM	Explorer.EXE	3296	RegOpenKey	HKCU\Software\Classes\CLSID\{00021401-0000-0000-C000-000000000046}	NAME NOT F...	Desired Access: Maximum Allowed
8	5:40:49.6098644 PM	Explorer.EXE	3296	RegQueryValue	HKCR\CLSID\{00021401-0000-0000-C000-000000000046}\EnableShareDenyNone	NAME NOT F...	Length: 144
9	5:40:49.6106617 PM	Explorer.EXE	3296	CreateFile	C:\Users\markruss\AppData\Roaming\Microsoft\Internet Explorer\Quick Launch\Mi...	SUCCESS	Desired Access: Generic Read, Disposition: Open, Options: Syn...
10	5:40:49.6106851 PM	svchost.exe	4052	ReadFile	C:\ProgramData\Microsoft\Windows Defender\Definition Updates\{767C7882-CCAA...	SUCCESS	Offset: 6,618,624, Length: 16,384, I/O Flags: Non-cached, Pagi...
11	5:40:49.6107466 PM	Explorer.EXE	3296	ReadFile	C:\Users\markruss\AppData\Roaming\Microsoft\Internet Explorer\Quick Launch\Mi...	SUCCESS	Offset: 0, Length: 1,271, Priority: Normal
12	5:40:49.6109160 PM	Explorer.EXE	3296	QueryBasicInformat...	C:\Users\markruss\AppData\Roaming\Microsoft\Internet Explorer\Quick Launch\Mi...	SUCCESS	CreationTime: 2/5/2008 12:13:46 PM, LastAccessTime: 2/5/20...
13	5:40:49.6109440 PM	Explorer.EXE	3296	QueryStandardInfor...	C:\Users\markruss\AppData\Roaming\Microsoft\Internet Explorer\Quick Launch\Mi...	SUCCESS	AllocationSize: 4,096, EndOfFile: 1,271, NumberOfLinks: 1, Del...
14	5:40:49.6113756 PM	Explorer.EXE	3296	RegQueryKey	HKCU\Software\Classes	SUCCESS	Query: Name
15	5:40:49.6114199 PM	Explorer.EXE	3296	RegQueryKey	HKCU\Software\Classes	SUCCESS	Query: HandleTags, HandleTags: 0x0
16	5:40:49.6114507 PM	Explorer.EXE	3296	RegQueryKey	HKCU\Software\Classes	SUCCESS	Query: HandleTags, HandleTags: 0x0
17	5:40:49.6114857 PM	Explorer.EXE	3296	RegOpenKey	HKCU\Software\Classes\CLSID\{20D04FE0-3AEA-1069-A2D8-08002B30309D}	NAME NOT F...	Desired Access: Read
18	5:40:49.6115254 PM	Explorer.EXE	3296	RegOpenKey	HKCR\CLSID\{20D04FE0-3AEA-1069-A2D8-08002B30309D}	SUCCESS	Desired Access: Read

Process Monitor

- Process Monitor is a real-time file, registry, process and thread monitor
- It replaces Filemon and Regmon
  - More advanced filtering
  - Operation call stacks
  - Boot-time logging
  - Data mining views
  - Process tree to see short-lived processes
- When in doubt, run Process Monitor!
  - It will often show you the cause for error messages
  - It many times tells you what is causing sluggish performance

How Process Monitor Works

- Process Monitor uses a device driver
  - Extracts the driver to \Windows\System32\Drivers
  - Installs the driver
  - Deletes the driver file
- Requires “Debug Programs” user right
  - First run requires the “Load Driver” user right



How Process Monitor Works (cont.)

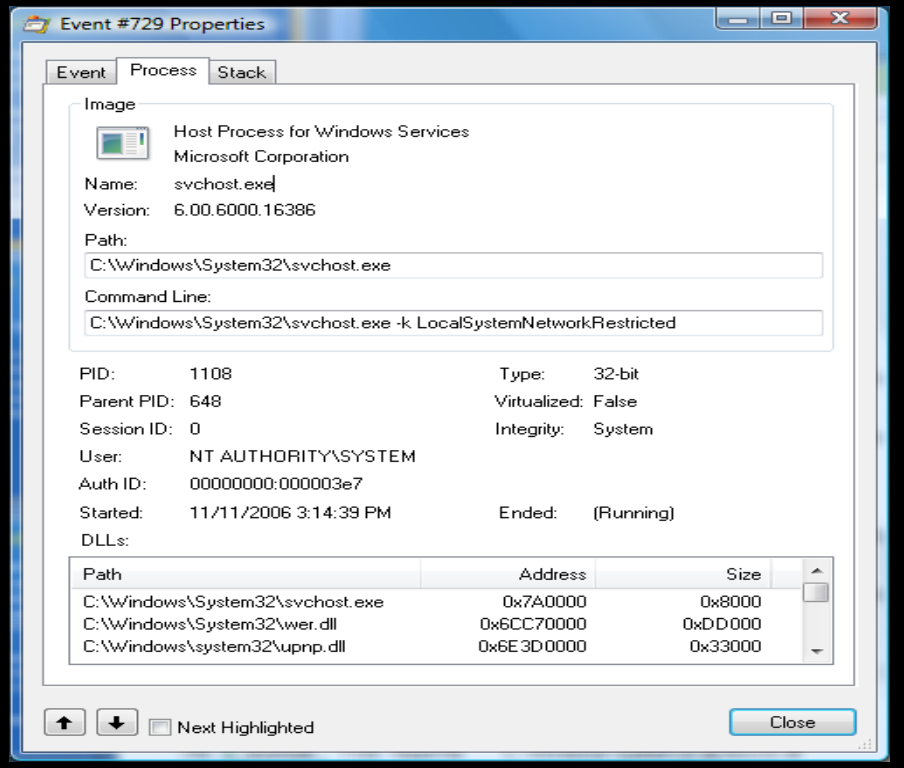
- Registry monitoring:
  - On Windows 2000, Windows XP 32-bit: system-call hooking
  - On Windows XP 64-bit, Server 2003, and Vista: registry callback
- File system monitoring:
  - File system mini-filter driver (causes Windows version requirements)
- Image loads:
  - Memory-manager image load callback
- Process/Thread create/exit:
  - Kernel process/thread callback
- TCP/IP
  - ETW events emitted by TCPIP.sys

Event Classes

- File system (Filemon)
  - Includes I/O command input and output details
- Registry (Regmon)
  - Includes all data (First 16-bytes part of REG_BINARY and first 2048-bytes for other types)
- Process
  - Process create and exit
  - Thread create and exit
  - Image loads, including drivers
- Network
  - ETW network tracing
- Profiling
  - Toolhelp thread snapshots

