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BRIEFINGS

Veni, No Vidi, No Vici: Attacks on ETW Blind EDR Sensors

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The Binarly Team

- Claudiu "to the rescue" Teodorescu – @cteo13
  - Digital Forensics, Reverse Engineering, Malware & Program Analysis
  - Instructor of Special Topics of Malware Analysis Course on BlackHat USA
  - Speaker at DEF CON, BSidesLV, DerbyCon, ReCon

- Igor Korkin – @IgorKorkin
  - PhD, Windows Kernel Researcher
  - Author of MemoryRanger
  - igorkorkin.blogspot.com

- Andrey "red plait" Golchikov – @real_redp
  - More than 20 years in researching operating system security and reversing Windows Internals
  - Author of EtwCheck
  - redplait.blogspot.com

Agenda

- Event Tracing for Windows (ETW)
  - Architecture and features
  - Applying ETW for security: academic and practical results
- Attacks on ETW blind the whole class of EDR solutions
  - Overview of existing attacks on ETW
  - Attacks on Process Monitor and Windows Defender
- EtwCheck detects attacks on ETW
- MemoryRanger prevents some kernel attacks on ETW

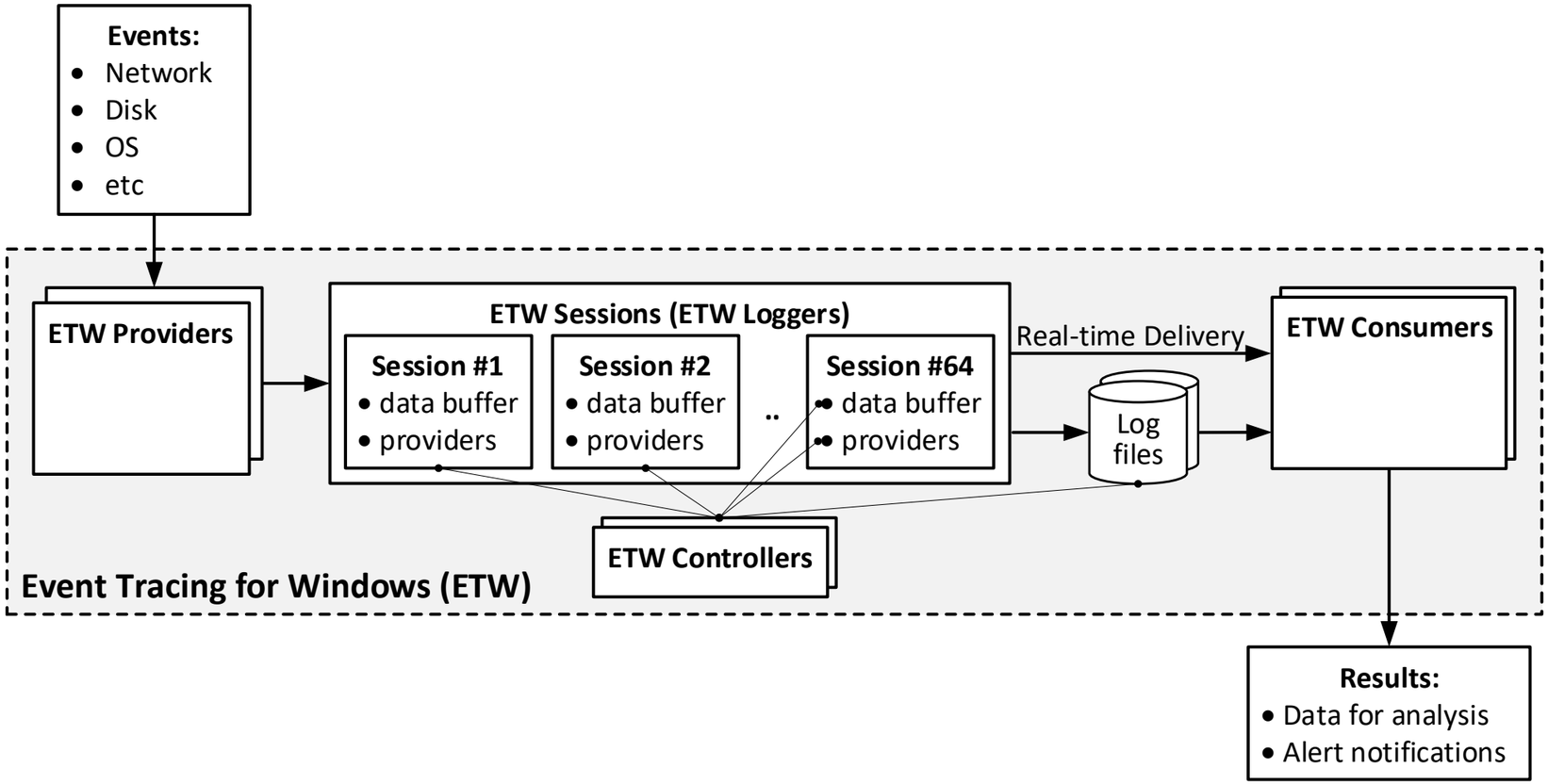
Event Tracing for Windows

ETW is a built-in diagnostic feature to log events from OS kernel, drivers and apps.

Windows 11: ETW can collect more that 50,000 events from about 1000 providers.

ETW features:

- System-wide
- Adjustable
- High speed logging
- Standardized
- Already Available
- Continual Features Growth
- Does not require rebooting
- Does not require driver installation
- Does not require any hardware features



ETW Providers: APPs, DLLs, OS Kernel and Drivers

Apps and services	DLLs	OS kernel and Drivers
• **OS system** • Smss • Wininit • Services • **Security and AV** • NisSrv • MsMpEng • SgrmBroker • **Common Apps**: • Explorer • Notepad • Msedge • Mspaint	• **OS system** • Ntdll • KernelBase • Shell32 \ Advapi32 \ SetupAPI • **Security and Encryption** • Wintrust \ Amsi \ Wscapi • Rsaenh \ Ncrypt \ Bcrypt \ Crypt32 • Firewallapi \ Fwpuclnt • **Network and WMI** • Urlmon\ WinHTTP • Webio \ Wbemcomn • Iertutil \ DnsApi	• **OS system** • Nt • Win32kbase \ Win32kfull • **Security and Encryption** • Cng \ FileCrypt • KSecdd • MsSecFlt • Tbs • **Network and Devices** • NTFS \ CimFS \ WciFS • VwifiFlt \ CldFlt \ BindFlt • HTTP \ TcpIp \ NetIO • Partmgr \ VolMgr \ NDIS • Disk \ CDrom \ ClassPNP

All these OS components can supply various ETW events

Using ETW for Malware Hunting

- Process
  - Process create and exit
  - Thread create and exit
  - Image loads, including c
- Network
  - ETW network tracing
- Profiling
  - Toolhelp thread snapsho

The first example of using ETW to trace malware activity:

(2012) *Malware Hunting with the Sysinternals Tools* by Mark Russinovich

2021: more than 10 market-leading EDR solutions use ETW for threat hunting

Disclaimer: This analysis is not designed to promote any products and solutions, it is meant to inform the cybersecurity community. The analysis of the products and solutions uses only materials freely available online.

Ideas of building EDRs based on ETW

Alex Ionescu
@aionescu

Build your own EDR with Microsoft's Threat Intelligence ETW channel: pastebin.com/6VGHjGjH cc @mattifestation @subTee @enigma0x3

Build Your own EDR - Pastebin.com
Pastebin.com is the number one paste tool since 2002.

Matt Graeber
@mattifestation

I had a fun malware analysis session w/ a co-worker today and we were doing some maldoc analysis. With how much insight can now be gleaned via AMSI, we turned it into a dynamic analysis tool. Here are the steps we used to start a trace and dump events: gist.github.com/mgraeber-rc/51... 1/3

Nasreddine Bencherchali
@nas_bench

Quick thread on how @symantec EDR uses event enrichment rules and ETW to detect "malicious activity"

Example : Brute Force attempt using event 4625

(1/) 🧵
#detection #symantec #edr #BlueTeam

11:55 PM · Aug 11, 2021 · Twitter Web App

Black Hat
@BlackHatEvents

Event Tracing for Windows (ETW) is a built-in feature, originally designed to perform software diagnostics, and nowadays ETW is essential for Endpoint Detection & Response (EDR) solutions. See a demo from @roberpupum at #BHEU Arsenal informatech.co/3jC89uu

9:33 PM · Sep 6, 2021 · Sprout Social

~100 research projects use ETW data

- *Tracing Adversaries: Detecting Attacks with ETW* by Matt Hastings (@_mhastings_) Dave Hull(@davehull)
- *Hidden Treasure: Detecting Intrusions with ETW* by Zac Brown (@zacbrown)
- *Hunting for Memory-Resident Malware* by Joe Desimone (@dez_)
- *Using Sysmon and ETW For So Much More* by David Kennedy (@HackingDave)

DARPA

- Windows Low-Level System Monitoring Data Collection
- Project MARPLE
- Project APTShield

MITRE

- MITRE-built ETW-based Security Sensor

ERNW providing security.

- SiSyPHuS Project analyzed Windows Logging Capabilities

ETW based academic papers: 2019-2021

Contents lists available at ScienceDirect

Computers & Security

journal homepage: www.elsevier.com/locate/cose

procmonML: Generating evasion resilient host-based behavioral analytics from tree ensembles

Joseph W. Mikhail*, Jamie C. Williams, George R. Roelke

The MITRE Corporation, United States

UNIVERSITY OF AMSTERDAM

Detecting Fileless Malicious Behaviour of .NET C2 Agents using ETW

Alexander Bode abode@os3.nl
Niels Warnars nwarnars@os3.nl

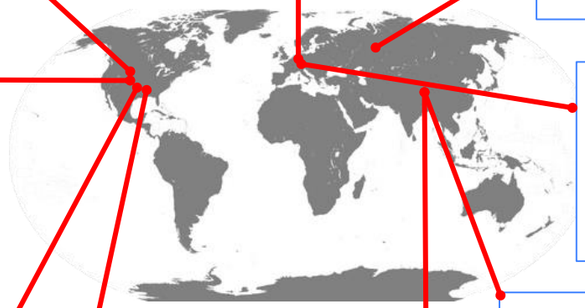
REVEALING CRYPTOCURRENCY MINING MALWARE VIA ETW

Kazakov O.A.[4], Korkin I.Y.[5]

Malware Characterization Using Behavioral Components

Chaitanya Yavvari, Arnur Tokhtabayev,
Huzefa Rangwala, and Angelos Stavrou

Computer Science Department, George Mason University, Fairfax, VA, USA
{cyavvari,atokhtab,astavrou}@gmu.edu, rangwala@cs.gmu.edu



Peeler: Profiling Kernel-Level Events to Detect Ransomware

Muhammad Ejaz Ahmed, Hyoungshick Kim, Seyit Camtepe, and Surya Nepal

RATSCOPE: Recording and Reconstructing Missing RAT Semantic Behaviors for Forensic Analysis on Windows

Runqing Yang *, Xutong Chen *, Haitao Xu, Yueqiang Cheng, Chunlin Xiong, Linqi Ruan, Mohammad Kavousi, Zhenyuan Li, Liheng Xu, and Yan Chen, *Fellow, IEEE*

PROBLEMCHILD: DISCOVERING ANOMALOUS PATTERNS BASED ON PARENT-CHILD PROCESS RELATIONSHIPS

Bobby Filar
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Tactical Provenance Analysis for Endpoint Detection and Response Systems

