Event Tracing for Windows Internals

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Motivation

Question

Can we use **Event Log** to detect all attacks?

Motivation

Question

Can we use **Event Log** to detect all attacks?

Answer

NO!

Motivation

Question

Can we use **Event Log** to detect all attacks?

Answer

NO!

We are looking for more **effective solutions.**

Motivation

Is there any log more detailed than Event Log on Windows OS?

↓

Event Tracing for Windows

Goal of This Presentation

Understand the internals of the Event Tracing for Windows (ETW) to take your incident response to the next level.

Presentation Topics

1. What is ETW?
2. ETW Internals
3. ETW using Incident Response
4. Attack Surface
5. Mitigation and Detection

1 What is ETW?

2 ETW Internals

3 ETW using Incident Response

4 Attack Surface

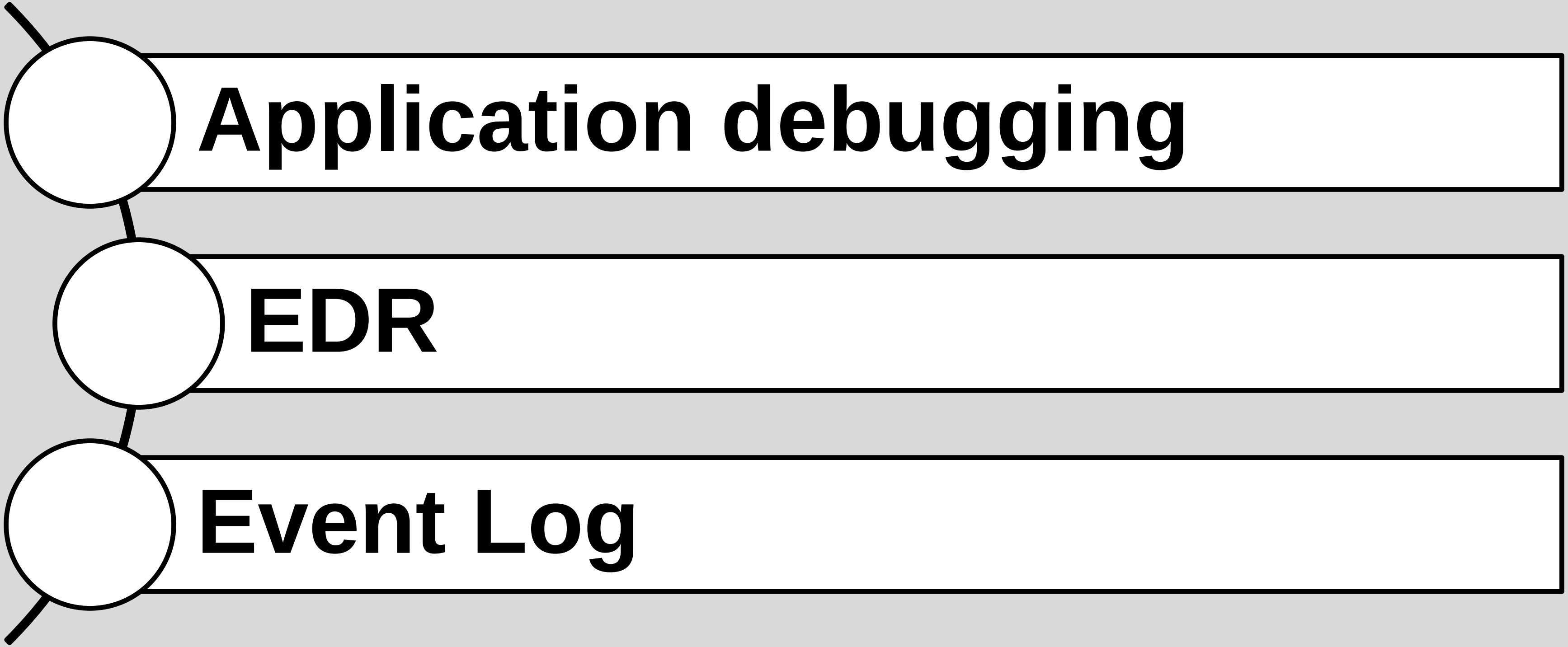
5 Mitigation and Detection

What is Event Tracing for Windows

Event Tracing for Windows is an efficient kernel-level tracing facility that lets you log kernel or application-defined events to a log file. You can consume the events in real time or from a log file and use them to debug an application or to determine where performance issues are occurring in the application.

What is Event Tracing for Windows

Uses of ETW



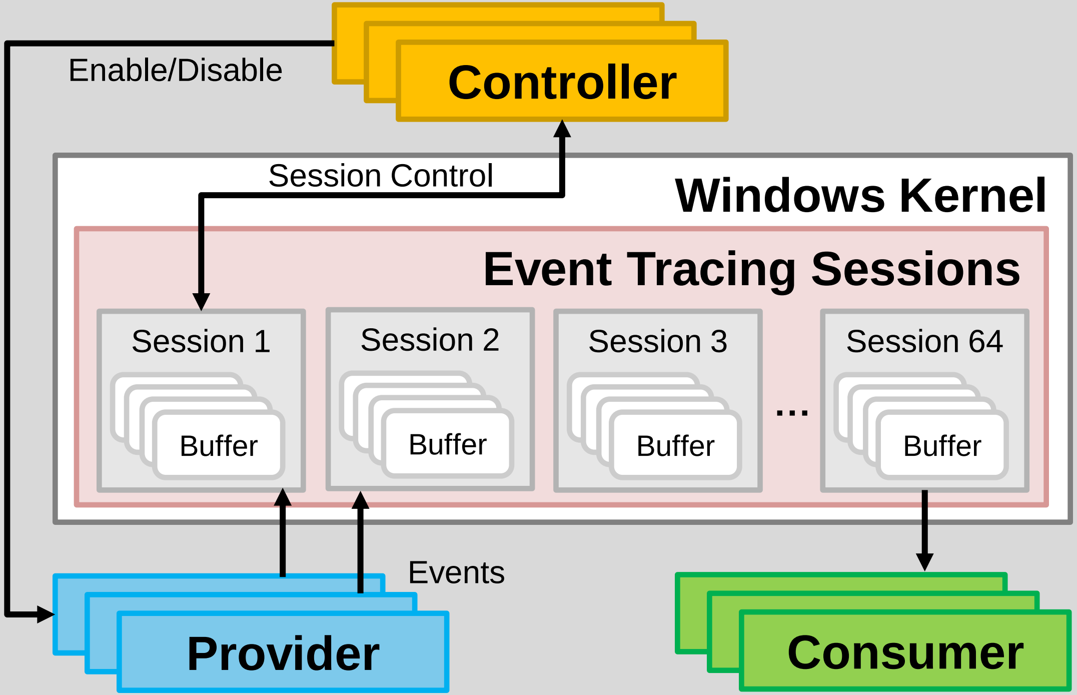
Application debugging

EDR

Event Log

What is Event Tracing for Windows

ETW has three functions

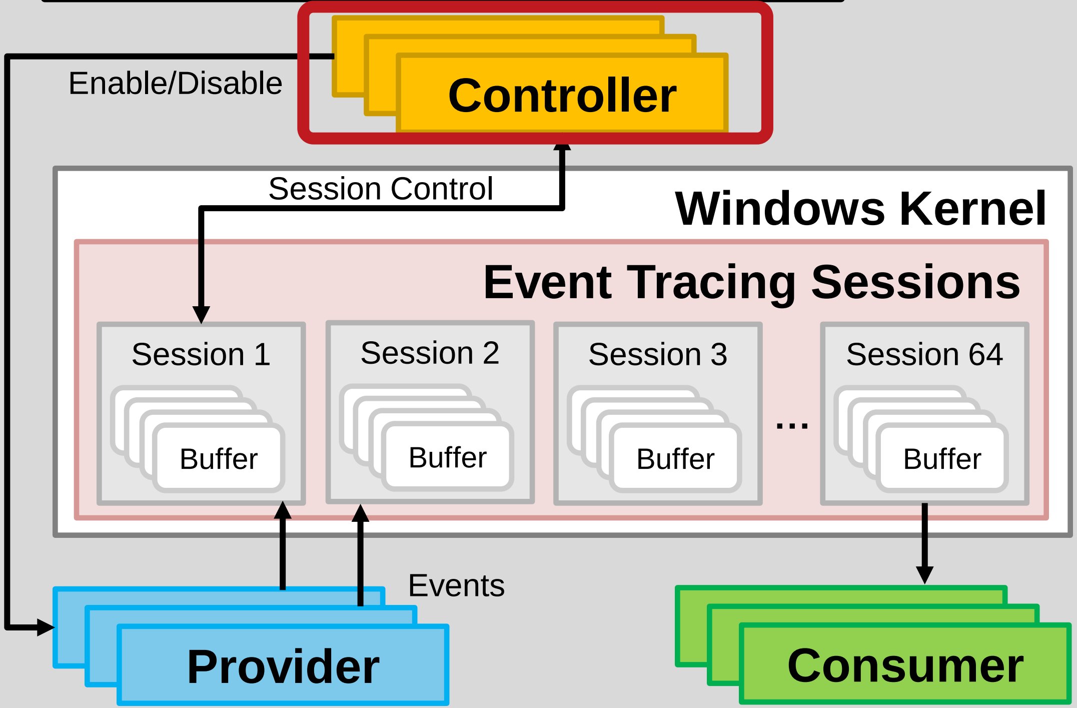


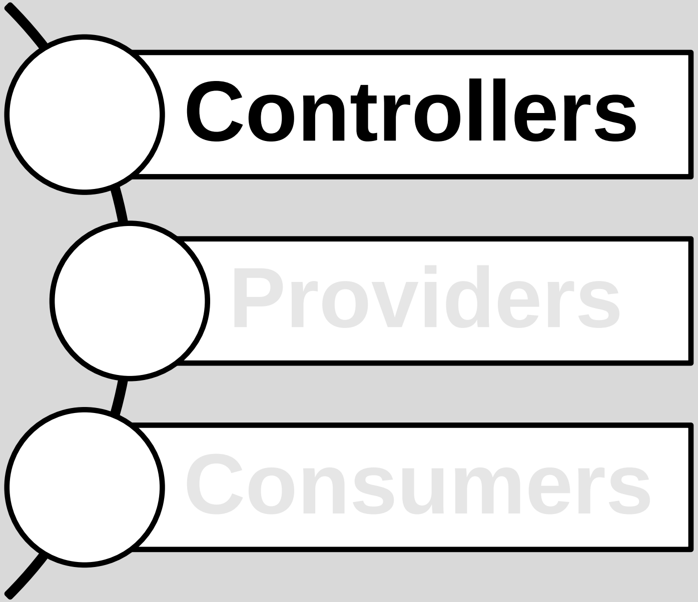
- Controllers
- Providers
- Consumers

https://learn.microsoft.com/ja-jp/windows/win32/etw/about-event-tracing

What is Event Tracing for Windows

ETW has three functions





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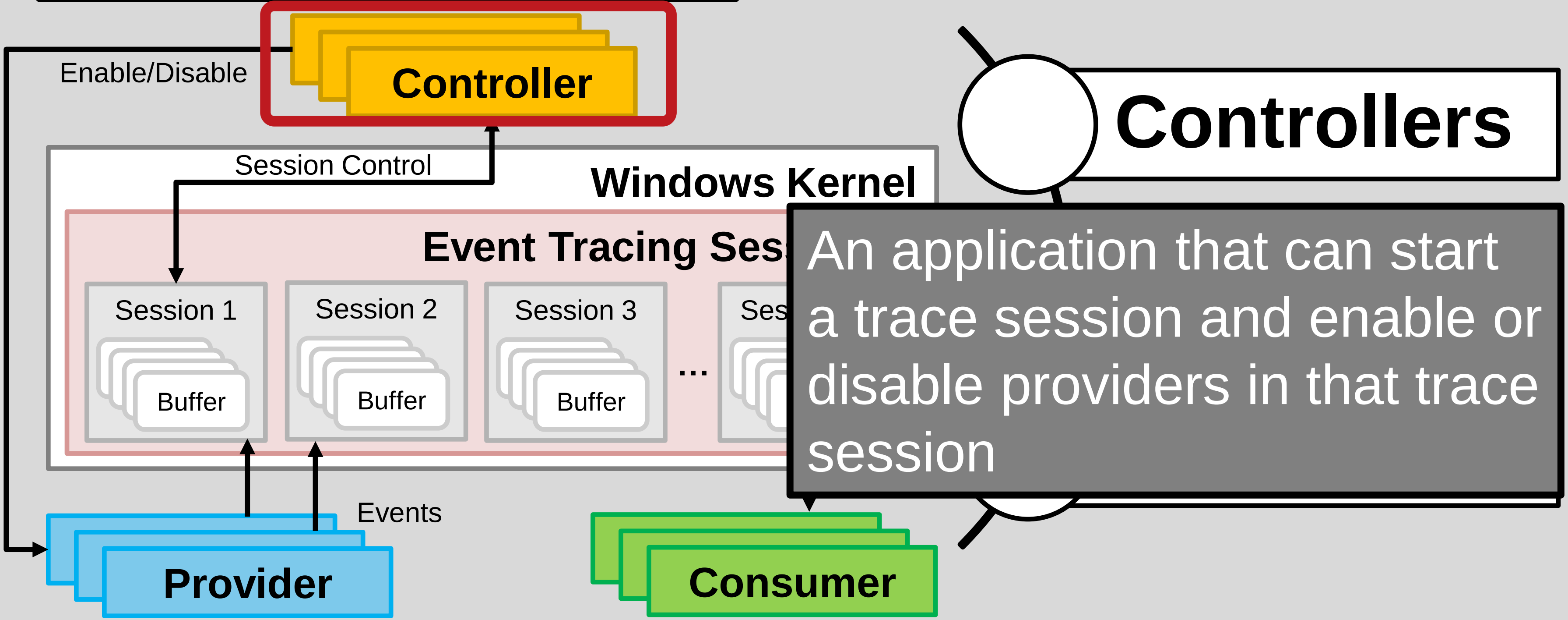
What is Event Tracing for Windows

ETW has three functions

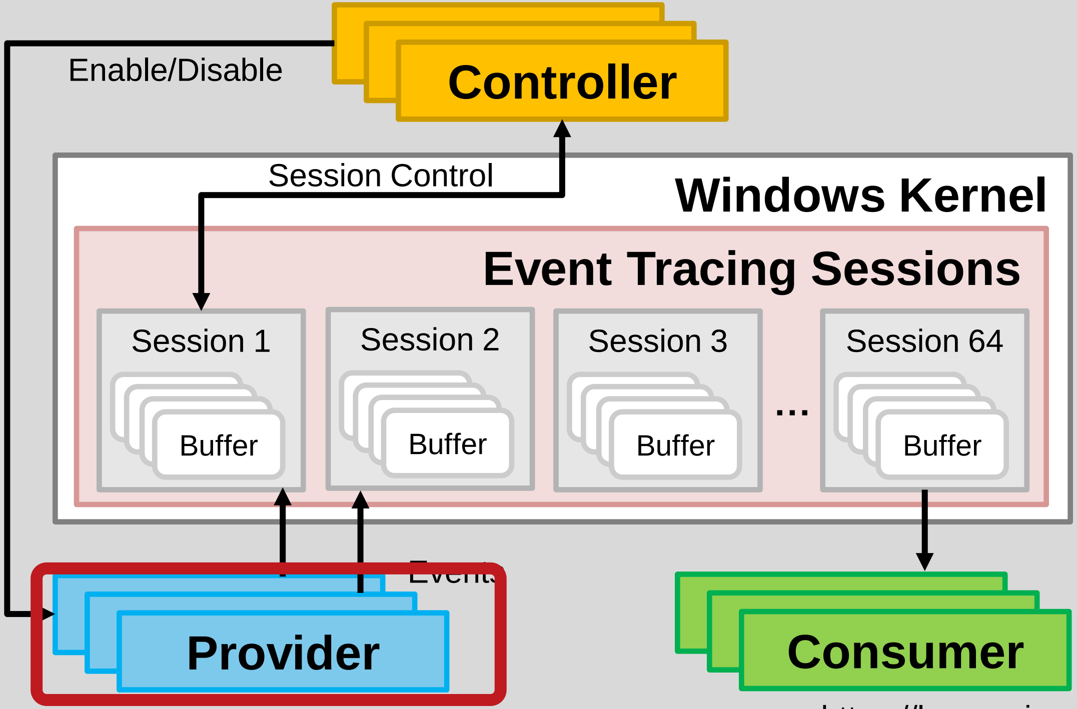


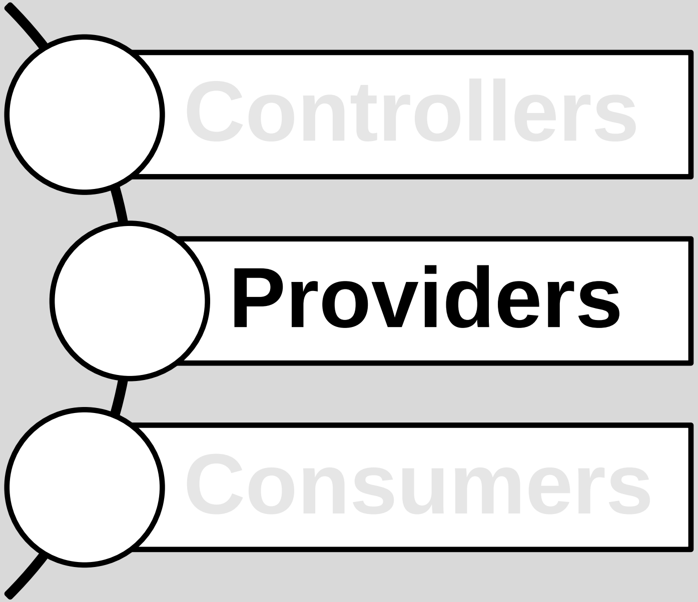
An application that can start a trace session and enable or disable providers in that trace session

https://learn.microsoft.com/ja-jp/windows/win32/etw/about-event-tracing

What is Event Tracing for Windows

ETW has three functions





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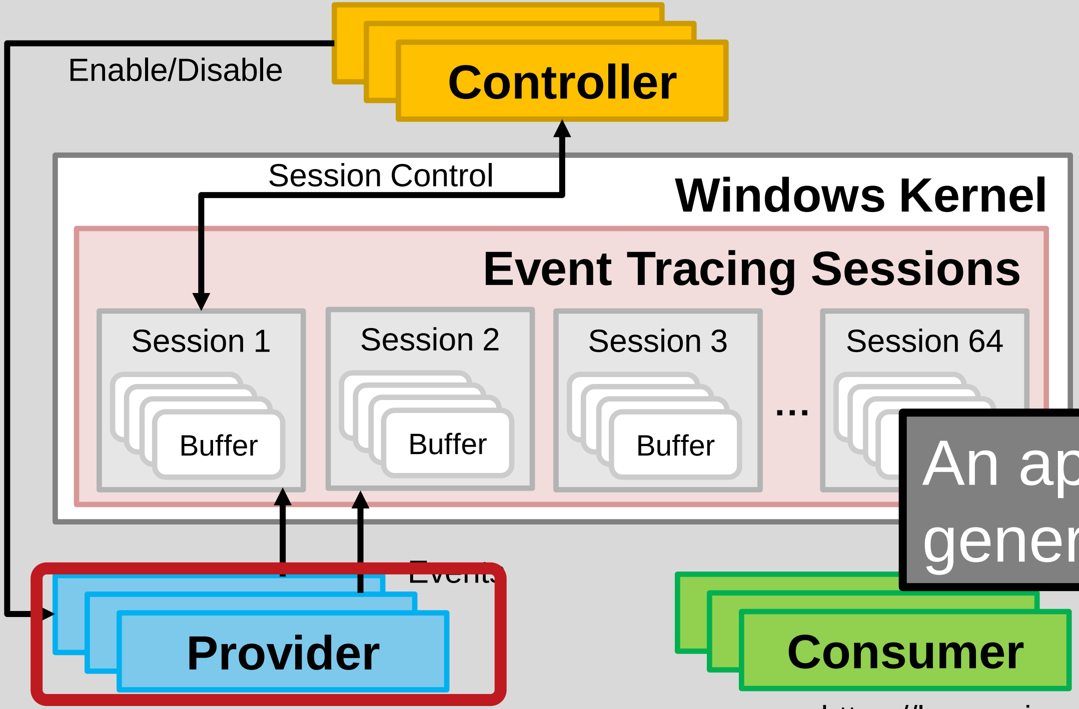
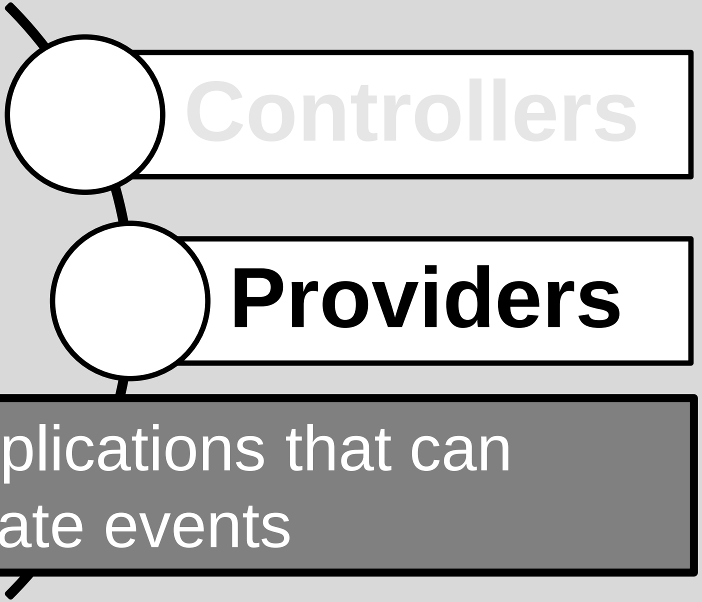
What is Event Tracing for Windows

ETW has three functions



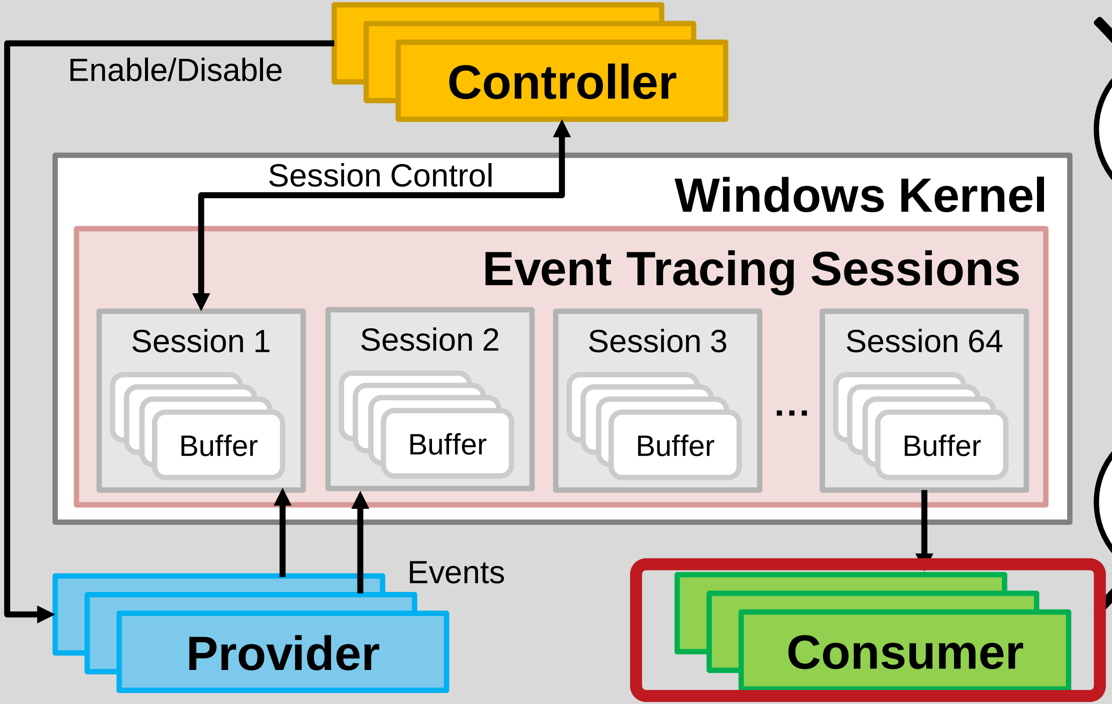


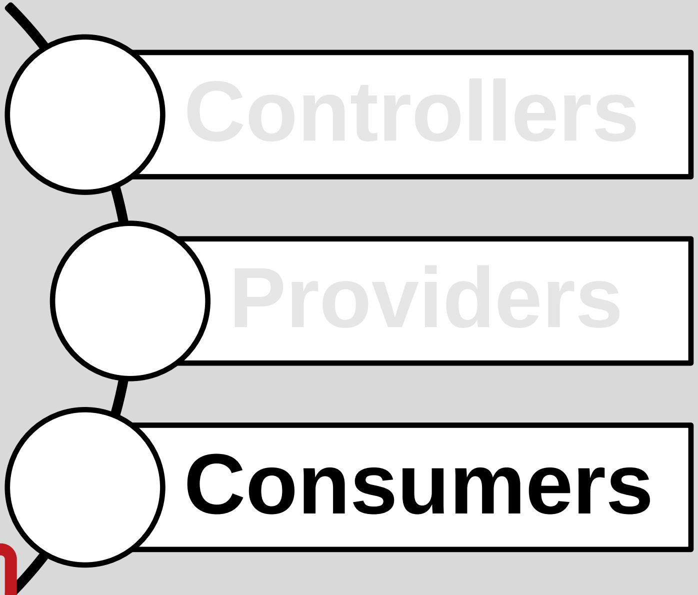
An applications that can generate events

https://learn.microsoft.com/ja-jp/windows/win32/etw/about-event-tracing

What is Event Tracing for Windows

ETW has three functions





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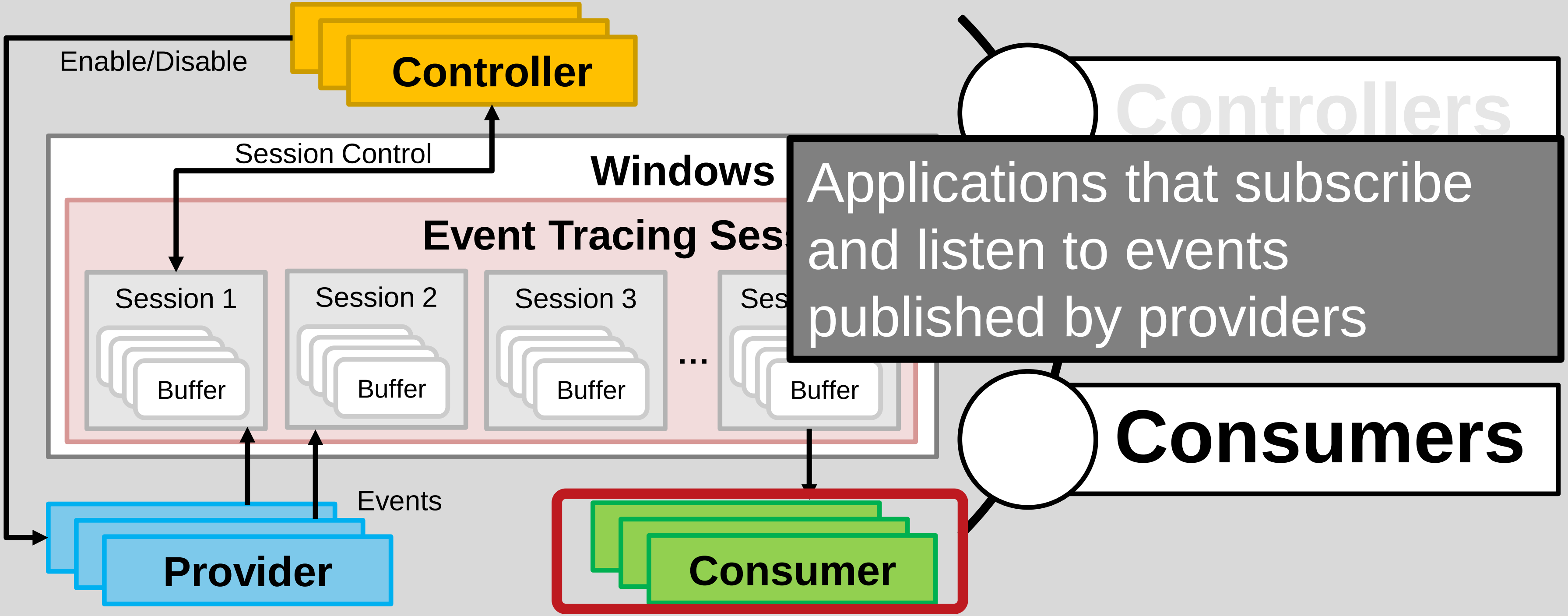
What is Event Tracing for Windows