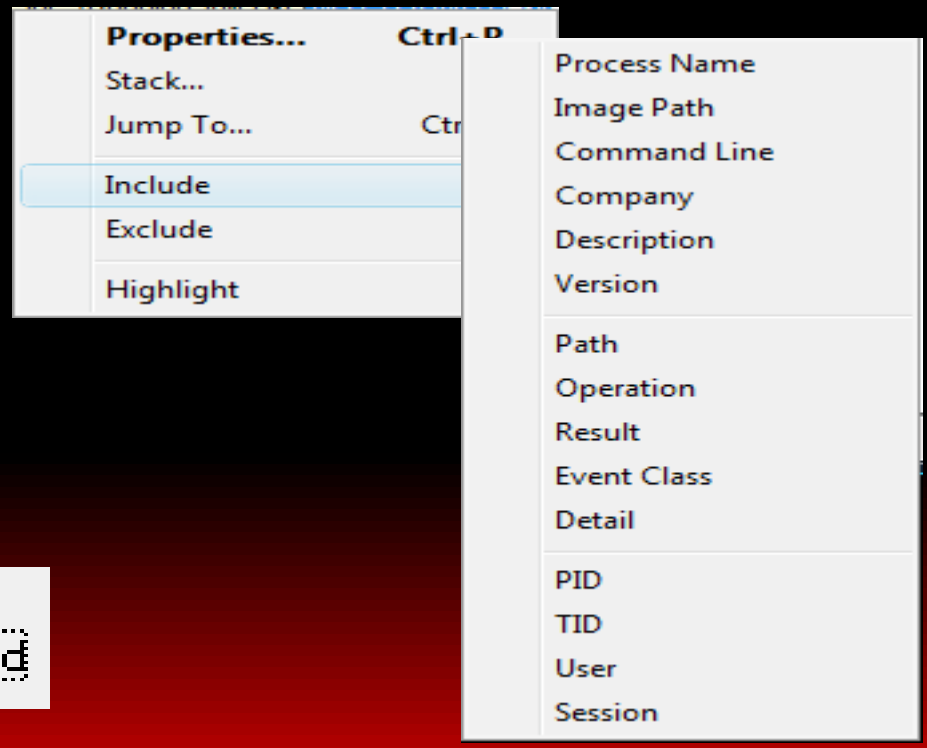
Event Properties

- Event details
  - Duration, process, thread, details, etc.
- Process information
  - Command line
  - User
  - Session and logon session
  - Image information
  - Start time
- Thread stack at time of event



Filtering

- To filter on a value, right-click on the line and select the attribute from the Include, Exclude or Highlight submenus
  - You can select multiple values simultaneously
- When you set a highlight filter you can move through highlighted event properties

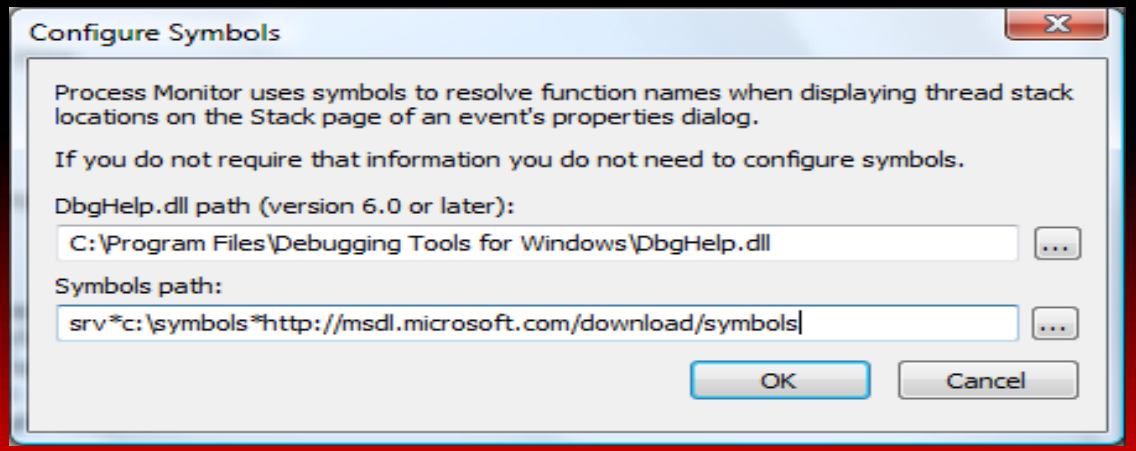


Demo: Watching a File Save

- Run Process Monitor, then:
  - Run Notepad
  - Type some text
  - Save the file as test.txt
- Find the real file save in the log file
  - Set a highlight filter on the saved file path

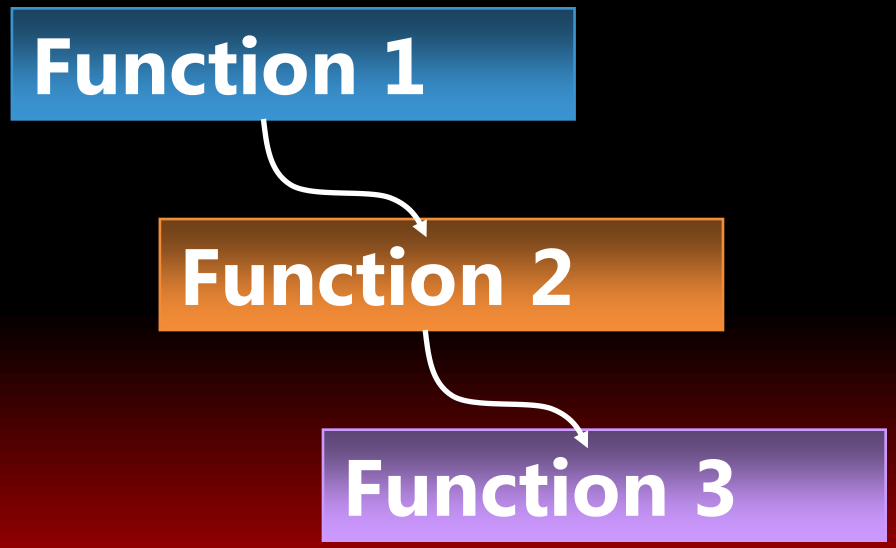
Symbols

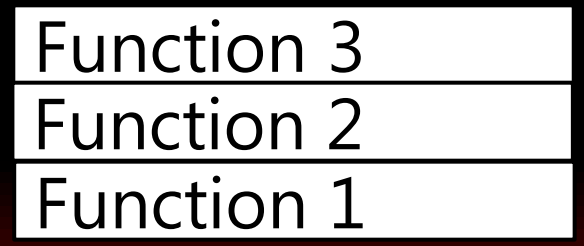
- Download the latest Debugging Tools for Windows from Microsoft (free)
- Configure Process Monitor's symbol engine:
  - Use dbghelp.dll from the Debugging Tools
  - Point at the Microsoft public symbol server
- To grab symbols for offline access, use Symchk, part of the Debugging Tools



Event Properties: Stack

- The stack tab shows the stack of the thread executing the operation
  - Stack is function-call history
  - Thread stacks can show root cause
  - Uses symbol engine