Wajih Ul Hassan
University of Illinois at Urbana-Champaign
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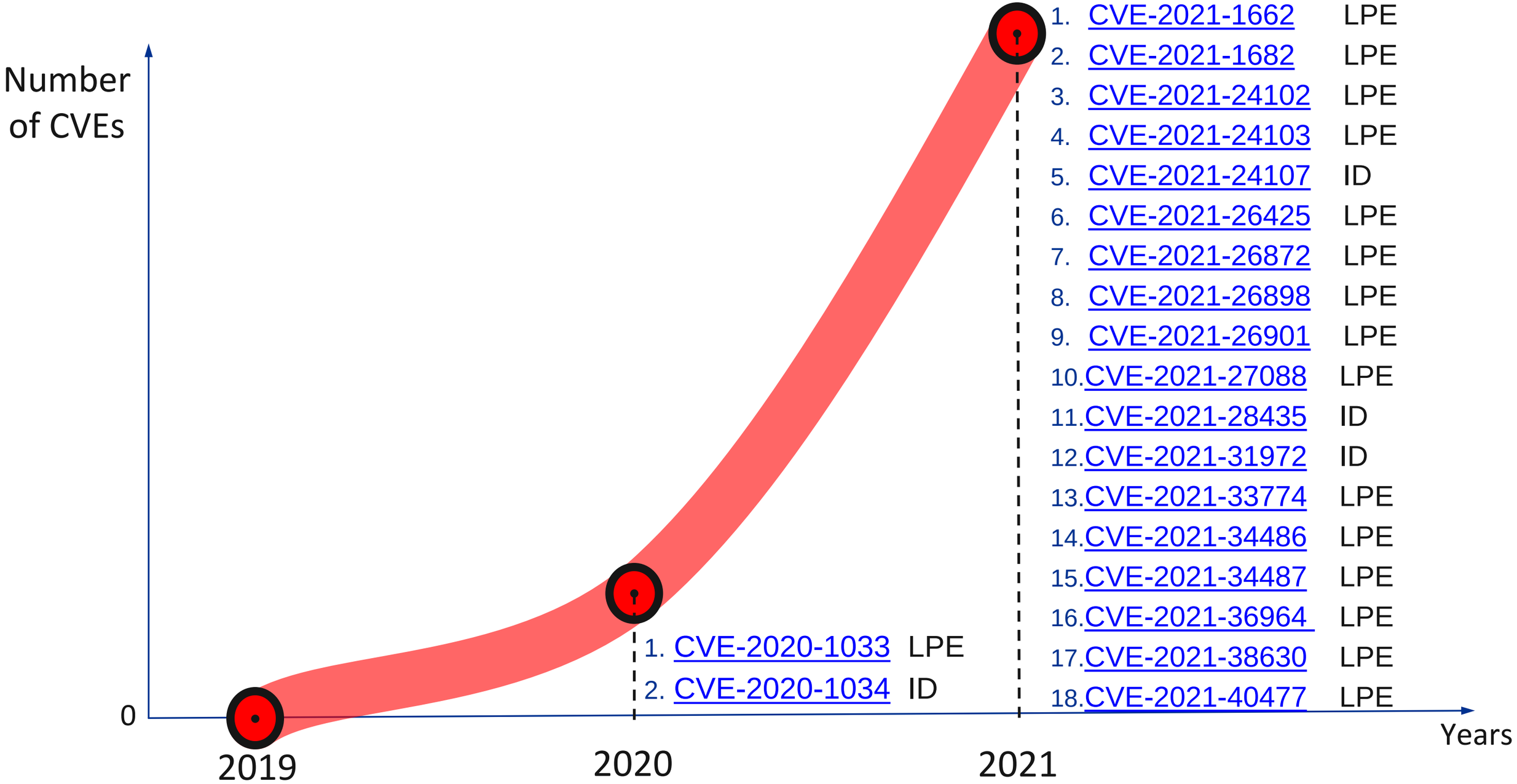
Adam Bates
University of Illinois at Urbana-Champaign
batesa@illinois.edu

Daniel Marino
NortonLifeLock Research Group
daniel.marino@nortonlifelock.com

CONAN: A Practical Real-time APT Detection System with High Accuracy and Efficiency

Chunlin Xiong, Tiantian Zhu, Weihao Dong, Linqi Ruan, Runqing Yang, Yueqiang Cheng, Yan Chen, *Fellow, IEEE*, Shuai Cheng, and Xutong Chen

ETW is under the microscope of bug hunters



ETW IS HELPFUL FOR DEFENSE

BUT, IT HAS SOME DRAWBACKS

ETW Undocumented features

- ETW was originally designed for internal use:
  - ETW API has opaque structure
  - ETW includes several undocumented providers
  - Some ETW providers deliver events which are undocumented
    (ETW templates about events are stored in WEVT_TEMPLATE resource inside PE file)

- ETW can be used for malicious purposes:
  - ETW can be used as a file, registry, network, process, thread, drivers, and keystroke **sniffer** without installing kernel driver or registering callback functions
  - ETW can flood HDD
  - Some ETW providers are available only for apps with enabled Protected Process Light (PPL), but malware can patch PPL Level without BSOD
  - ETW can help to detect sandbox detonations
  - No footprints: WinAPI do not return information about which app is consuming events.

ETW CAN BE BYPASSED

Disabling ETW is widely discussed

Grzegorz Tworek
@0gtweet

Ever wanted to stop Eventlog-Security logger? Me too… And now I know it is not about ACLs. The way to stop unstoppable logger is to issue "TRUE" as the last parameter in EtwpStopTrace() call. And user can call it only through NtTraceCont
"FALSE". 🤦‍♂️

Joe Desimone
@dez_

Disable those pesky user mode etw loggers

```
void DisableEtw()
{
    // Disable any usermode etw loggers in the current process
    DWORD dwOld = 0;
    void * pEventWrite = GetProcAddress(GetModuleHandle(L"ntdll.dll"), "EtwEventWrite");
                                                                        &dwOld);
                                                                        5);
```

red plait
@real_redp

how you can find structure _TlgProvider_t and dynamically disable #etw tracing in any running processes: redplait.blogspot.com/2020/07/tlgpro…

5:38 PM · Jul 24, 2020 · Twitter Web App

Malware Examples of evading ETW-based logging

2018

APT Slingshot

- renames ETW-logs to avoid leaving traces
- cyber-espionage platform

2019

Ransomware LockerGoga

- disables ETW to bypass host-based sensors
- Sends Norsk Hydro Into Manual Mode

2020-2021

APT41 Group

- disables ETW to evade detection
- Targets Indo-Pacific countries

Defense Evasion (post-exploitation) Frameworks:

- SharpSploit disable ETW monitoring for current process
- ScareCrow – payload creation framework bypasses EDR
- EDR Evasion – about 10 examples of blocking ETW logging

MITRE ATT&CK – Impair Defenses

- Indicator Blocking
- Disable Cloud Logs

Malware Examples of evading ETW-based logging

MITRE | ATT&CK®

Impair Defenses: Indicator Blocking (ID T1562.006)

- An adversary may attempt to block indicators or events typically captured by sensors from being gathered and analyzed.
- This could include maliciously redirecting [1] or even disabling host-based sensors, such as Event Tracing for Windows (ETW),[2] by tampering settings that control the collection and flow of event telemetry. [3]

Defense Evasion (post-exploitation) Frameworks:

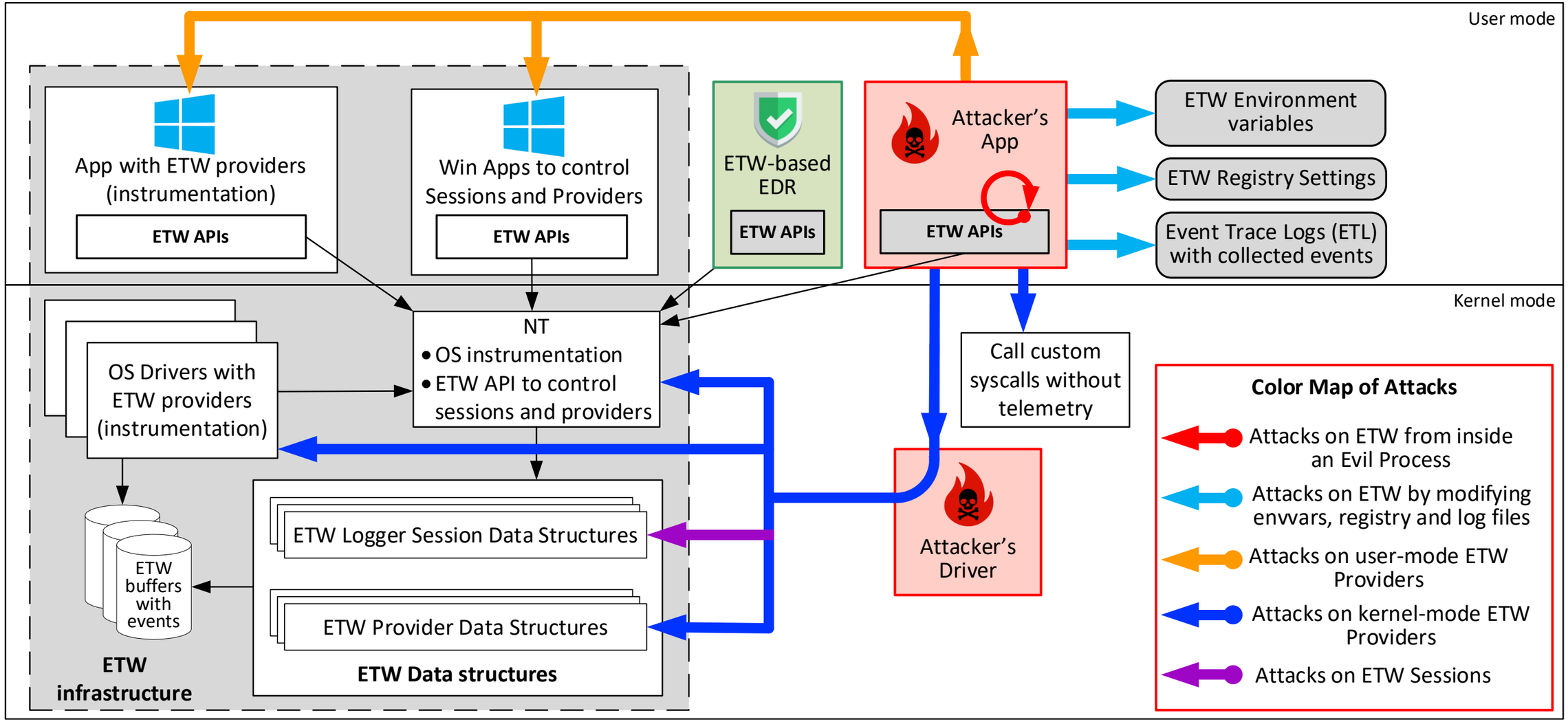
- SharpSploit disable ETW monitoring for current process
- ScareCrow – payload creation framework bypasses EDR
- EDR Evasion – about 10 examples of blocking ETW logging

MITRE ATT&CK – Impair Defenses

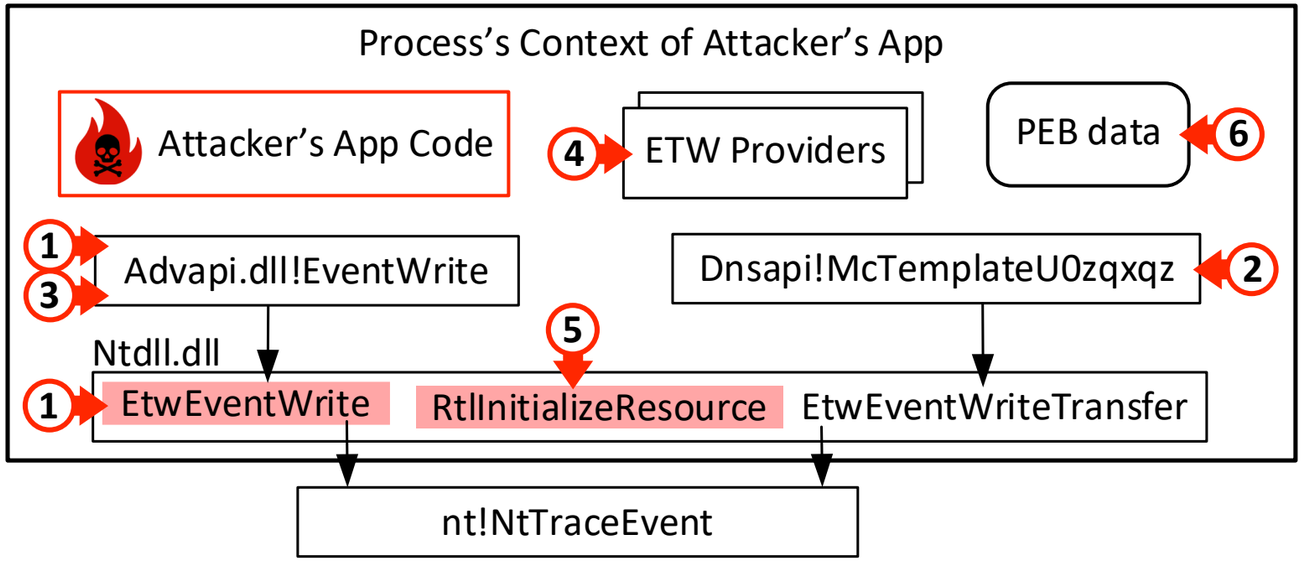
- Indicator Blocking
- Disable Cloud Logs