ETW has three functions

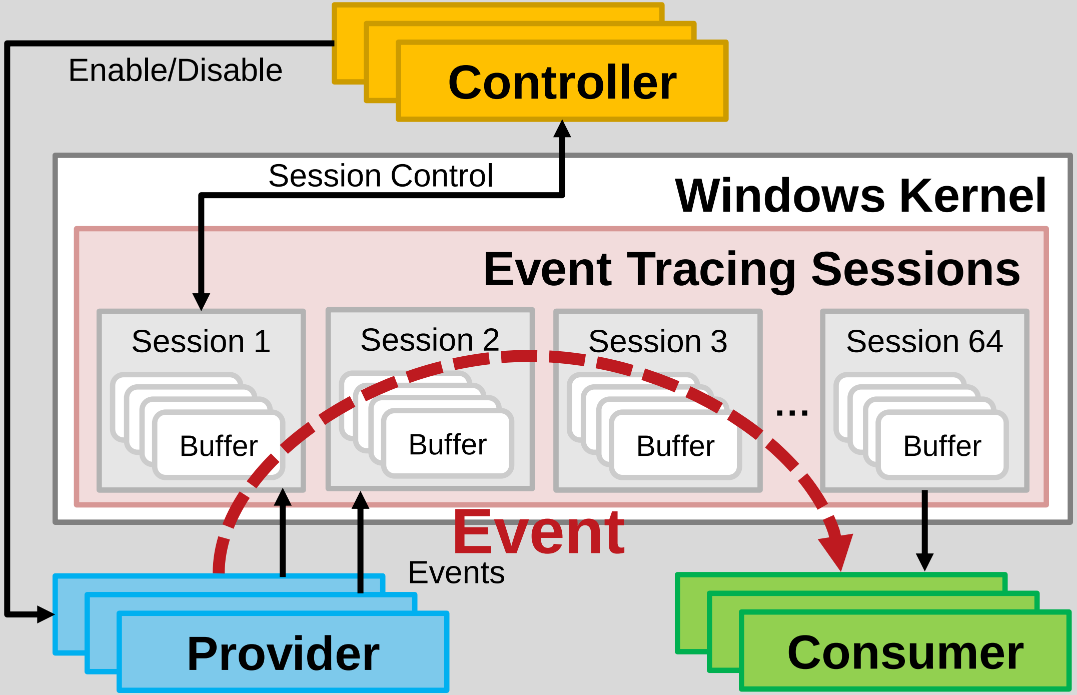


Applications that subscribe and listen to events published by providers

https://learn.microsoft.com/ja-jp/windows/win32/etw/about-event-tracing

What is Event Tracing for Windows

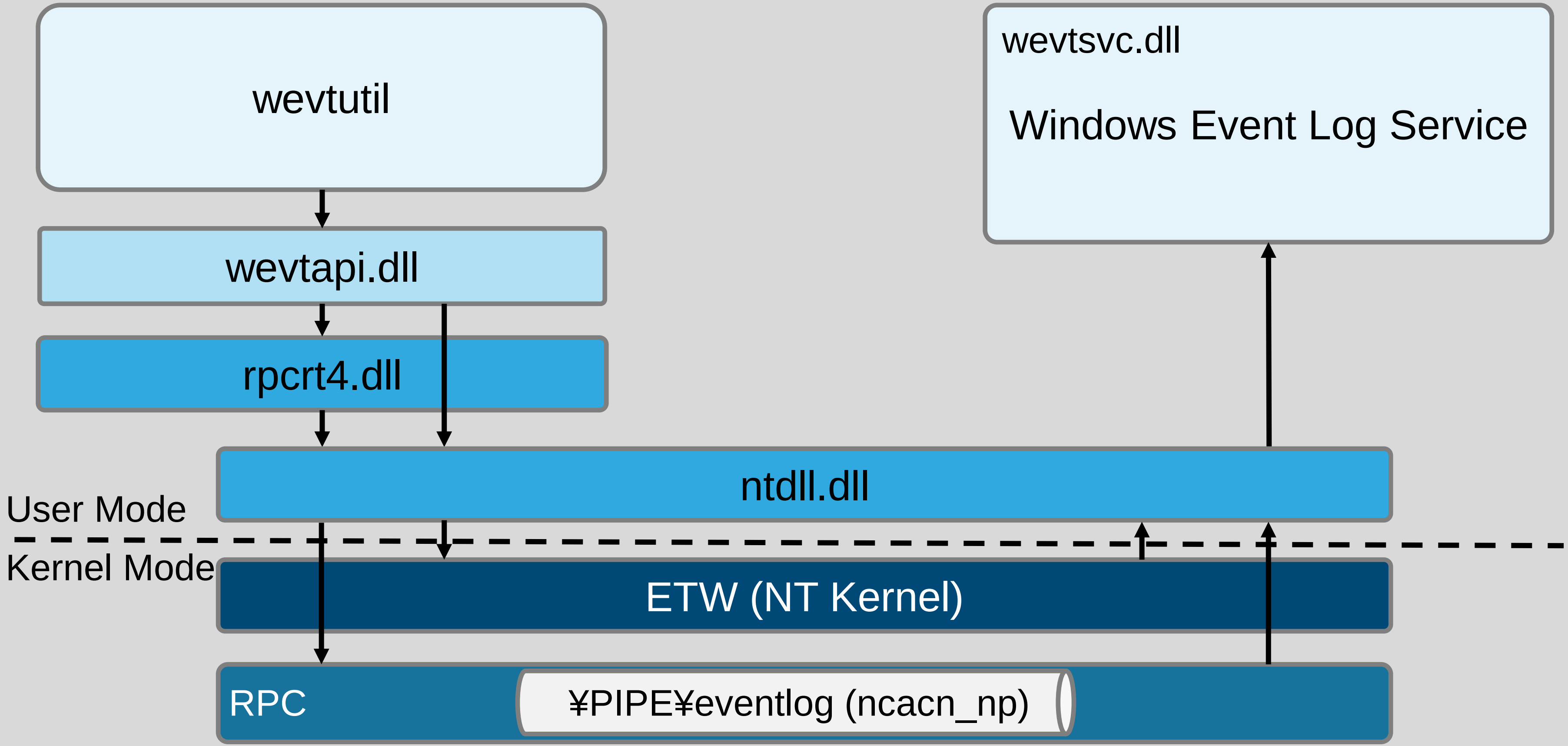
ETW has three functions



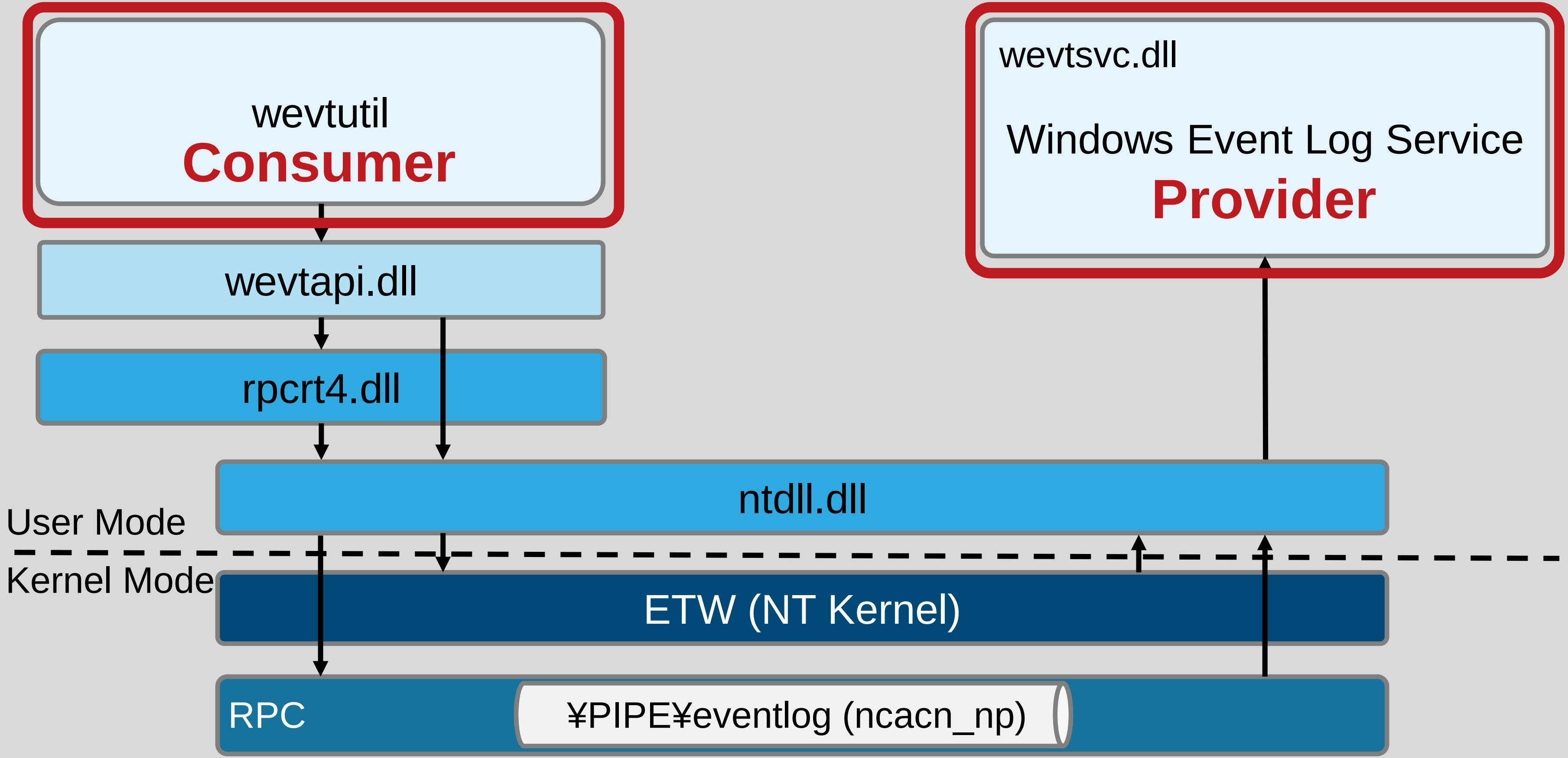
- Controllers
- Providers
- Consumers

https://learn.microsoft.com/ja-jp/windows/win32/etw/about-event-tracing

Windows Event Log Control Flow using ETW

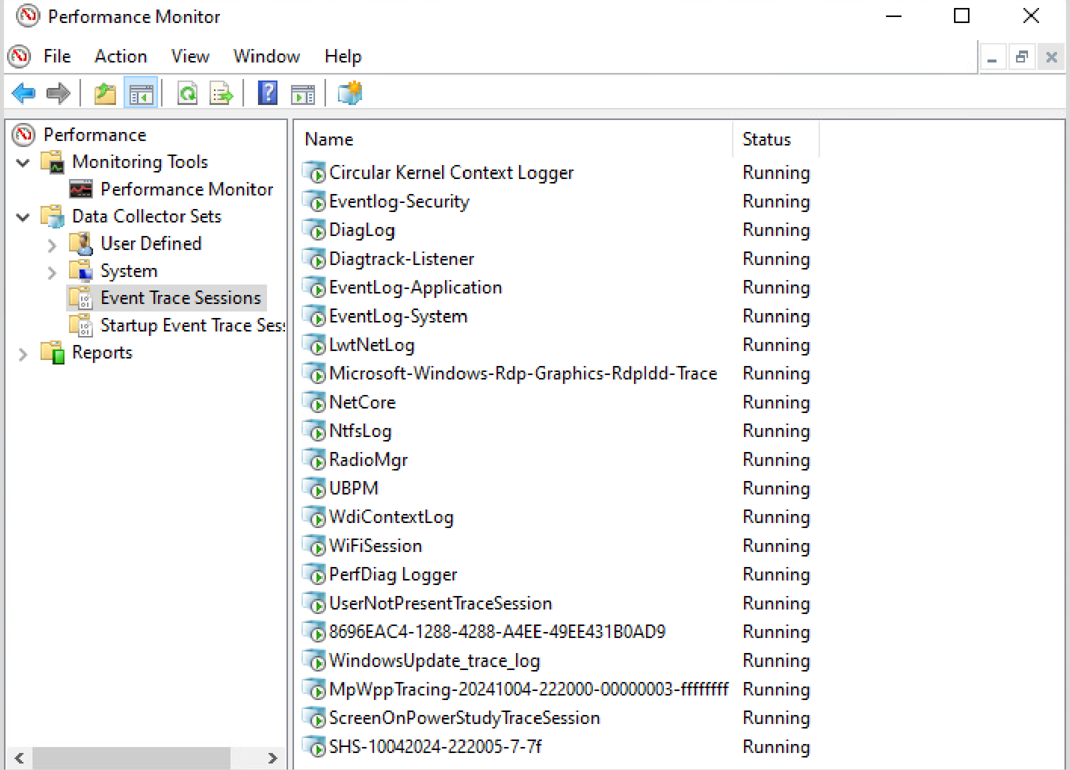


Windows Event Log Control Flow using ETW



How to Find ETW Sessions

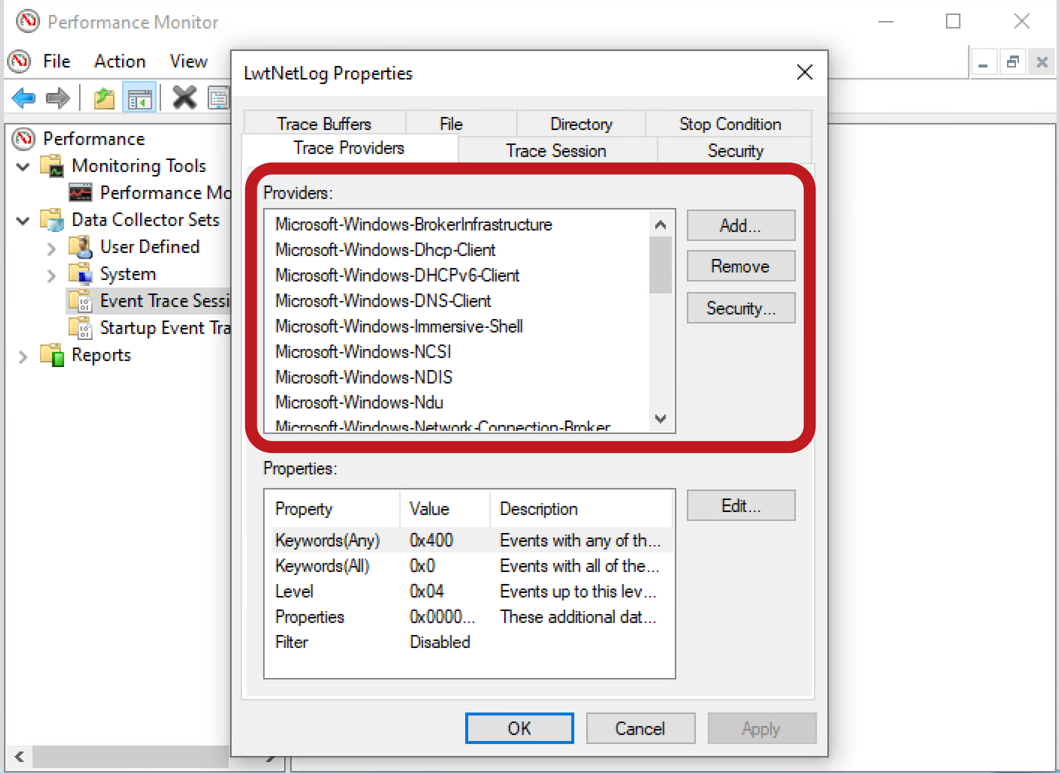
Performance Monitor (perfmon) > Data Collector Set > Event Trace Sessions



Name	Status
Circular Kernel Context Logger	Running
Eventlog-Security	Running
DiagLog	Running
Diagtrack-Listener	Running
EventLog-Application	Running
EventLog-System	Running
LwtNetLog	Running
Microsoft-Windows-Rdp-Graphics-Rdpldd-Trace	Running
NetCore	Running
NtfsLog	Running
RadioMgr	Running
UBPM	Running
WdiContextLog	Running
WiFiSession	Running
PerfDiag Logger	Running
UserNotPresentTraceSession	Running
8696EAC4-1288-4288-A4EE-49EE431B0AD9	Running
WindowsUpdate_trace_log	Running
MpWppTracing-20241004-222000-00000003-ffffffff	Running
ScreenOnPowerStudyTraceSession	Running
SHS-10042024-222005-7-7f	Running

How to Find ETW Sessions

Performance Monitor (perfmon) > Data Collector Set > Event Trace Sessions



Providers:

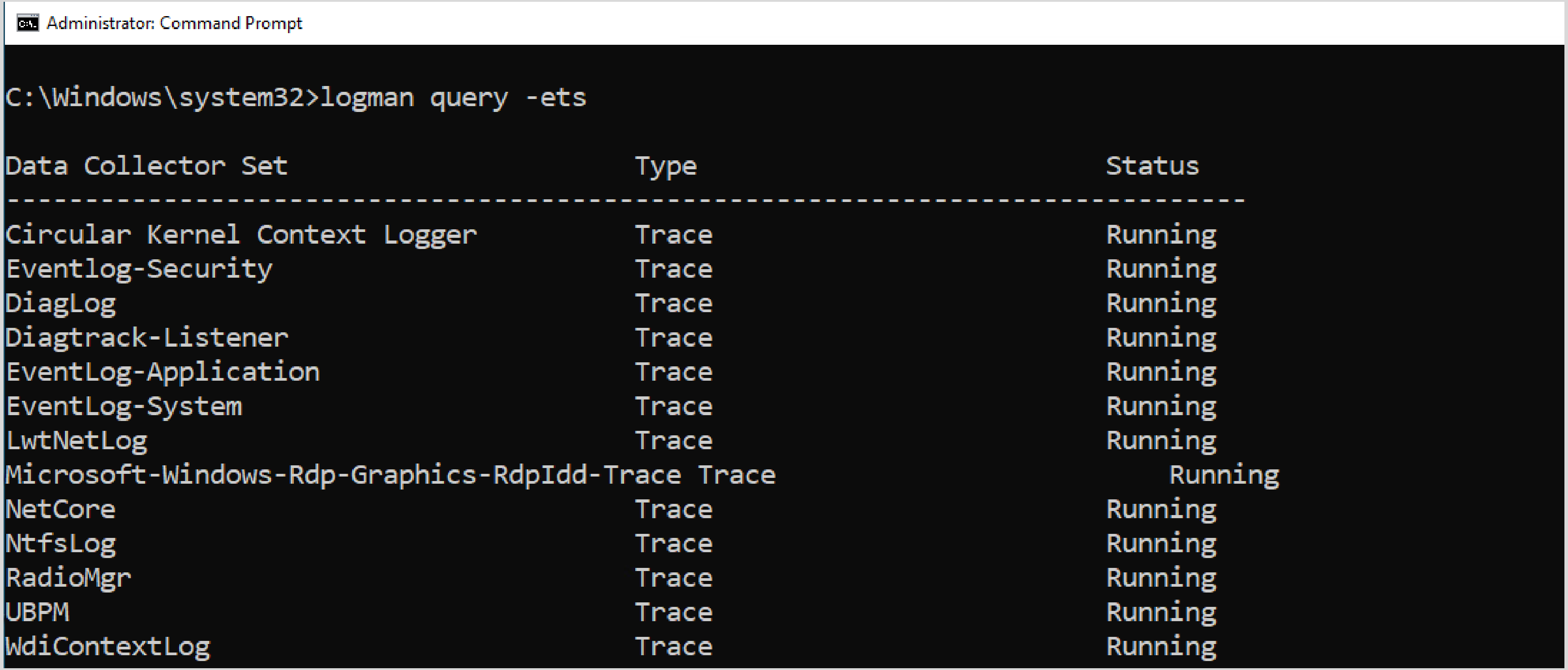
- Microsoft-Windows-BrokerInfrastructure
- Microsoft-Windows-Dhcp-Client
- Microsoft-Windows-DHCPv6-Client
- Microsoft-Windows-DNS-Client
- Microsoft-Windows-Immersive-Shell
- Microsoft-Windows-NCSI
- Microsoft-Windows-NDIS
- Microsoft-Windows-Ndu
- Microsoft-Windows-Network-Connection-Broker

Properties:

Property	Value	Description
Keywords(Any)	0x400	Events with any of th...
Keywords(All)	0x0	Events with all of the...
Level	0x04	Events up to this lev...
Properties	0x0000...	These additional dat...
Filter	Disabled	

How to Find ETW Sessions Using Command-line

> logman query -ets



Administrator: Command Prompt

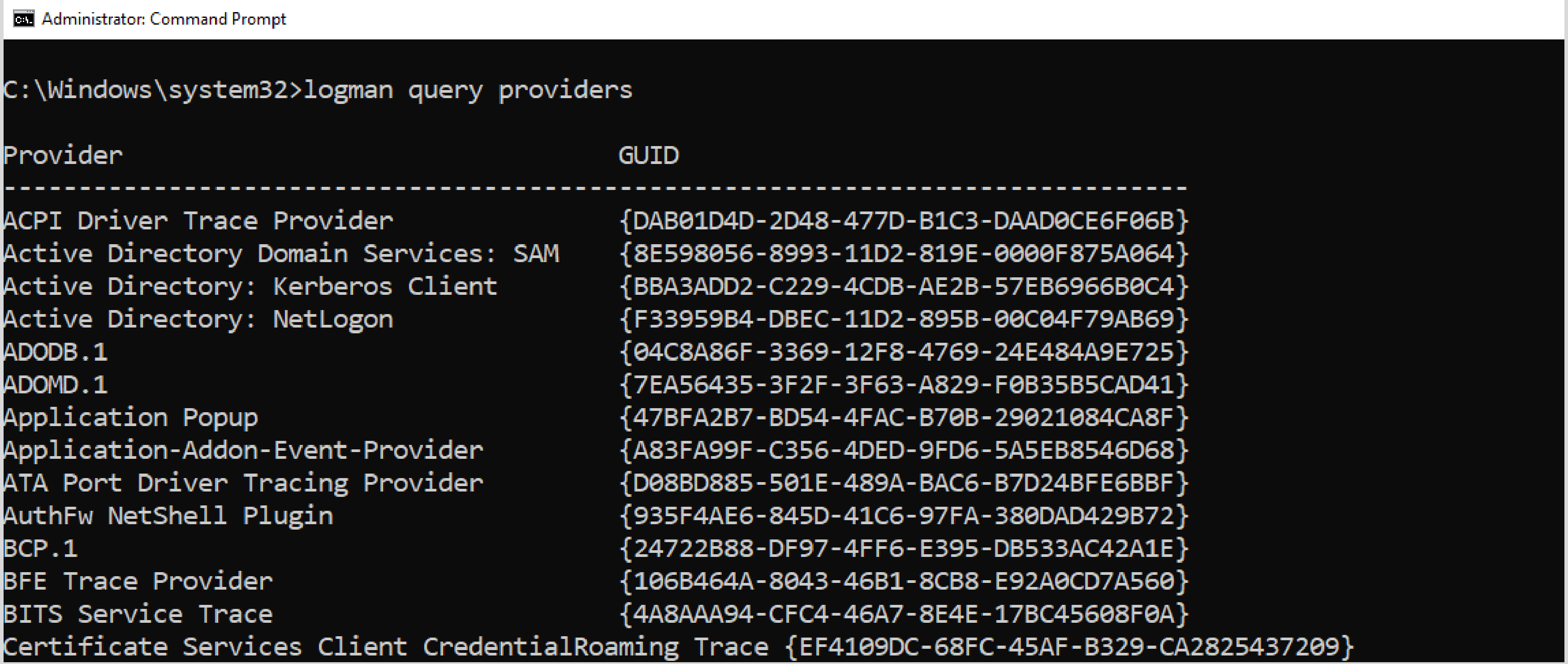
```

C:\Windows\system32>logman query -ets

Data Collector Set                      Type                          Status
-------------------------------------------------------------------------------
Circular Kernel Context Logger          Trace                         Running
Eventlog-Security                       Trace                         Running
DiagLog                                 Trace                         Running
Diagtrack-Listener                      Trace                         Running
EventLog-Application                    Trace                         Running
EventLog-System                         Trace                         Running
LwtNetLog                               Trace                         Running
Microsoft-Windows-Rdp-Graphics-RdpIdd-Trace Trace                         Running
NetCore                                 Trace                         Running
NtfsLog                                 Trace                         Running
RadioMgr                                Trace                         Running
UBPM                                    Trace                         Running
WdiContextLog                           Trace                         Running
```

How to Find ETW Providers

> logman query providers



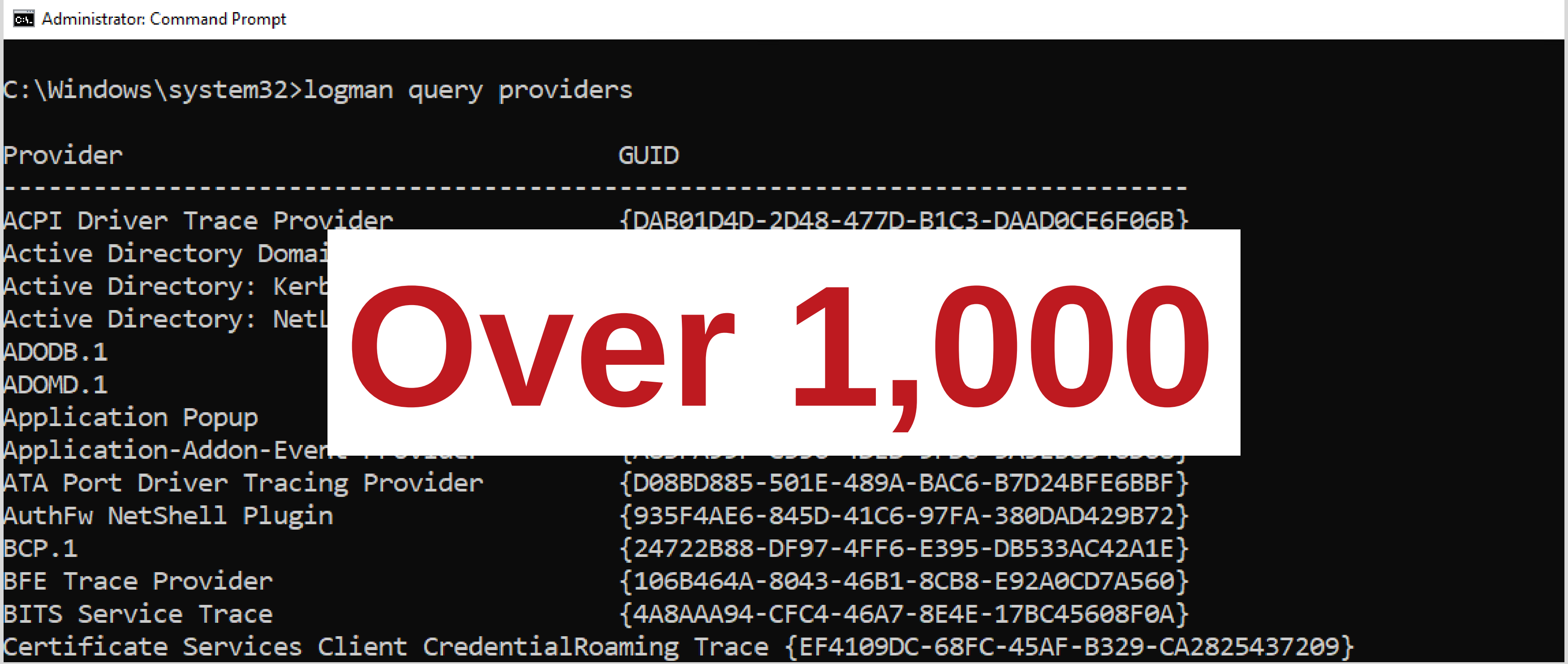
Administrator: Command Prompt

```
C:\Windows\system32>logman query providers

Provider                                 GUID
-------------------------------------------------------------------------------
ACPI Driver Trace Provider               {DAB01D4D-2D48-477D-B1C3-DAAD0CE6F06B}
Active Directory Domain Services: SAM    {8E598056-8993-11D2-819E-0000F875A064}
Active Directory: Kerberos Client        {BBA3ADD2-C229-4CDB-AE2B-57EB6966B0C4}
Active Directory: NetLogon               {F33959B4-DBEC-11D2-895B-00C04F79AB69}
ADODB.1                                  {04C8A86F-3369-12F8-4769-24E484A9E725}
ADOMD.1                                  {7EA56435-3F2F-3F63-A829-F0B35B5CAD41}
Application Popup                        {47BFA2B7-BD54-4FAC-B70B-29021084CA8F}
Application-Addon-Event-Provider         {A83FA99F-C356-4DED-9FD6-5A5EB8546D68}
ATA Port Driver Tracing Provider         {D08BD885-501E-489A-BAC6-B7D24BFE6BBF}
AuthFw NetShell Plugin                   {935F4AE6-845D-41C6-97FA-380DAD429B72}
BCP.1                                    {24722B88-DF97-4FF6-E395-DB533AC42A1E}
BFE Trace Provider                       {106B464A-8043-46B1-8CB8-E92A0CD7A560}
BITS Service Trace                       {4A8AAA94-CFC4-46A7-8E4E-17BC45608F0A}
Certificate Services Client CredentialRoaming Trace {EF4109DC-68FC-45AF-B329-CA2825437209}
```

How to Find ETW Providers

> logman query providers



Administrator: Command Prompt

```
C:\Windows\system32>logman query providers

Provider                                 GUID
-------------------------------------------------------------------------------
ACPI Driver Trace Provider               {DAB01D4D-2D48-477D-B1C3-DAAD0CE6F06B}
Active Directory Domai
Active Directory: Kerb
Active Directory: NetL
ADODB.1
ADOMD.1
Application Popup
Application-Addon-Event
ATA Port Driver Tracing Provider         {D08BD885-501E-489A-BAC6-B7D24BFE6BBF}
AuthFw NetShell Plugin                   {935F4AE6-845D-41C6-97FA-380DAD429B72}
BCP.1                                    {24722B88-DF97-4FF6-E395-DB533AC42A1E}
BFE Trace Provider                       {106B464A-8043-46B1-8CB8-E92A0CD7A560}
BITS Service Trace                       {4A8AAA94-CFC4-46A7-8E4E-17BC45608F0A}
Certificate Services Client CredentialRoaming Trace {EF4109DC-68FC-45AF-B329-CA2825437209}
```

Over 1,000

ETW Providers for Threat Intelligence

For Example

- Microsoft-Windows-Threat-Intelligence
- Microsoft-Windows-Security-Auditing
- Microsoft-Windows-Kernel-Audit-API-Calls
- Microsoft-Antimalware-Protection
- Microsoft-Antimalware-AMFilter
- Microsoft-Windows-Eventlog
- Microsoft-Windows-PowerShell
- Microsoft-Windows-WMI

ETW Providers for Threat Intelligence

For Example

Microsoft-Windows-Threat-Intelligence	Microsoft-Windows-Security-Auditing	**Microsoft-Windows-Kernel-Audit-API-Calls**	Microsoft-Antimalware-Protection
Microsoft-Antimalware-AMFilter	Microsoft-Windows-Eventlog	Microsoft-Windows-PowerShell	Microsoft-Windows-WMI

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ETW Providers for Threat Intelligence

For Example

- Microsoft-Windows-Threat-Intelligence
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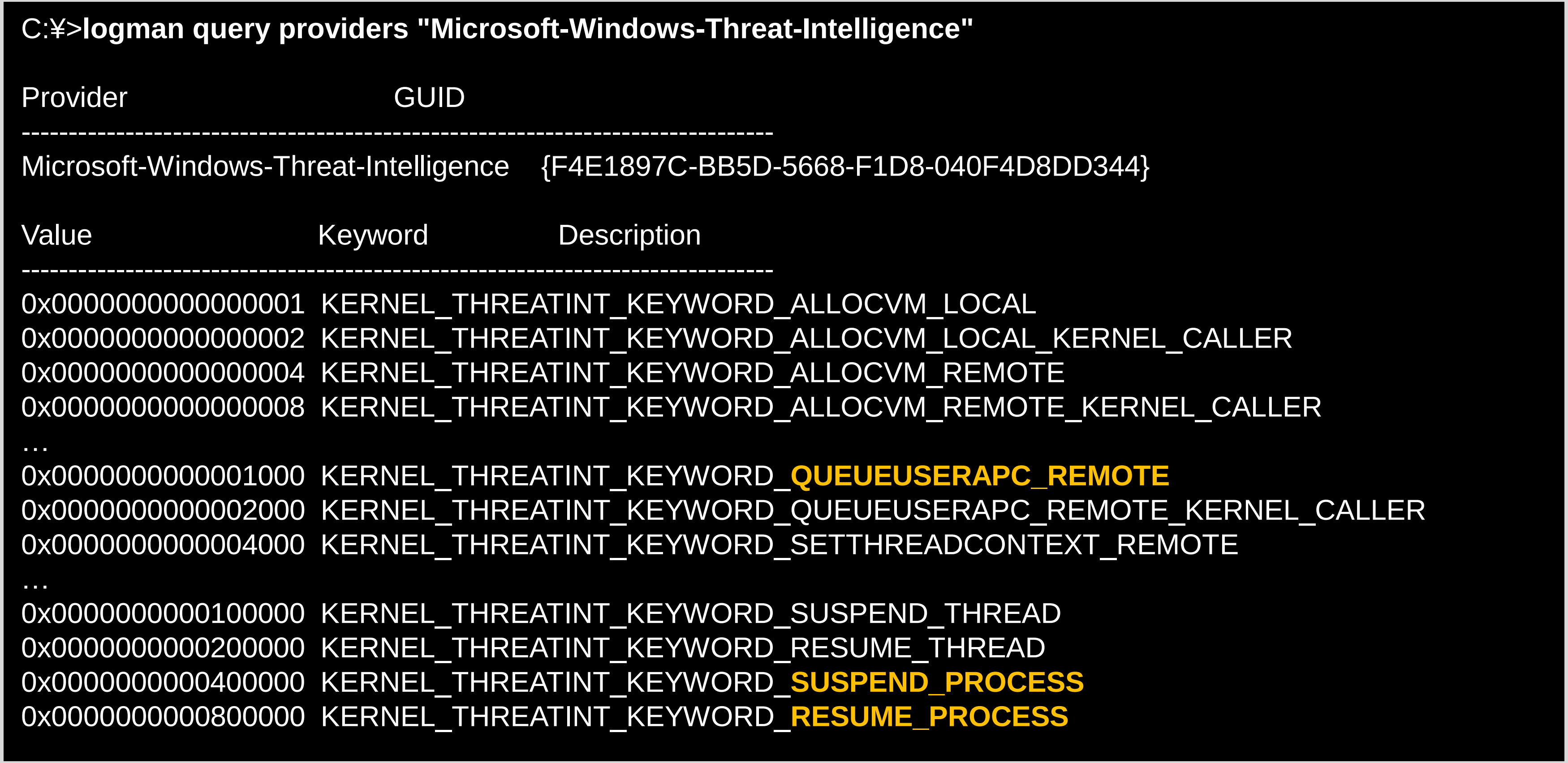
- Microsoft-Antimalware-Protection
- Microsoft-Antimalware-AMFilter
- Microsoft-Windows-Eventlog
- **Microsoft-Windows-PowerShell**
- Microsoft-Windows-WMI