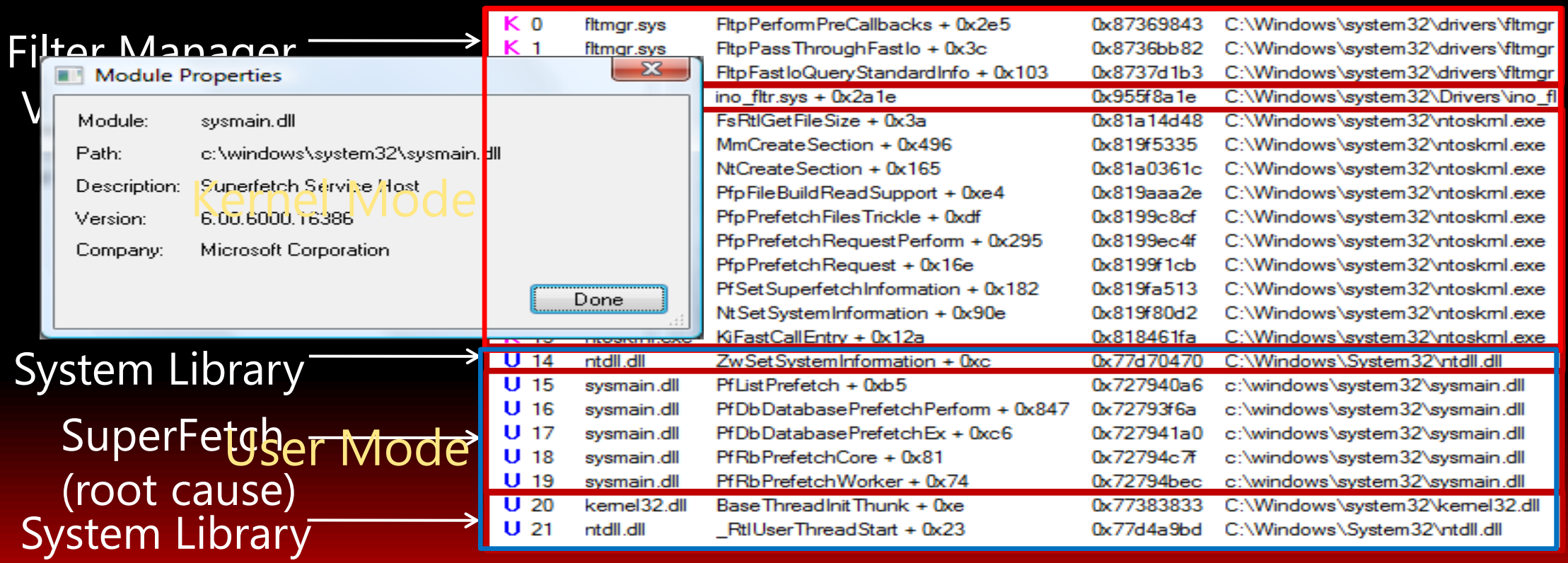




Stack Display

Analyzing a Stack

- Look at the function names and DLLs to identify the root cause
  - Double-click on a line to see the DLL properties



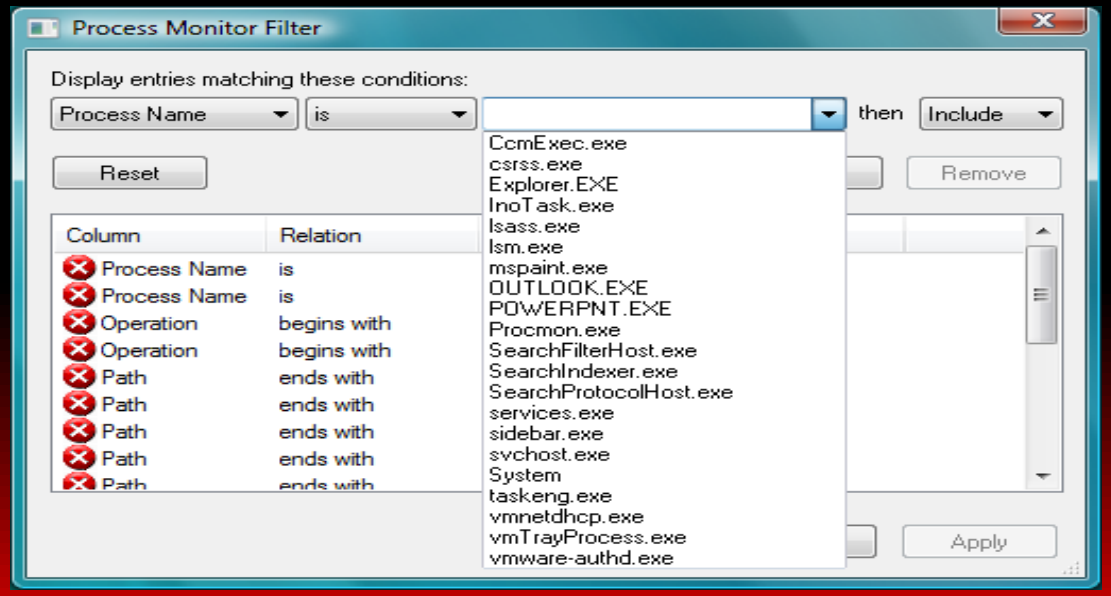
Note: user stack capture isn't supported on 64-bit versions of Windows XP/Server 2003

Analyzing Process Startup with Stacks

- There are lots of file system I/Os and Registry operations during Notepad's startup
- Using the stack we can identify three phases:
  - Prefetch
    - Reads in directories
    - Faults in DLLs
  - DLL initialization
    - Loader walks import tables
  - Application initialization
    - Initializes DLLs e.g. OLE
    - Reads global settings

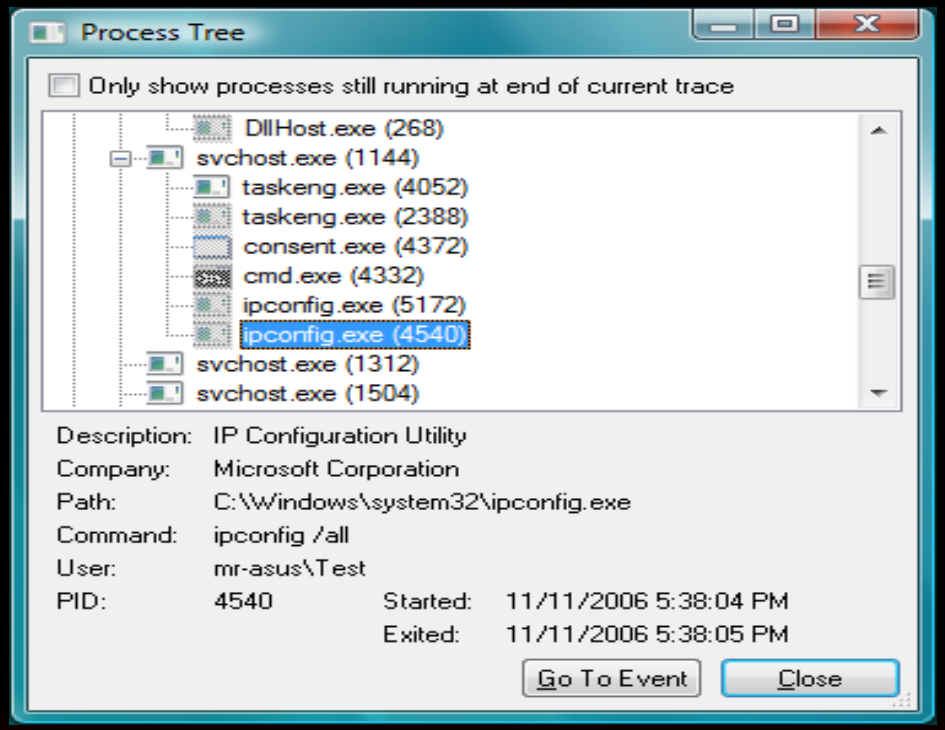
Advanced Filters

- Multiple-filter behavior:
  - Values from different attributes are AND'd
  - Values for the same attribute are OR'd
- More complex filtering is available in the Filter dialog
  - Outlook-style rule definition
- You can save and restore filters
- Filter for watching malware impact:
  "Category is Write"