ATTACKS ON ETW – THE BIG PICTURE

Threat Modeling ETW

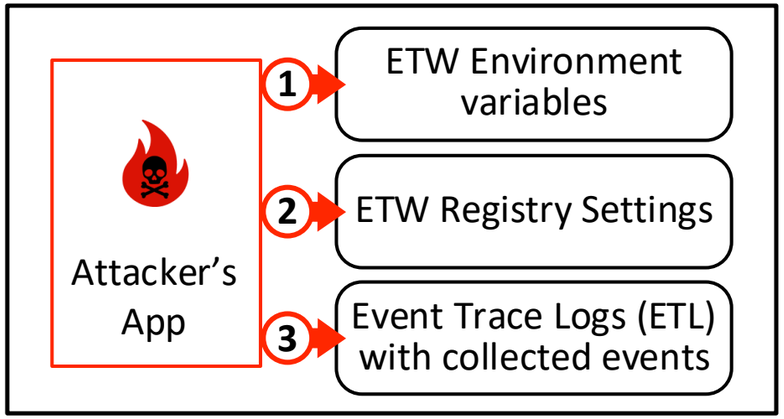


Local Attacks on ETW from inside an evil app



Attacks	References	Techniques
1 5 **Block** logging events about malware user-mode activity	1a, 1b, 1c, 1d, 1e, 1f, 5	Change the control flow using: • **Import Address Table (IAT) Hooking** • **Inline hooking\Splicing** • **Function patching with RET** • **Hardware Breakpoints**
2 **Block** logging events from *Microsoft-Windows-DNS-Client* provider	2	
3 **Send bogus** ETW events	3	
4 **Disable** Suspicious ScriptBlock Logging via PowerShell	4a, 4b	Set **m_enabled** in **PSEtwLogProvider** ETW Provider to **FALSE**
6 **Fake source** process image file and fake the list of loaded modules	6	Overwrite fields inside **PEB**

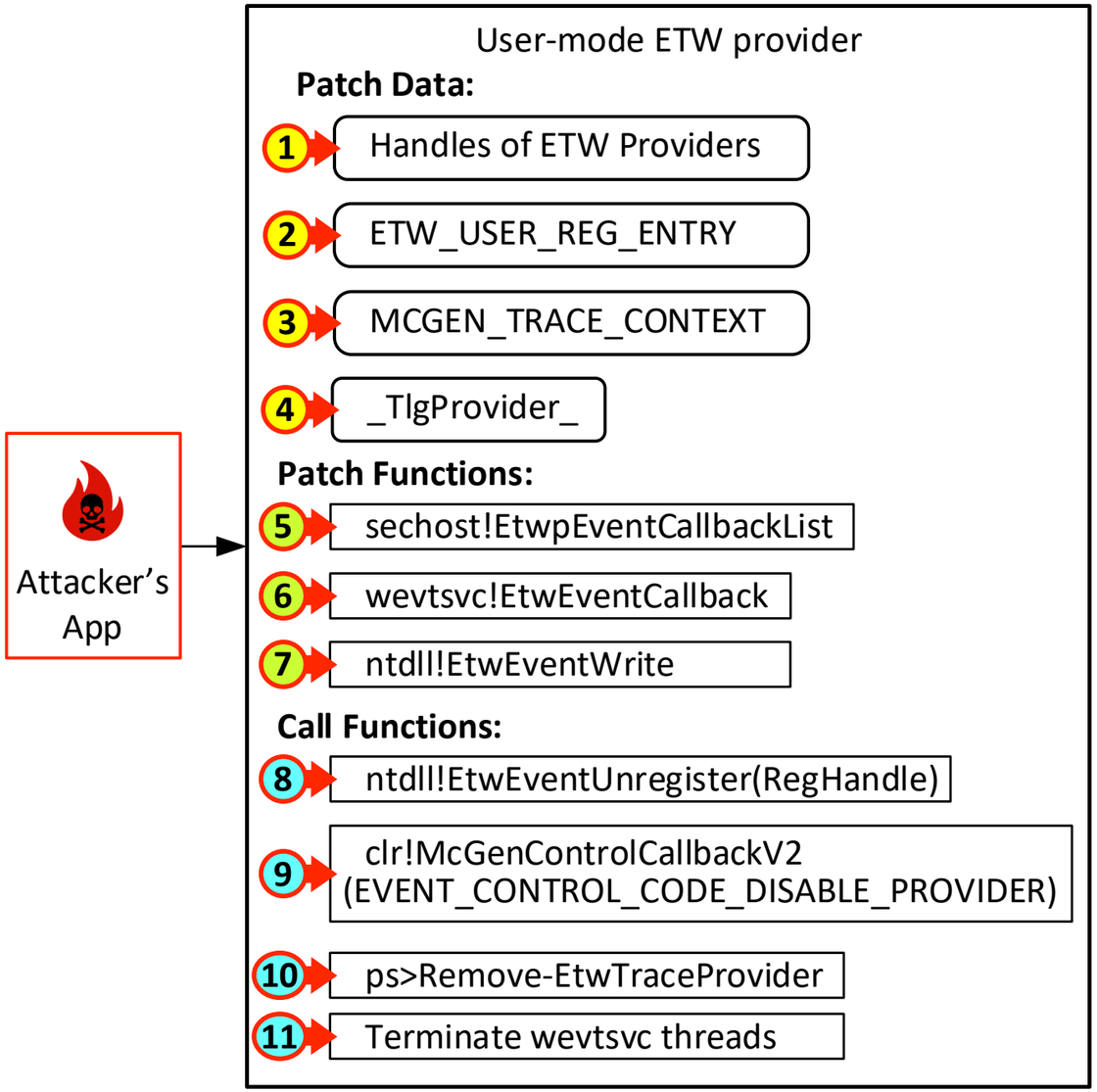
Attacks on ETW: EnvVars, Registry, and Log Files



Attacks	Techniques	References
1 **Disable** Runtime Event Provider in .NET apps	Set the variables to **zero**: ▪ COMPlus_ETWFlags ▪ COMPlus_ETWEnabled	1a, 1b
3 **Tamper with** ETL file	Slingshot APT avoids leaving traces of its activity by **renaming** the ETW-logs	3

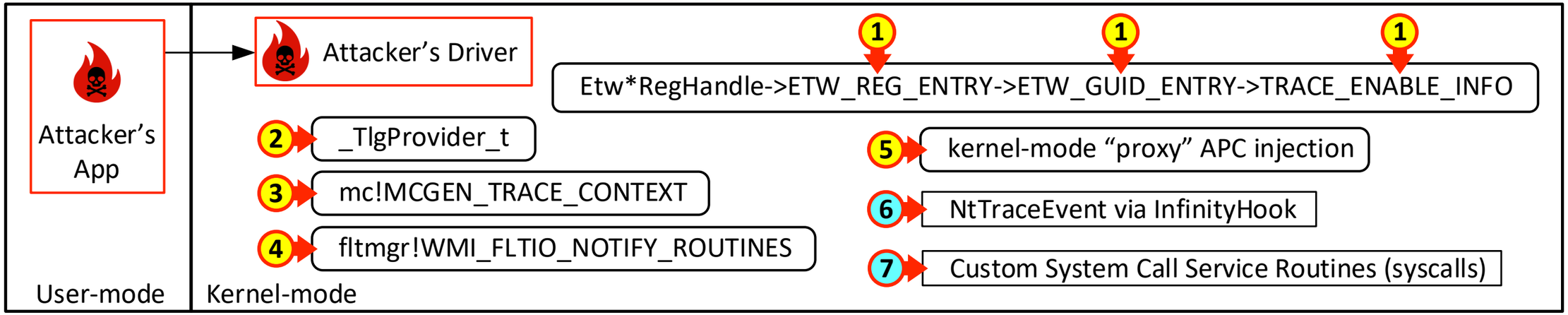
Attack Techniques	References
1 2 **Disable** Runtime Event Provider in .NET apps by **modifying** environment variables or by **patching** registry "HKLM\SYSTEM\CurrentControlSet\Control\Session Manager\Environment"	1a, 1b, 1c, 1d
2 **Blind** services.exe: value "**TracingDisabled**" in Software\Microsoft\Windows NT\CurrentVersion\Tracing\SCM\Regular **Blind** rpcrt4.dll: value "**ExtErrorInformation**" in "HKLM\Software\Policies\Microsoft\Windows NT\Rpc"	2
2 **Blind** Microsoft-Windows-PowerShell provider: by **zeroing** value "**EnableProperty**" in HKLM\System\CurrentControlSet\Control\WMI\Autologger\EventLog-Application\{GIUD}\ **Blind** Autologger events: by **key deletion** "HKLM\SYSTEM\CurrentControlSet\Control\WMI\Autologger\AUTOLOGGER_NAME\{PROVIDER_GUID}" **Blind** Autologger events: by **zeroing** value "**Enable**" in "HKLM\SYSTEM\CurrentControlSet\Control\WMI\Autologger\AUTOLOGGER_NAME\{PROVIDER_GUID}"	2
2 **Patch security descriptors** for ETW logger sessions: "HKLM\System\CurrentControlSet\Control\Wmi\Security"	2

Attacks on user-mode ETW providers



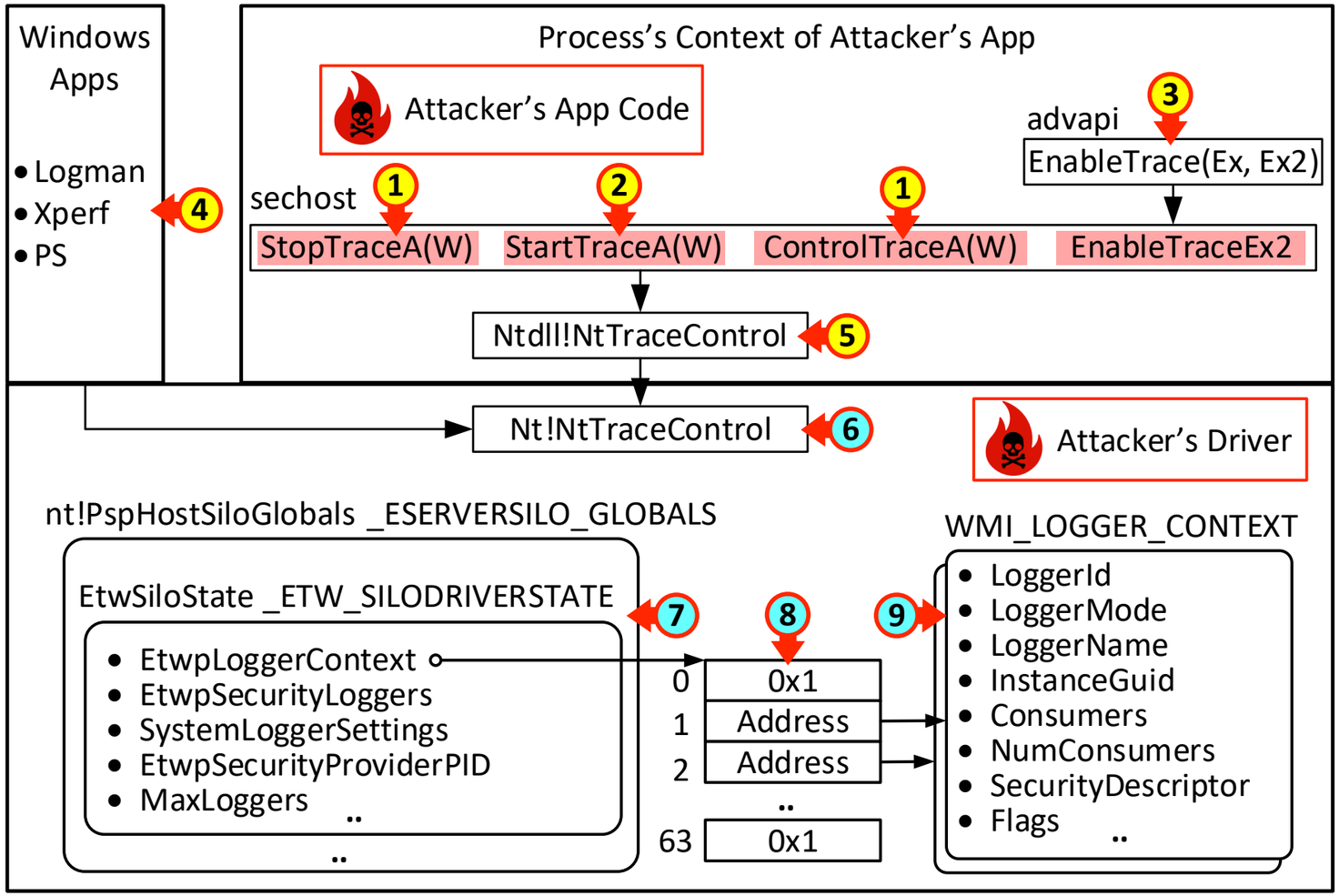
Attacks	Technique	Links
Disable ETW Provider for all processes globally	**Patch Data:** 1 ▪ ETW handles ▪ Trace level, EventsEnableBits	1a, 1b
Disable ETW Provider for the one process	**Patch Data:** 2 ▪ ETW_USER_REG_ENTRY.Callback 3 ▪ MCGEN_TRACE_CONTEXT fields IsEnabled, level	2, 3
	4 ▪ _TlgProvider_t fields LevelPlus1, KeywordAny, KeywordAll	4a, 4b
	Patch Code with RET: 5 ▪ sechost!EtwpEventCallbackList	5a, 5b, 5c
	7 ▪ ntdll!EtwEventWrite	7
	Call functions: 8 ▪ ntdll!EtwEventUnregister(Handle)	8a, 8b
	9 ▪ clr!McGenControlCallbackV2()	9a, 9b
	10 ▪ Remove-EtwTraceProvider	10a, 10b
	11 ▪ Terminate threads (wevtsvs)	11a, 11b, 11c
Block specific events in one process	**Hook Function:** 6 ▪ wevtsvc!EtwEventCallback	6a, 6b