Microsoft-Windows-Threat-Intelligence



```
C:¥>logman query providers "Microsoft-Windows-Threat-Intelligence"

Provider                                 GUID
-------------------------------------------------------------------------------
Microsoft-Windows-Threat-Intelligence    {F4E1897C-BB5D-5668-F1D8-040F4D8DD344}

Value                            Keyword                Description
-------------------------------------------------------------------------------
0x0000000000000001  KERNEL_THREATINT_KEYWORD_ALLOCVM_LOCAL
0x0000000000000002  KERNEL_THREATINT_KEYWORD_ALLOCVM_LOCAL_KERNEL_CALLER
0x0000000000000004  KERNEL_THREATINT_KEYWORD_ALLOCVM_REMOTE
0x0000000000000008  KERNEL_THREATINT_KEYWORD_ALLOCVM_REMOTE_KERNEL_CALLER
…
0x0000000000001000  KERNEL_THREATINT_KEYWORD_QUEUEUSERAPC_REMOTE
0x0000000000002000  KERNEL_THREATINT_KEYWORD_QUEUEUSERAPC_REMOTE_KERNEL_CALLER
0x0000000000004000  KERNEL_THREATINT_KEYWORD_SETTHREADCONTEXT_REMOTE
…
0x0000000000100000  KERNEL_THREATINT_KEYWORD_SUSPEND_THREAD
0x0000000000200000  KERNEL_THREATINT_KEYWORD_RESUME_THREAD
0x0000000000400000  KERNEL_THREATINT_KEYWORD_SUSPEND_PROCESS
0x0000000000800000  KERNEL_THREATINT_KEYWORD_RESUME_PROCESS
```

ETW Providers used by AV/EDR

Research AV/EDR

- □ Windows Defender
- □ Kaspersky
- □ ESET
- □ TrendMicro
- □ Symantec
- □ McAfee
- □ Cylance
- □ Filebeat (Elastic)

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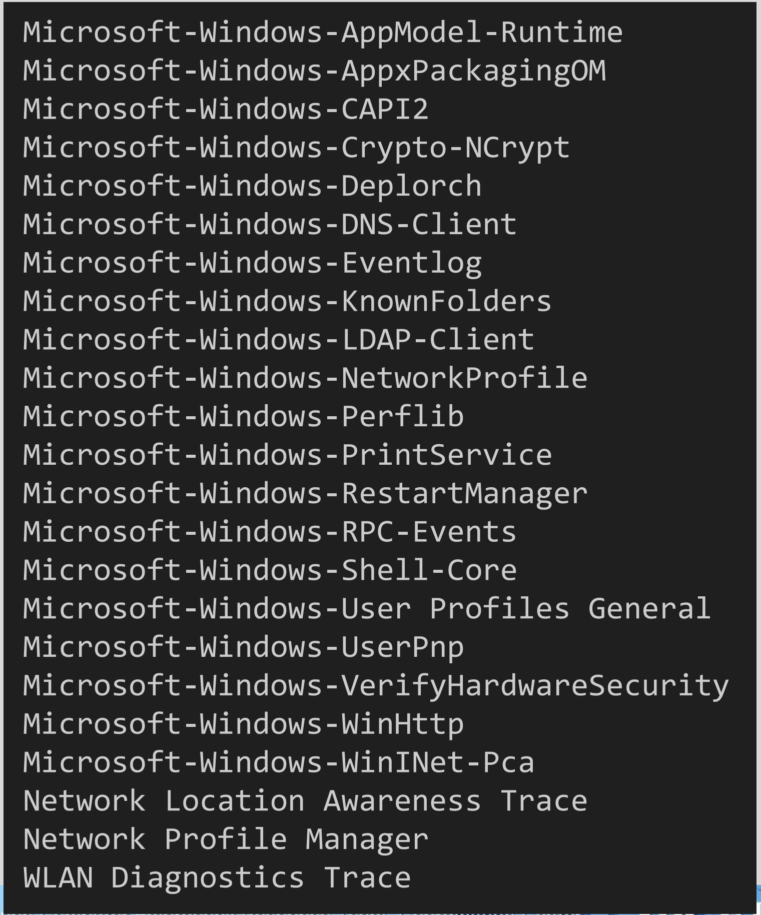


```
Microsoft-Windows-AppModel-Runtime
Microsoft-Windows-AppxPackagingOM
Microsoft-Windows-CAPI2
Microsoft-Windows-Crypto-NCrypt
Microsoft-Windows-Deplorch
Microsoft-Windows-DNS-Client
Microsoft-Windows-Eventlog
Microsoft-Windows-KnownFolders
Microsoft-Windows-LDAP-Client
Microsoft-Windows-NetworkProfile
Microsoft-Windows-Perflib
Microsoft-Windows-PrintService
Microsoft-Windows-RestartManager
Microsoft-Windows-RPC-Events
Microsoft-Windows-Shell-Core
Microsoft-Windows-User Profiles General
Microsoft-Windows-UserPnp
Microsoft-Windows-VerifyHardwareSecurity
Microsoft-Windows-WinHttp
Microsoft-Windows-WinINet-Pca
Network Location Awareness Trace
Network Profile Manager
WLAN Diagnostics Trace
```

ETW Providers used by AV/EDR

Research AV/EDR

- □ Windows Defender
- □ Kaspersky
- □ ESET
- □ TrendMicro
- □ Symantec
- □ McAfee
- □ Cylance →
- □ Filebeat (Elastic)

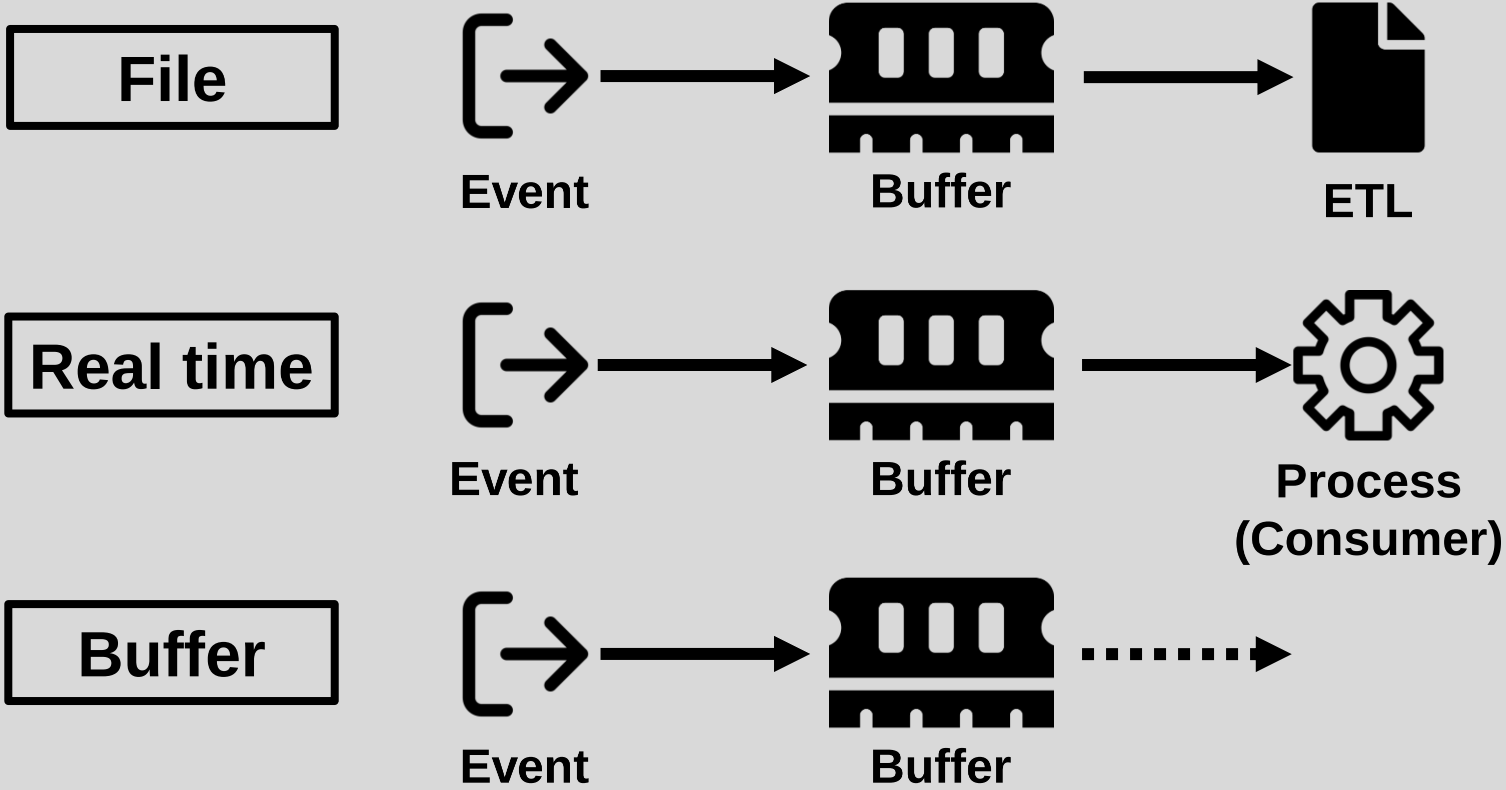
```
Microsoft-Windows-AppModel-Runtime
Microsoft-Windows-CAPI2
Microsoft-Windows-Crypto-NCrypt
Microsoft-Windows-Deplorch
Microsoft-Windows-DNS-Client
Microsoft-Windows-Eventlog
Microsoft-Windows-Kernel-AppCompat
Microsoft-Windows-KnownFolders
Microsoft-Windows-LDAP-Client
Microsoft-Windows-Networking-Correlation
Microsoft-Windows-RPC
Microsoft-Windows-RPC-Events
Microsoft-Windows-Shell-Core
Microsoft-Windows-User Profiles General
Microsoft-Windows-UserPnp
Microsoft-Windows-WinHttp
Microsoft-Windows-WinINet-Pca
```

ETW Providers used by AV/EDR

Important ETW Provider List

Microsoft-Windows-AppModel-Runtime
Microsoft-Windows-CAPI2
Microsoft-Windows-COMRuntime
Microsoft-Windows-Crypto-NCrypt
Microsoft-Windows-Deplorch
Microsoft-Windows-DNS-Client
Microsoft-Windows-Eventlog
Microsoft-Windows-Kernel-AppCompat
Microsoft-Windows-KnownFolders
Microsoft-Windows-LDAP-Client
Microsoft-Windows-Networking-Correlation
Microsoft-Windows-NetworkProfile
Microsoft-Windows-PrintService
Microsoft-Windows-RPC
Microsoft-Windows-RPC-Events
Microsoft-Windows-Shell-Core
Microsoft-Windows-User Profiles General
Microsoft-Windows-UserPnp
Microsoft-Windows-VerifyHardwareSecurity
Microsoft-Windows-WinHttp
Microsoft-Windows-WinINet-Pca
Network Profile Manager
WLAN Diagnostics Trace

ETW Stream Mode



1 What is ETW?

2 ETW Internals

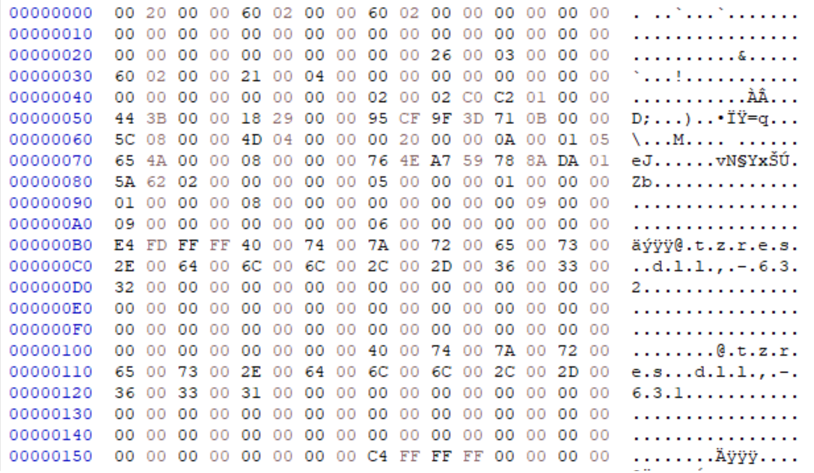
3 ETW using Incident Response

4 Attack Surface

5 Mitigation and Detection

What is ETL?

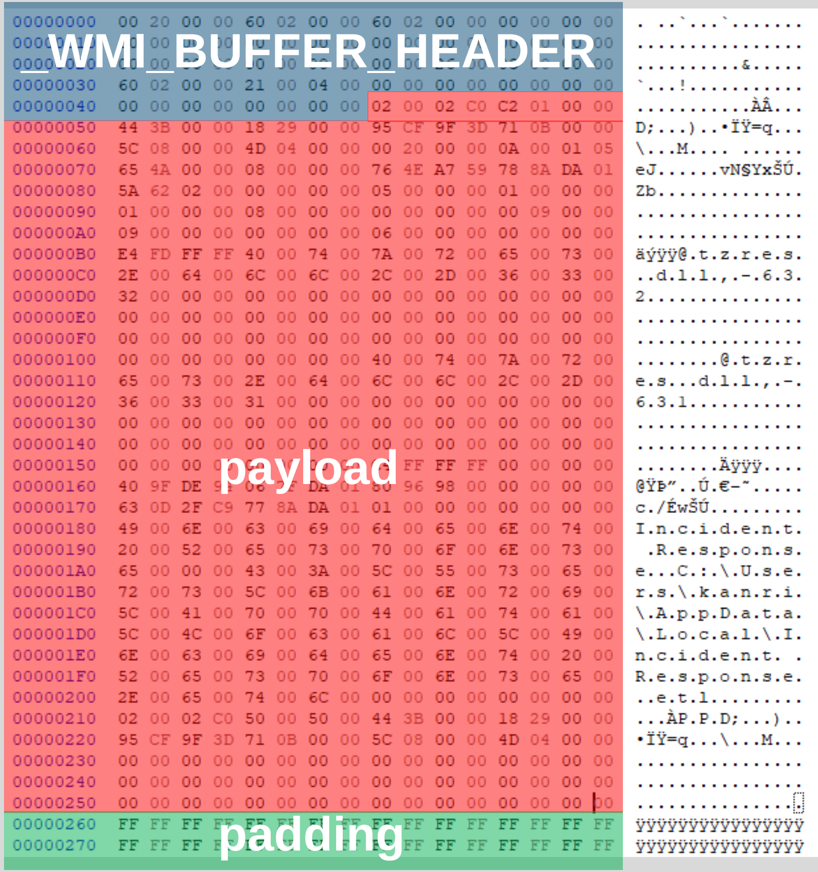
ETW events are saved in a ETL (Event Trace Log) file.



```
00000000  00 20 00 00 60 02 00 00 60 02 00 00 00 00 00 00  . ..`...`.......
00000010  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000020  00 00 00 00 00 00 00 00 00 00 26 00 03 00 00 00  ..........&.....
00000030  60 02 00 00 21 00 04 00 00 00 00 00 00 00 00 00  `...!...........
00000040  00 00 00 00 00 00 00 00 02 00 02 C0 C2 01 00 00  ...........ÀÂ...
00000050  44 3B 00 00 18 29 00 00 95 CF 9F 3D 71 0B 00 00  D;...)..•ÏŸ=q...
00000060  5C 08 00 00 4D 04 00 00 00 20 00 00 0A 00 01 05  \...M.... ......
00000070  65 4A 00 00 08 00 00 00 76 4E A7 59 78 8A DA 01  eJ......vN§YxŠÚ.
00000080  5A 62 02 00 00 00 00 00 05 00 00 00 01 00 00 00  Zb..............
00000090  01 00 00 00 08 00 00 00 00 00 00 00 00 09 00 00  ................
000000A0  09 00 00 00 00 00 00 00 06 00 00 00 00 00 00 00  ................
000000B0  E4 FD FF FF 40 00 74 00 7A 00 72 00 65 00 73 00  äýÿÿ@.t.z.r.e.s.
000000C0  2E 00 64 00 6C 00 6C 00 2C 00 2D 00 36 00 33 00  ..d.l.l.,.-.6.3.
000000D0  32 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  2...............
000000E0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
000000F0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000100  00 00 00 00 00 00 00 00 40 00 74 00 7A 00 72 00  ........@.t.z.r.
00000110  65 00 73 00 2E 00 64 00 6C 00 6C 00 2C 00 2D 00  e.s...d.l.l.,.-.
00000120  36 00 33 00 31 00 00 00 00 00 00 00 00 00 00 00  6.3.1...........
00000130  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000140  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000150  00 00 00 00 00 00 00 00 C4 FF FF FF 00 00 00 00  ........Äÿÿÿ....
```

ETL files are in binary format and cannot be viewed without converting their contents.

ETL File Format

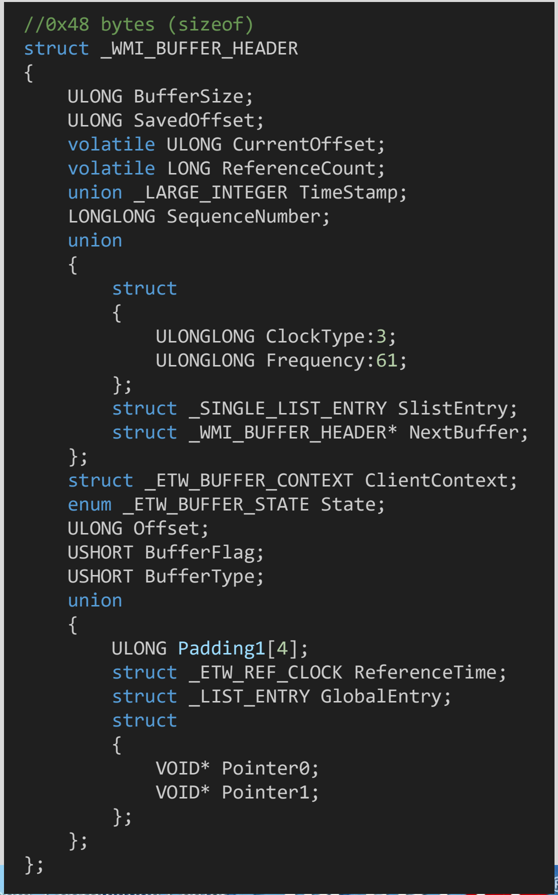


```
00000000  00 20 00 00 60 02 00 00 60 02 00 00 00 00 00 00  . ..`...`.......
00000010  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000020  00 00 00 00 00 00 00 00 00 00 26 00 00 00 00 00  ..........&.....
00000030  60 02 00 00 21 00 04 00 00 00 00 00 00 00 00 00  `...!...........
00000040  00 00 00 00 00 00 00 00 02 00 02 C0 C2 01 00 00  ..........ÀÂ...
00000050  44 3B 00 00 18 29 00 00 95 CF 9F 3D 71 0B 00 00  D;...)..•ÏŸ=q...
00000060  5C 08 00 00 4D 04 00 00 00 20 00 00 0A 00 01 05  \...M.... ......
00000070  65 4A 00 00 08 00 00 00 76 4E A7 59 78 8A DA 01  eJ......vN§YxŠÚ.
00000080  5A 62 02 00 00 00 00 00 05 00 00 00 01 00 00 00  Zb..............
00000090  01 00 00 00 08 00 00 00 00 00 00 00 00 09 00 00  ................
000000A0  09 00 00 00 00 00 00 00 06 00 00 00 00 00 00 00  ................
000000B0  E4 FD FF FF 40 00 74 00 7A 00 72 00 65 00 73 00  äýÿÿ@.t.z.r.e.s.
000000C0  2E 00 64 00 6C 00 6C 00 2C 00 2D 00 36 00 33 00  ..d.l.l.,.-.6.3.
000000D0  32 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  2...............
000000E0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
000000F0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000100  00 00 00 00 00 00 00 00 40 00 74 00 7A 00 72 00  ........@.t.z.r.
00000110  65 00 73 00 2E 00 64 00 6C 00 6C 00 2C 00 2D 00  e.s...d.l.l.,.-.
00000120  36 00 33 00 31 00 00 00 00 00 00 00 00 00 00 00  6.3.1...........
00000130  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000140  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000150  00 00 00 00 00 00 00 00 C4 FF FF FF 00 00 00 00  ........Äÿÿÿ....
00000160  40 9F DE 94 06 7F DA 01 80 96 98 00 00 00 00 00  @ŸÞ"..Ú.€–˜.....
00000170  63 0D 2F C9 77 8A DA 01 01 00 00 00 00 00 00 00  c./ÉwŠÚ.........
00000180  49 00 6E 00 63 00 69 00 64 00 65 00 6E 00 74 00  I.n.c.i.d.e.n.t.
00000190  20 00 52 00 65 00 73 00 70 00 6F 00 6E 00 73 00   .R.e.s.p.o.n.s.
000001A0  65 00 00 00 43 00 3A 00 5C 00 55 00 73 00 65 00  e...C.:.\.U.s.e.
000001B0  72 00 73 00 5C 00 6B 00 61 00 6E 00 72 00 69 00  r.s.\.k.a.n.r.i.
000001C0  5C 00 41 00 70 00 70 00 44 00 61 00 74 00 61 00  \.A.p.p.D.a.t.a.
000001D0  5C 00 4C 00 6F 00 63 00 61 00 6C 00 5C 00 49 00  \.L.o.c.a.l.\.I.
000001E0  6E 00 63 00 69 00 64 00 65 00 6E 00 74 00 20 00  n.c.i.d.e.n.t. .
000001F0  52 00 65 00 73 00 70 00 6F 00 6E 00 73 00 65 00  R.e.s.p.o.n.s.e.
00000200  2E 00 65 00 74 00 6C 00 00 00 00 00 00 00 00 00  ..e.t.l.........
00000210  02 00 02 C0 50 00 50 00 44 3B 00 00 18 29 00 00  ...ÀP.P.D;...)..
00000220  95 CF 9F 3D 71 0B 00 00 5C 08 00 00 4D 04 00 00  •ÏŸ=q...\...M...
00000230  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000240  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000250  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000260  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
00000270  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
```

ETL File Header

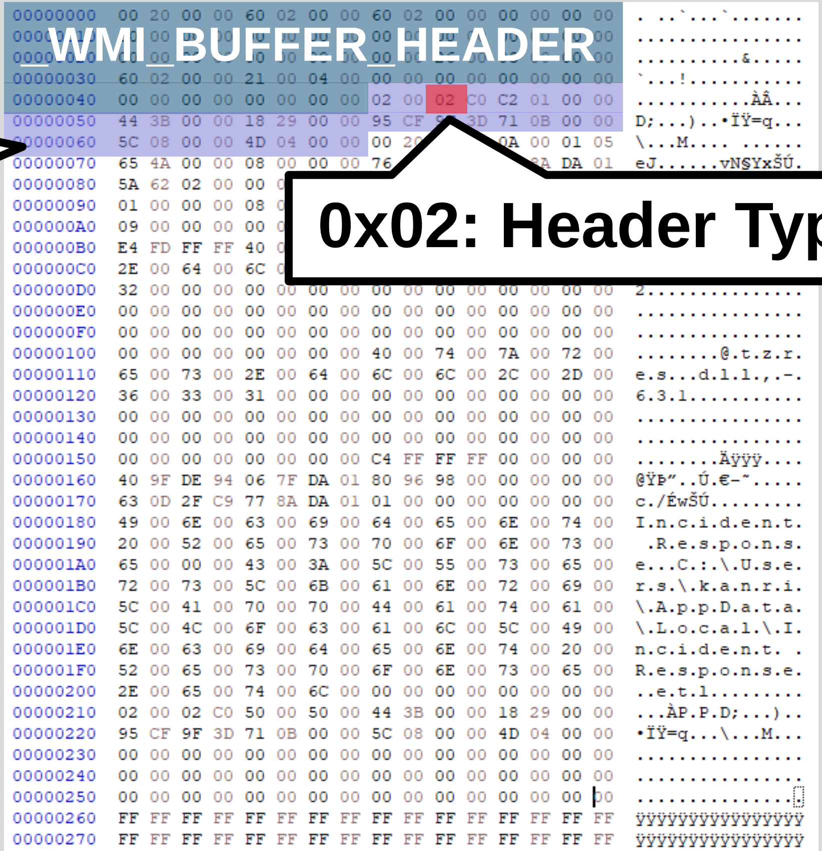
_WMI_BUFFER_HEADER

- ETL file format is **undocumented**.
- ETL header is defined in the **WMI_BUFFER_HEADER structure** in the Windows symbol.
- No signature.



```
//0x48 bytes (sizeof)
struct _WMI_BUFFER_HEADER
{
    ULONG BufferSize;
    ULONG SavedOffset;
    volatile ULONG CurrentOffset;
    volatile LONG ReferenceCount;
    union _LARGE_INTEGER TimeStamp;
    LONGLONG SequenceNumber;
    union
    {
        struct
        {
            ULONGLONG ClockType:3;
            ULONGLONG Frequency:61;
        };
        struct _SINGLE_LIST_ENTRY SlistEntry;
        struct _WMI_BUFFER_HEADER* NextBuffer;
    };
    struct _ETW_BUFFER_CONTEXT ClientContext;
    enum _ETW_BUFFER_STATE State;
    ULONG Offset;
    USHORT BufferFlag;
    USHORT BufferType;
    union
    {
        ULONG Padding1[4];
        struct _ETW_REF_CLOCK ReferenceTime;
        struct _LIST_ENTRY GlobalEntry;
        struct
        {
            VOID* Pointer0;
            VOID* Pointer1;
        };
    };
};
```

ETL File Format



```
00000000  00 20 00 00 60 02 00 00 60 02 00 00 00 00 00 00   . ..`...`.......
0000      00                      00                   00   ................
          00                      00                   00   ..........&.....
00000030  60 02 00 00 21 00 04 00 00 00 00 00 00 00 00 00   `...!...........
00000040  00 00 00 00 00 00 00 00 02 00 02 C0 C2 01 00 00   ..........ÀÂ...
00000050  44 3B 00 00 18 29 00 00 95 CF 9  3D 71 0B 00 00   D;...)..•ÏŸ=q...
00000060  5C 08 00 00 4D 04 00 00 00 20       0A 00 01 05   \...M.... ......
00000070  65 4A 00 00 08 00 00 00 76          8A DA 01      eJ......vN§YxŠÚ.
00000080  5A 62 02 00 00
00000090  01 00 00 00 08
000000A0  09 00 00 00 00
000000B0  E4 FD FF FF 40
000000C0  2E 00 64 00 6C
000000D0  32 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   2...............
000000E0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
000000F0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00000100  00 00 00 00 00 00 00 00 40 00 74 00 7A 00 72 00   ........@.t.z.r.
00000110  65 00 73 00 2E 00 64 00 6C 00 6C 00 2C 00 2D 00   e.s...d.l.l.,.-.
00000120  36 00 33 00 31 00 00 00 00 00 00 00 00 00 00 00   6.3.1...........
00000130  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00000140  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00000150  00 00 00 00 00 00 00 00 C4 FF FF FF 00 00 00 00   ........Äÿÿÿ....
00000160  40 9F DE 94 06 7F DA 01 80 96 98 00 00 00 00 00   @ŸÞ”..Ú.€–˜.....
00000170  63 0D 2F C9 77 8A DA 01 01 00 00 00 00 00 00 00   c./ÉwŠÚ.........
00000180  49 00 6E 00 63 00 69 00 64 00 65 00 6E 00 74 00   I.n.c.i.d.e.n.t.
00000190  20 00 52 00 65 00 73 00 70 00 6F 00 6E 00 73 00    .R.e.s.p.o.n.s.
000001A0  65 00 00 00 43 00 3A 00 5C 00 55 00 73 00 65 00   e...C.:.\.U.s.e.
000001B0  72 00 73 00 5C 00 6B 00 61 00 6E 00 72 00 69 00   r.s.\.k.a.n.r.i.
000001C0  5C 00 41 00 70 00 70 00 44 00 61 00 74 00 61 00   \.A.p.p.D.a.t.a.
000001D0  5C 00 4C 00 6F 00 63 00 61 00 6C 00 5C 00 49 00   \.L.o.c.a.l.\.I.
000001E0  6E 00 63 00 69 00 64 00 65 00 6E 00 74 00 20 00   n.c.i.d.e.n.t. .
000001F0  52 00 65 00 73 00 70 00 6F 00 6E 00 73 00 65 00   R.e.s.p.o.n.s.e.
00000200  2E 00 65 00 74 00 6C 00 00 00 00 00 00 00 00 00   ..e.t.l.........
00000210  02 00 02 C0 50 00 50 00 44 3B 00 00 18 29 00 00   ...ÀP.P.D;...)..
00000220  95 CF 9F 3D 71 0B 00 00 5C 08 00 00 4D 04 00 00   •ÏŸ=q...\...M...
00000230  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00000240  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00000250  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00000260  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF   ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
00000270  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF   ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
```