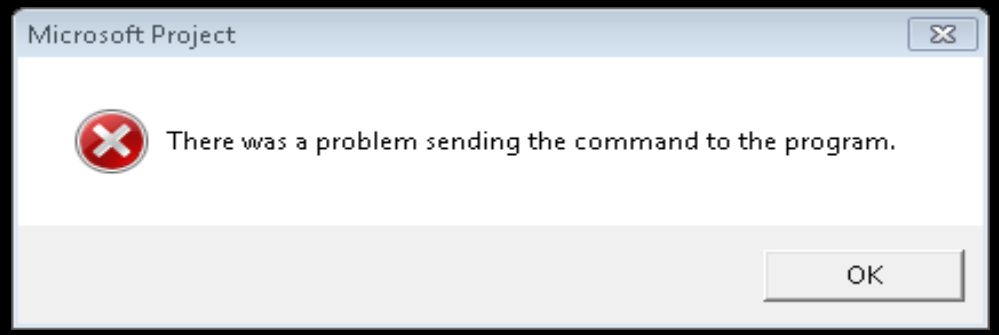
The Process Tree

- Tools->Process Tree
  - Shows all processes that have been seen in the trace (including parents)
  - Can toggle on and off terminated processes
- The process tree provides an easy way to see process relationships
  - Short-lived processes
  - Command lines
  - User names



The Case of the Slow Project File Opens

- Customer reported that opens of Project files from a network were slow and 1 of 10 opens resulted in an error:



- Microsoft support asked them to captured a Process Monitor trace

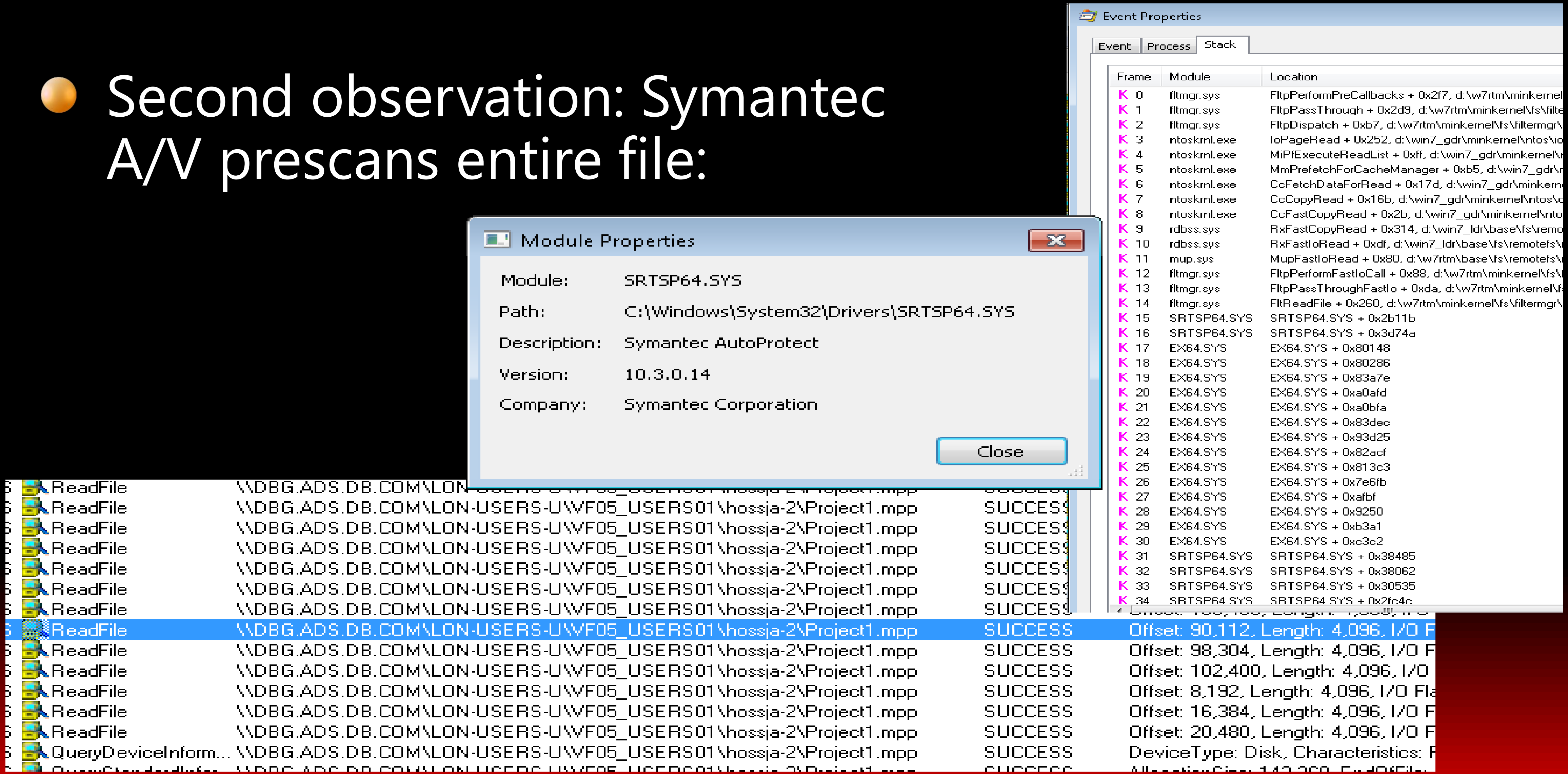
The Case of the Slow Project File Opens (Cont)

- First observation: tremendous number of access to share because user-profiles stored there:

Total Events	Path
4,103	<Total>
2,038	\\DBG.ADS.DB.COM\LON-USERS-U\VF05_USERS01\hossja-2\config\AppData\Microsoft\MS Project\...
577	\\DBG.ADS.DB.COM\LON-USERS-U\VF05_USERS01\hossja-2\config\AppData\Microsoft\Windows\R...
451	\\DBG.ADS.DB.COM\LON-USERS-U\VF05_USERS01\hossja-2\Project1.mpp
271	\\DBG.ADS.DB.COM\LON-USERS-U\VF05_USERS01\hossja-2\config\AppData\Microsoft\Windows\R...
110	\\DBG.ADS.DB.COM\LON-USERS-U\
100	\\DBG.ADS.DB.COM\LON-USERS-U\VF05_USERS01\hossja-2
88	\\Dbg.ads.db.com\lon-users-u\
56	\\DBG.ADS.DB.COM\LON-USERS-U\VF05_USERS01\hossja-2\config\AppData
45	\\Dbg.ads.db.com\lon-users-u\VF05_USERS01\hossja-2
24	\\DBG.ADS.DB.COM\LON-USERS-U\VF05_USERS01
24	\\Dbg.ads.db.com\lon-users-u\VF05_USERS01
22	\\DBG.ADS.DB.COM\LON-USERS-U\VF05_USERS01\hossja-2\config\AppData\Microsoft
22	\\DBG.ADS.DB.COM\LON-USERS-U\VF05_USERS01\hossja-2\config\AppData\Microsoft\Office\Rec...
22	\\Dbg.ads.db.com\lon-users-u\VF05_USERS01\hossja-2\config\AppData\Microsoft\Windows\Recent\...