Attacks on kernel-mode ETW providers



No	Attacks	Technique	Links
1	**Disable** tracing	▪ Zeroing TRACE_ENABLE_INFO ProviderEnableInfo fields IsEnabled and Level ▪ Zeroing ETW_GUID_ENTRY.ProviderEnableInfo (e.g. EtwpPsProvRegHandle)	1a, 1b
	Hijack gen. events	▪ Patching ETW_REG_ENTRY-> PETW_GUID_ENTRY GuidEntry	
2	**Disable** tracing	▪ **Zeroing** LevelPlus1, ▪ **Patching** EnableCallback ▪ **Patching** RegHandle->ETW_REG_ENTRY.ProviderEnableInfo ▪ **Patching** ETW_REG_ENTRY ->ETW_GUID_ENTRY	2a, 2b, 2c
	Hijack gen. events	**Patching** RegHandle->ETW_REG_ENTRY	
3	**Disable** tracing	**Patching** IsEnabled and Level	3a, 3b, 3c
4		**Patching** data structures designed for filter operations	4
5		Kernel **APC injection** can blind *Microsoft-Windows-Threat-Intelligence* sensor \ fake process name	5
6		**InfinityHook** helps to redirect the control flow. 7 – Use custom syscalls to avoid being logged.	6a, 6b, 7

Attacks on ETW sessions



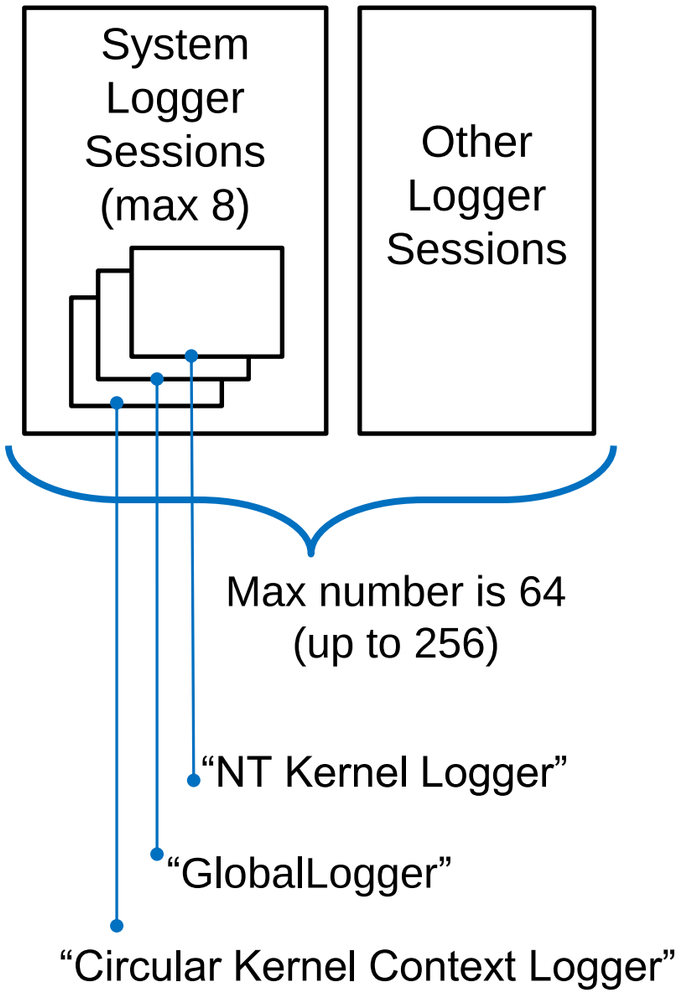
Attack	Technique	Link
Stop legal session	1 ▪ StopTrace ▪ ControlTrace(EVENT_TRACE_CONTROL_STOP)	1a, 1b, 1c
	5 ▪ NtTraceControl	5
	6 ▪ NtTraceControl	6
	4 ▪ PS>Stop-EtwTraceSession ▪ logman stop LoggerName –ets ▪ xperf -stop LoggerName	4a, 4b, 4c, 4d
	8 ▪ Patch EtwpLoggerContext array	new
Start fake session with legal name	2 5 6 ▪ StartTrace / NtTraceControl	2a, 2b
	4 ▪ PS>Start-EtwTraceSession ▪ logman start LoggerName –ets ▪ xperf -start LoggerName –on Flag	4e, 4f, 4g
CVE-2020-1034	5 ▪ NtTraceControl (EtwReceiveNotification)	5
Remove Provider	3 ▪ EnableTraceEx2(EVENT_CONTROL_CODE_DISABLE_PROVIDER)	3
	4 ▪ PS>Remove-EtwTraceProvider	4k
Change settings	7 ▪ Patch MaxLoggers ▪ Patch EtwpSecurityLoggers ▪ Patch SystemLoggerSettings	7
Modify secure level	9 ▪ Patch Logger ▪ Patch Flags.SecurityTrace ▪ Patch SecurityDescriptor.Object	new

Summary of ETW Attacks

Type of Attack	Number of different techniques
Attacks from inside AN EVIL process	6
Attacks on ETW env variables, registry, and files	3
Attacks on user-mode ETW providers	11
Attacks on kernel-mode ETW providers	7
Attacks on ETW sessions	9
All in all	**36**

These numbers are likely to increase, attacking ETW research is ongoing

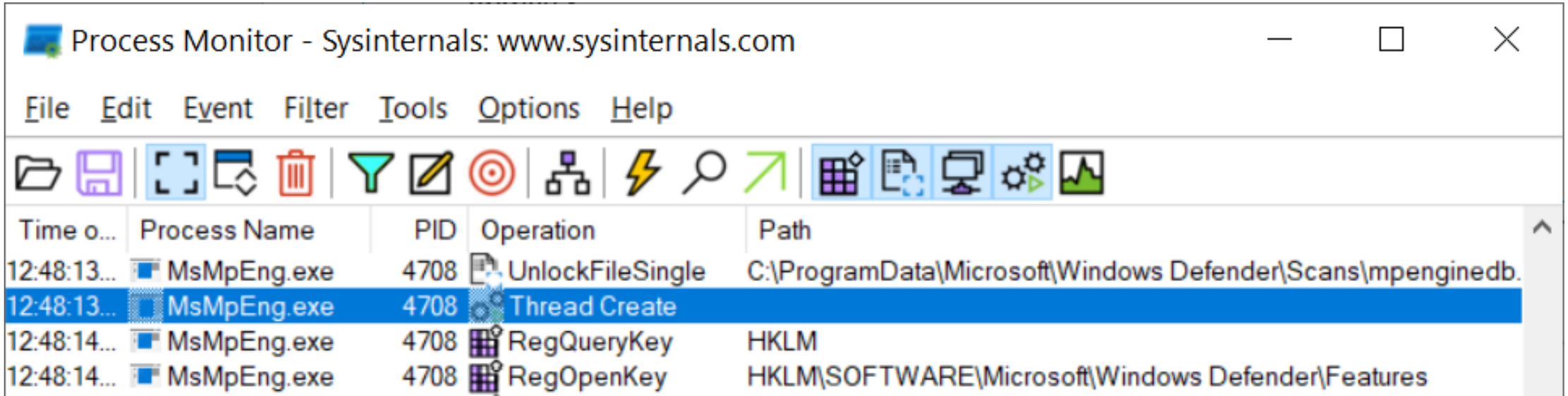
ETW Sessions



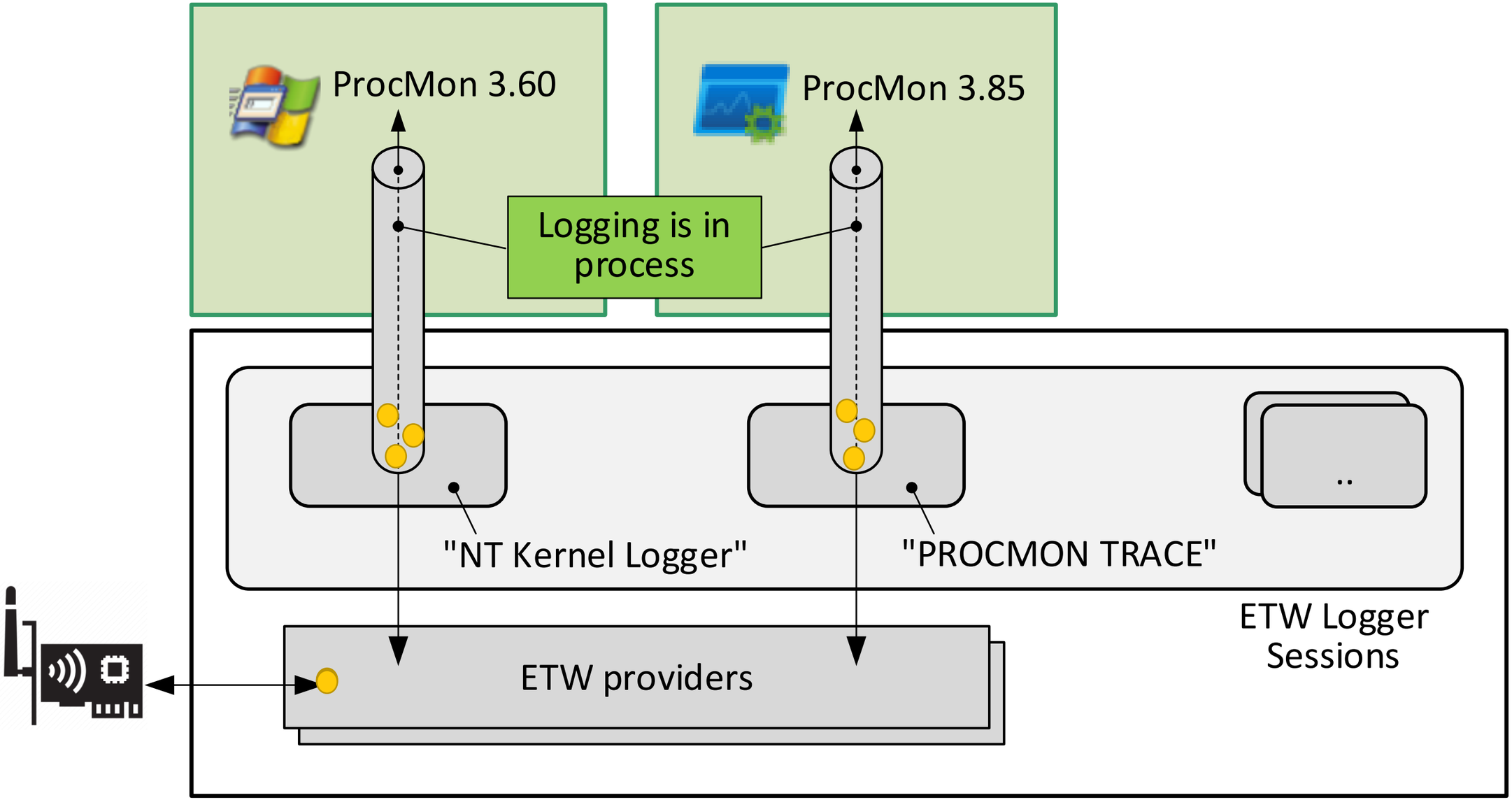
- ETW Session features:
  - ETW session is a global object with a unique name.
  - Each session can provide events for several consumer apps
  - There are no documented ways to find which app is receiving events from which session. But **EtwCheck** can do it.
- Special Logger Sessions:
  - **NT Kernel Logger Session** receives data from ETW providers implemented by ntoskrnl.exe and OS core drivers
  - Windows supports only one active Logger Session at a time.
  - Windows allows to start (stop) Logger Session for any app with admin privileges.