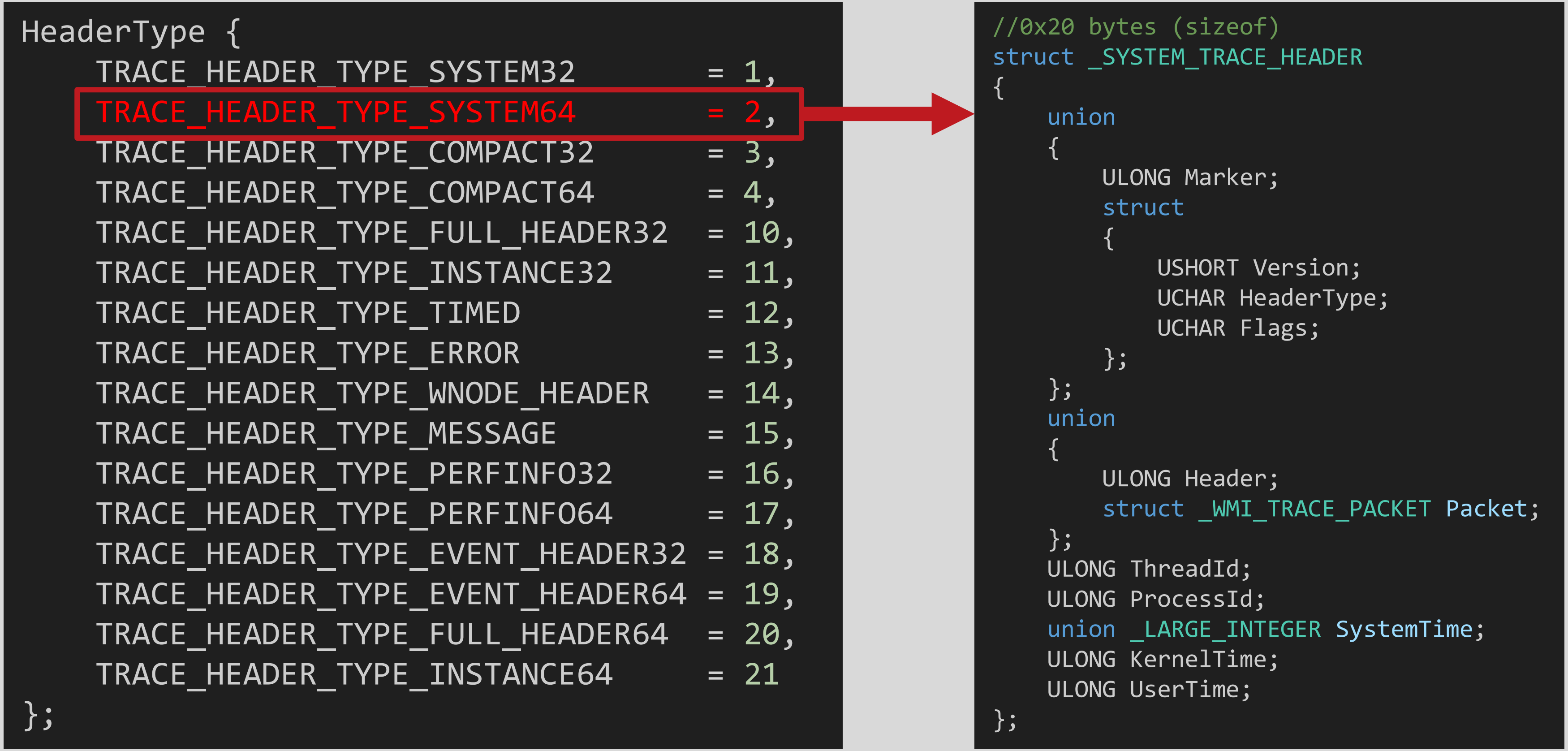
Trace Header

0x02: Header Type

Trace Header

```
HeaderType {
    TRACE_HEADER_TYPE_SYSTEM32         = 1,
    TRACE_HEADER_TYPE_SYSTEM64         = 2,
    TRACE_HEADER_TYPE_COMPACT32        = 3,
    TRACE_HEADER_TYPE_COMPACT64        = 4,
    TRACE_HEADER_TYPE_FULL_HEADER32    = 10,
    TRACE_HEADER_TYPE_INSTANCE32       = 11,
    TRACE_HEADER_TYPE_TIMED            = 12,
    TRACE_HEADER_TYPE_ERROR            = 13,
    TRACE_HEADER_TYPE_WNODE_HEADER     = 14,
    TRACE_HEADER_TYPE_MESSAGE          = 15,
    TRACE_HEADER_TYPE_PERFINFO32       = 16,
    TRACE_HEADER_TYPE_PERFINFO64       = 17,
    TRACE_HEADER_TYPE_EVENT_HEADER32 = 18,
    TRACE_HEADER_TYPE_EVENT_HEADER64 = 19,
    TRACE_HEADER_TYPE_FULL_HEADER64    = 20,
    TRACE_HEADER_TYPE_INSTANCE64       = 21
};
```

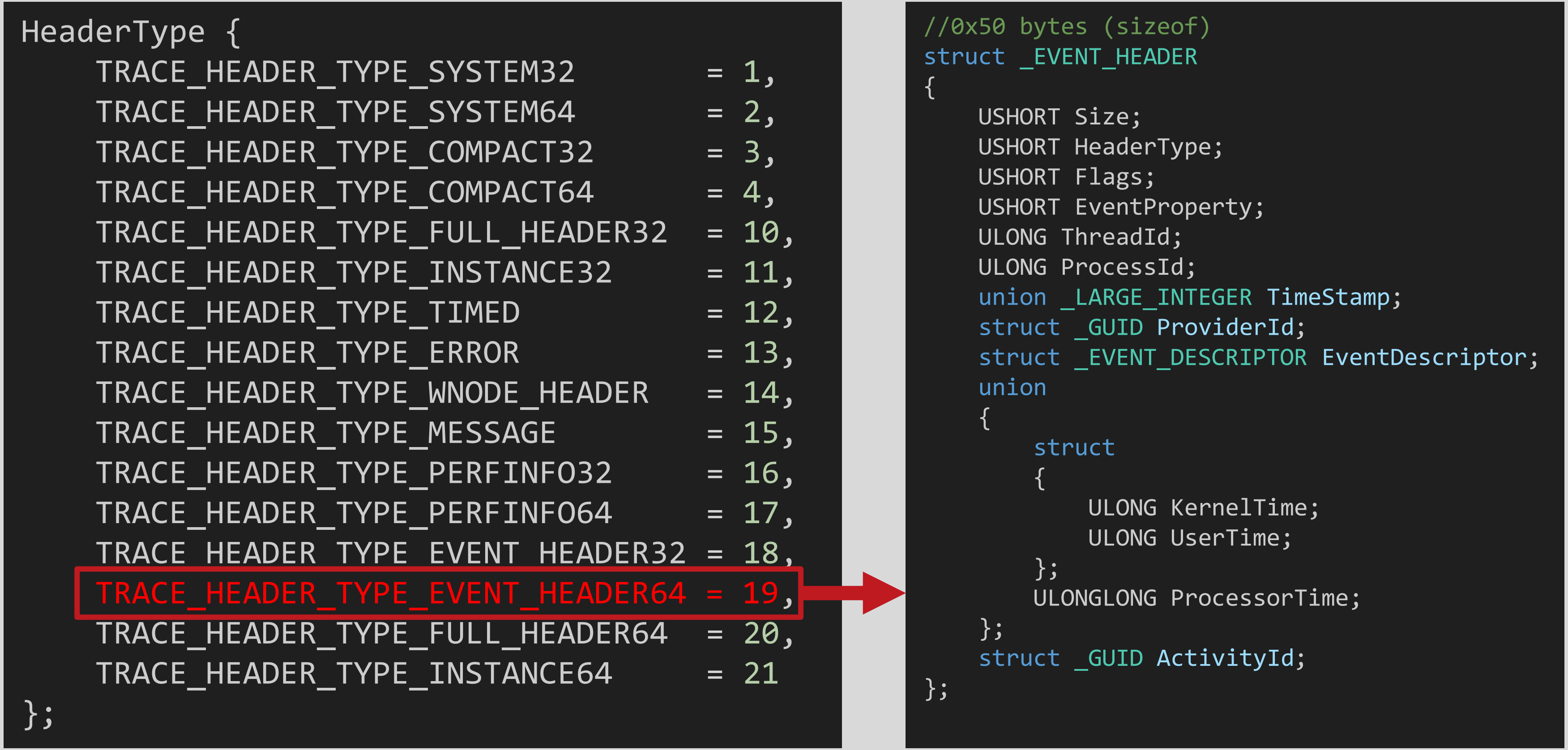
Trace Header



```
HeaderType {
    TRACE_HEADER_TYPE_SYSTEM32          = 1,
    TRACE_HEADER_TYPE_SYSTEM64          = 2,
    TRACE_HEADER_TYPE_COMPACT32         = 3,
    TRACE_HEADER_TYPE_COMPACT64         = 4,
    TRACE_HEADER_TYPE_FULL_HEADER32     = 10,
    TRACE_HEADER_TYPE_INSTANCE32        = 11,
    TRACE_HEADER_TYPE_TIMED             = 12,
    TRACE_HEADER_TYPE_ERROR             = 13,
    TRACE_HEADER_TYPE_WNODE_HEADER      = 14,
    TRACE_HEADER_TYPE_MESSAGE           = 15,
    TRACE_HEADER_TYPE_PERFINFO32        = 16,
    TRACE_HEADER_TYPE_PERFINFO64        = 17,
    TRACE_HEADER_TYPE_EVENT_HEADER32    = 18,
    TRACE_HEADER_TYPE_EVENT_HEADER64    = 19,
    TRACE_HEADER_TYPE_FULL_HEADER64     = 20,
    TRACE_HEADER_TYPE_INSTANCE64        = 21
};
```

```
//0x20 bytes (sizeof)
struct _SYSTEM_TRACE_HEADER
{
    union
    {
        ULONG Marker;
        struct
        {
            USHORT Version;
            UCHAR HeaderType;
            UCHAR Flags;
        };
    };
    union
    {
        ULONG Header;
        struct _WMI_TRACE_PACKET Packet;
    };
    ULONG ThreadId;
    ULONG ProcessId;
    union _LARGE_INTEGER SystemTime;
    ULONG KernelTime;
    ULONG UserTime;
};
```

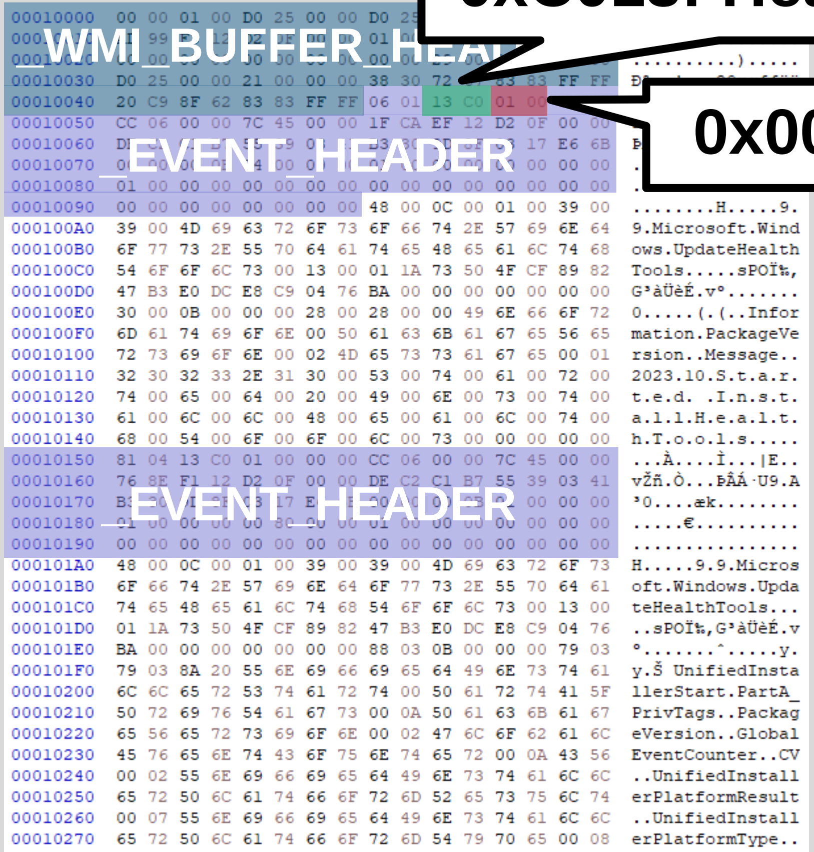
Trace Header



```
HeaderType {
    TRACE_HEADER_TYPE_SYSTEM32        = 1,
    TRACE_HEADER_TYPE_SYSTEM64        = 2,
    TRACE_HEADER_TYPE_COMPACT32       = 3,
    TRACE_HEADER_TYPE_COMPACT64       = 4,
    TRACE_HEADER_TYPE_FULL_HEADER32   = 10,
    TRACE_HEADER_TYPE_INSTANCE32      = 11,
    TRACE_HEADER_TYPE_TIMED           = 12,
    TRACE_HEADER_TYPE_ERROR           = 13,
    TRACE_HEADER_TYPE_WNODE_HEADER    = 14,
    TRACE_HEADER_TYPE_MESSAGE         = 15,
    TRACE_HEADER_TYPE_PERFINFO32      = 16,
    TRACE_HEADER_TYPE_PERFINFO64      = 17,
    TRACE_HEADER_TYPE_EVENT_HEADER32  = 18,
    TRACE_HEADER_TYPE_EVENT_HEADER64  = 19,
    TRACE_HEADER_TYPE_FULL_HEADER64   = 20,
    TRACE_HEADER_TYPE_INSTANCE64      = 21
};
```

```
//0x50 bytes (sizeof)
struct _EVENT_HEADER
{
    USHORT Size;
    USHORT HeaderType;
    USHORT Flags;
    USHORT EventProperty;
    ULONG ThreadId;
    ULONG ProcessId;
    union _LARGE_INTEGER TimeStamp;
    struct _GUID ProviderId;
    struct _EVENT_DESCRIPTOR EventDescriptor;
    union
    {
        struct
        {
            ULONG KernelTime;
            ULONG UserTime;
        };
        ULONGLONG ProcessorTime;
    };
    struct _GUID ActivityId;
};
```

_EVENT_HEADER

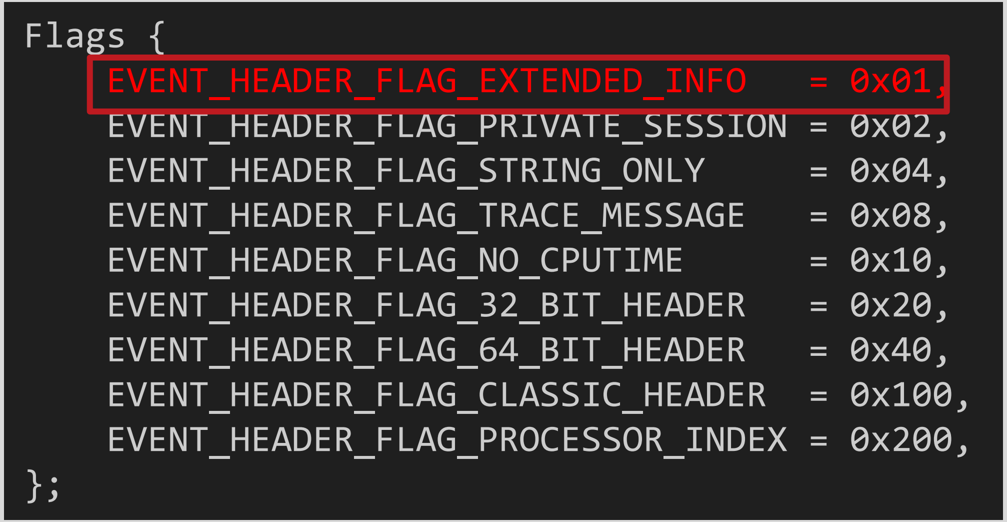


0xC013: Header Type

0x0001: Flags

```
00010000  00 00 01 00 D0 25 00 00 D0 25 [illegible]
00010010  [illegible] 99 F[illegible] 12 D2 0F 00 00 01 [illegible]
00010020  00 00 [illegible] 00 00 00 00 00 00 00 00 29 00 [illegible]   ..........).....
00010030  D0 25 00 00 21 00 00 00 38 30 72 [illegible] 83 83 FF FF   Ð[illegible]
00010040  20 C9 8F 62 83 83 FF FF 06 01 13 C0 01 00 [illegible]
00010050  CC 06 00 00 7C 45 00 00 1F CA EF 12 D2 0F 00 00
00010060  D[illegible] 55 [illegible] B3 [illegible] 17 E6 6B   Þ[illegible]
00010070  0[illegible] 00 00 00 00   .[illegible]
00010080  01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   .[illegible]
00010090  00 00 00 00 00 00 00 00 48 00 0C 00 01 00 39 00   ........H.....9.
000100A0  39 00 4D 69 63 72 6F 73 6F 66 74 2E 57 69 6E 64   9.Microsoft.Wind
000100B0  6F 77 73 2E 55 70 64 61 74 65 48 65 61 6C 74 68   ows.UpdateHealth
000100C0  54 6F 6F 6C 73 00 13 00 01 1A 73 50 4F CF 89 82   Tools.....sPOÏ‰‚
000100D0  47 B3 E0 DC E8 C9 04 76 BA 00 00 00 00 00 00 00   G³àÜèÉ.vº.......
000100E0  30 00 0B 00 00 00 28 00 28 00 00 49 6E 66 6F 72   0.....(.(..Infor
000100F0  6D 61 74 69 6F 6E 00 50 61 63 6B 61 67 65 56 65   mation.PackageVe
00010100  72 73 69 6F 6E 00 02 4D 65 73 73 61 67 65 00 01   rsion..Message..
00010110  32 30 32 33 2E 31 30 00 53 00 74 00 61 00 72 00   2023.10.S.t.a.r.
00010120  74 00 65 00 64 00 20 00 49 00 6E 00 73 00 74 00   t.e.d. .I.n.s.t.
00010130  61 00 6C 00 6C 00 48 00 65 00 61 00 6C 00 74 00   a.l.l.H.e.a.l.t.
00010140  68 00 54 00 6F 00 6F 00 6C 00 73 00 00 00 00 00   h.T.o.o.l.s.....
00010150  81 04 13 C0 01 00 00 00 CC 06 00 00 7C 45 00 00   ...À....Ì...|E..
00010160  76 8E F1 12 D2 0F 00 00 DE C2 C1 B7 55 39 03 41   vŽñ.Ò...ÞÂÁ·U9.A
00010170  B3 [illegible] 00 00 00   ³0....æk........
00010180  01 00 00 00 00 80 00 00 01 00 00 00 00 00 00 00   .....€..........
00010190  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
000101A0  48 00 0C 00 01 00 39 00 39 00 4D 69 63 72 6F 73   H.....9.9.Micros
000101B0  6F 66 74 2E 57 69 6E 64 6F 77 73 2E 55 70 64 61   oft.Windows.Upda
000101C0  74 65 48 65 61 6C 74 68 54 6F 6F 6C 73 00 13 00   teHealthTools...
000101D0  01 1A 73 50 4F CF 89 82 47 B3 E0 DC E8 C9 04 76   ..sPOÏ‰‚G³àÜèÉ.v
000101E0  BA 00 00 00 00 00 00 00 88 03 0B 00 00 00 79 03   º.......ˆ.....y.
000101F0  79 03 8A 20 55 6E 69 66 69 65 64 49 6E 73 74 61   y.Š UnifiedInsta
00010200  6C 6C 65 72 53 74 61 72 74 00 50 61 72 74 41 5F   llerStart.PartA_
00010210  50 72 69 76 54 61 67 73 00 0A 50 61 63 6B 61 67   PrivTags..Packag
00010220  65 56 65 72 73 69 6F 6E 00 02 47 6C 6F 62 61 6C   eVersion..Global
00010230  45 76 65 6E 74 43 6F 75 6E 74 65 72 00 0A 43 56   EventCounter..CV
00010240  00 02 55 6E 69 66 69 65 64 49 6E 73 74 61 6C 6C   ..UnifiedInstall
00010250  65 72 50 6C 61 74 66 6F 72 6D 52 65 73 75 6C 74   erPlatformResult
00010260  00 07 55 6E 69 66 69 65 64 49 6E 73 74 61 6C 6C   ..UnifiedInstall
00010270  65 72 50 6C 61 74 66 6F 72 6D 54 79 70 65 00 08   erPlatformType..
```

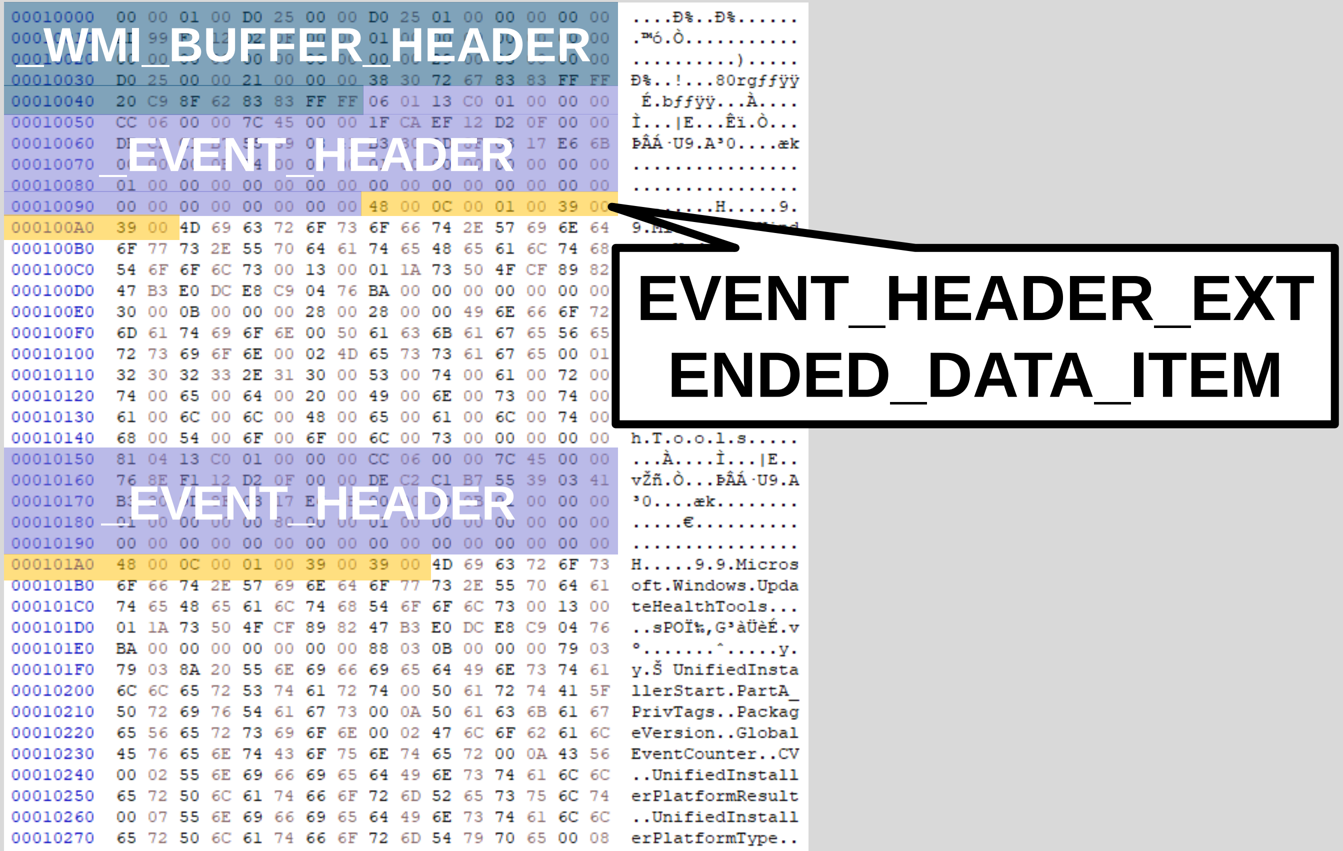
_EVENT_HEADER



```
Flags {
    EVENT_HEADER_FLAG_EXTENDED_INFO   = 0x01,
    EVENT_HEADER_FLAG_PRIVATE_SESSION = 0x02,
    EVENT_HEADER_FLAG_STRING_ONLY     = 0x04,
    EVENT_HEADER_FLAG_TRACE_MESSAGE   = 0x08,
    EVENT_HEADER_FLAG_NO_CPUTIME      = 0x10,
    EVENT_HEADER_FLAG_32_BIT_HEADER   = 0x20,
    EVENT_HEADER_FLAG_64_BIT_HEADER   = 0x40,
    EVENT_HEADER_FLAG_CLASSIC_HEADER  = 0x100,
    EVENT_HEADER_FLAG_PROCESSOR_INDEX = 0x200,
};
```

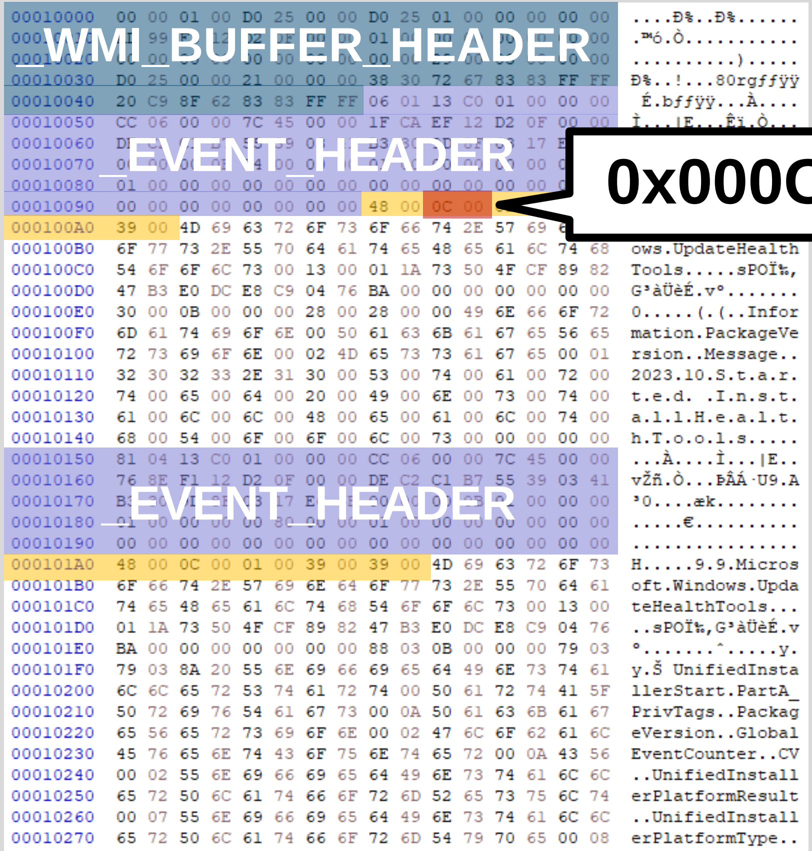
EVENT_HEADER_FLAG_EXTENDED_INFO adds 8 bytes of header after _EVENT_HEADER.

_EVENT_HEADER



```
00010000  00 00 01 00 D0 25 00 00 D0 25 01 00 00 00 00 00  ....Ð%..Ð%......
00010010  [illegible] 99 [illegible] 12 D2 0F 00 [illegible] 01 [illegible] 00  .™ó.Ò...........
00010020  [illegible] 00  ..........).....
00010030  D0 25 00 00 21 00 00 00 38 30 72 67 83 83 FF FF  Ð%..!...80rgƒƒÿÿ
00010040  20 C9 8F 62 83 83 FF FF 06 01 13 C0 01 00 00 00   É.bƒƒÿÿ...À....
00010050  CC 06 00 00 7C 45 00 00 1F CA EF 12 D2 0F 00 00  Ì...|E...Êï.Ò...
00010060  DE [illegible] 55 39 [illegible] B3 30 [illegible] 17 E6 6B  ÞÂÁ·U9.A³0....æk
00010070  [illegible] 00 00 00  ................
00010080  01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00010090  00 00 00 00 00 00 00 00 48 00 0C 00 01 00 39 00  ........H.....9.
000100A0  39 00 4D 69 63 72 6F 73 6F 66 74 2E 57 69 6E 64  9.Mi[illegible]
000100B0  6F 77 73 2E 55 70 64 61 74 65 48 65 61 6C 74 68  [illegible]
000100C0  54 6F 6F 6C 73 00 13 00 01 1A 73 50 4F CF 89 82  [illegible]
000100D0  47 B3 E0 DC E8 C9 04 76 BA 00 00 00 00 00 00 00  [illegible]
000100E0  30 00 0B 00 00 00 28 00 28 00 00 49 6E 66 6F 72  [illegible]
000100F0  6D 61 74 69 6F 6E 00 50 61 63 6B 61 67 65 56 65  [illegible]
00010100  72 73 69 6F 6E 00 02 4D 65 73 73 61 67 65 00 01  [illegible]
00010110  32 30 32 33 2E 31 30 00 53 00 74 00 61 00 72 00  [illegible]
00010120  74 00 65 00 64 00 20 00 49 00 6E 00 73 00 74 00  [illegible]
00010130  61 00 6C 00 6C 00 48 00 65 00 61 00 6C 00 74 00  [illegible]
00010140  68 00 54 00 6F 00 6F 00 6C 00 73 00 00 00 00 00  h.T.o.o.l.s.....
00010150  81 04 13 C0 01 00 00 00 CC 06 00 00 7C 45 00 00  ...À....Ì...|E..
00010160  76 8E F1 12 D2 0F 00 00 DE C2 C1 B7 55 39 03 41  vŽñ.Ò...ÞÂÁ·U9.A
00010170  B3 [illegible] 00 00 00  ³0....æk........
00010180  01 00 00 00 00 80 00 00 01 00 00 00 00 00 00 00  .....€..........
00010190  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
000101A0  48 00 0C 00 01 00 39 00 39 00 4D 69 63 72 6F 73  H.....9.9.Micros
000101B0  6F 66 74 2E 57 69 6E 64 6F 77 73 2E 55 70 64 61  oft.Windows.Upda
000101C0  74 65 48 65 61 6C 74 68 54 6F 6F 6C 73 00 13 00  teHealthTools...
000101D0  01 1A 73 50 4F CF 89 82 47 B3 E0 DC E8 C9 04 76  ..sPOÏ‰‚G³àÜèÉ.v
000101E0  BA 00 00 00 00 00 00 00 88 03 0B 00 00 00 79 03  º.......ˆ.....y.
000101F0  79 03 8A 20 55 6E 69 66 69 65 64 49 6E 73 74 61  y.Š UnifiedInsta
00010200  6C 6C 65 72 53 74 61 72 74 00 50 61 72 74 41 5F  llerStart.PartA_
00010210  50 72 69 76 54 61 67 73 00 0A 50 61 63 6B 61 67  PrivTags..Packag
00010220  65 56 65 72 73 69 6F 6E 00 02 47 6C 6F 62 61 6C  eVersion..Global
00010230  45 76 65 6E 74 43 6F 75 6E 74 65 72 00 0A 43 56  EventCounter..CV
00010240  00 02 55 6E 69 66 69 65 64 49 6E 73 74 61 6C 6C  ..UnifiedInstall
00010250  65 72 50 6C 61 74 66 6F 72 6D 52 65 73 75 6C 74  erPlatformResult
00010260  00 07 55 6E 69 66 69 65 64 49 6E 73 74 61 6C 6C  ..UnifiedInstall
00010270  65 72 50 6C 61 74 66 6F 72 6D 54 79 70 65 00 08  erPlatformType..
```