The Case of the Slow Project File Opens (Cont)

- Second observation: Symantec A/V prescans entire file:



The Case of the Slow Project File Opens: Solved

- Recommendation 1: Move user profile AppData folders to local system
- Recommendation 2: Disable local scanning of files on network share since the server also has antivirus
- After recommendations followed, no more issues: problem solved

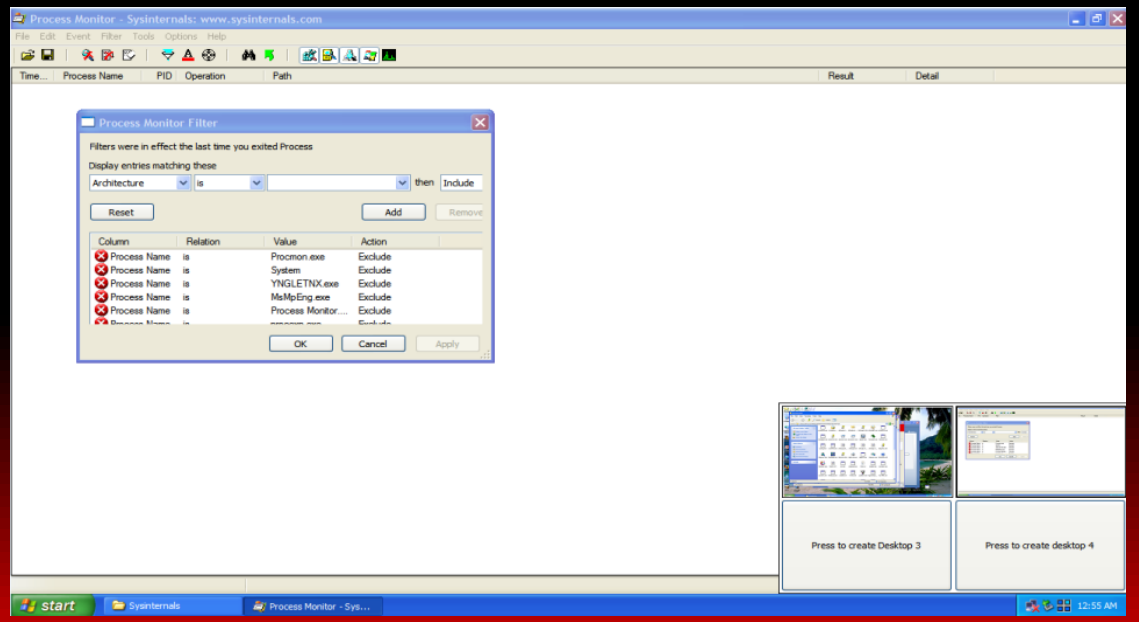
The Case of the Sysinternals-Blocking Malware

http://blogs.technet.com/b/markrussinovich/archive/2011/03/08/3392087.aspx

- Friend asked user to take a look at system suspected of being infected with malware
  - Boot and logons took a long time
  - Microsoft Security Essentials (MSE) malware scan would never complete
  - Nothing jumped out in Task Manager
- Tried running Sysinternals tools, but all exited immediately after starting:
  - Autoruns
  - Process Monitor
  - Process Explorer
  - Even Notepad opening a text file named “Process Explorer” would also terminate

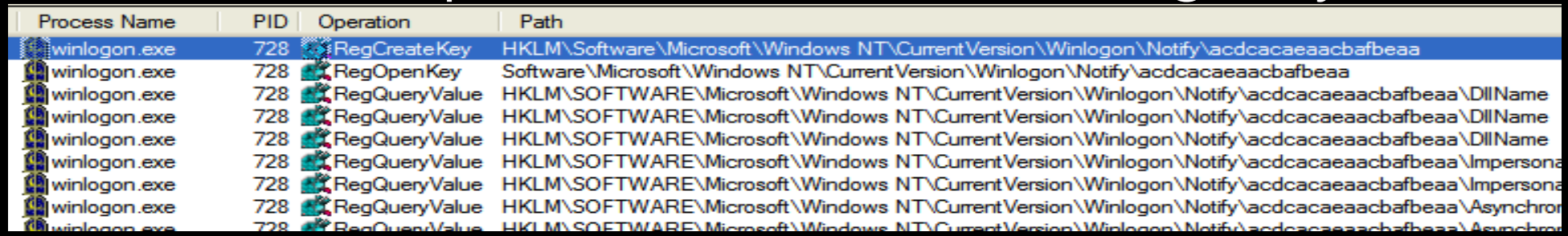
The Case of the Sysinternals-Blocking Malware (Cont)

- Looking through Sysinternals suite, noticed Desktops utility
  - Hoped malware might not be smart enough to monitor additional desktops
- Sure enough, was able to launch Process Monitor and other tools:
  - Malware probably looks for tools in window titles
  - Window enumeration only returns windows of current desktop



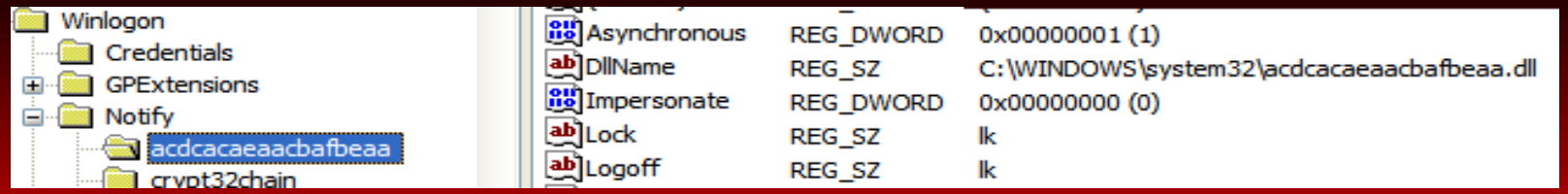
The Case of the Sysinternals-Blocking Malware (Cont)

- Nothing suspicious in Process Explorer
- Next, ran Process Monitor
  - Noticed a lot of Winlogon activity, so set a filter to include it
  - Could see a once-per-second check of a strange key:



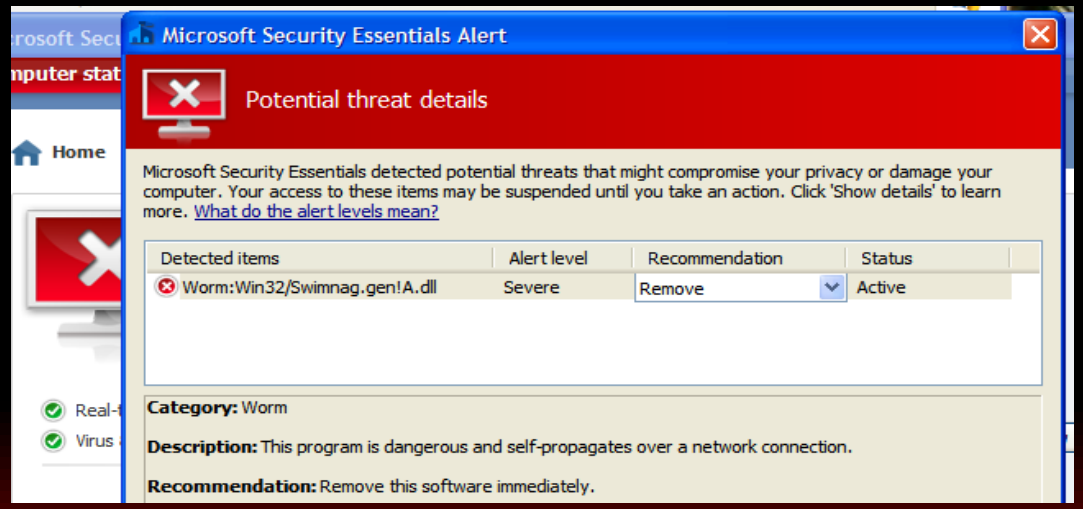
Process Name	PID	Operation	Path
winlogon.exe	728	RegCreateKey	HKLM\Software\Microsoft\Windows NT\CurrentVersion\Winlogon\Notify\acdcacaeaacbafbeaa
winlogon.exe	728	RegOpenKey	Software\Microsoft\Windows NT\CurrentVersion\Winlogon\Notify\acdcacaeaacbafbeaa
winlogon.exe	728	RegQueryValue	HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Winlogon\Notify\acdcacaeaacbafbeaa\DllName
winlogon.exe	728	RegQueryValue	HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Winlogon\Notify\acdcacaeaacbafbeaa\DllName
winlogon.exe	728	RegQueryValue	HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Winlogon\Notify\acdcacaeaacbafbeaa\DllName
winlogon.exe	728	RegQueryValue	HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Winlogon\Notify\acdcacaeaacbafbeaa\Impersona
winlogon.exe	728	RegQueryValue	HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Winlogon\Notify\acdcacaeaacbafbeaa\Impersona
winlogon.exe	728	RegQueryValue	HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Winlogon\Notify\acdcacaeaacbafbeaa\Asynchron

- Saw name of random DLL in the key:



The Case of the Sysinternals-Blocking Malware: Solved

- Tried deleting the key, but after refreshing it was back
- Went back to MSE and directed it to scan just the random DLL image file on disk:



- After clean, was able to delete Registry key and system was back to normal: problem solved

The Case of the Malicious Autostart

http://blogs.technet.com/b/markrussinovich/archive/2011/02/27/3390475.aspx

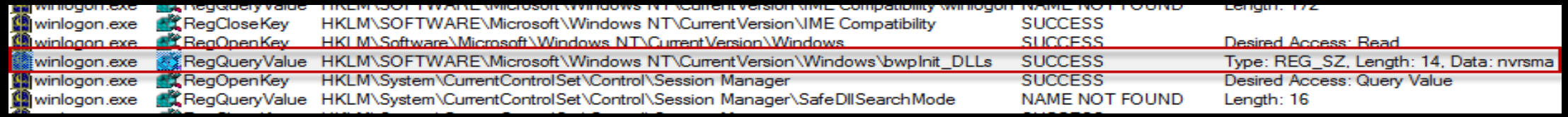
- Microsoft Support got a report of Marioforever.exe malware spreading within a company
- Malware infected Winlogon:
  - Couldn't delete it while system was running

```
C:\>listdlls winlogon -d nvrsma.dll

ListDLLs v2.25 - DLL lister for Win9x/NT
Copyright (C) 1997-2004 Mark Russinovich
Sysinternals - www.sysinternals.com

------------------------------------------------------------------------------
winlogon.exe pid: 416
Command line: winlogon.exe

  Base         Size      Version         Path
  0x10000000   0x34000                   C:\WINDOWS\system32\nvrsma.dll
```

- The malware didn't show up in Autoruns, so how it loaded was a mystery

The Case of the Malicious Autostart (Cont)

- Captured a Process Monitor boot log and searched for nvrsma:



winlogon.exe	RegCloseKey	HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\IME Compatibility	SUCCESS	
winlogon.exe	RegOpenKey	HKLM\Software\Microsoft\Windows NT\CurrentVersion\Windows	SUCCESS	Desired Access: Read
winlogon.exe	RegQueryValue	HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Windows\bwpInit_DLLs	SUCCESS	Type: REG_SZ, Length: 14, Data: nvrsma
winlogon.exe	RegOpenKey	HKLM\System\CurrentControlSet\Control\Session Manager	SUCCESS	Desired Access: Query Value
winlogon.exe	RegQueryValue	HKLM\System\CurrentControlSet\Control\Session Manager\SafeDllSearchMode	NAME NOT FOUND	Length: 16

- Reference is in "bwpInit_DLLs" key
  - That's not a Windows autostart key
  - Similar to AppInit_DLLs, a legitimate key
- Why was Winlogon loading DLLs referenced there?

The Case of the Malicious Autostart (Cont)

- Launched Autoruns again on infected system and User32.dll stood out:

rpcrt4	Remote Procedure Call Runtime	(Verified) Microsoft Windows Component...	c:\windows\system32\rpcrt4.dll
shell32	Windows Shell Common Dll	(Verified) Microsoft Windows Component...	c:\windows\system32\shell32.dll
url	Internet Shortcut Shell Extension DLL	(Verified) Microsoft Windows Component...	c:\windows\system32\url.dll
urlmon	OLE32 Extensions for Win32	(Verified) Microsoft Windows Component...	c:\windows\system32\urlmon.dll
user32	Windows XP USER API Client DLL	(Not verified) Microsoft Corporation	c:\windows\system32\user32.dll
version	Version Checking and File Installation ...	(Verified) Microsoft Windows Component...	c:\windows\system32\version.dll
wininet	Internet Extensions for Win32	(Verified) Microsoft Windows Component...	c:\windows\system32\wininet.dll
wldap32	Win32 LDAP API DLL	(Verified) Microsoft Windows Component...	c:\windows\system32\wldap32.dll