Process Monitor – a tool from Windows Sysinternals suite

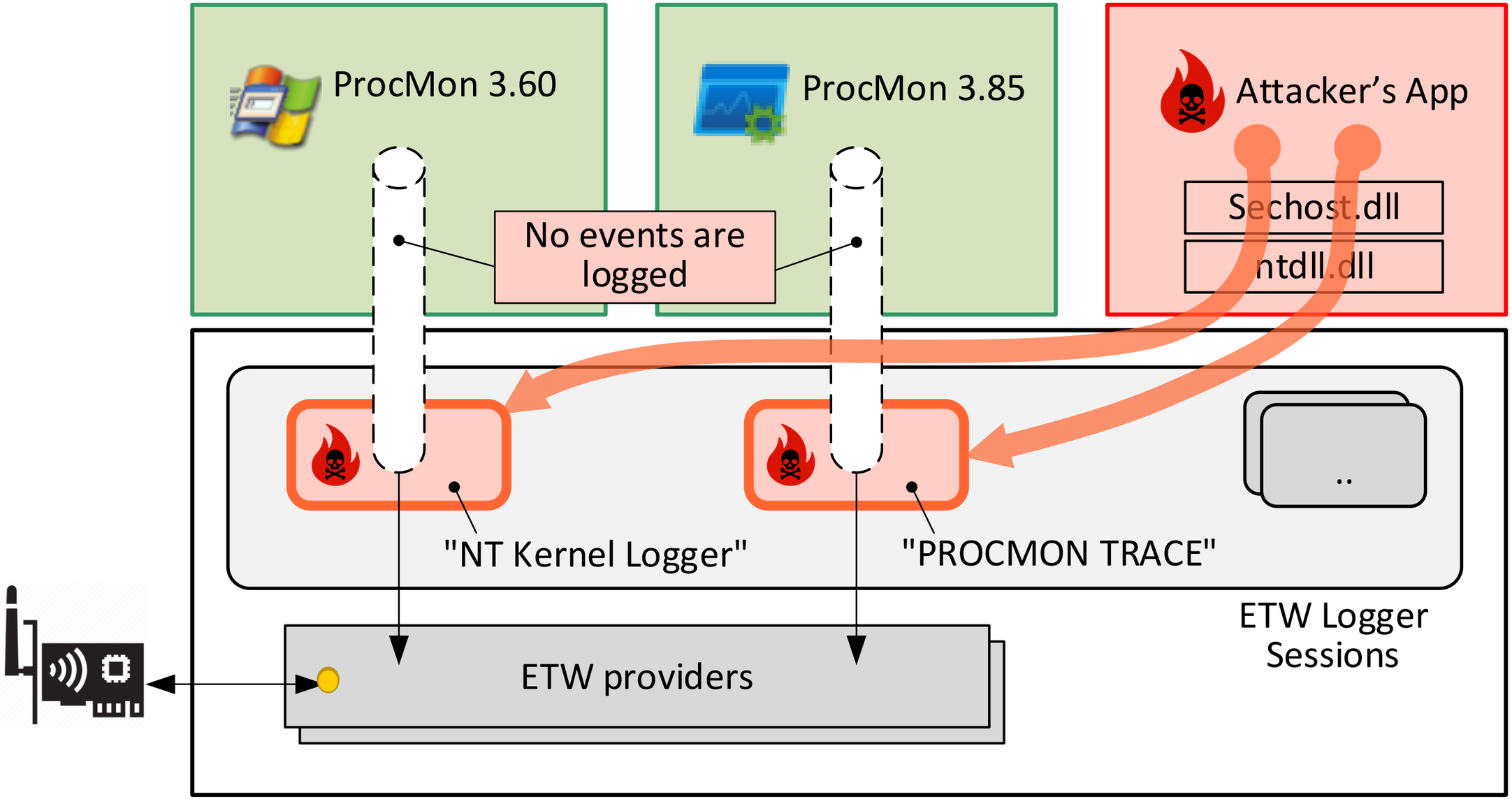
- Process Monitor is an advanced monitoring tool that shows in real-time activity on:
  - file system, ← based on file system minifilter
  - Registry ← based on registry minifilter
  - Process/Thread ← based on process/thread callbacks
  - Network ← based on ETW
- Process Monitor uses the same technologies as many EDR solutions.



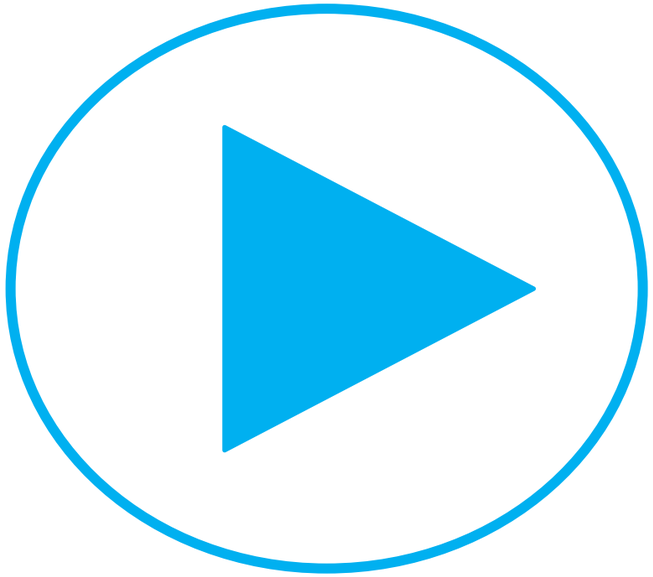
Process Monitor uses ETW to sniff network events



ETW Hijacker blinds Process Monitor

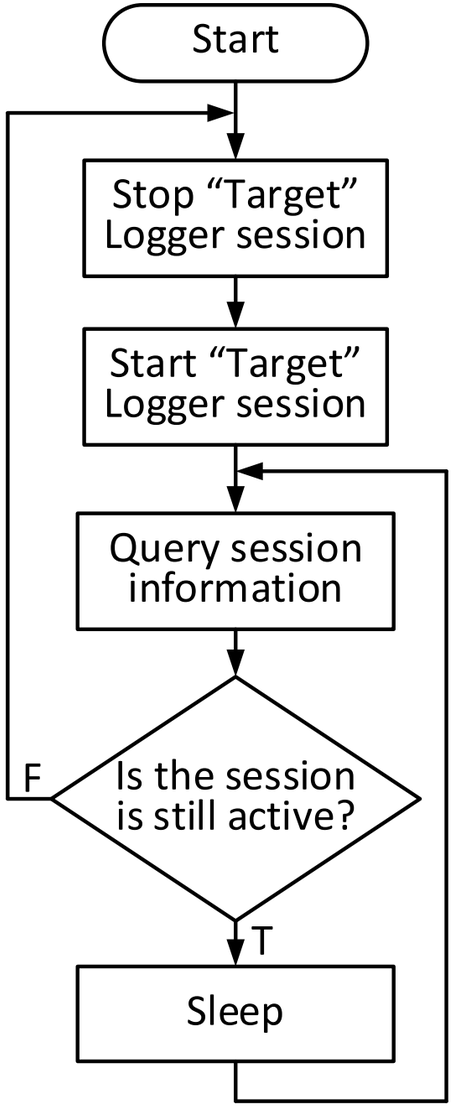


ETW Hijacker blinds Process Monitor

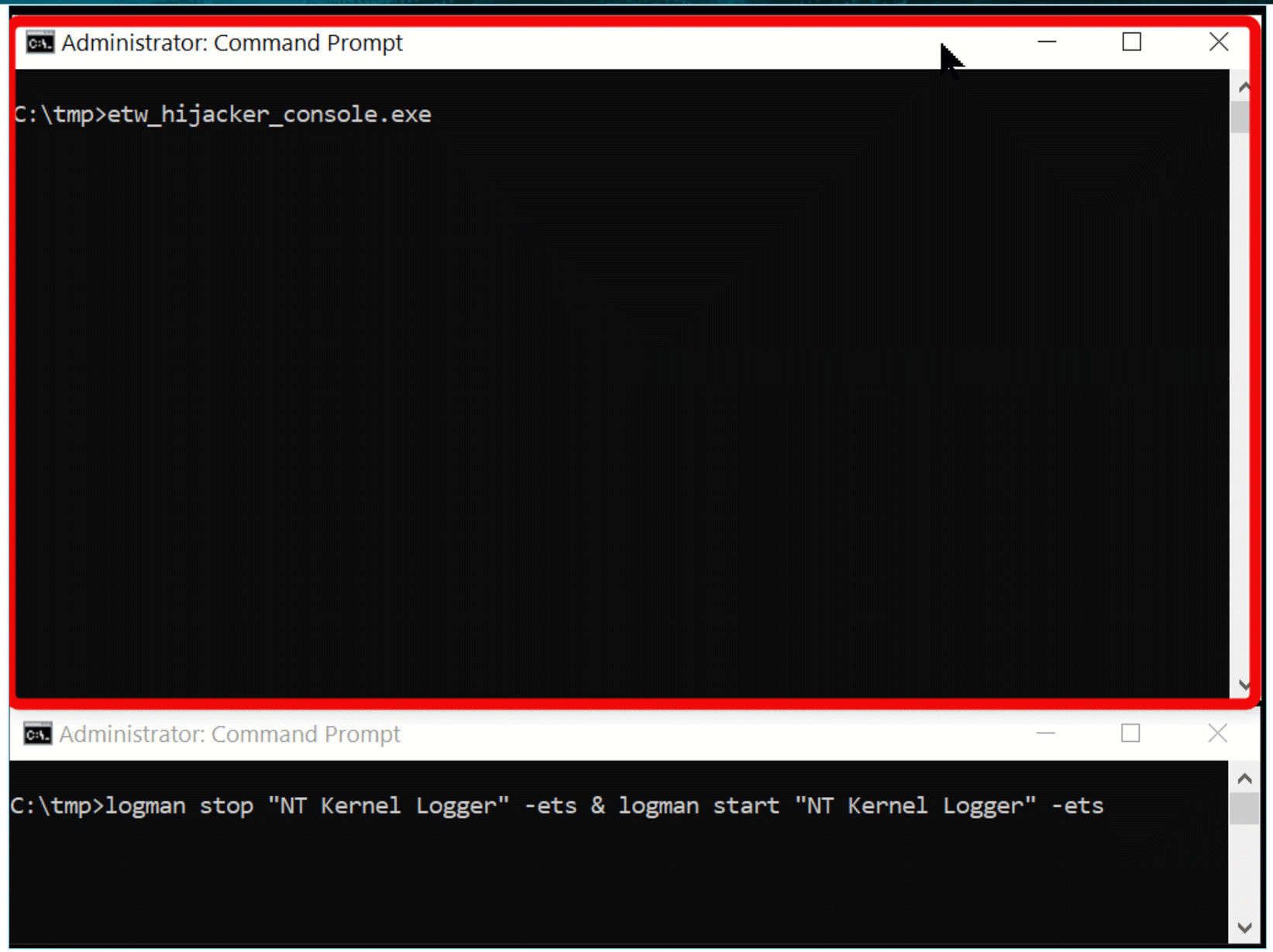


The online version is here – https://www.binarly.io/posts

ETW HIJACKER



Source code is here
github.com/binarly-io



ETWCHECK BY @REAL_REDP

It is a super advanced tool that can extract various kernel data:

- Basic information:
  - OS system details
  - Active Processes and Parent PID, List of loaded drivers
- Internal information:
  - Kernel Processor Control Block
  - Kernel ETW handles (EtwpNetProvRegHandle etc)
  - Etwp*NotifyRoutines (EtwpDiskIoNotifyRoutines etc)
  - WMI guidentries, regentries,
  - EtwSiloState, EtwpHostSiloState
  - The whole list of WMI_LOGGER_CONTEXT with their **SecurityDescriptors**, Flags and consumers PID.
- Checks the integrity of DRV_OBJs, Major_Function[] arrays for various drivers.