_EVENT_HEADER



0x000C: ExtType

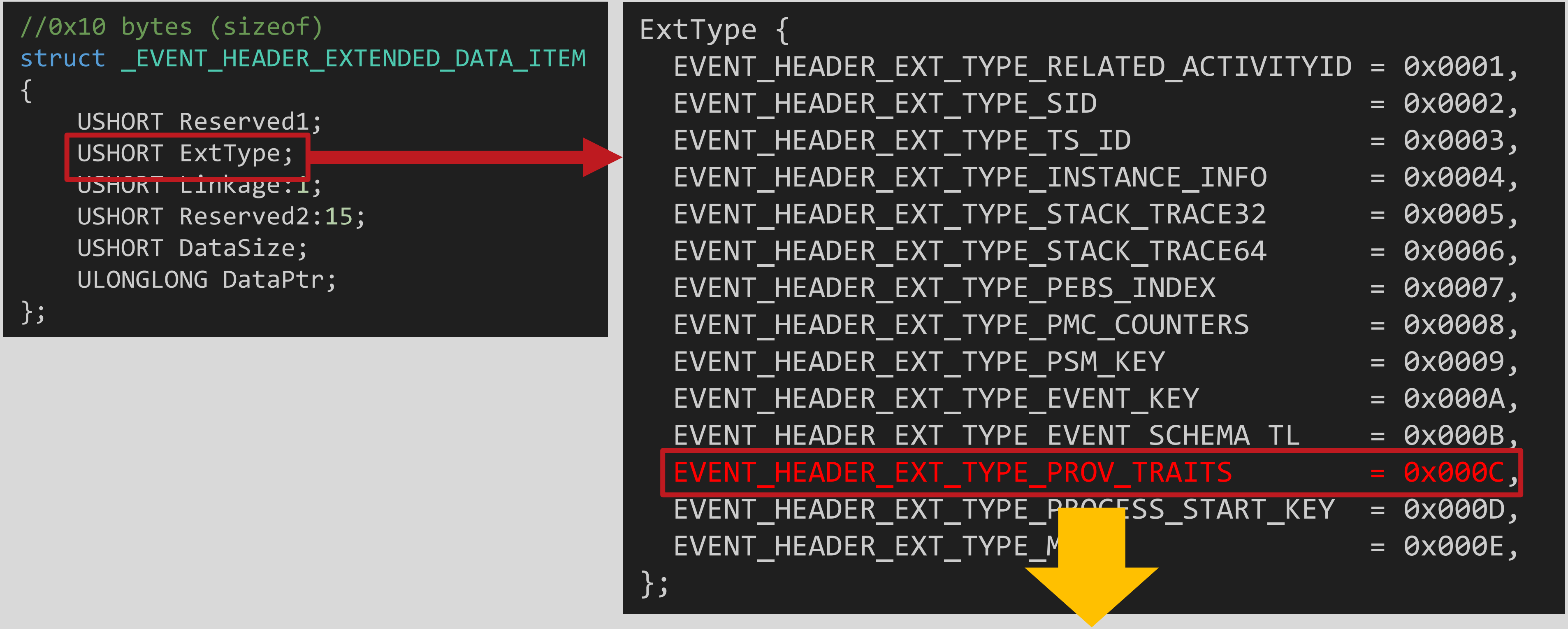
```
00010000  00 00 01 00 D0 25 00 00 D0 25 01 00 00 00 00 00  ....Ð%..Ð%......
00010010  [illegible] 99 F[illegible] 12 D2 0F 00 00 01 00 00 00 00 00 00 00  .™ó.Ò...........
00010020  00 00 00 00 00 00 00 00 00 00 29 00 00 00 00 00  ..........).....
00010030  D0 25 00 00 21 00 00 00 38 30 72 67 83 83 FF FF  Ð%..!...80rgƒƒÿÿ
00010040  20 C9 8F 62 83 83 FF FF 06 01 13 C0 01 00 00 00   É.bƒƒÿÿ...À....
00010050  CC 06 00 00 7C 45 00 00 1F CA EF 12 D2 0F 00 00  Ì...|E...Êï.Ò...
00010060  DE C2 C1 B7 55 39 03 41 B3 30 DD 8F 03 17 E[illegible]
00010070  00 00 00 0B [illegible] 00 00 00 00 00 0[illegible]
00010080  01 00 00 00 00 00 00 00 00 00 00 00 00 00 0[illegible]
00010090  00 00 00 00 00 00 00 00 48 00 0C 00 [illegible]
000100A0  39 00 4D 69 63 72 6F 73 6F 66 74 2E 57 69 6[illegible]
000100B0  6F 77 73 2E 55 70 64 61 74 65 48 65 61 6C 74 68  ows.UpdateHealth
000100C0  54 6F 6F 6C 73 00 13 00 01 1A 73 50 4F CF 89 82  Tools.....sPOÏ‰‚
000100D0  47 B3 E0 DC E8 C9 04 76 BA 00 00 00 00 00 00 00  G³àÜèÉ.vº.......
000100E0  30 00 0B 00 00 00 28 00 28 00 00 49 6E 66 6F 72  0.....(.(..Infor
000100F0  6D 61 74 69 6F 6E 00 50 61 63 6B 61 67 65 56 65  mation.PackageVe
00010100  72 73 69 6F 6E 00 02 4D 65 73 73 61 67 65 00 01  rsion..Message..
00010110  32 30 32 33 2E 31 30 00 53 00 74 00 61 00 72 00  2023.10.S.t.a.r.
00010120  74 00 65 00 64 00 20 00 49 00 6E 00 73 00 74 00  t.e.d. .I.n.s.t.
00010130  61 00 6C 00 6C 00 48 00 65 00 61 00 6C 00 74 00  a.l.l.H.e.a.l.t.
00010140  68 00 54 00 6F 00 6F 00 6C 00 73 00 00 00 00 00  h.T.o.o.l.s.....
00010150  81 04 13 C0 01 00 00 00 CC 06 00 00 7C 45 00 00  ...À....Ì...|E..
00010160  76 8E F1 12 D2 0F 00 00 DE C2 C1 B7 55 39 03 41  vŽñ.Ò...ÞÂÁ·U9.A
00010170  B3 [illegible] 00 00 00  ³0....æk........
00010180  01 00 00 00 00 80 00 00 01 00 00 00 00 00 00 00  .....€..........
00010190  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
000101A0  48 00 0C 00 01 00 39 00 39 00 4D 69 63 72 6F 73  H.....9.9.Micros
000101B0  6F 66 74 2E 57 69 6E 64 6F 77 73 2E 55 70 64 61  oft.Windows.Upda
000101C0  74 65 48 65 61 6C 74 68 54 6F 6F 6C 73 00 13 00  teHealthTools...
000101D0  01 1A 73 50 4F CF 89 82 47 B3 E0 DC E8 C9 04 76  ..sPOÏ‰‚G³àÜèÉ.v
000101E0  BA 00 00 00 00 00 00 00 88 03 0B 00 00 00 79 03  º.......ˆ.....y.
000101F0  79 03 8A 20 55 6E 69 66 69 65 64 49 6E 73 74 61  y.Š UnifiedInsta
00010200  6C 6C 65 72 53 74 61 72 74 00 50 61 72 74 41 5F  llerStart.PartA_
00010210  50 72 69 76 54 61 67 73 00 0A 50 61 63 6B 61 67  PrivTags..Packag
00010220  65 56 65 72 73 69 6F 6E 00 02 47 6C 6F 62 61 6C  eVersion..Global
00010230  45 76 65 6E 74 43 6F 75 6E 74 65 72 00 0A 43 56  EventCounter..CV
00010240  00 02 55 6E 69 66 69 65 64 49 6E 73 74 61 6C 6C  ..UnifiedInstall
00010250  65 72 50 6C 61 74 66 6F 72 6D 52 65 73 75 6C 74  erPlatformResult
00010260  00 07 55 6E 69 66 69 65 64 49 6E 73 74 61 6C 6C  ..UnifiedInstall
00010270  65 72 50 6C 61 74 66 6F 72 6D 54 79 70 65 00 08  erPlatformType..
```

_EVENT_HEADER_EXTENDED_DATA_ITEM

```
//0x10 bytes (sizeof)
struct _EVENT_HEADER_EXTENDED_DATA_ITEM
{
    USHORT Reserved1;
    USHORT ExtType;
    USHORT Linkage:1;
    USHORT Reserved2:15;
    USHORT DataSize;
    ULONGLONG DataPtr;
};
```

```
ExtType {
  EVENT_HEADER_EXT_TYPE_RELATED_ACTIVITYID = 0x0001,
  EVENT_HEADER_EXT_TYPE_SID                = 0x0002,
  EVENT_HEADER_EXT_TYPE_TS_ID              = 0x0003,
  EVENT_HEADER_EXT_TYPE_INSTANCE_INFO      = 0x0004,
  EVENT_HEADER_EXT_TYPE_STACK_TRACE32      = 0x0005,
  EVENT_HEADER_EXT_TYPE_STACK_TRACE64      = 0x0006,
  EVENT_HEADER_EXT_TYPE_PEBS_INDEX         = 0x0007,
  EVENT_HEADER_EXT_TYPE_PMC_COUNTERS       = 0x0008,
  EVENT_HEADER_EXT_TYPE_PSM_KEY            = 0x0009,
  EVENT_HEADER_EXT_TYPE_EVENT_KEY          = 0x000A,
  EVENT_HEADER_EXT_TYPE_EVENT_SCHEMA_TL    = 0x000B,
  EVENT_HEADER_EXT_TYPE_PROV_TRAITS        = 0x000C,
  EVENT_HEADER_EXT_TYPE_PROCESS_START_KEY  = 0x000D,
  EVENT_HEADER_EXT_TYPE_MAX                = 0x000E,
};
```

_EVENT_HEADER_EXTENDED_DATA_ITEM

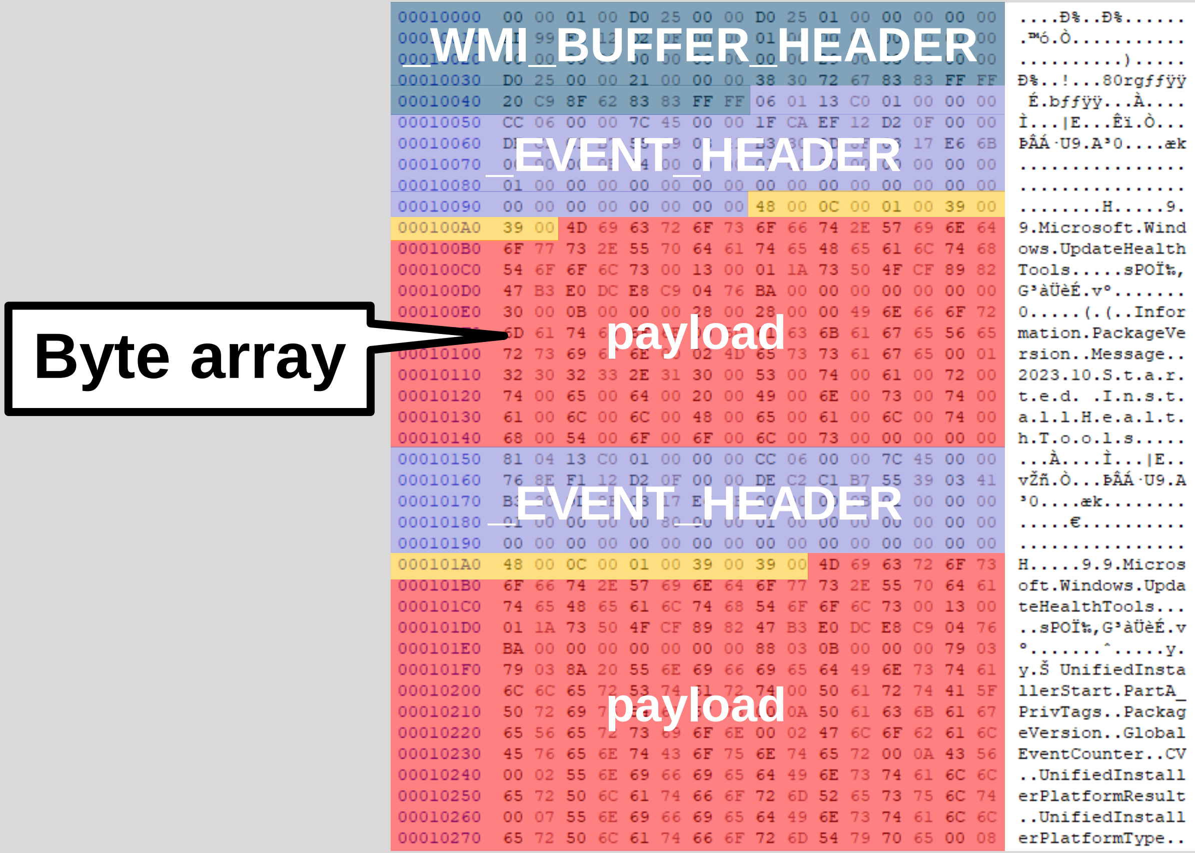


```
//0x10 bytes (sizeof)
struct _EVENT_HEADER_EXTENDED_DATA_ITEM
{
    USHORT Reserved1;
    USHORT ExtType;
    USHORT Linkage:1;
    USHORT Reserved2:15;
    USHORT DataSize;
    ULONGLONG DataPtr;
};
```

```
ExtType {
  EVENT_HEADER_EXT_TYPE_RELATED_ACTIVITYID = 0x0001,
  EVENT_HEADER_EXT_TYPE_SID                = 0x0002,
  EVENT_HEADER_EXT_TYPE_TS_ID              = 0x0003,
  EVENT_HEADER_EXT_TYPE_INSTANCE_INFO      = 0x0004,
  EVENT_HEADER_EXT_TYPE_STACK_TRACE32      = 0x0005,
  EVENT_HEADER_EXT_TYPE_STACK_TRACE64      = 0x0006,
  EVENT_HEADER_EXT_TYPE_PEBS_INDEX         = 0x0007,
  EVENT_HEADER_EXT_TYPE_PMC_COUNTERS       = 0x0008,
  EVENT_HEADER_EXT_TYPE_PSM_KEY            = 0x0009,
  EVENT_HEADER_EXT_TYPE_EVENT_KEY          = 0x000A,
  EVENT_HEADER_EXT_TYPE_EVENT_SCHEMA_TL    = 0x000B,
  EVENT_HEADER_EXT_TYPE_PROV_TRAITS        = 0x000C,
  EVENT_HEADER_EXT_TYPE_PROCESS_START_KEY  = 0x000D,
  EVENT_HEADER_EXT_TYPE_M                  = 0x000E,
};
```

byte array

_EVENT_HEADER



```
00010000  00 00 01 00 D0 25 00 00 D0 25 01 00 00 00 00 00  ....Ð%..Ð%......
00010010  [illegible] 99 [illegible] 12 D2 0F 00 [illegible] 01 [illegible] 00  .™ó.Ò...........
00010020  00 00 [illegible] 00 [illegible] 00  ..........).....
00010030  D0 25 00 00 21 00 00 00 38 30 72 67 83 83 FF FF  Ð%..!...80rgƒƒÿÿ
00010040  20 C9 8F 62 83 83 FF FF 06 01 13 C0 01 00 00 00   É.bƒƒÿÿ...À....
00010050  CC 06 00 00 7C 45 00 00 1F CA EF 12 D2 0F 00 00  Ì...|E...Êï.Ò...
00010060  DE [illegible] 55 39 [illegible] B3 30 [illegible] 17 E6 6B  ÞÂÁ·U9.A³0....æk
00010070  [illegible] 00 00 00  ................
00010080  01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00010090  00 00 00 00 00 00 00 00 48 00 0C 00 01 00 39 00  ........H.....9.
000100A0  39 00 4D 69 63 72 6F 73 6F 66 74 2E 57 69 6E 64  9.Microsoft.Wind
000100B0  6F 77 73 2E 55 70 64 61 74 65 48 65 61 6C 74 68  ows.UpdateHealth
000100C0  54 6F 6F 6C 73 00 13 00 01 1A 73 50 4F CF 89 82  Tools.....sPOÏ‰‚
000100D0  47 B3 E0 DC E8 C9 04 76 BA 00 00 00 00 00 00 00  G³àÜèÉ.vº.......
000100E0  30 00 0B 00 00 00 28 00 28 00 00 49 6E 66 6F 72  0.....(.(..Infor
000100F0  6D 61 74 [illegible] 63 6B 61 67 65 56 65  mation.PackageVe
00010100  72 73 69 [illegible] 02 4D 65 73 73 61 67 65 00 01  rsion..Message..
00010110  32 30 32 33 2E 31 30 00 53 00 74 00 61 00 72 00  2023.10.S.t.a.r.
00010120  74 00 65 00 64 00 20 00 49 00 6E 00 73 00 74 00  t.e.d. .I.n.s.t.
00010130  61 00 6C 00 6C 00 48 00 65 00 61 00 6C 00 74 00  a.l.l.H.e.a.l.t.
00010140  68 00 54 00 6F 00 6F 00 6C 00 73 00 00 00 00 00  h.T.o.o.l.s.....
00010150  81 04 13 C0 01 00 00 00 CC 06 00 00 7C 45 00 00  ...À....Ì...|E..
00010160  76 8E F1 12 D2 0F 00 00 DE C2 C1 B7 55 39 03 41  vŽñ.Ò...ÞÂÁ·U9.A
00010170  B3 [illegible] 00 00 00  ³0....æk........
00010180  01 00 00 00 00 80 00 00 01 00 00 00 00 00 00 00  .....€..........
00010190  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
000101A0  48 00 0C 00 01 00 39 00 39 00 4D 69 63 72 6F 73  H.....9.9.Micros
000101B0  6F 66 74 2E 57 69 6E 64 6F 77 73 2E 55 70 64 61  oft.Windows.Upda
000101C0  74 65 48 65 61 6C 74 68 54 6F 6F 6C 73 00 13 00  teHealthTools...
000101D0  01 1A 73 50 4F CF 89 82 47 B3 E0 DC E8 C9 04 76  ..sPOÏ‰‚G³àÜèÉ.v
000101E0  BA 00 00 00 00 00 00 00 88 03 0B 00 00 00 79 03  º.......ˆ.....y.
000101F0  79 03 8A 20 55 6E 69 66 69 65 64 49 6E 73 74 61  y.Š UnifiedInsta
00010200  6C 6C 65 72 53 74 61 72 74 00 50 61 72 74 41 5F  llerStart.PartA_
00010210  50 72 69 [illegible] 0A 50 61 63 6B 61 67  PrivTags..Packag
00010220  65 56 65 72 73 69 6F 6E 00 02 47 6C 6F 62 61 6C  eVersion..Global
00010230  45 76 65 6E 74 43 6F 75 6E 74 65 72 00 0A 43 56  EventCounter..CV
00010240  00 02 55 6E 69 66 69 65 64 49 6E 73 74 61 6C 6C  ..UnifiedInstall
00010250  65 72 50 6C 61 74 66 6F 72 6D 52 65 73 75 6C 74  erPlatformResult
00010260  00 07 55 6E 69 66 69 65 64 49 6E 73 74 61 6C 6C  ..UnifiedInstall
00010270  65 72 50 6C 61 74 66 6F 72 6D 54 79 70 65 00 08  erPlatformType..
```

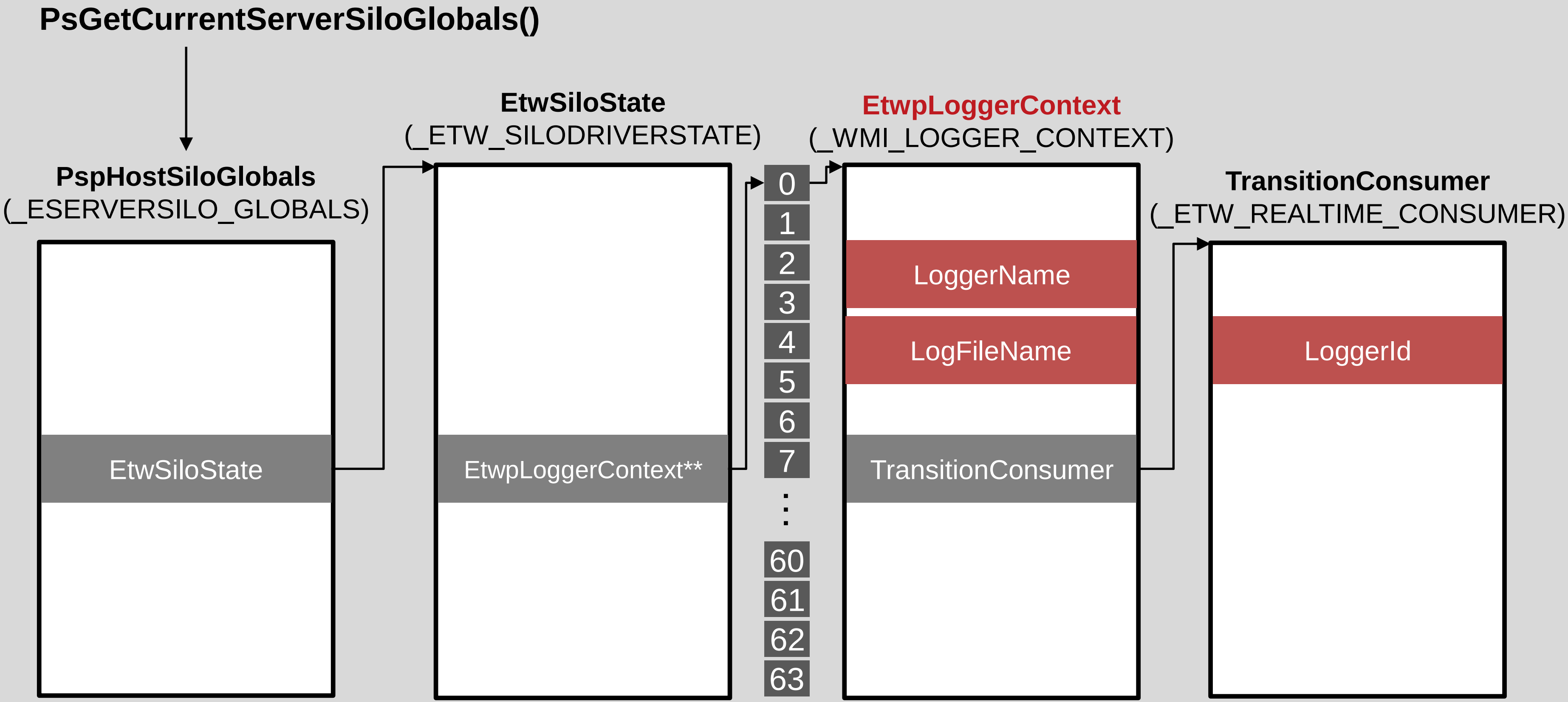
Tracing ETW from Structures

ETW data can be traced from **PspHostSiloGlobals** structure.

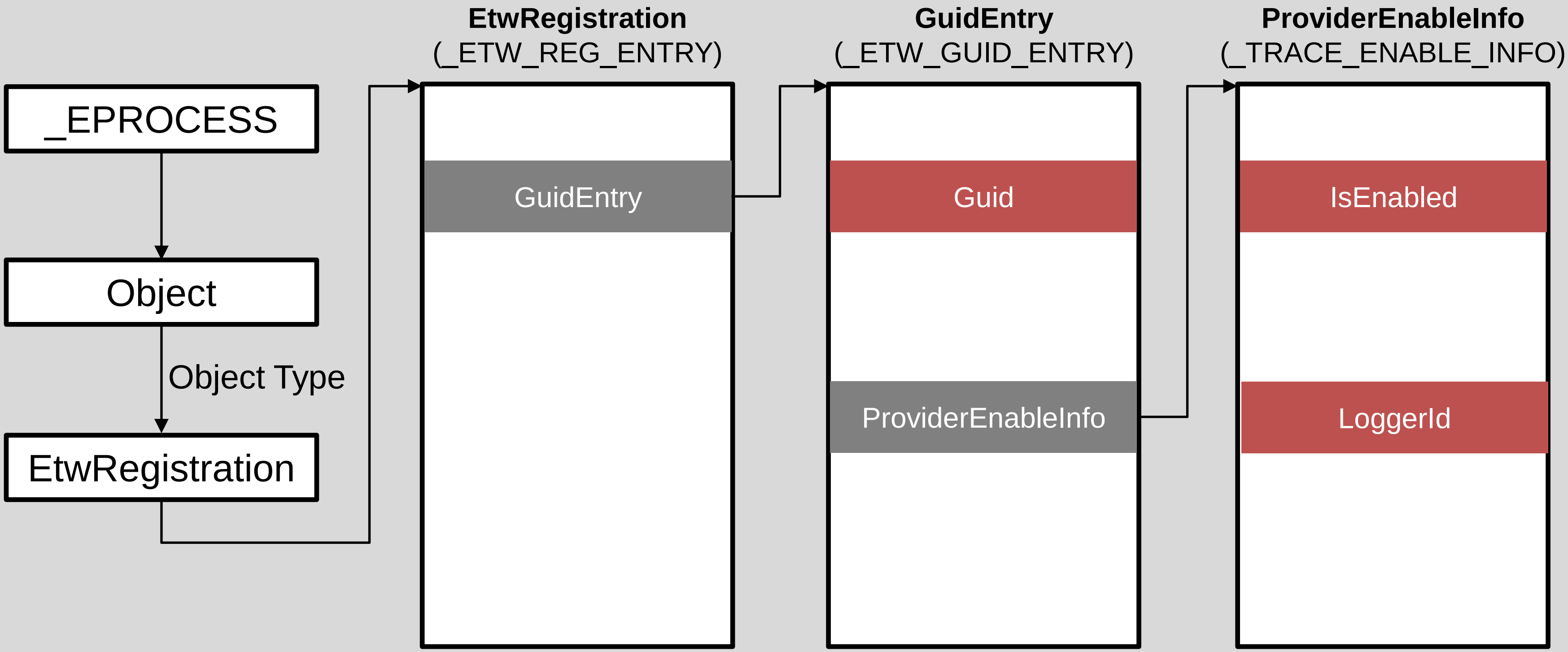
↓

PspHostSiloGlobals structure can be retrieved from the **PsGetCurrentServerSiloGlobals()** Windows API.

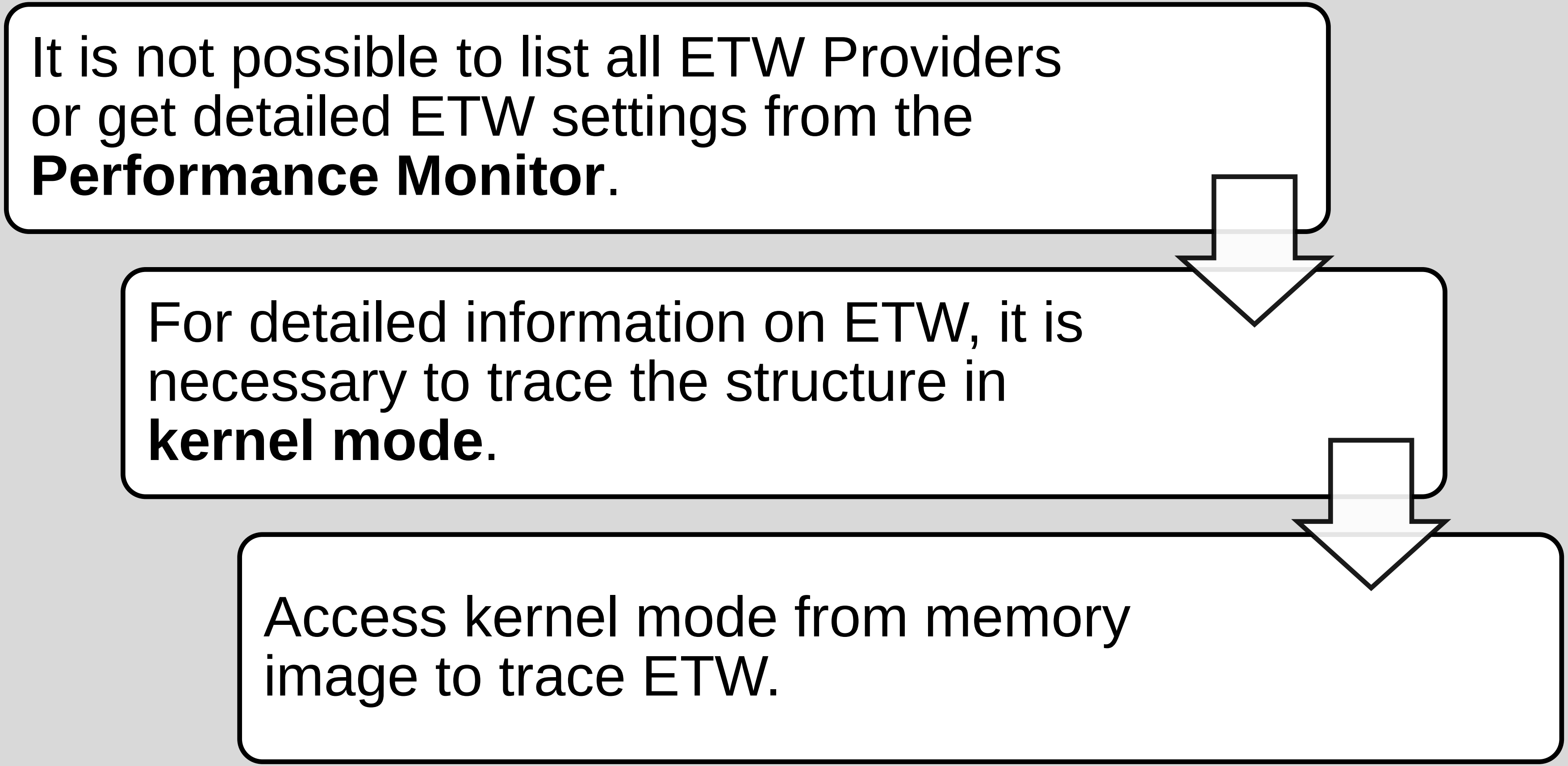
How to Get ETW Consumers from Structures



How to Get ETW Providers from Structures



ETW Data Structure



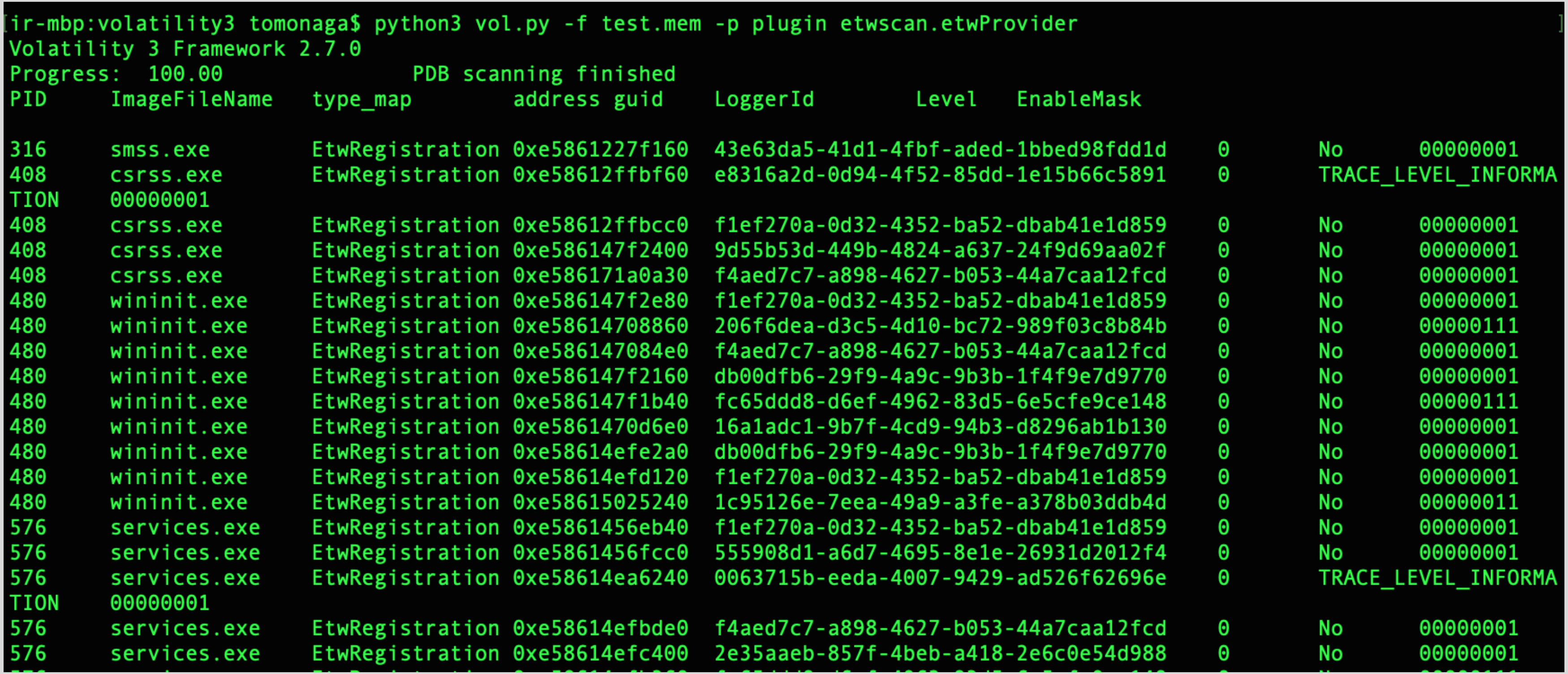
It is not possible to list all ETW Providers or get detailed ETW settings from the **Performance Monitor**.

For detailed information on ETW, it is necessary to trace the structure in **kernel mode**.

Access kernel mode from memory image to trace ETW.