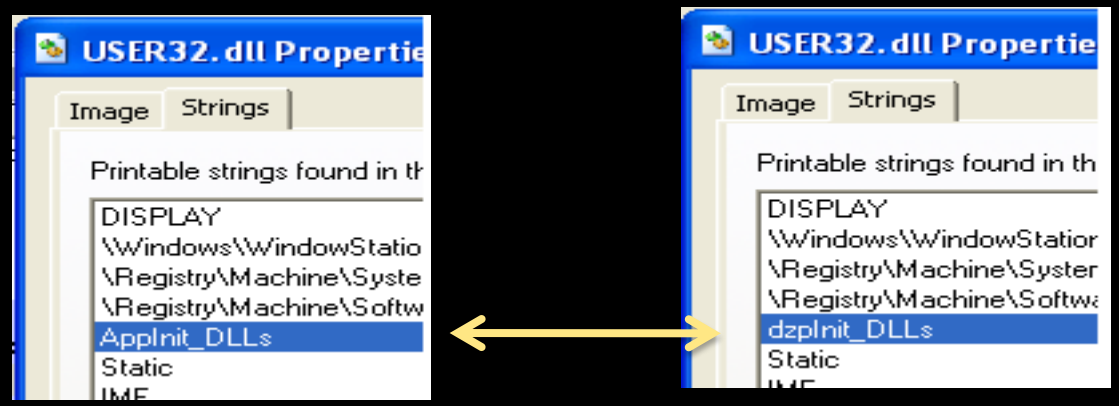
- Autorunsc confirmed that they were different:

```
user32.dll
  Windows XP USER API Client DLL
  (Not verified) Microsoft Corporation
  5.1.2600.5512
  c:\windows\system32\user32.dll
  5088c5a9fac811dcbcbd63924ae824fa (MD5)
  1be263d5ca3b4ea01f0378d1177aa9cc27459b98 (SHA-1)
  b820443071859c2d6a0f53b011dd3ffaa2d7a48f7a930c08dc55096ddfe2aedb (SHA-256)
```

```
user32.dll
  Windows XP USER API Client DLL
  (Verified) Microsoft Windows Component Publisher
  5.1.2600.5512
  c:\windows\system32\user32.dll
  b26b135ff1b9f60c9388b4a7d16f600b (MD5)
  08fe9ff1fe9b8fd237adedb10d65fb0447b91fe5 (SHA-1)
  acd0ae7b4d5f871e148276c6cc4ae3a216e33f67fc78d827c16986e1f945438c (SHA-256)
```

The Case of the Malicious Autostart Solved

- Looked at DLL properties in Process Explorer
  - In-memory strings were the same
  - On-disk strings had one difference:



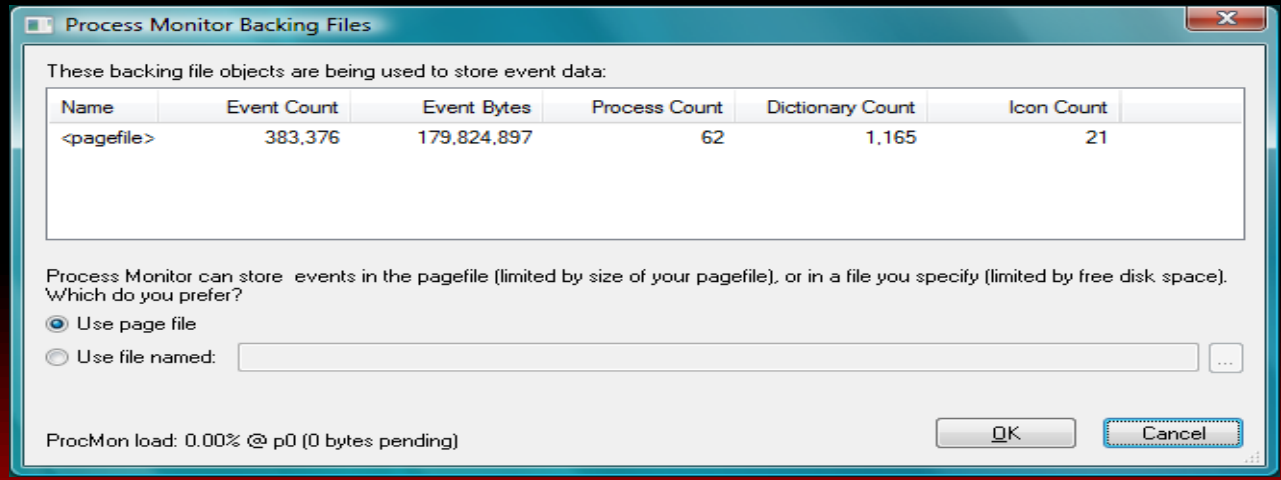
- Rebooted system into Microsoft Diagnostic and Repair Toolkit and replaced User32.dll with good version: Malware cleaned

Basic vs Advanced Mode

- Basic mode includes filters that exclude system activity
  - Process Monitor activity
  - Paging file
  - System process
  - NTFS metadata files
- Basic mode massages I/O names:
  - E.g. IRP_MJ_READ => ReadFile

Logging to a File

- By default, logging is page-file backed
  - Use Options->History Depth to avoid memory exhaustion
  - Or use Filter->Drop Filtered Events
- Use the File->Backing File dialog to specify logging to a file
  - Data is written in native as its captured
  - Log size is limited only by available disk space
  - Dialog also shows trace statistics



Running Process Monitor Before Logon

- Sometimes need to capture I/O or registry activity during boot, the logon or logoff process
  - Problem: when you logoff all your processes are terminated
- Solutions: Run Process Monitor in a different logon session
  - psexec –s –i –d

Boot Logging

- Process Monitor can capture all activity from very early in the boot process:
  - Options->Enable Boot Logging
- Capture continues through shutdown or you run Process Monitor
  - Log data is saved as raw data to %Windir%\Procmon.pmb
  - The next time you run Process Monitor it will offer to transform the data to a native PML log
- Enable Advanced Output to see all events
- Typical Windows Vista boot->Log in->Shutdown generates 1-2 million events

Stuxnet and Alureon

Analyzing a Stuxnet Infection

http://blogs.technet.com/b/markrussinovich/archive/2011/03/30/3416253.aspx

- Discovered June 2010 after it had spread for year
- Exploited 4 zero day Windows vulnerabilities
  - Print spooler for remote code execution
  - Shell link Explorer code execution from infected key
  - Win2K/Windows XP Win32k.sys privilege elevation
  - Windows 7 Task Scheduler privilege elevation
- Drivers signed by certificates stolen from RealTek and JMicron
- Rootkit code for Siemens Step 7 SCADA PLC for centrifuges
- Suspected to have targeted Iranian centrifuges used for Uranium enrichment at Natanz nuclear facility
  - Iran confirms in September 2010 that thousands were destroyed
  - Suspected to be created by Israel and US

Iranian President Mahmoud Ahmadinejad observes computer monitors at the Natanz uranium enrichment plant in central Iran, where Stuxnet was believed to have infected PCs and damaged centrifuges. *(Photo: Office of the Presidency of the Islamic Republic of Iran)*