Download EtwCheck from here https://github.com/binarly-io

Output fragment with WMI_LOGGER_CONTEXTs

```
WMI_LOGGER_CONTEXTs at FFFF828D61D2A980 size 560 index 15
 ctx[2] at FFFF828D61DD9840 GetCpuClock 0000000000000000
   LoggerMode: 2800480
   Flags: 10023
   SecurityDescriptor: FFFFCB86458F9EE0
   SD: O:BAG:BAD:(A;;0x120fff;;;SY)(A;;0x120fff;;;BA)(A;;0x100f
   LoggerStatus 0 NumConsumers 0
   LoggerName: Circular Kernel Context Logger
 ctx[3] at FFFF828D61D3B040 GetCpuClock 0000000000000000
   LoggerMode: 188001C0
   Flags: F
   SecurityDescriptor: FFFFCB86459F6560
   SD: O:BAG:BAD:(A;;0x1800;;;WD)(A;;0x120fff;;;SY)(A;;0x120fff
   LoggerStatus 0 NumConsumers 1
   LoggerName: Eventlog-Security
   read 1 clients:
    [0] at FFFF828D675A6910 EPROCESS FFFF828D674DC080 PID 1300
 ctx[4] at FFFF828D61D2C040 GetCpuClock 0000000000000000
   LoggerMode: 18800180
   Flags: 400F
   SecurityDescriptor: FFFFCB86459E00A0
   SD: O:BAG:BAD:(A;;0x120fff;;;SY)(A;;WP;;;SY)
   LoggerStatus 0 NumConsumers 1
   LoggerName: DefenderApiLogger
   read 1 clients:
    [0] at FFFF828D67DF7E60 EPROCESS FFFF828D67987080 PID 2428
 ctx[5] at FFFF828D61D30040 GetCpuClock 0000000000000000
   LoggerMode: 188001C0
   Flags: 400F
   SecurityDescriptor: FFFFCB86459E00A0
   SD: O:BAG:BAD:(A;;0x120fff;;;SY)(A;;WP;;;SY)
   LoggerStatus 0 NumConsumers 1
   LoggerName: DefenderAuditLogger
   read 1 clients:
    [0] at FFFF828D67DF8080 EPROCESS FFFF828D67987080 PID 2428
```

Internals of a Secure ETW:

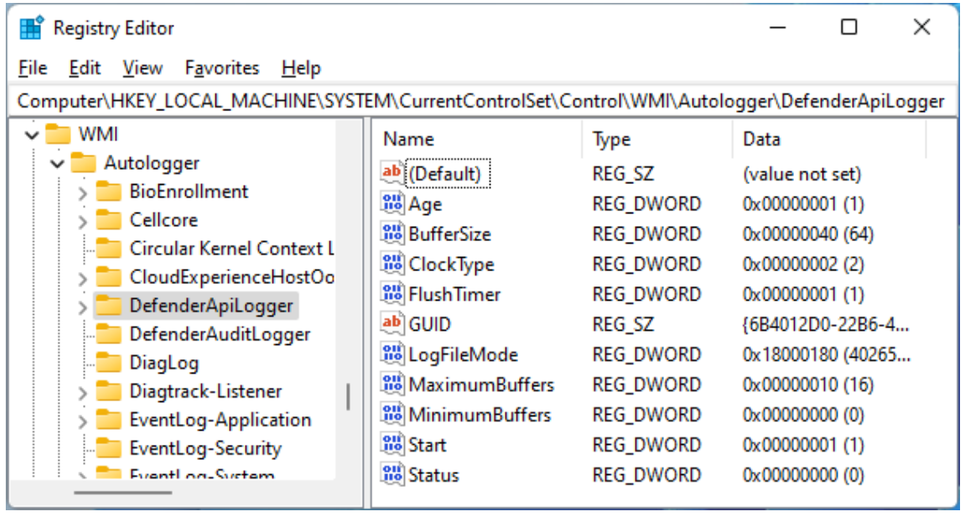
Query and Stop Defender's ETW Sessions

Windows Defender uses two ETW logger sessions

- List of Defenders ETW sessions:

LoggerId	LoggerName	InstanceGuid
4	DefenderApiLogger	{6B4012D0-22B6-464D-A553-20E9618403A**2**}
5	DefenderAuditLogger	{6B4012D0-22B6-464D-A553-20E9618403A**1**}

- Launched on Startup as a Autologger



HKLM\SYSTEM\CurrentControlSet\Control\WMI\Autologger\DefenderApiLogger

- Can be disabled by zeroing registry values:

```
reg add
"HKLM\System\CurrentControlSet\Control\
WMI\Autologger\DefenderApiLogger" /v
"Start" /t REG_DWORD /d "0" /f
```

Security descriptor for DefenderApiLogger

Computer\HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\WMI\Security

- Autologger
- GlobalLogger
- Security
- WorkplaceJoin
- WPN
- Enum
- Hardware Profiles
- Policies

Name	Type	Data
697d5a7e-2062-11d4-97eb-00c04f79c403	REG_BINARY	01 00 04 80 14 00 00 00 24 00 00 00 00 00 00 00 34 00 00 00 01 02 00 00 00 00 00 05 20 00 00 00 20 02 00 00 01
69aaa7c4-2062-11d4-97eb-00c04f79c403	REG_BINARY	01 00 04 80 14 00 00 00 24 00 00 00 00 00 00 00 34 00 00 00 01 02 00 00 00 00 00 05 20 00 00 00 20 02 00 00 01
6B4012D0-22B6-464D-A553-20E9618403A1	REG_BINARY	01 00 04 80 14 00 00 00 24 00 00 00 00 00 00 00 34 00 00 00 01 02 00 00 00 00 00 05 20 00 00 00 20 02 00 00 01
6B4012D0-22B6-464D-A553-20E9618403A2	REG_BINARY	01 00 04 80 14 00 00 00 24 00 00 00 00 00 00 00 34 00 00 00 01 02 00 00 00 00 00 05 20 00 00 00 20 02 00 00 01
6bba3851-2c7e-4dea-8f54-31e5afd029e3	REG_BINARY	01 00 04 80 14 00 00 00 24 00 00 00 00 00 00 00 34 00 00 00 01 02 00 00 00 00 00 05 20 00 00 00 20 02 00 00 01
6c744b0e-ee9c-4205-90a2-015f6d65f403	REG_BINARY	01 00 04 80 14 00 00 00 24 00 00 00 00 00 00 00 34 00 00 00 01 02 00 00 00 00 00 05 20 00 00 00 20 02 00 00 01

Edit Binary Value

Value name:
6B4012D0-22B6-464D-A553-20E9618403A2

Value data:

```
00000000  01 00 04 80 14 00 00 00   ........
00000008  24 00 00 00 00 00 00 00   $.......
00000010  34 00 00 00 01 02 00 00   4.......
00000018  00 00 00 05 20 00 00 00   .... ...
00000020  20 02 00 00 01 02 00 00    .......
00000028  00 00 00 05 20 00 00 00   .... ...
00000030  20 02 00 00 02 00 30 00    .....0.
00000038  02 00 00 00 00 00 14 00   ........
00000040  FF 0F 12 00 01 01 00 00   ÿ.......
00000048  00 00 00 05 12 00 00 00   ........
00000050  00 00 14 00 20 00 00 00   .... ...
00000058  01 01 00 00 00 00 00 05   ........
```

OK Cancel

Security Descriptor in Registry

Memory

Virtual: 0xffffe780791d17 Previous Display format: Byte Next

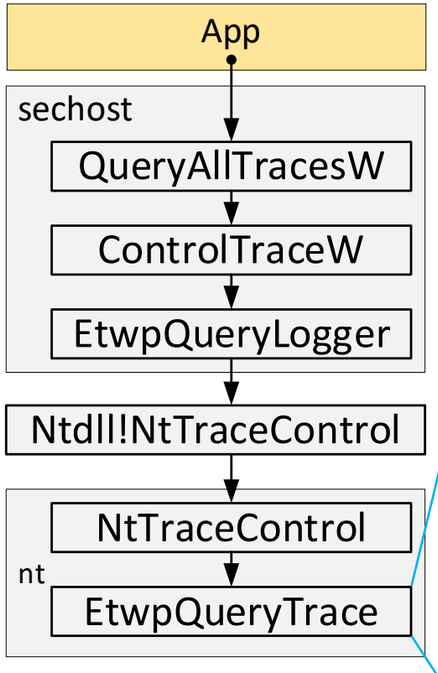
```
ffffe780`791d17a0 01 00 04 80 14 00 00 00   ........
ffffe780`791d17a8 24 00 00 00 00 00 00 00   $.......
ffffe780`791d17b0 34 00 00 00 01 02 00 00   4.......
ffffe780`791d17b8 00 00 00 05 20 00 00 00   .... ...
ffffe780`791d17c0 20 02 00 00 01 02 00 00    .......
ffffe780`791d17c8 00 00 00 05 20 00 00 00   .... ...
ffffe780`791d17d0 20 02 00 00 02 00 30 00    .....0.
ffffe780`791d17d8 02 00 00 00 00 00 14 00   ........
ffffe780`791d17e0 ff 0f 12 00 01 01 00 00   ........
ffffe780`791d17e8 00 00 00 05 12 00 00 00   ........
ffffe780`791d17f0 00 00 14 00 20 00 00 00   .... ...
ffffe780`791d17f8 01 01 00 00 00 00 00 05   ........
```

The corresponding Security Descriptor in kernel memory (WMI_LOGGER_CONTEXT.SecurityDescriptor.Object)

Query Secure ETW Sessions

Analysis of QueryAllTracesW() to get info about Defenders sessions

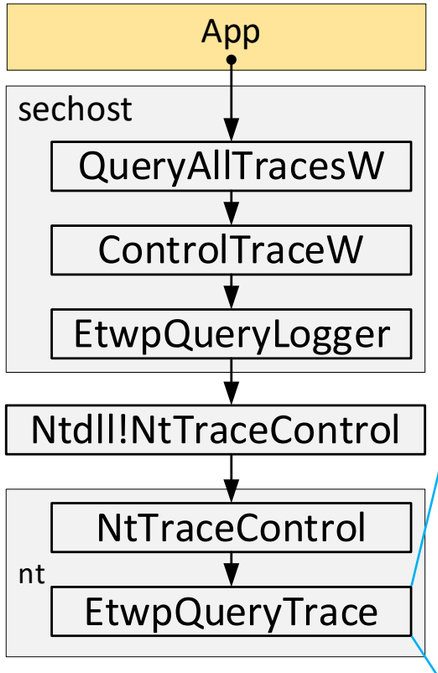
- Why apps even with admin privileges cannot get info about Defenders Sessions?




```
NTSTATUS EtwpQueryTrace(OUTPUT * outputInfo)
{
  WMI_LOGGER_CONTEXT * pcontext = 0;
  result = EtwpValidateLoggerInfo(..);
  if ( result < 0 ) {   goto EXIT;   }
  result = EtwpAcquireLoggerContext(&pcontext);
  if ( result < 0 ) {   goto EXIT;   }
  result = EtwpCheckLoggerControlAccess(DesiredAccess, pcontext);
  if ( result >= 0 )
  {
    if (pcontext->flags.SecurityTrace)
    {
        result = EtwCheckSecurityLoggerAccess(Process);
        if ( result < 0 ) {   goto EXIT;   }
    }
    result = EtwpGetLoggerInfoFromContext(outputInfo, pcontext);
  }
EXIT:
    EtwpReleaseLoggerContext(pcontext);
  return result;
}
```