Tracing ETW from Memory

Tracing ETW Providers using Volatility



```
[ir-mbp:volatility3 tomonaga$ python3 vol.py -f test.mem -p plugin etwscan.etwProvider
Volatility 3 Framework 2.7.0
Progress:  100.00               PDB scanning finished
PID     ImageFileName   type_map        address guid    LoggerId        Level   EnableMask

316     smss.exe        EtwRegistration 0xe5861227f160  43e63da5-41d1-4fbf-aded-1bbed98fdd1d    0       No      00000001
408     csrss.exe       EtwRegistration 0xe58612ffbf60  e8316a2d-0d94-4f52-85dd-1e15b66c5891    0       TRACE_LEVEL_INFORMA
TION    00000001
408     csrss.exe       EtwRegistration 0xe58612ffbcc0  f1ef270a-0d32-4352-ba52-dbab41e1d859    0       No      00000001
408     csrss.exe       EtwRegistration 0xe586147f2400  9d55b53d-449b-4824-a637-24f9d69aa02f    0       No      00000001
408     csrss.exe       EtwRegistration 0xe586171a0a30  f4aed7c7-a898-4627-b053-44a7caa12fcd    0       No      00000001
480     wininit.exe     EtwRegistration 0xe586147f2e80  f1ef270a-0d32-4352-ba52-dbab41e1d859    0       No      00000001
480     wininit.exe     EtwRegistration 0xe58614708860  206f6dea-d3c5-4d10-bc72-989f03c8b84b    0       No      00000111
480     wininit.exe     EtwRegistration 0xe586147084e0  f4aed7c7-a898-4627-b053-44a7caa12fcd    0       No      00000001
480     wininit.exe     EtwRegistration 0xe586147f2160  db00dfb6-29f9-4a9c-9b3b-1f4f9e7d9770    0       No      00000001
480     wininit.exe     EtwRegistration 0xe586147f1b40  fc65ddd8-d6ef-4962-83d5-6e5cfe9ce148    0       No      00000111
480     wininit.exe     EtwRegistration 0xe5861470d6e0  16a1adc1-9b7f-4cd9-94b3-d8296ab1b130    0       No      00000001
480     wininit.exe     EtwRegistration 0xe58614efe2a0  db00dfb6-29f9-4a9c-9b3b-1f4f9e7d9770    0       No      00000001
480     wininit.exe     EtwRegistration 0xe58614efd120  f1ef270a-0d32-4352-ba52-dbab41e1d859    0       No      00000001
480     wininit.exe     EtwRegistration 0xe58615025240  1c95126e-7eea-49a9-a3fe-a378b03ddb4d    0       No      00000011
576     services.exe    EtwRegistration 0xe5861456eb40  f1ef270a-0d32-4352-ba52-dbab41e1d859    0       No      00000001
576     services.exe    EtwRegistration 0xe5861456fcc0  555908d1-a6d7-4695-8e1e-26931d2012f4    0       No      00000001
576     services.exe    EtwRegistration 0xe58614ea6240  0063715b-eeda-4007-9429-ad526f62696e    0       TRACE_LEVEL_INFORMA
TION    00000001
576     services.exe    EtwRegistration 0xe58614efbde0  f4aed7c7-a898-4627-b053-44a7caa12fcd    0       No      00000001
576     services.exe    EtwRegistration 0xe58614efc400  2e35aaeb-857f-4beb-a418-2e6c0e54d988    0       No      00000001
```

What is Volatility Framework?

The Volatility Framework was developed as an **open-source memory forensics tool** written in Python.

This tool is the **de facto standard** for memory forensics.

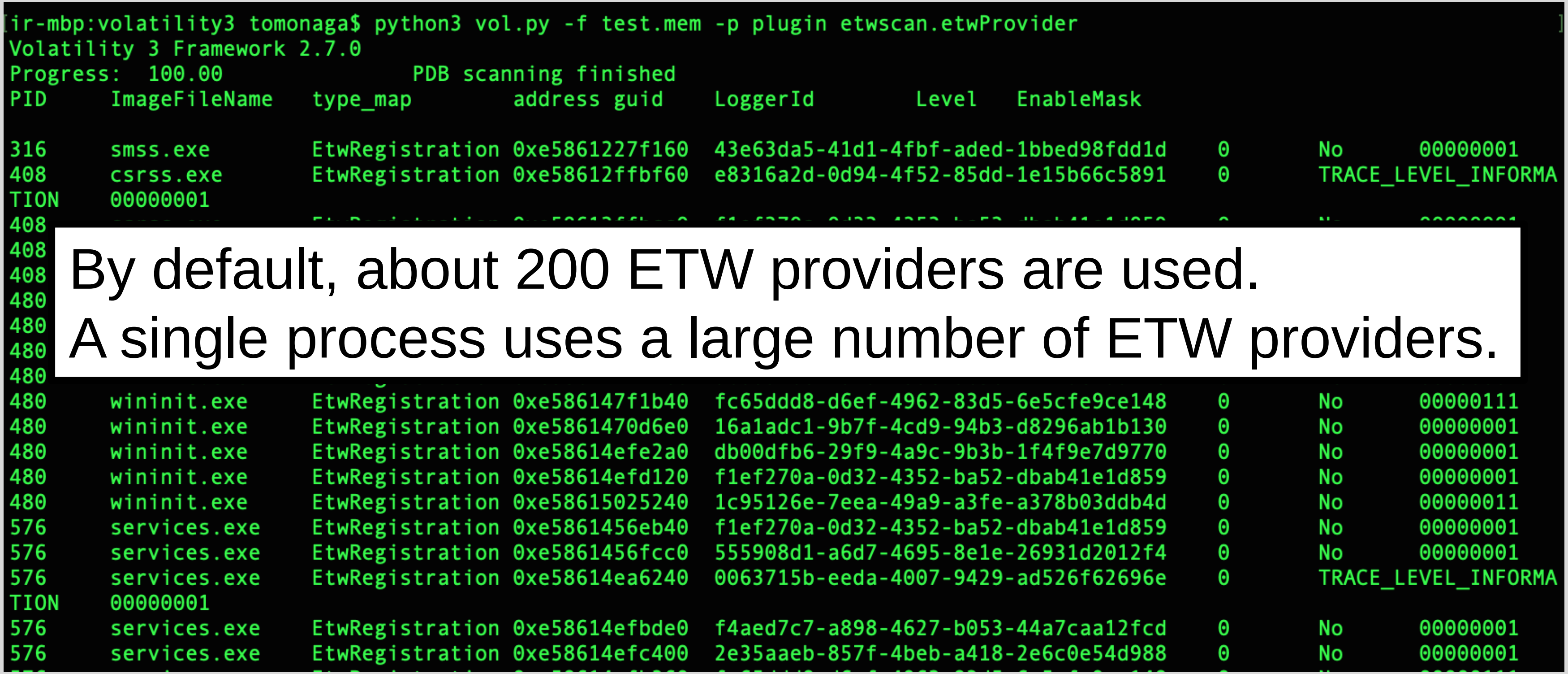
How to Use

```
$ git clone https://github.com/volatilityfoundation/volatility3.git
$ cd volatility3
$ pip3 install -r requirements.txt
$ python3 vol.py -f test.mem windows.info
```

https://volatilityfoundation.org/

Tracing ETW from Memory

Tracing ETW Providers using Volatility

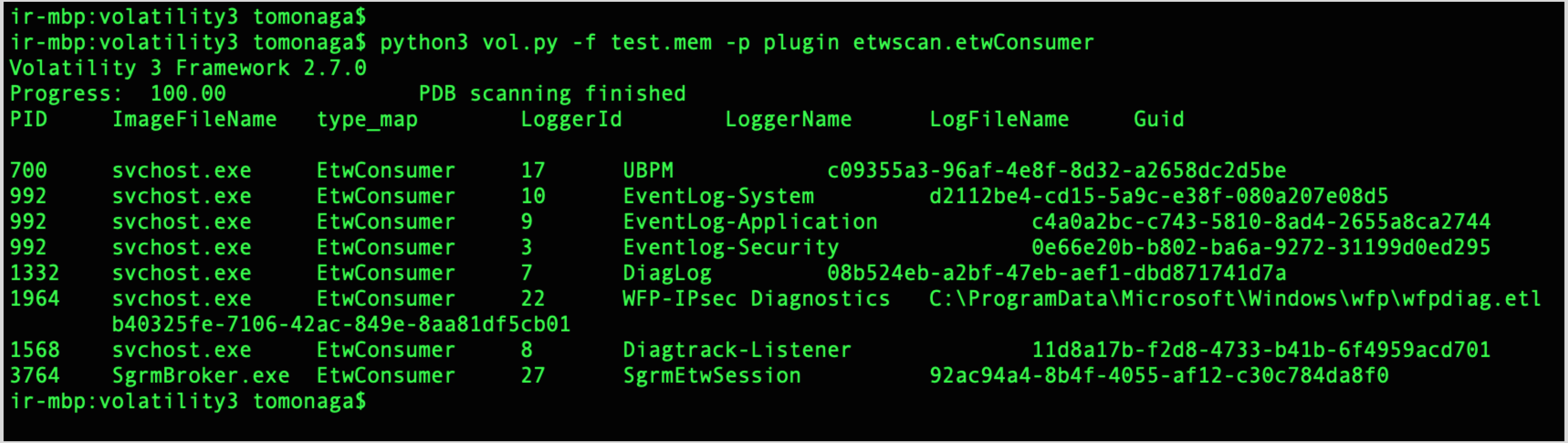


```
ir-mbp:volatility3 tomonaga$ python3 vol.py -f test.mem -p plugin etwscan.etwProvider
Volatility 3 Framework 2.7.0
Progress:  100.00               PDB scanning finished
PID     ImageFileName   type_map        address guid    LoggerId        Level   EnableMask

316     smss.exe        EtwRegistration 0xe5861227f160  43e63da5-41d1-4fbf-aded-1bbed98fdd1d    0       No      00000001
408     csrss.exe       EtwRegistration 0xe58612ffbf60  e8316a2d-0d94-4f52-85dd-1e15b66c5891    0       TRACE_LEVEL_INFORMA
TION    00000001
408
408
408
480
480
480
480
480     wininit.exe     EtwRegistration 0xe586147f1b40  fc65ddd8-d6ef-4962-83d5-6e5cfe9ce148    0       No      00000111
480     wininit.exe     EtwRegistration 0xe5861470d6e0  16a1adc1-9b7f-4cd9-94b3-d8296ab1b130    0       No      00000001
480     wininit.exe     EtwRegistration 0xe58614efe2a0  db00dfb6-29f9-4a9c-9b3b-1f4f9e7d9770    0       No      00000001
480     wininit.exe     EtwRegistration 0xe58614efd120  f1ef270a-0d32-4352-ba52-dbab41e1d859    0       No      00000001
480     wininit.exe     EtwRegistration 0xe58615025240  1c95126e-7eea-49a9-a3fe-a378b03ddb4d    0       No      00000011
576     services.exe    EtwRegistration 0xe5861456eb40  f1ef270a-0d32-4352-ba52-dbab41e1d859    0       No      00000001
576     services.exe    EtwRegistration 0xe5861456fcc0  555908d1-a6d7-4695-8e1e-26931d2012f4    0       No      00000001
576     services.exe    EtwRegistration 0xe58614ea6240  0063715b-eeda-4007-9429-ad526f62696e    0       TRACE_LEVEL_INFORMA
TION    00000001
576     services.exe    EtwRegistration 0xe58614efbde0  f4aed7c7-a898-4627-b053-44a7caa12fcd    0       No      00000001
576     services.exe    EtwRegistration 0xe58614efc400  2e35aaeb-857f-4beb-a418-2e6c0e54d988    0       No      00000001
```

By default, about 200 ETW providers are used.
A single process uses a large number of ETW providers.

Tracing ETW from Memory

Tracing ETW Consumer using Volatility

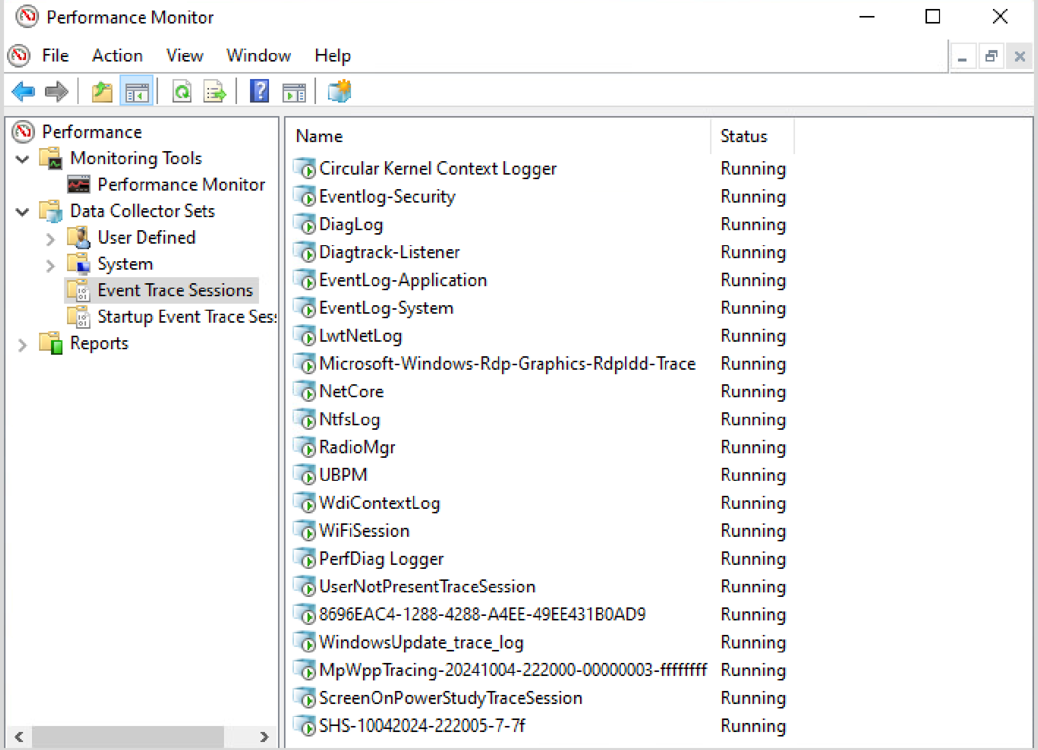


```
ir-mbp:volatility3 tomonaga$
ir-mbp:volatility3 tomonaga$ python3 vol.py -f test.mem -p plugin etwscan.etwConsumer
Volatility 3 Framework 2.7.0
Progress:  100.00               PDB scanning finished
PID     ImageFileName   type_map        LoggerId        LoggerName      LogFileName     Guid

700     svchost.exe     EtwConsumer     17      UBPM            c09355a3-96af-4e8f-8d32-a2658dc2d5be
992     svchost.exe     EtwConsumer     10      EventLog-System         d2112be4-cd15-5a9c-e38f-080a207e08d5
992     svchost.exe     EtwConsumer     9       EventLog-Application            c4a0a2bc-c743-5810-8ad4-2655a8ca2744
992     svchost.exe     EtwConsumer     3       Eventlog-Security               0e66e20b-b802-ba6a-9272-31199d0ed295
1332    svchost.exe     EtwConsumer     7       DiagLog         08b524eb-a2bf-47eb-aef1-dbd871741d7a
1964    svchost.exe     EtwConsumer     22      WFP-IPsec Diagnostics   C:\ProgramData\Microsoft\Windows\wfp\wfpdiag.etl
        b40325fe-7106-42ac-849e-8aa81df5cb01
1568    svchost.exe     EtwConsumer     8       Diagtrack-Listener              11d8a17b-f2d8-4733-b41b-6f4959acd701
3764    SgrmBroker.exe  EtwConsumer     27      SgrmEtwSession          92ac94a4-8b4f-4055-af12-c30c784da8f0
ir-mbp:volatility3 tomonaga$
```

All ETW settings(including undocument) can be traced from the memory image.

EDR/AV using ETW

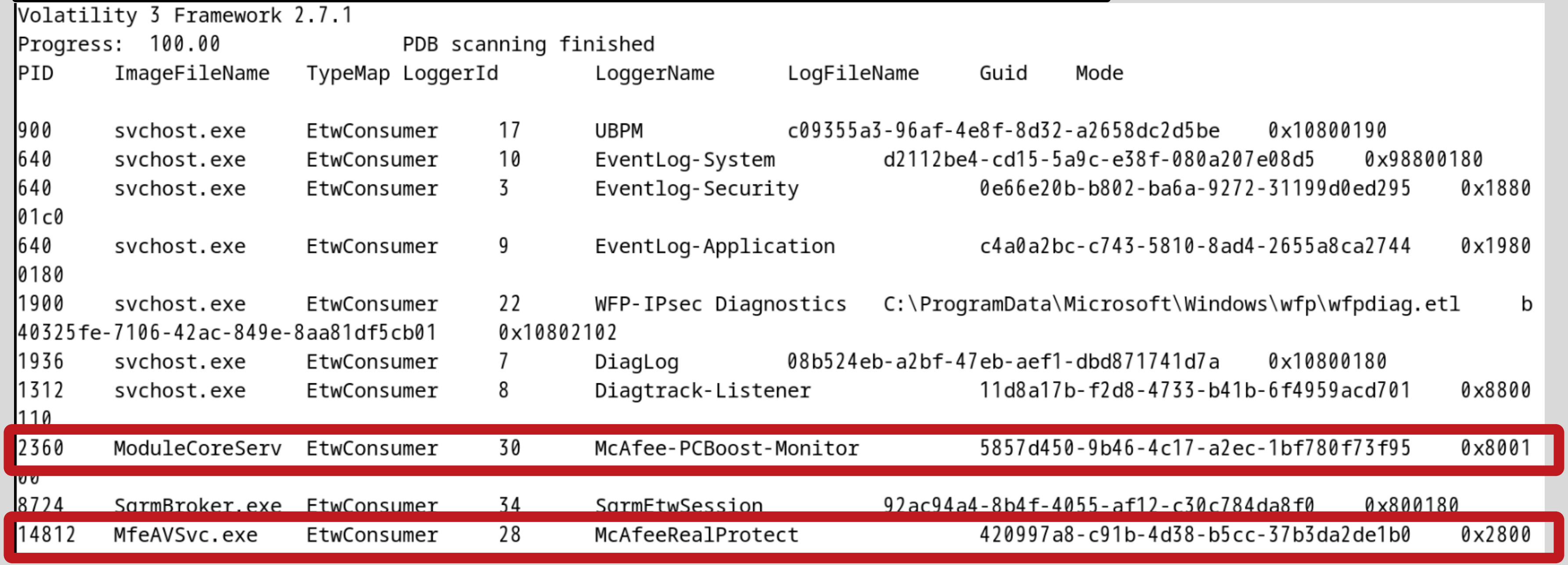
Where is the ETW session for EDR/AV?



Name	Status
Circular Kernel Context Logger	Running
Eventlog-Security	Running
DiagLog	Running
Diagtrack-Listener	Running
EventLog-Application	Running
EventLog-System	Running
LwtNetLog	Running
Microsoft-Windows-Rdp-Graphics-RdpIdd-Trace	Running
NetCore	Running
NtfsLog	Running
RadioMgr	Running
UBPM	Running
WdiContextLog	Running
WiFiSession	Running
PerfDiag Logger	Running
UserNotPresentTraceSession	Running
8696EAC4-1288-4288-A4EE-49EE431B0AD9	Running
WindowsUpdate_trace_log	Running
MpWppTracing-20241004-222000-00000003-ffffffff	Running
ScreenOnPowerStudyTraceSession	Running
SHS-10042024-222005-7-7f	Running

EDR/AV using ETW

Where is the ETW session for EDR/AV?



```
Volatility 3 Framework 2.7.1
Progress:  100.00               PDB scanning finished
PID     ImageFileName   TypeMap LoggerId        LoggerName      LogFileName     Guid    Mode

900     svchost.exe     EtwConsumer     17      UBPM            c09355a3-96af-4e8f-8d32-a2658dc2d5be    0x10800190
640     svchost.exe     EtwConsumer     10      EventLog-System         d2112be4-cd15-5a9c-e38f-080a207e08d5    0x98800180
640     svchost.exe     EtwConsumer     3       Eventlog-Security               0e66e20b-b802-ba6a-9272-31199d0ed295    0x1880
01c0
640     svchost.exe     EtwConsumer     9       EventLog-Application            c4a0a2bc-c743-5810-8ad4-2655a8ca2744    0x1980
0180
1900    svchost.exe     EtwConsumer     22      WFP-IPsec Diagnostics   C:\ProgramData\Microsoft\Windows\wfp\wfpdiag.etl      b
40325fe-7106-42ac-849e-8aa81df5cb01     0x10802102
1936    svchost.exe     EtwConsumer     7       DiagLog         08b524eb-a2bf-47eb-aef1-dbd871741d7a    0x10800180
1312    svchost.exe     EtwConsumer     8       Diagtrack-Listener              11d8a17b-f2d8-4733-b41b-6f4959acd701    0x8800
110
2360    ModuleCoreServ  EtwConsumer     30      McAfee-PCBoost-Monitor          5857d450-9b46-4c17-a2ec-1bf780f73f95    0x8001
00
8724    SgrmBroker.exe  EtwConsumer     34      SgrmEtwSession          92ac94a4-8b4f-4055-af12-c30c784da8f0    0x800180
14812   MfeAVSvc.exe    EtwConsumer     28      McAfeeRealProtect               420997a8-c91b-4d38-b5cc-37b3da2de1b0    0x2800
```

EDR/AV ETW sessions can only be checked from **memory forensics** or kernel mode.

AV ETW Session List

Microsoft Defender

- DefenderAuditLogger
- DefenderApiLogger

Kaspersky

- 28E38D72-F060-45EB-B3AE-CAD4834C3A1C
- Eventlog-Security
- {6A7019B4-156F-4092-BC31-828DFA159B56}

ESET

- Eset-Windows-Audit-CVE
- Eset-Threat-Intelligence-Session

McAfee

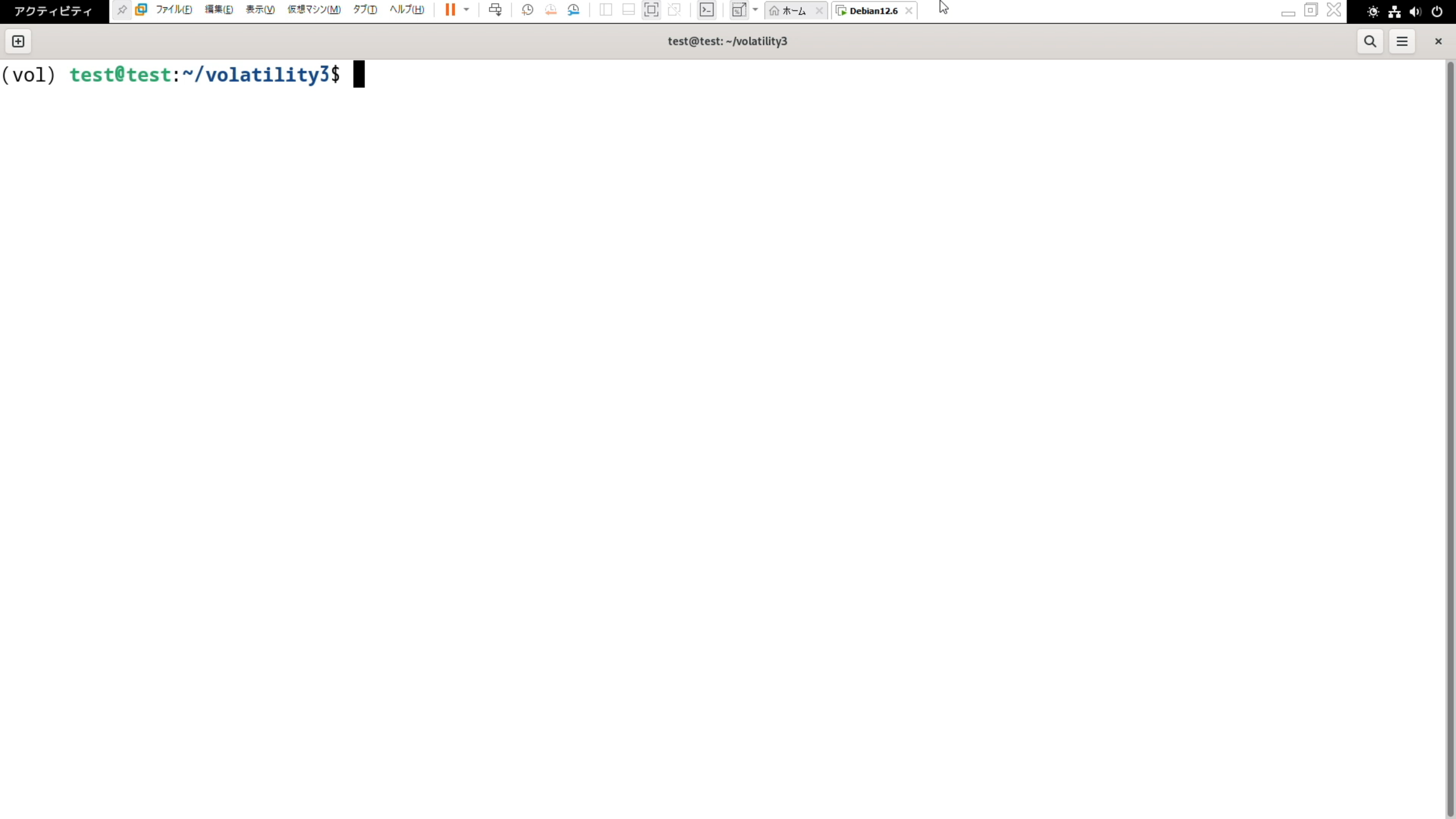
- McAfee-PCBoost-Monitor McAfeeRealProtect
- McAfee-Mmss
- McAfee.{E4367DA7-2B80-47f3-86D2-7626A18FC6F4}
- CSP.{02063ec6-2498-4fff-a32f-d3d693784a18}

EDR ETW Session List

Cylance

- CR_AP_TRACE_SESSION_EX3
- CR_AP_TRACE_SESSION_EX2
- CR_AP_TRACE_SESSION_EX
- CR_AP_TRACE_SESSION
- [Random Logger Name]

Demo



```
(vol) test@test:~/volatility3$ 
```

Presentation Topics

1 What is ETW?

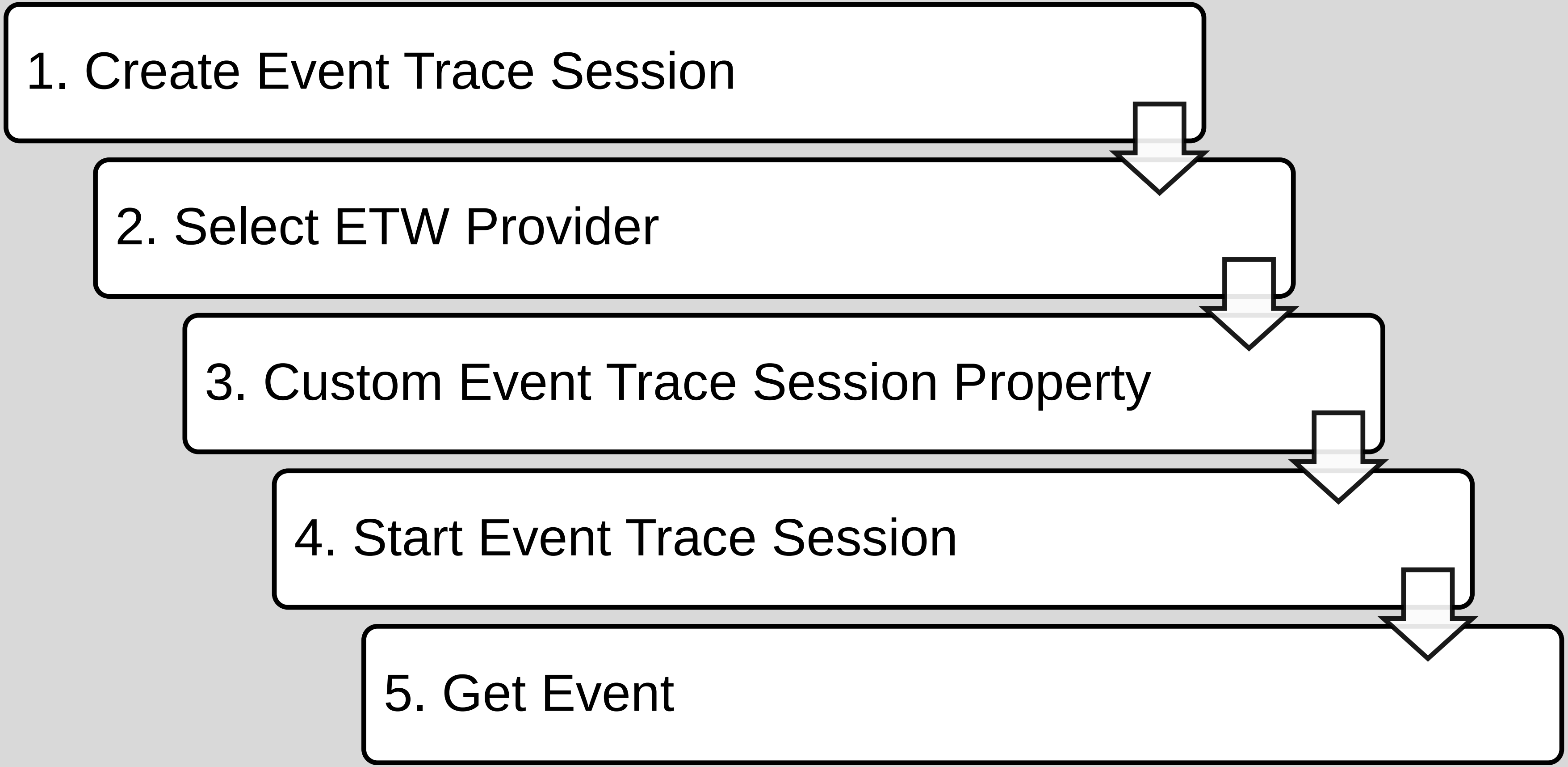
2 ETW Internals

3 ETW using Incident Response

4 Attack Surface

5 Mitigation and Detection

How to Get New ETW Event



1. Create Event Trace Session

2. Select ETW Provider

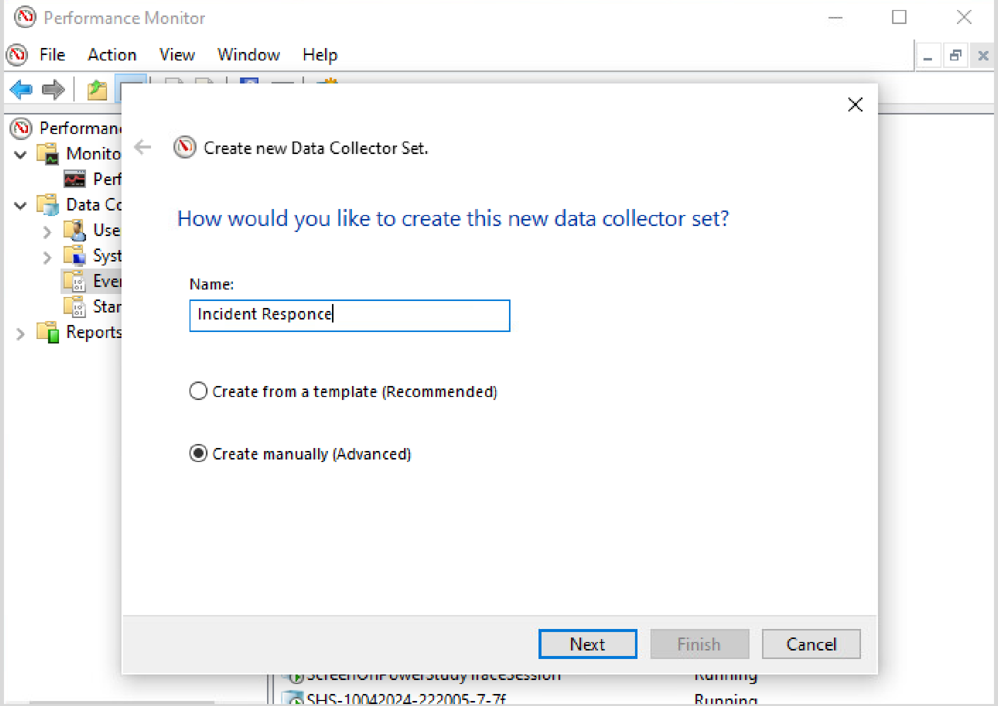
3. Custom Event Trace Session Property

4. Start Event Trace Session

5. Get Event

1. Create Event Trace Session

Performance Monitor (perfmon) > Data Collector Set > Event Trace Sessions > New(Data Collector Set)



Create new Data Collector Set.