Analyzing an Alureon Infection

- First malware to bypass 64-bit Windows Kernel-mode Code Integrity
  - Modifies MBR and boots system in “WinPE” mode – code integrity is off
  - Loads malicious unsigned Kdcom.dll from hidden sectors off end of volume
  - Modifies registry boot flags to hide WinPE mode so system continues to boot normally
  - Uses modified disk driver to mask modified MBR
- Took A/V several months to develop on-line cleaning
- Very little visible sign of infection

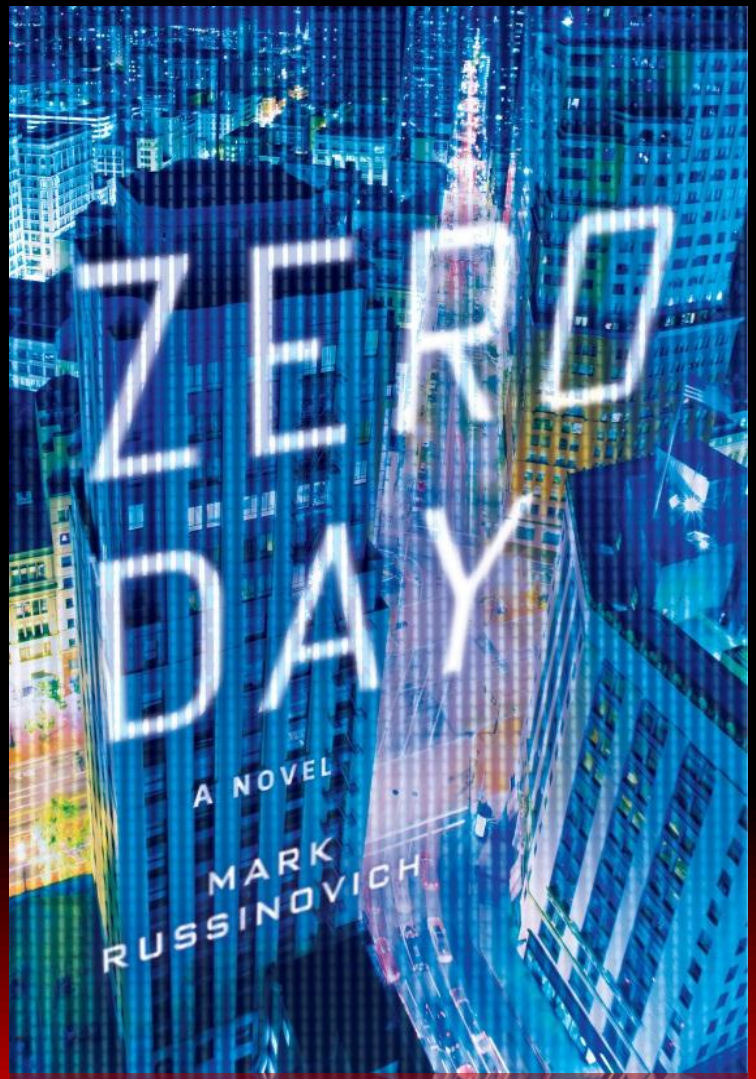
Summary and the Future

The Future of Malware

- We've seen the trends:
  - Malware that pretends to be from Microsoft or other legitimate companies
  - Malware protected by sophisticated rootkits
  - Malware that has stolen certificates
- Cleaning is going to get much, much harder
  - Targeted and polymorphic malware won't get AV/AS signatures
  - Malware can directly manipulate Windows structures to cause misdirection
  - All standard tools will be directly attacked by malware
  - There will be more un-cleanable malware
  - Malware will adapt to a limited-user environment
- You can't know you're infected unless you find a symptom
- The bottom line is that prevention and containment is the best defense

Zero Day – A Novel

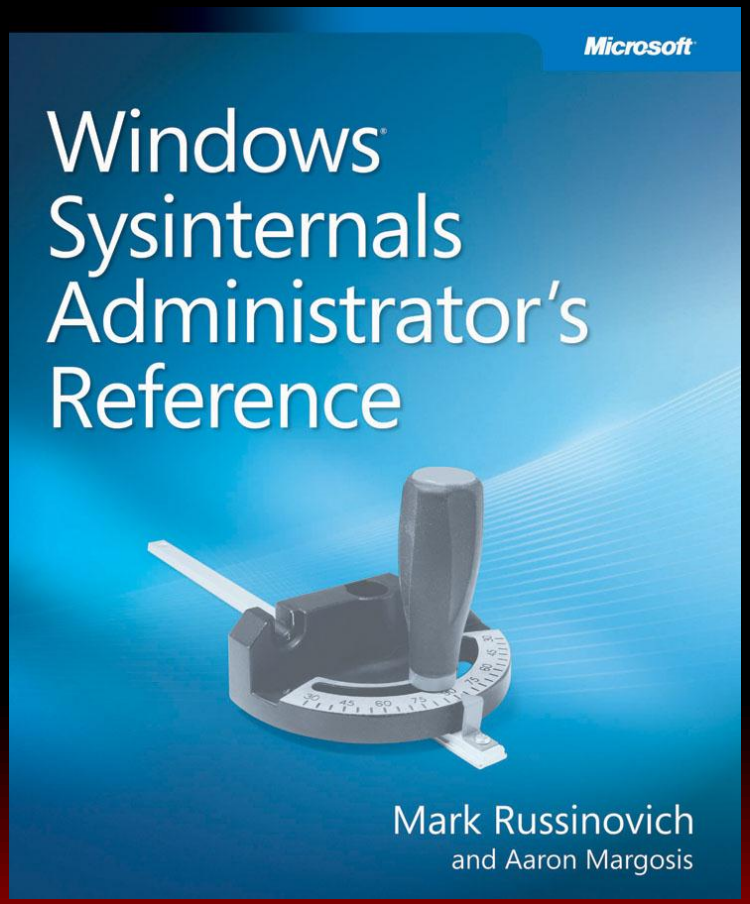
- A cyberthriller true to the science
- www.zerodaythebook.com
- Signing from 3-3:30 at the bookstore



http://www.youtube.com/watch?v=ucyMBYg9RWU

The Sysinternals Administrator's Reference

- The official guide to the Sysinternals tools
  - Covers every tool, every feature, with tips
  - Written by markruss and aaronmar
  - Available in June
- Full chapters on the major tools:
  - Process Explorer
  - Process Monitor
  - Autoruns
- Other chapters by tool group
  - Security, process, AD, desktop, …



http://technet.microsoft.com/en-us/sysinternals/hh290819

References

- Sysinternals
  - Sysinternals Administrator's Reference, by Mark Russinovich and Aaron Margosis, Microsoft Press
  - Mark's Sysinternals Blog
  - Mark's Webcasts
- Symantec Stuxnet Dossier http://www.symantec.com/content/en/us/enterprise/media/security_response/whitepapers/w32_stuxnet_dossier.pdf
- Arstechnica Stuxnet story http://www.wired.com/threatlevel/2011/07/how-digital-detectives-deciphered-stuxnet/
- Joe Johnson: Alureon: the first 64-bit Rootkit http://www.virusbtn.com/pdf/conference_slides/2010/Johnson-VB2010.pdf
- Windows Internals, by Mark Russinovich and David Solomon with Alex Ionescu, Microsoft Press