Analysis of QueryAllTracesW() to get info about Defenders sessions

- Why apps even with admin privileges cannot get info about Defenders Sessions?




```
NTSTATUS EtwpQueryTrace(OUTPUT * outputInfo)
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  result = EtwpValidateLoggerInfo(..);
  if ( result < 0 ) {   goto EXIT;   }
  result = EtwpAcquireLoggerContext(&pcontext);
  if ( result < 0 ) {   goto EXIT;   }
  result = EtwpCheckLoggerControlAccess(DesiredAccess, pcontext);
  if ( result >= 0 )
  {
    if (pcontext->flags.SecurityTrace)
    {
        result = EtwCheckSecurityLoggerAccess(Process);
        if ( result <
    }
    result = EtwpGetLogger
  }
EXIT:
    EtwpReleaseLoggerContext(pcontext);
  return result;
}
```
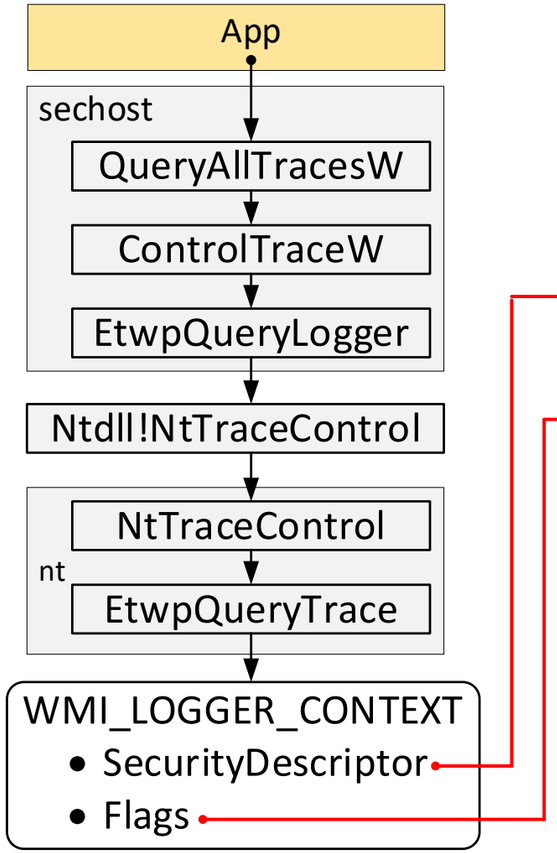

EtwpAccessCheck() → SeAccessCheck()

For sessions with **enabled SecurityTrace** we have an additional security check RtlTestProtectedAccess()

Analysis of QueryAllTracesW() to get info about Defenders sessions

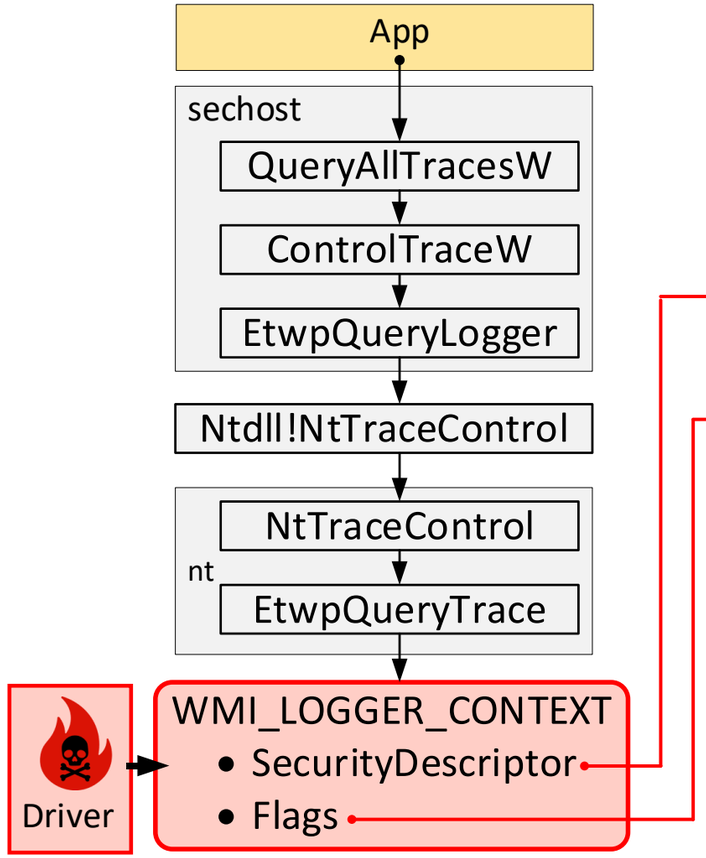
- Why apps even with admin privileges cannot get info about Defenders Sessions?




```
1  NTSTATUS EtwpQueryTrace(OUTPUT * outputInfo)
2  {
3    WMI_LOGGER_CONTEXT * pcontext = 0;
4    result = EtwpValidateLoggerInfo(..);
5    if ( result < 0 ) {   goto EXIT;   }
6    result = EtwpAcquireLoggerContext(&pcontext);
7    if ( result < 0 ) {   goto EXIT;   }
8    result = EtwpCheckLoggerControlAccess(DesiredAccess, pcontext);
9    if ( result >= 0 )
10   {
11     if (pcontext->flags.SecurityTrace)
12     {
13       result = EtwCheckSecurityLoggerAccess(Process);
14       if ( result < 0 ) {   goto EXIT;   }
15     }
16     result = EtwpGetLoggerInfoFromContext(outputInfo, pcontext);
17   }
18 EXIT:
19     EtwpReleaseLoggerContext(pcontext);
20   return result;
21 }
```

Analysis of QueryAllTracesW() to get info about Defenders sessions

- Why apps even with admin privileges cannot get info about Defenders Sessions?




```
1  NTSTATUS EtwpQueryTrace(OUTPUT * outputInfo)
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5    if ( result < 0 ) {   goto EXIT;   }
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7    if ( result < 0 ) {   goto EXIT;   }
8    result = EtwpCheckLoggerControlAccess(DesiredAccess, pcontext);
9    if ( result >= 0 )
10   {
11     if (pcontext->flags.SecurityTrace)
12     {
13       result = EtwCheckSecurityLoggerAccess(Process);
14       if ( result < 0 ) {   goto EXIT;   }
15     }
16     result = EtwpGetLoggerInfoFromContext(outputInfo, pcontext);
17   }
18 EXIT:
19     EtwpReleaseLoggerContext(pcontext);
20   return result;
21 }
```
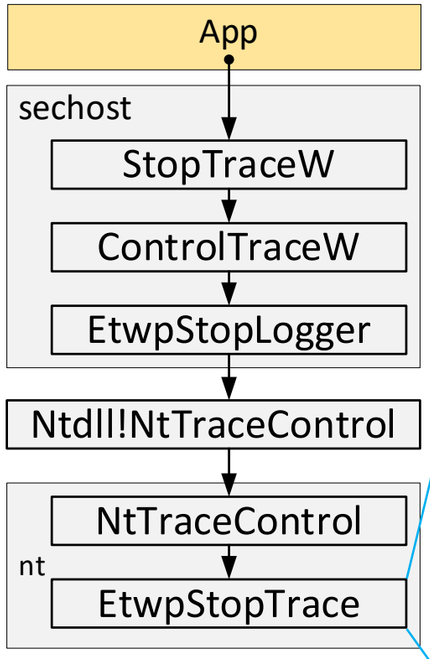

Stop Secure ETW Sessions

Analysis of StopTraceW() to stop Defenders sessions

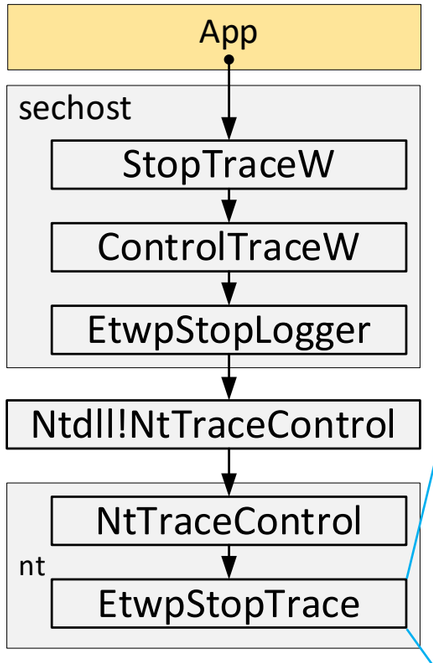
- Why apps even with admin privileges cannot stop Defenders Sessions?




```
NTSTATUS EtwpStopTrace(..)
{
  WMI_LOGGER_CONTEXT * pcontext = 0;
  result = EtwpValidateLoggerInfo(..);
  if ( result < 0 ) {   goto EXIT;   }
  result = EtwpAcquireLoggerContext(&pcontext);
  if ( result < 0 ) {   goto EXIT;   }
  if ((pcontext->LoggerMode & ETW_NONSTOPPABLE_MODE) != 0)
  {
    result = EtwpCheckLoggerControlAccess(DesiredAccess, pcontext);
    if ( result >= 0 )
    {
      result = EtwpStopLoggerInstance(..);
    }
  }
EXIT:
    EtwpReleaseLoggerContext(pcontext);
  return result;
}
```

Analysis of StopTraceW() to stop Defenders sessions

- Why apps even with admin privileges cannot stop Defenders Sessions?



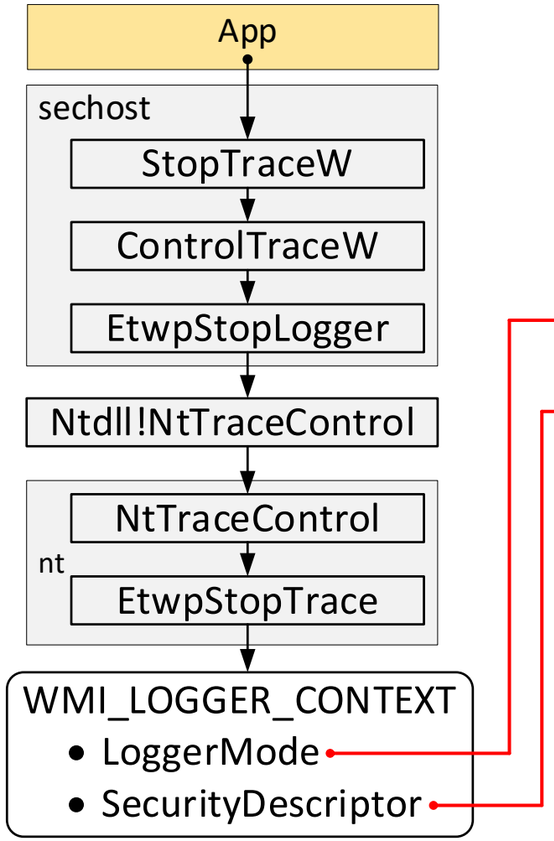

```
NTSTATUS EtwpStopTrace(..)
{
  WMI_LOGGER_CONTEXT * pcontext = 0;
  result = EtwpValidateLoggerInfo(..);
  if ( result < 0 ) {   goto EXIT;   }
  result = EtwpAcquireL
  if ( result < 0 ) {
  if ((pcontext->LoggerMode & ETW_NONSTOPPABLE_MODE) != 0)
  {
    result = EtwpCheckLoggerControlAccess(DesiredAccess, pcontext);
    if ( result >= 0 )
    {
      result = EtwpStopLoggerInstance(..);
    }
  }
EXIT:
    EtwpReleaseLoggerContext(pcontext);
  return result;
}
```

Only "stoppable" sessions can be stopped

EtwpAccessCheck() → SeAccessCheck()