How would you like to create this new data collector set?

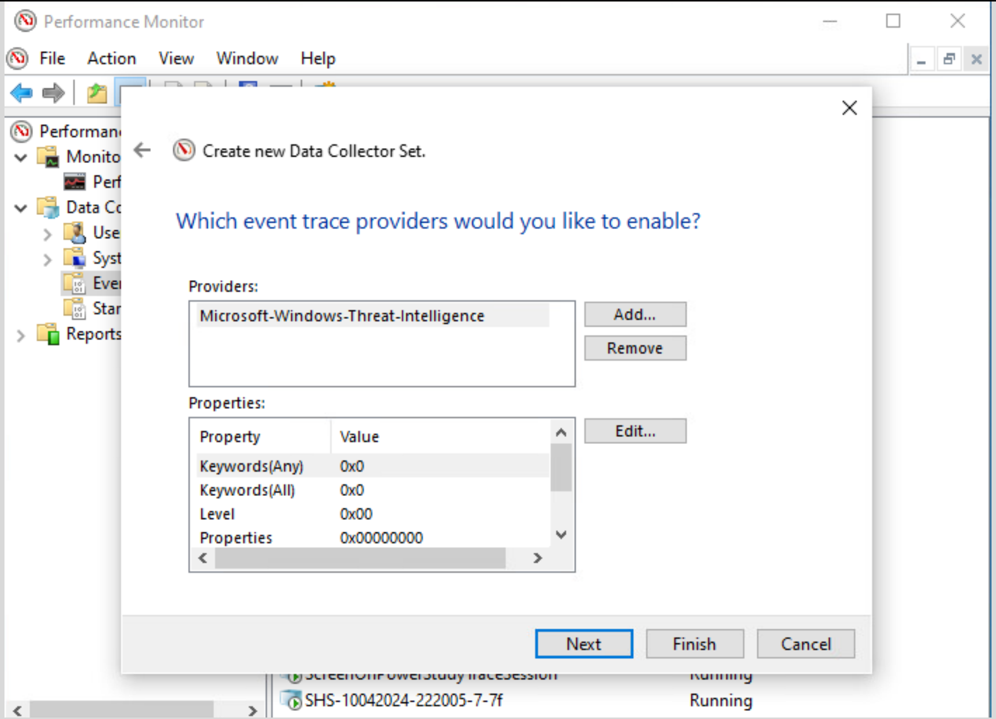
Name: Incident Responce

○ Create from a template (Recommended)

● Create manually (Advanced)

2. Select ETW Provider

Performance Monitor (perfmon) > Data Collector Set > Event Trace Sessions > New(Data Collector Set)



Create new Data Collector Set.

Which event trace providers would you like to enable?

Providers:

Microsoft-Windows-Threat-Intelligence

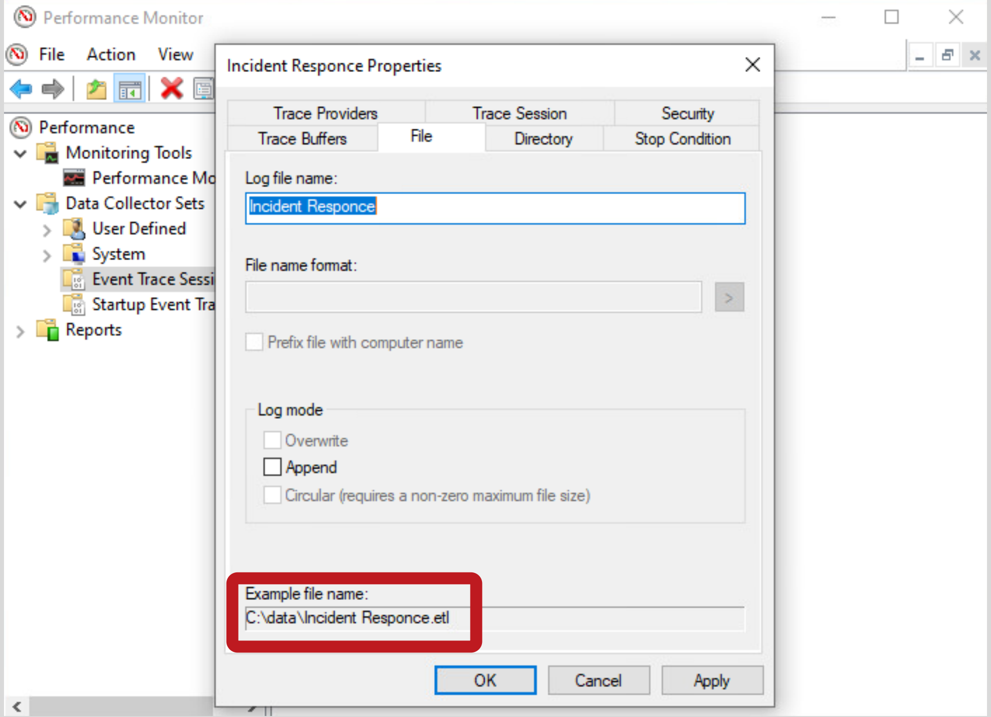
Properties:

Property	Value
Keywords(Any)	0x0
Keywords(All)	0x0
Level	0x00
Properties	0x00000000

ScreenOnPowerStudyTraceSession Running
SHS-10042024-222005-7-7f Running

3. Custom Event Trace Session Property

Property > File > Log File Name



Log file name: Incident Responce

File name format:

□ Prefix file with computer name

Log mode

□ Overwrite

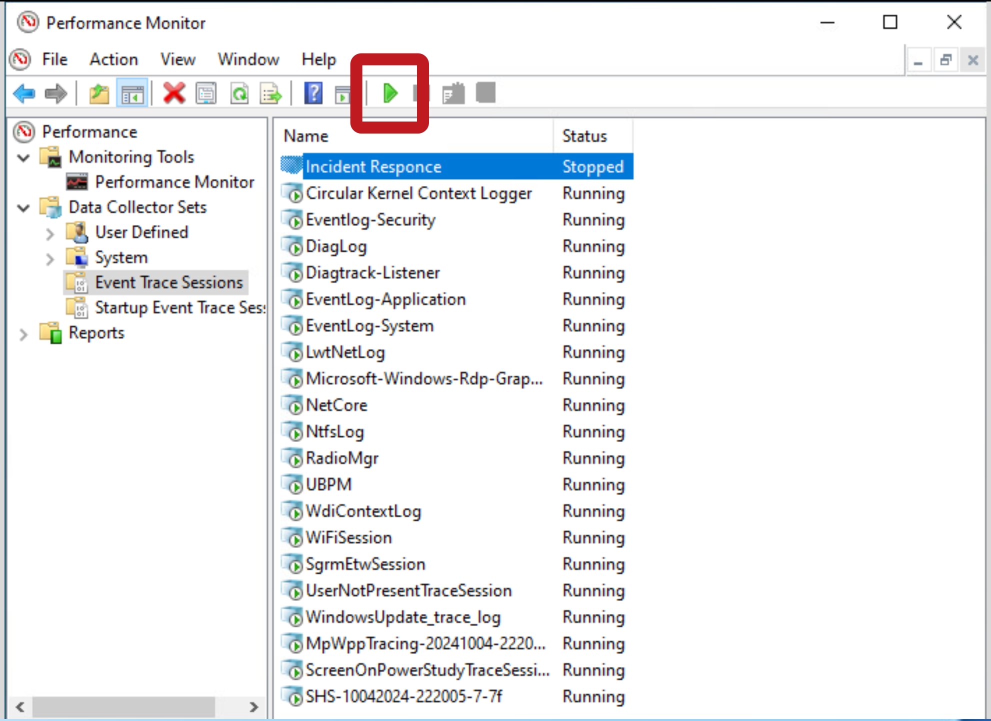
□ Append

□ Circular (requires a non-zero maximum file size)

Example file name:
C:\data\Incident Responce.etl

4. Start Event Trace Session

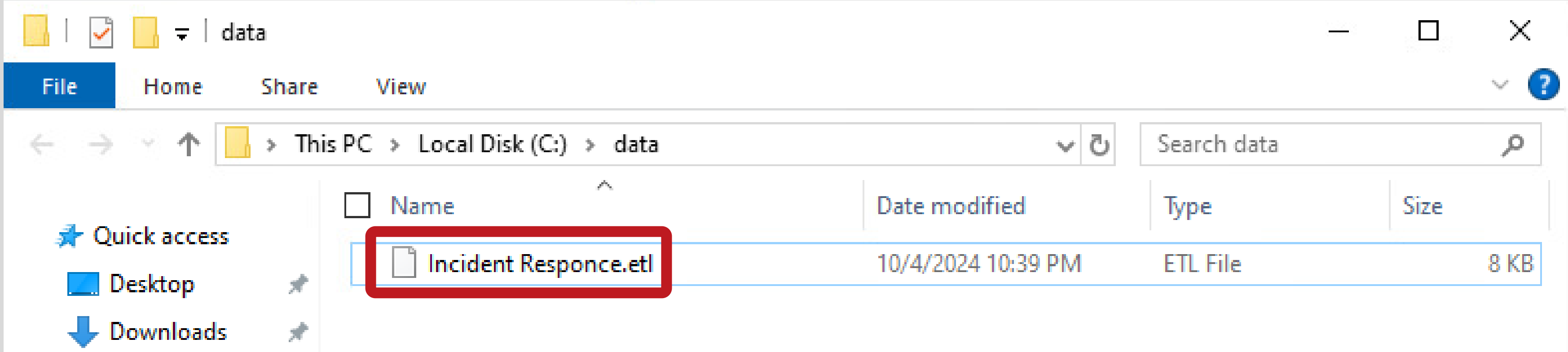
Menu bar > Start



- Performance
  - Monitoring Tools
    - Performance Monitor
  - Data Collector Sets
    - User Defined
    - System
    - Event Trace Sessions
    - Startup Event Trace Ses:
  - Reports

Name	Status
Incident Responce	Stopped
Circular Kernel Context Logger	Running
Eventlog-Security	Running
DiagLog	Running
Diagtrack-Listener	Running
EventLog-Application	Running
EventLog-System	Running
LwtNetLog	Running
Microsoft-Windows-Rdp-Grap...	Running
NetCore	Running
NtfsLog	Running
RadioMgr	Running
UBPM	Running
WdiContextLog	Running
WiFiSession	Running
SgrmEtwSession	Running
UserNotPresentTraceSession	Running
WindowsUpdate_trace_log	Running
MpWppTracing-20241004-2220...	Running
ScreenOnPowerStudyTraceSessi...	Running
SHS-10042024-222005-7-7f	Running

5. Get Event



Name	Date modified	Type	Size
Incident Responce.etl	10/4/2024 10:39 PM	ETL File	8 KB

ETW to EVTX

```
tracerpt MyFile.etl -o MyFile.etl.evtx -of EVTX -lr
```

ETW to JSON

```
ETW2JSON MyFile.etl MyFile.Kernel.etl --output=MyFile.json
```

https://github.com/microsoft/ETW2JSON

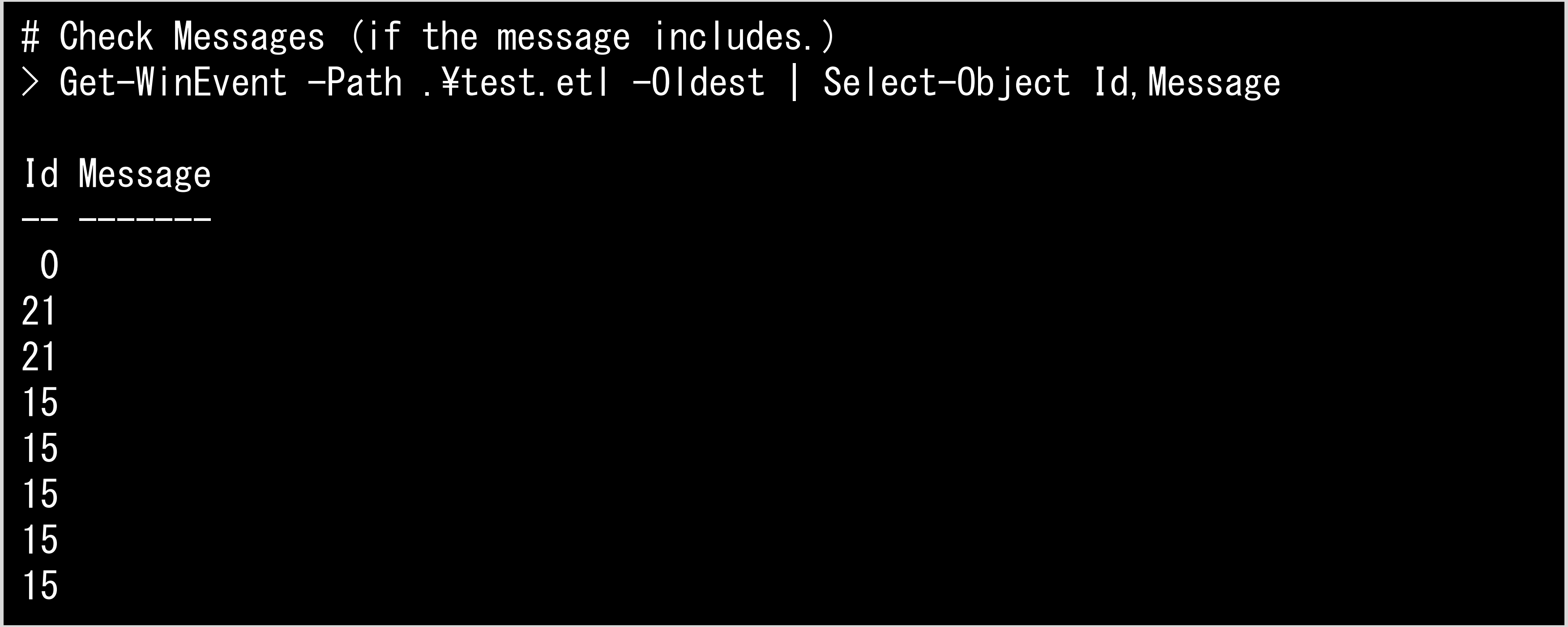
How to Analysis ETW using PowerShell

Get-WinEvent can parse ETL files as well as EVTX.

```
# Check Messages (if the message includes.)
> Get-WinEvent -Path .¥test.etl -Oldest | Select-Object Id,Message

Id Message
-- -------
 0
 7 Base CPU priority of thread 14308 in process 4148 was changed from 8 t...
 7 Base CPU priority of thread 14308 in process 4148 was changed from 9 t...
 3 Thread 8892 (in Process 4148) started.
 3 Thread 15972 (in Process 4148) started.
 3 Thread 9956 (in Process 4148) started.
 3 Thread 9152 (in Process 4148) started.
 3 Thread 12444 (in Process 4148) started.
```

How to Analysis ETW using PowerShell

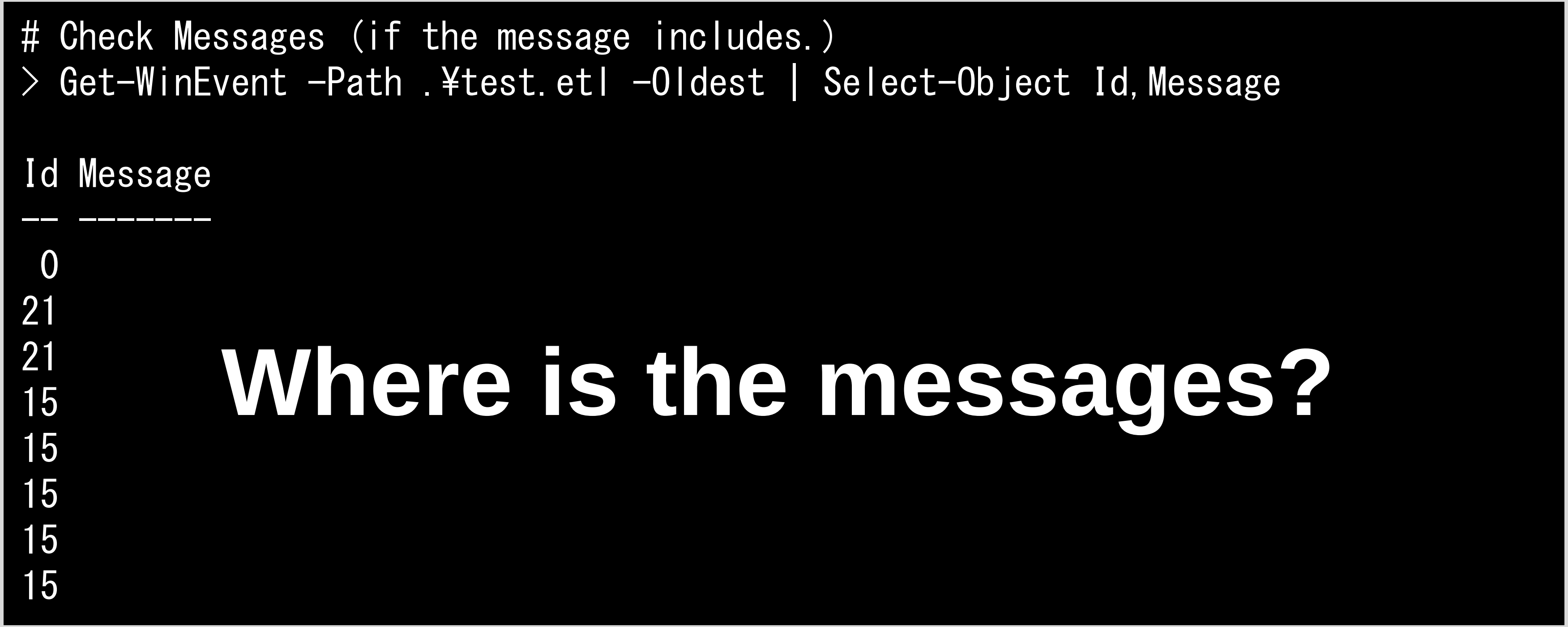
Get-WinEvent can parse ETL files as well as EVTX.



```
# Check Messages (if the message includes.)
> Get-WinEvent -Path .¥test.etl -Oldest | Select-Object Id,Message

Id Message
-- -------
 0
21
21
15
15
15
15
15
```

How to Analysis ETW using PowerShell

Get-WinEvent can parse ETL files as well as EVTX.

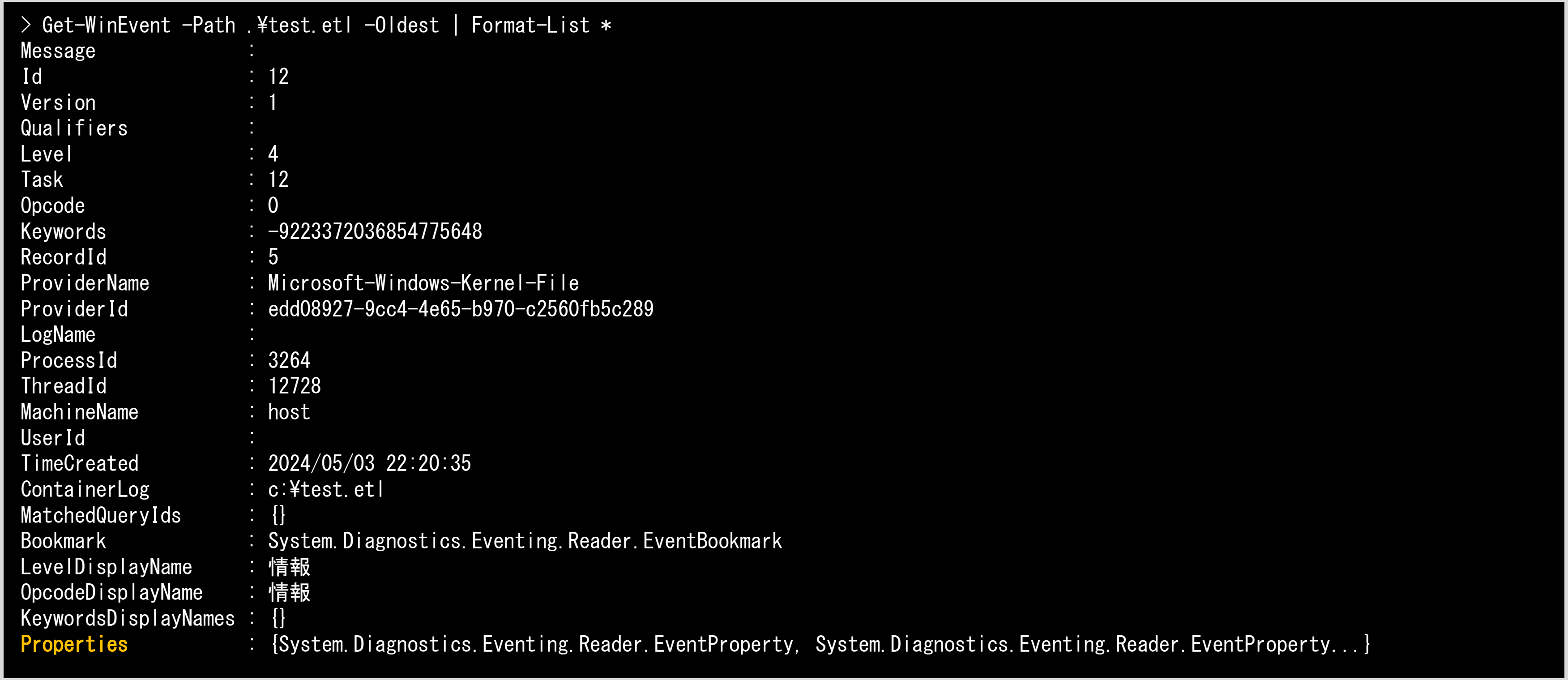


```
# Check Messages (if the message includes.)
> Get-WinEvent -Path .¥test.etl -Oldest | Select-Object Id,Message

Id Message
-- -------
 0
21
21
15
15
15
15
15
```

Where is the messages?

How to Analysis ETW using PowerShell

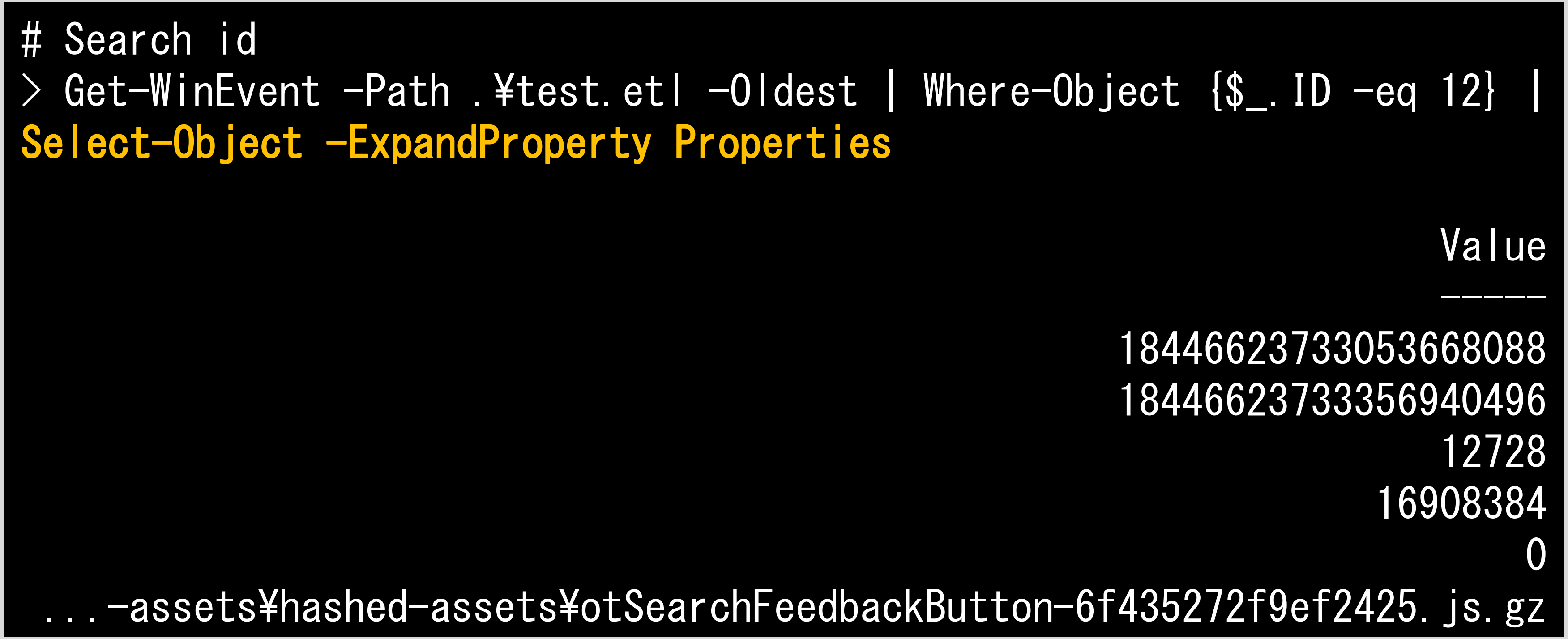
Get-WinEvent can parse ETL files as well as EVTX.



```
> Get-WinEvent -Path .¥test.etl -Oldest | Format-List *
Message              :
Id                   : 12
Version              : 1
Qualifiers           :
Level                : 4
Task                 : 12
Opcode               : 0
Keywords             : -9223372036854775648
RecordId             : 5
ProviderName         : Microsoft-Windows-Kernel-File
ProviderId           : edd08927-9cc4-4e65-b970-c2560fb5c289
LogName              :
ProcessId            : 3264
ThreadId             : 12728
MachineName          : host
UserId               :
TimeCreated          : 2024/05/03 22:20:35
ContainerLog         : c:¥test.etl
MatchedQueryIds      : {}
Bookmark             : System.Diagnostics.Eventing.Reader.EventBookmark
LevelDisplayName     : 情報
OpcodeDisplayName    : 情報
KeywordsDisplayNames : {}
Properties           : {System.Diagnostics.Eventing.Reader.EventProperty, System.Diagnostics.Eventing.Reader.EventProperty...}
```

How to Analysis ETW using PowerShell

Get-WinEvent can parse ETL files as well as EVTX.



```
# Search id
> Get-WinEvent -Path .¥test.etl -Oldest | Where-Object {$_.ID -eq 12} |
Select-Object -ExpandProperty Properties


                                                                  Value
                                                                  -----
                                                   18446623733053668088
                                                   18446623733356940496
                                                                  12728
                                                               16908384
                                                                      0
 ...-assets¥hashed-assets¥otSearchFeedbackButton-6f435272f9ef2425.js.gz
```

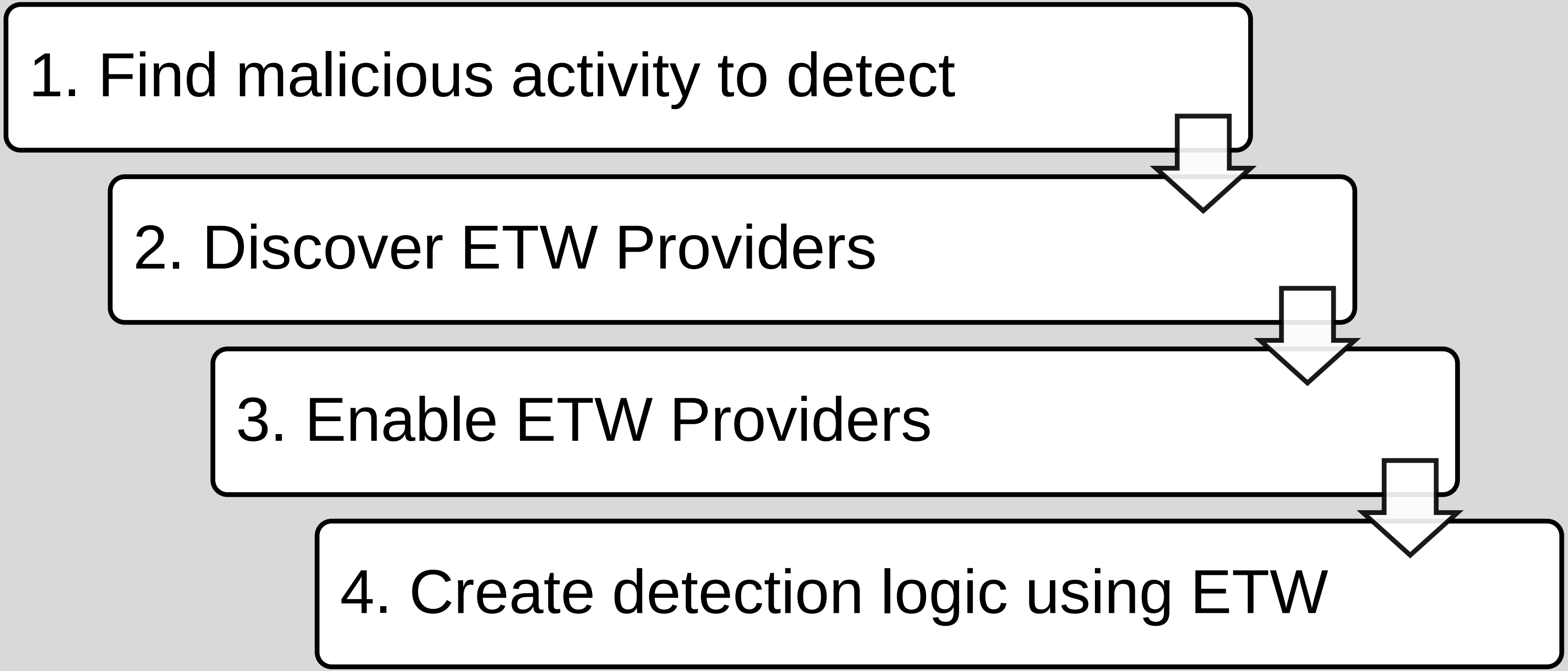
How to Create Your EDR

EDR uses ETW to detect malicious activity
on the Windows OS.

If you understand and use ETW, you can create your own EDR tools (ETW Consumers).