Analysis of StopTraceW() to stop Defenders sessions

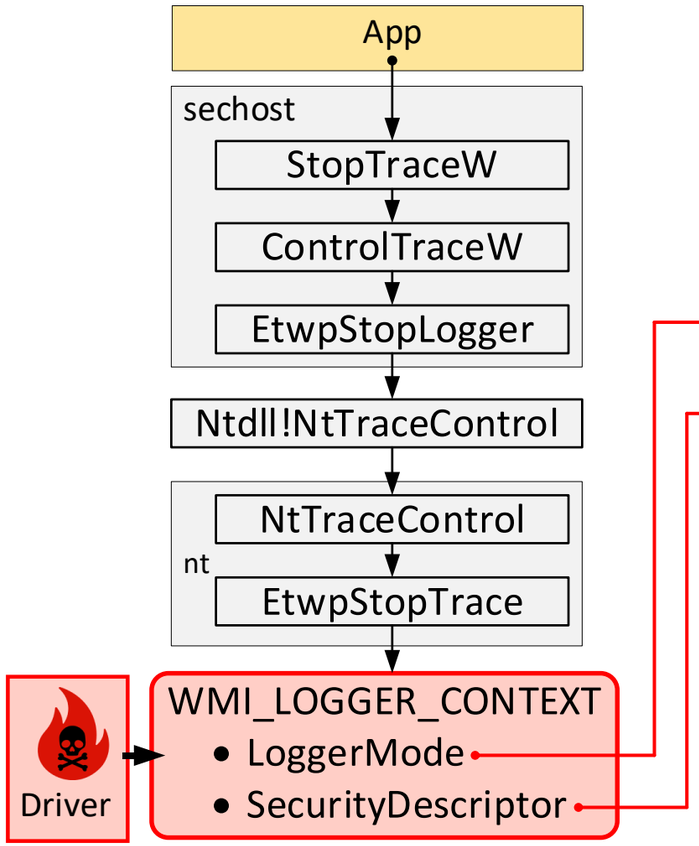
- Why apps even with admin privileges cannot stop Defenders Sessions?




```
1  NTSTATUS EtwpStopTrace(..)
2  {
3    WMI_LOGGER_CONTEXT * pcontext = 0;
4    result = EtwpValidateLoggerInfo(..);
5    if ( result < 0 ) {   goto EXIT;   }
6    result = EtwpAcquireLoggerContext(&pcontext);
7    if ( result < 0 ) {   goto EXIT;   }
8    if ((pcontext->LoggerMode & ETW_NONSTOPPABLE_MODE) != 0)
9    {
10     result = EtwpCheckLoggerControlAccess(DesiredAccess, pcontext);
11     if ( result >= 0 )
12     {
13       result = EtwpStopLoggerInstance(..);
14     }
15   }
16 EXIT:
17     EtwpReleaseLoggerContext(pcontext);
18   return result;
19 }
```

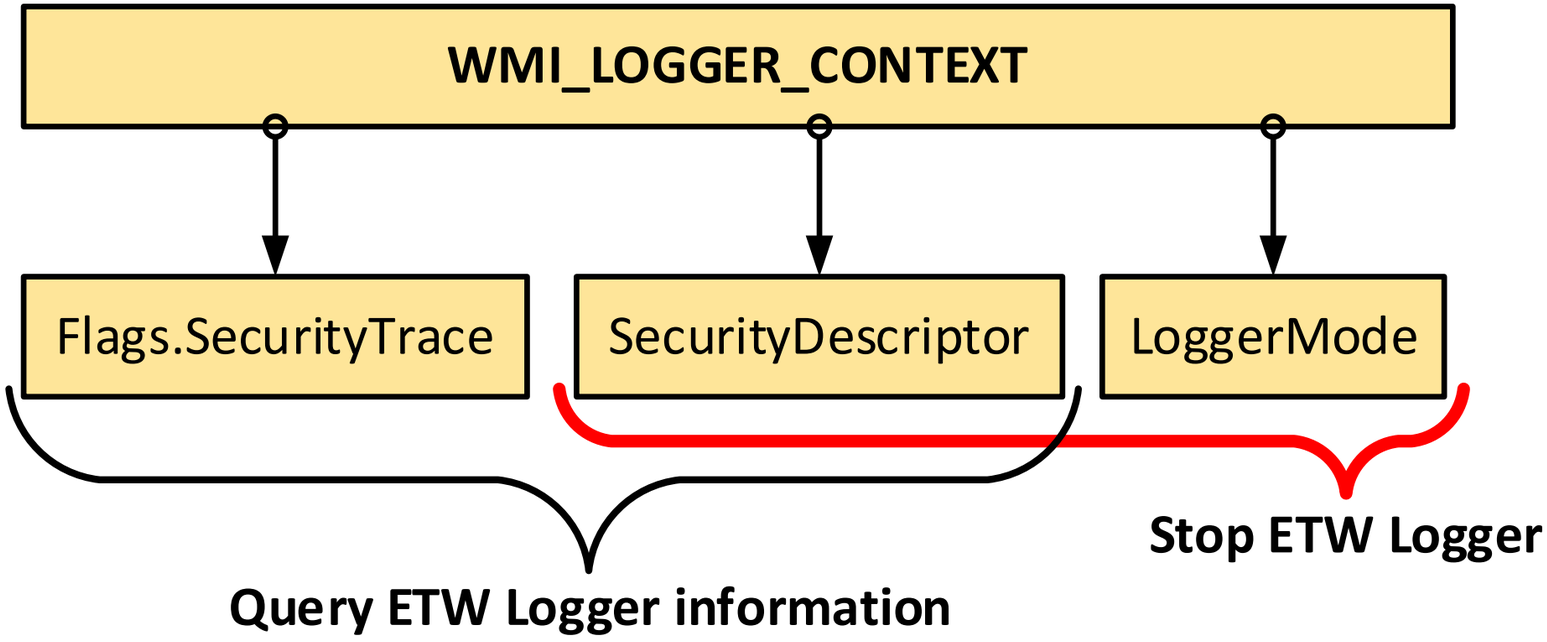
Analysis of StopTraceW() to stop Defenders sessions

- Why apps even with admin privileges cannot stop Defenders Sessions?

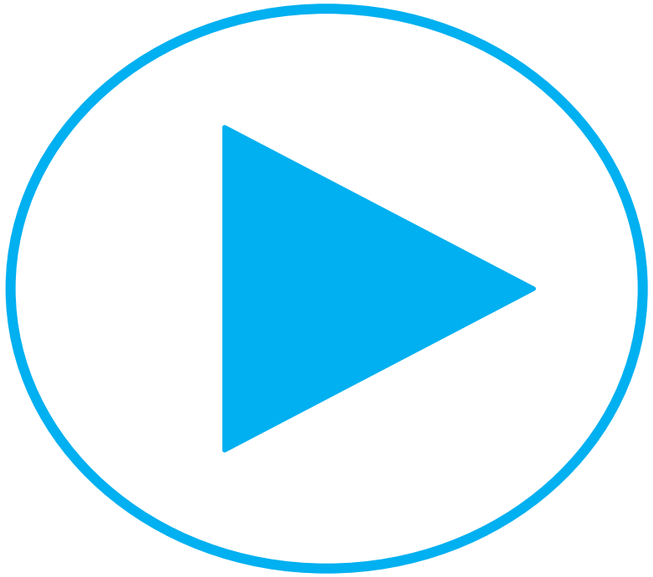



```
1  NTSTATUS EtwpStopTrace(..)
2  {
3    WMI_LOGGER_CONTEXT * pcontext = 0;
4    result = EtwpValidateLoggerInfo(..);
5    if ( result < 0 ) {   goto EXIT;   }
6    result = EtwpAcquireLoggerContext(&pcontext);
7    if ( result < 0 ) {   goto EXIT;   }
8    if ((pcontext->LoggerMode & ETW_NONSTOPPABLE_MODE) != 0)
9    {
10     result = EtwpCheckLoggerControlAccess(DesiredAccess, pcontext);
11     if ( result >= 0 )
12     {
13       result = EtwpStopLoggerInstance(..);
14     }
15   }
16 EXIT:
17     EtwpReleaseLoggerContext(pcontext);
18   return result;
19 }
```

Summary of the Attack



Query Info and Stop DefenderApiLogger



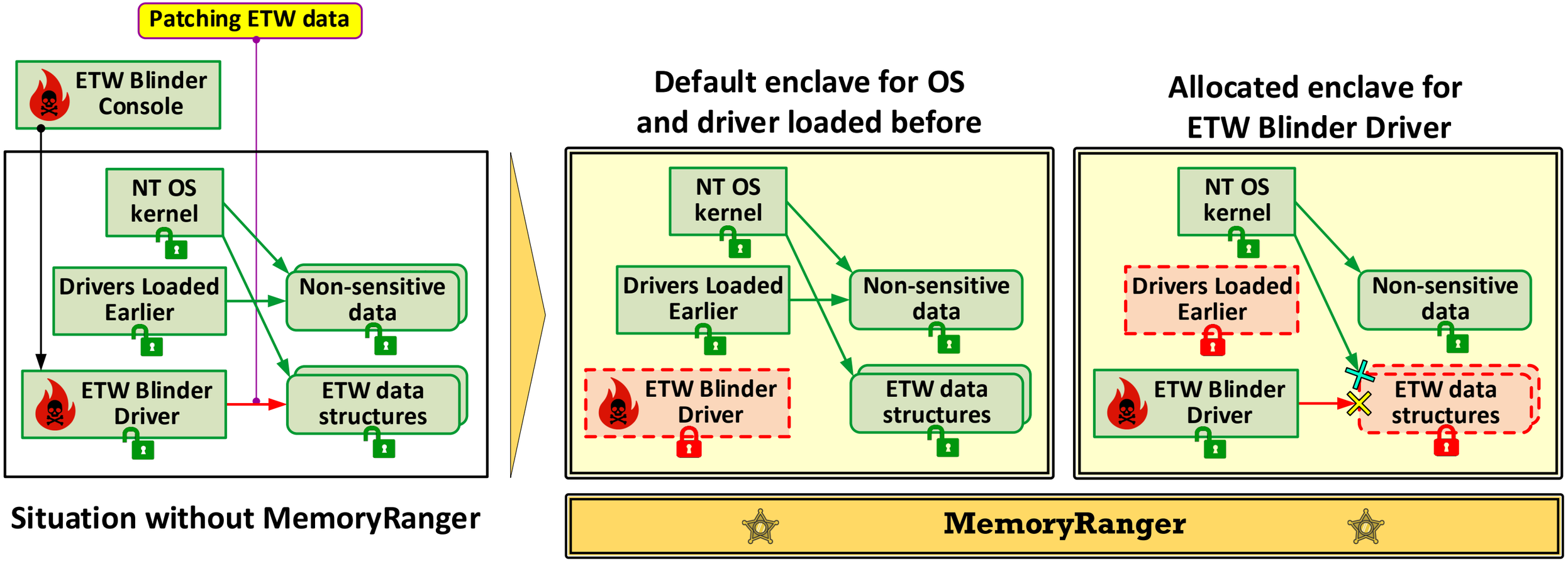
The online version is here – https://www.binarly.io/posts

PatchGuard does not protect ETW

- Kernel Patch Protection (KPP, PatchGuard) is a Windows built-in security feature designed to provide integrity of critical kernel data:
  - EPROCESS,
  - DRV_OBJ
  - etc

- Unfortunately, ETW data structures are NOT protected

MemoryRanger can prevent patching ETW session structures



Situation without MemoryRanger

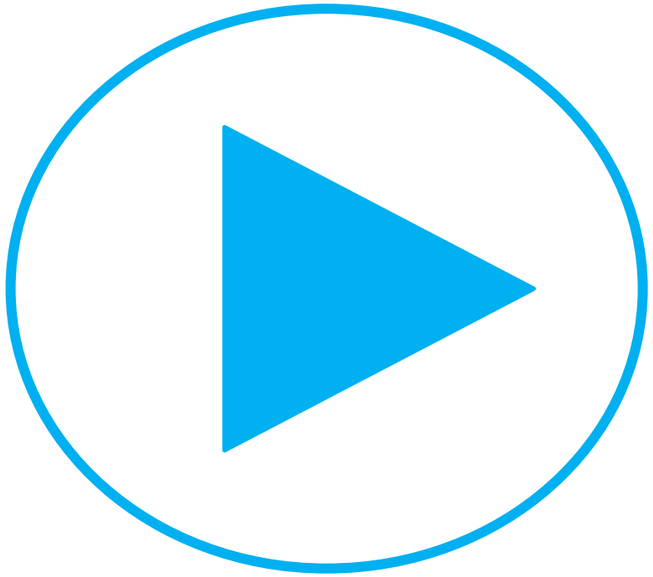
– MemoryRanger traps illegal access to the sensitive data and redirects it to the fake memory page

– MemoryRanger switches between enclaves to allow authorized access

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

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

MemoryRanger prevents patching ETW structures



The online version is here – https://www.binarly.io/posts

Conclusion

- ETW was created for performance monitoring and telemetry.
- ETW is widely used by various EDRs and cybersecurity solutions.
- ETW architecture weaknesses allow bypassing ETW via various attack vectors.

- EtwCheck provides trustworthy runtime checking to detect ETW attacks.
- MemoryRanger can prevent patching ETW data in kernel memory.

- Conclusion to conclusion: attack vectors on ETW originating in the **firmware**

Thank you

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github.com/binarly-io