How to Create Your EDR

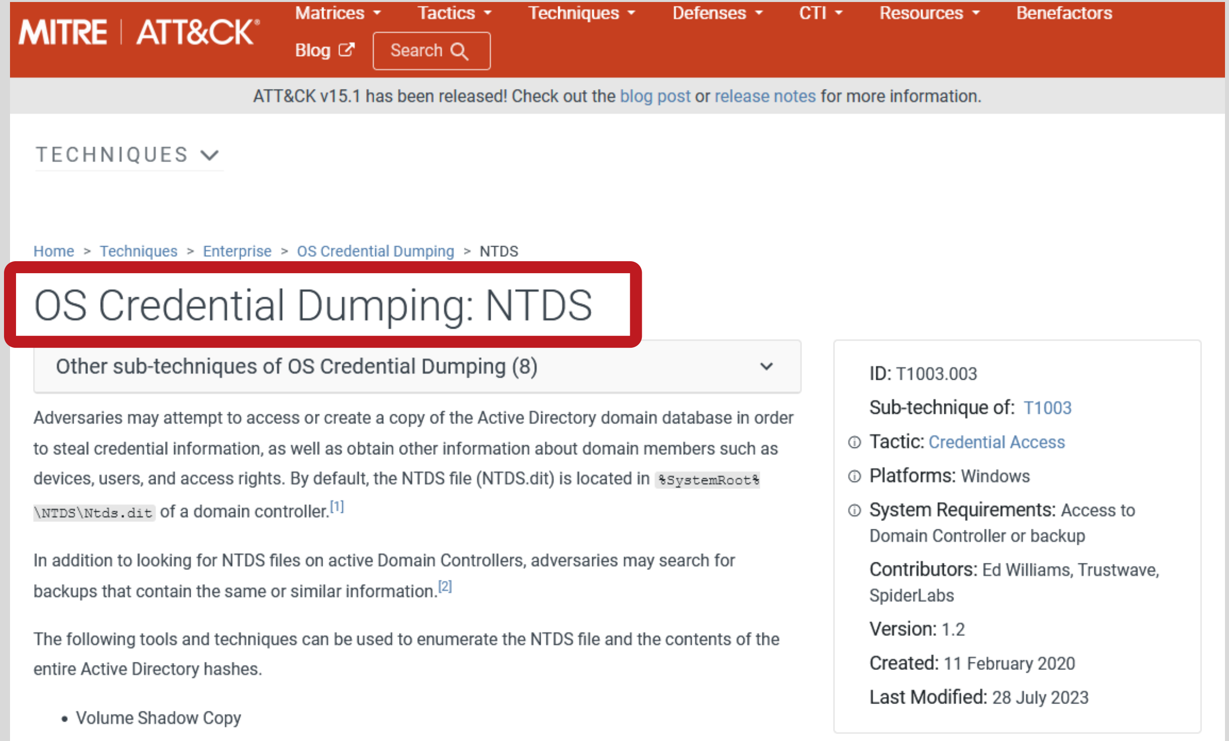
Steps



1. Find malicious activity to detect
2. Discover ETW Providers
3. Enable ETW Providers
4. Create detection logic using ETW

1. Find malicious activity to detect

Detect activity in NTDS dumps



ATT&CK v15.1 has been released! Check out the blog post or release notes for more information.

Home > Techniques > Enterprise > OS Credential Dumping > NTDS

OS Credential Dumping: NTDS

Other sub-techniques of OS Credential Dumping (8)

Adversaries may attempt to access or create a copy of the Active Directory domain database in order to steal credential information, as well as obtain other information about domain members such as devices, users, and access rights. By default, the NTDS file (NTDS.dit) is located in `%SystemRoot%\NTDS\Ntds.dit` of a domain controller.[1]

In addition to looking for NTDS files on active Domain Controllers, adversaries may search for backups that contain the same or similar information.[2]

The following tools and techniques can be used to enumerate the NTDS file and the contents of the entire Active Directory hashes.

- Volume Shadow Copy

ID: T1003.003

Sub-technique of: T1003

Tactic: Credential Access

Platforms: Windows

System Requirements: Access to Domain Controller or backup

Contributors: Ed Williams, Trustwave, SpiderLabs

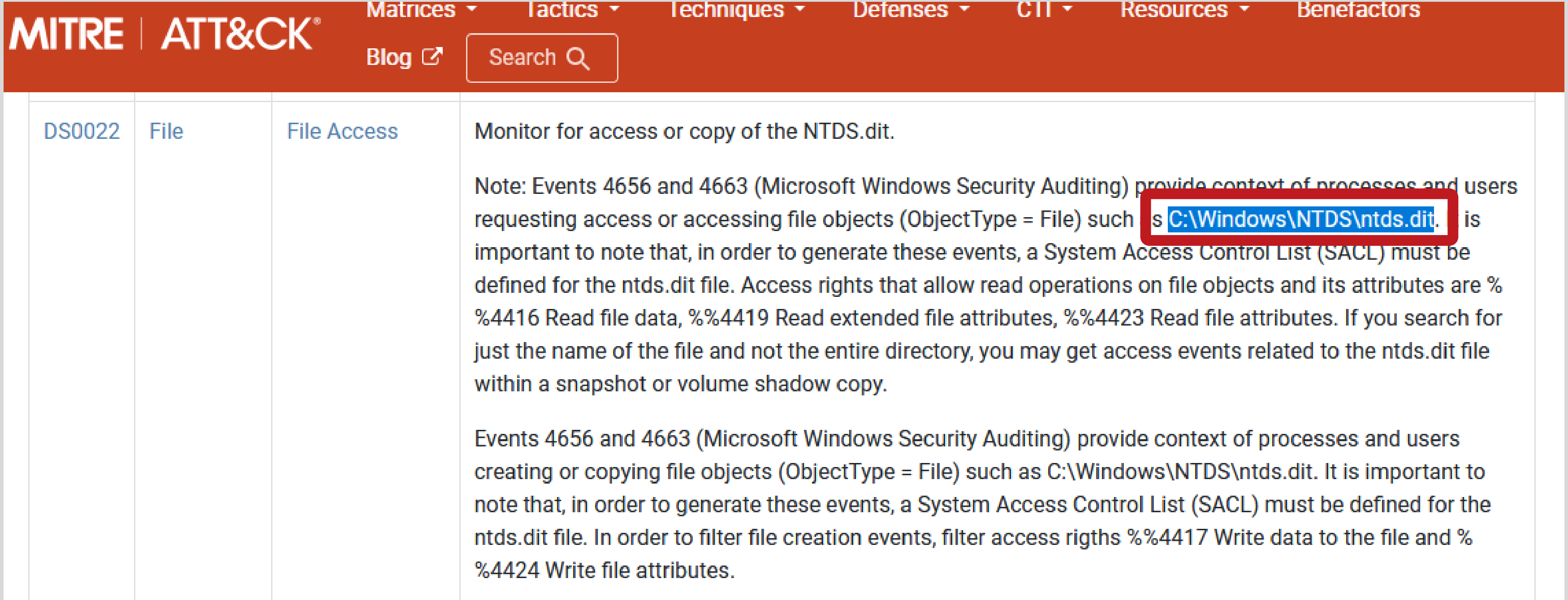
Version: 1.2

Created: 11 February 2020

Last Modified: 28 July 2023

1. Find malicious activity to detect

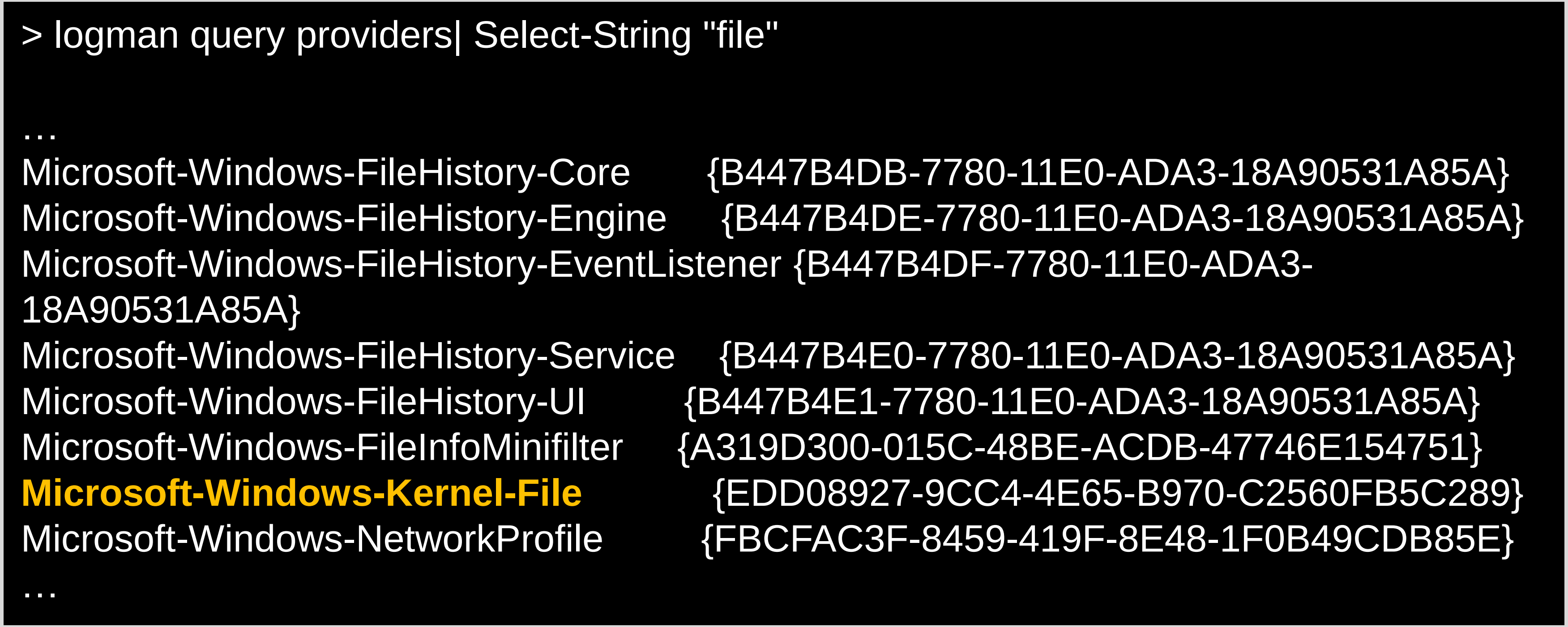
Detect activity in NTDS dumps



DS0022	File	File Access	Monitor for access or copy of the NTDS.dit. Note: Events 4656 and 4663 (Microsoft Windows Security Auditing) provide context of processes and users requesting access or accessing file objects (ObjectType = File) such s C:\Windows\NTDS\ntds.dit. is important to note that, in order to generate these events, a System Access Control List (SACL) must be defined for the ntds.dit file. Access rights that allow read operations on file objects and its attributes are %%4416 Read file data, %%4419 Read extended file attributes, %%4423 Read file attributes. If you search for just the name of the file and not the entire directory, you may get access events related to the ntds.dit file within a snapshot or volume shadow copy. Events 4656 and 4663 (Microsoft Windows Security Auditing) provide context of processes and users creating or copying file objects (ObjectType = File) such as C:\Windows\NTDS\ntds.dit. It is important to note that, in order to generate these events, a System Access Control List (SACL) must be defined for the ntds.dit file. In order to filter file creation events, filter access rigths %%4417 Write data to the file and %%4424 Write file attributes.

2. Discover ETW Providers

Find a provider to trace CreateFile



```
> logman query providers| Select-String "file"


…
Microsoft-Windows-FileHistory-Core          {B447B4DB-7780-11E0-ADA3-18A90531A85A}
Microsoft-Windows-FileHistory-Engine        {B447B4DE-7780-11E0-ADA3-18A90531A85A}
Microsoft-Windows-FileHistory-EventListener {B447B4DF-7780-11E0-ADA3-
18A90531A85A}
Microsoft-Windows-FileHistory-Service       {B447B4E0-7780-11E0-ADA3-18A90531A85A}
Microsoft-Windows-FileHistory-UI            {B447B4E1-7780-11E0-ADA3-18A90531A85A}
Microsoft-Windows-FileInfoMinifilter        {A319D300-015C-48BE-ACDB-47746E154751}
Microsoft-Windows-Kernel-File               {EDD08927-9CC4-4E65-B970-C2560FB5C289}
Microsoft-Windows-NetworkProfile            {FBCFAC3F-8459-419F-8E48-1F0B49CDB85E}
…
```

3. Enable ETW Providers

Enable ETW Providers using PowerShell

```
> New-NetEventSession -Name “FileActivity" -LocalFilePath “%TEMP%¥FileActivity.etl"

> Add-NetEventProvider -Name " Microsoft-Windows-Kernel-File" -SessionName
"FileActivity"

> Start-NetEventSession -Name "FileActivity"

> Stop-NetEventSession -Name "FileActivity"
```

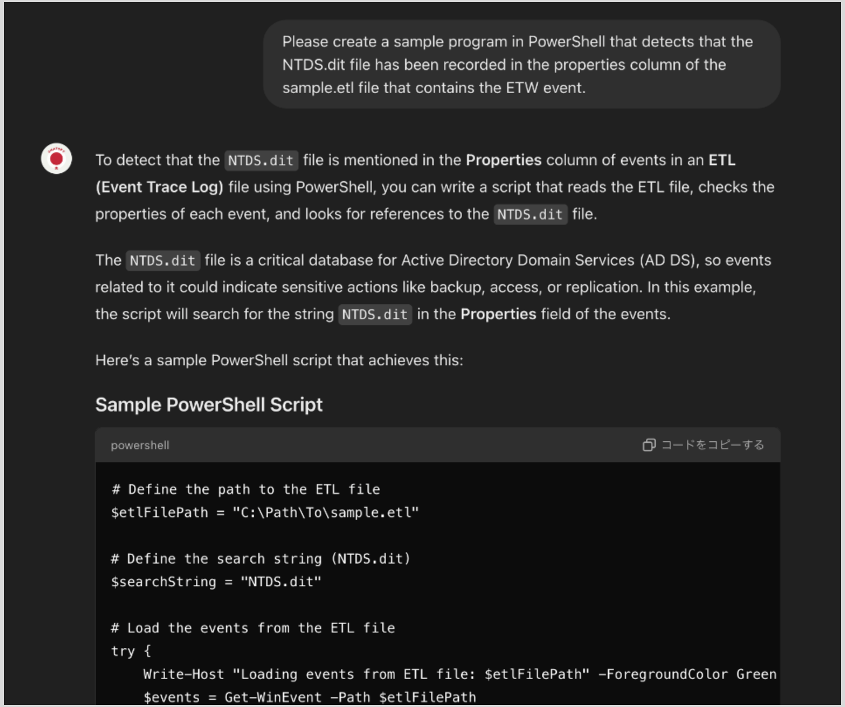
4. Create detection logic using ETW

Detect suspicious file activity with PowerShell

```
$SearchFileName = "*%SystemRoot%¥NTDS¥Ntds.dit"
$LogName = ".¥FileTrace.etl"
$Interval = 60

while ($true) {
    $events = Get-WinEvent -Path $LogName -Oldest | Where-Object {$_.ID -eq 12} |
              Select-Object  -ExpandProperty Properties | Where-Object {$_.Value -like $SearchFileName} |
              Select-Object -ExpandProperty Value

    if ($events) {
        foreach ($event in $events) {
            $message = “Access to $event"
            Write-Host $message -ForegroundColor Red
        }
    } else {
        Write-Host "No events" -ForegroundColor Green
    }

    Start-Sleep -Seconds $Interval
}
```

Tips: How to programming the detection logic?

Answer Please ask ChatGPT!



Please create a sample program in PowerShell that detects that the NTDS.dit file has been recorded in the properties column of the sample.etl file that contains the ETW event.

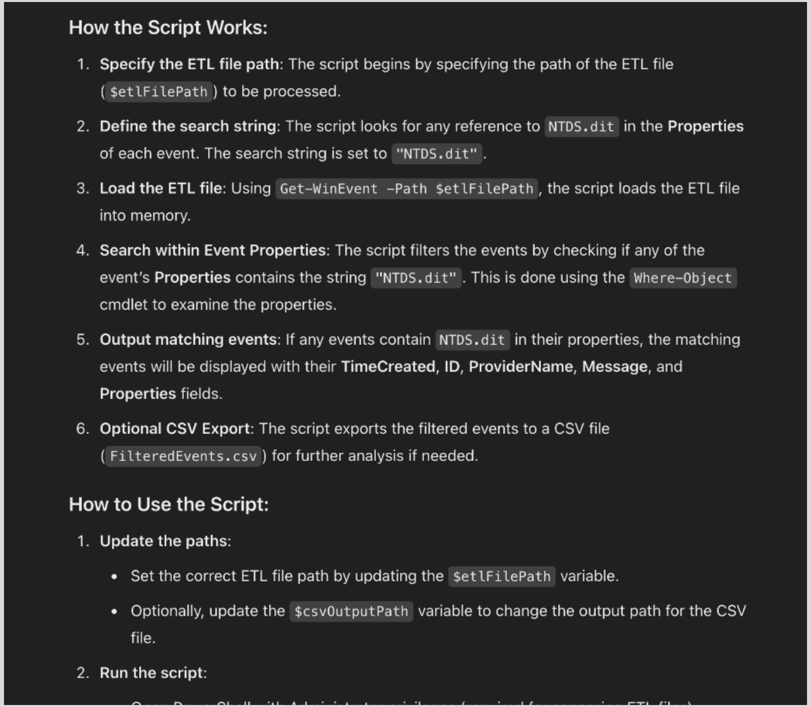
To detect that the `NTDS.dit` file is mentioned in the **Properties** column of events in an **ETL (Event Trace Log)** file using PowerShell, you can write a script that reads the ETL file, checks the properties of each event, and looks for references to the `NTDS.dit` file.

The `NTDS.dit` file is a critical database for Active Directory Domain Services (AD DS), so events related to it could indicate sensitive actions like backup, access, or replication. In this example, the script will search for the string `NTDS.dit` in the **Properties** field of the events.

Here's a sample PowerShell script that achieves this:

Sample PowerShell Script

```powershell
# Define the path to the ETL file
$etlFilePath = "C:\Path\To\sample.etl"

# Define the search string (NTDS.dit)
$searchString = "NTDS.dit"

# Load the events from the ETL file
try {
    Write-Host "Loading events from ETL file: $etlFilePath" -ForegroundColor Green
    $events = Get-WinEvent -Path $etlFilePath
```



How the Script Works:

1. **Specify the ETL file path**: The script begins by specifying the path of the ETL file (`$etlFilePath`) to be processed.
2. **Define the search string**: The script looks for any reference to `NTDS.dit` in the **Properties** of each event. The search string is set to `"NTDS.dit"`.
3. **Load the ETL file**: Using `Get-WinEvent -Path $etlFilePath`, the script loads the ETL file into memory.
4. **Search within Event Properties**: The script filters the events by checking if any of the event's **Properties** contains the string `"NTDS.dit"`. This is done using the `Where-Object` cmdlet to examine the properties.
5. **Output matching events**: If any events contain `NTDS.dit` in their properties, the matching events will be displayed with their **TimeCreated**, **ID**, **ProviderName**, **Message**, and **Properties** fields.
6. **Optional CSV Export**: The script exports the filtered events to a CSV file (`FilteredEvents.csv`) for further analysis if needed.

How to Use the Script:

1. **Update the paths**:
   - Set the correct ETL file path by updating the `$etlFilePath` variable.
   - Optionally, update the `$csvOutputPath` variable to change the output path for the CSV file.
2. **Run the script**:
   - Open PowerShell with Administrator privileges (required for accessing ETL files).

Sysmon vs ETW

	Sysmon	ETW
Advantage	✓ Easy to setup	✓ Installed by default ✓ More data than Sysmon
Disadvantage	✓ Not installed by default	✓ limited information on how to use
Use case	✓ Log archive and analysis	✓ Real-time detection

➡ If you want to create a real-time detection system like EDR, **ETW** is recommended.
If you want an incident response tool, **Sysmon** is recommended.

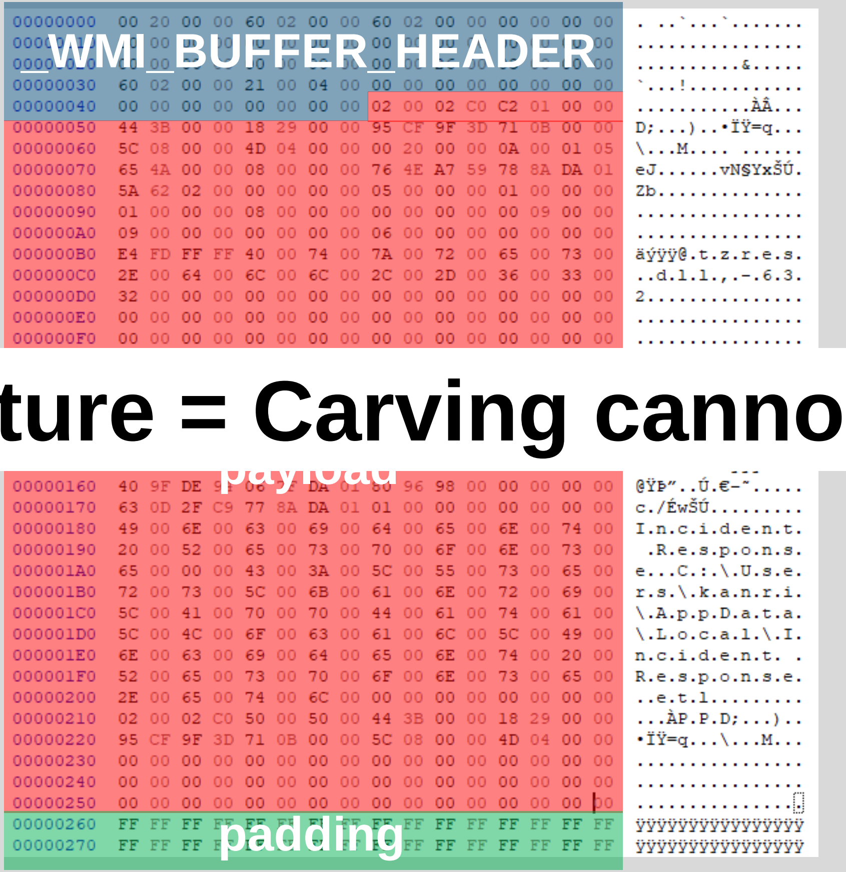
ETW in Forensics

Question

(If the etl file has been deleted) Can ETW events be **recovered**?

ETW Carving from Memory

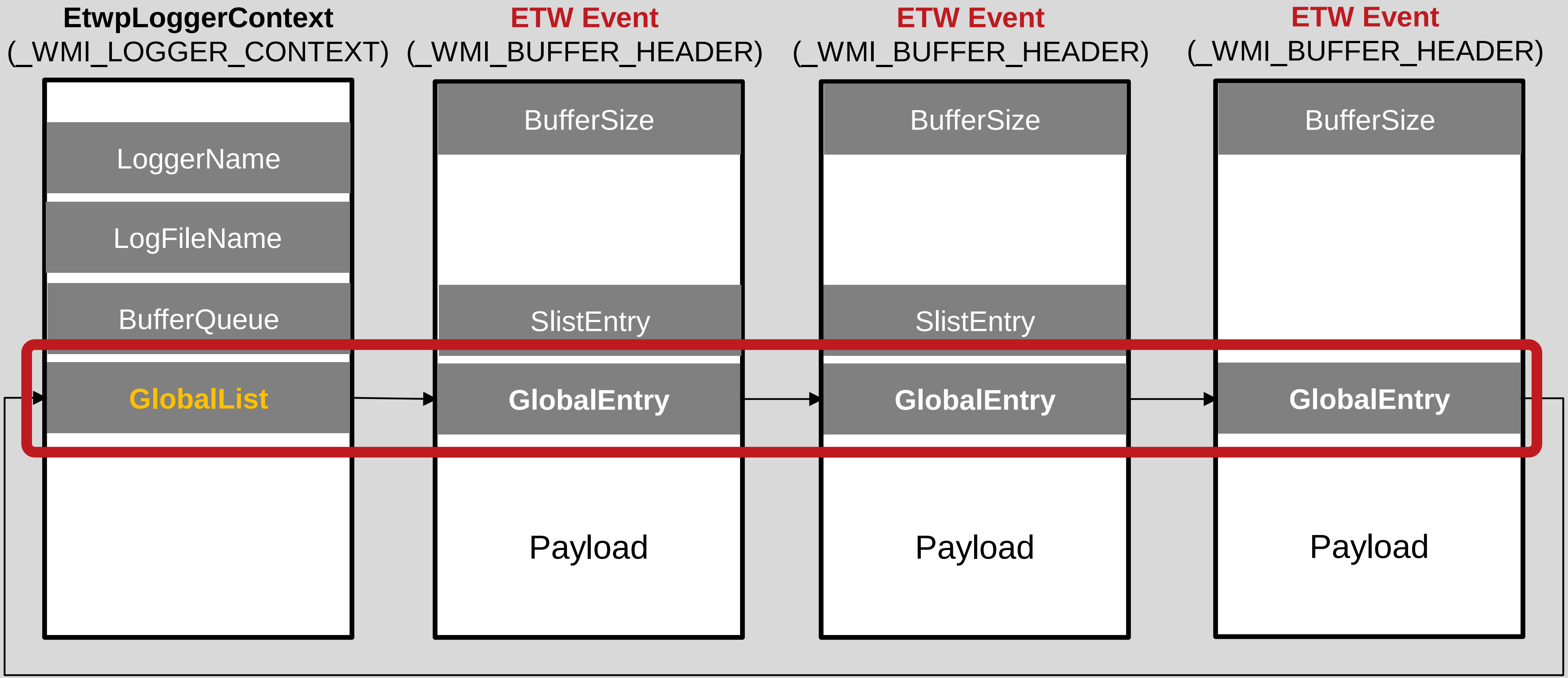
ETL file format



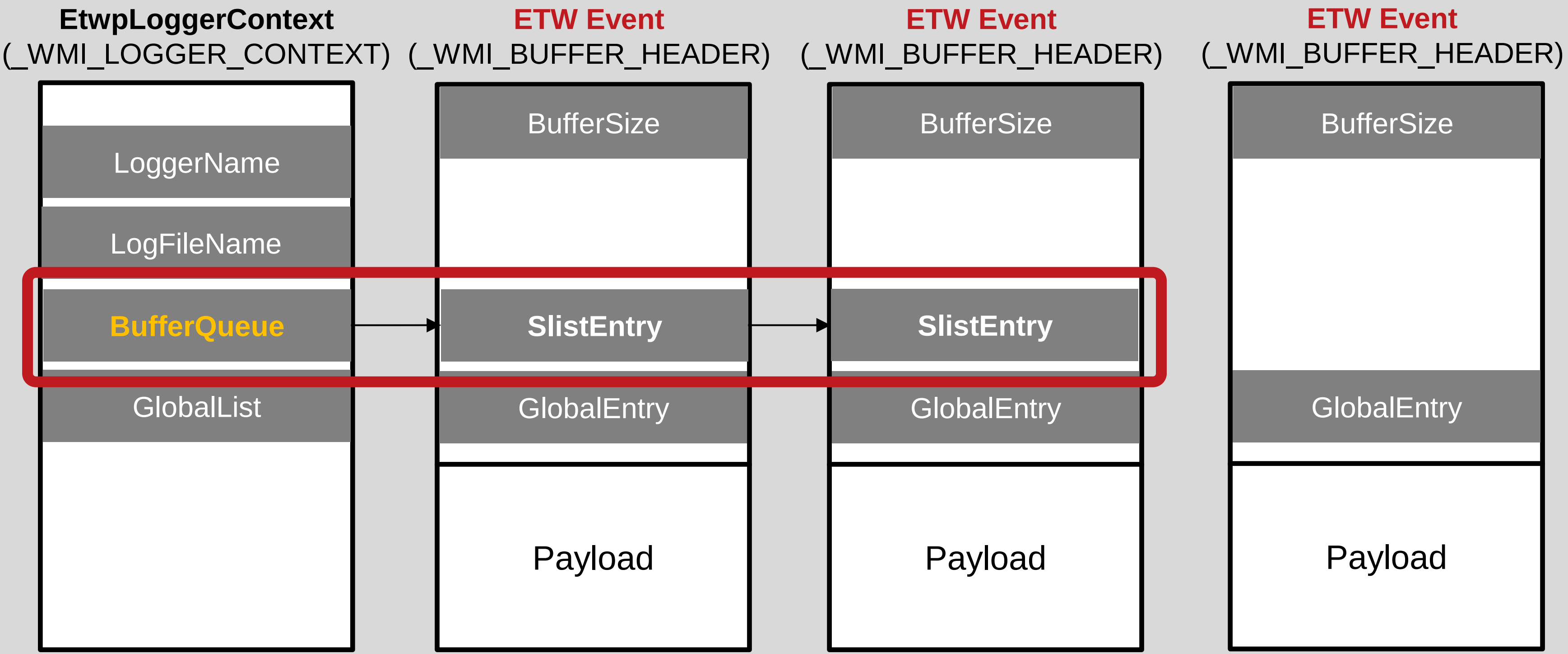
```
00000000  00 20 00 00 60 02 00 00 60 02 00 00 00 00 00 00  . ..`...`.......
00000030  60 02 00 00 21 00 04 00 00 00 00 00 00 00 00 00  `...!...........
00000040  00 00 00 00 00 00 00 00 02 00 02 C0 C2 01 00 00  ..........ÀÂ...
00000050  44 3B 00 00 18 29 00 00 95 CF 9F 3D 71 0B 00 00  D;...)..•ÏŸ=q...
00000060  5C 08 00 00 4D 04 00 00 00 20 00 00 0A 00 01 05  \...M.... ......
00000070  65 4A 00 00 08 00 00 00 76 4E A7 59 78 8A DA 01  eJ......vN§YxŠÚ.
00000080  5A 62 02 00 00 00 00 00 05 00 00 00 01 00 00 00  Zb..............
00000090  01 00 00 00 08 00 00 00 00 00 00 00 00 09 00 00  ................
000000A0  09 00 00 00 00 00 00 00 06 00 00 00 00 00 00 00  ................
000000B0  E4 FD FF FF 40 00 74 00 7A 00 72 00 65 00 73 00  äýÿÿ@.t.z.r.e.s.
000000C0  2E 00 64 00 6C 00 6C 00 2C 00 2D 00 36 00 33 00  ..d.l.l.,.-.6.3.
000000D0  32 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  2...............
000000E0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
000000F0  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000160  40 9F DE 94 06 7F DA 01 80 96 98 00 00 00 00 00  @ŸÞ”..Ú.€–˜.....
00000170  63 0D 2F C9 77 8A DA 01 01 00 00 00 00 00 00 00  c./ÉwŠÚ.........
00000180  49 00 6E 00 63 00 69 00 64 00 65 00 6E 00 74 00  I.n.c.i.d.e.n.t.
00000190  20 00 52 00 65 00 73 00 70 00 6F 00 6E 00 73 00   .R.e.s.p.o.n.s.
000001A0  65 00 00 00 43 00 3A 00 5C 00 55 00 73 00 65 00  e...C.:.\.U.s.e.
000001B0  72 00 73 00 5C 00 6B 00 61 00 6E 00 72 00 69 00  r.s.\.k.a.n.r.i.
000001C0  5C 00 41 00 70 00 70 00 44 00 61 00 74 00 61 00  \.A.p.p.D.a.t.a.
000001D0  5C 00 4C 00 6F 00 63 00 61 00 6C 00 5C 00 49 00  \.L.o.c.a.l.\.I.
000001E0  6E 00 63 00 69 00 64 00 65 00 6E 00 74 00 20 00  n.c.i.d.e.n.t. .
000001F0  52 00 65 00 73 00 70 00 6F 00 6E 00 73 00 65 00  R.e.s.p.o.n.s.e.
00000200  2E 00 65 00 74 00 6C 00 00 00 00 00 00 00 00 00  ..e.t.l.........
00000210  02 00 02 C0 50 00 50 00 44 3B 00 00 18 29 00 00  ...ÀP.P.D;...)..
00000220  95 CF 9F 3D 71 0B 00 00 5C 08 00 00 4D 04 00 00  •ÏŸ=q...\...M...
00000230  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000240  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000250  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00000260  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
00000270  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF  ÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿÿ
```

No signature = Carving cannot be used

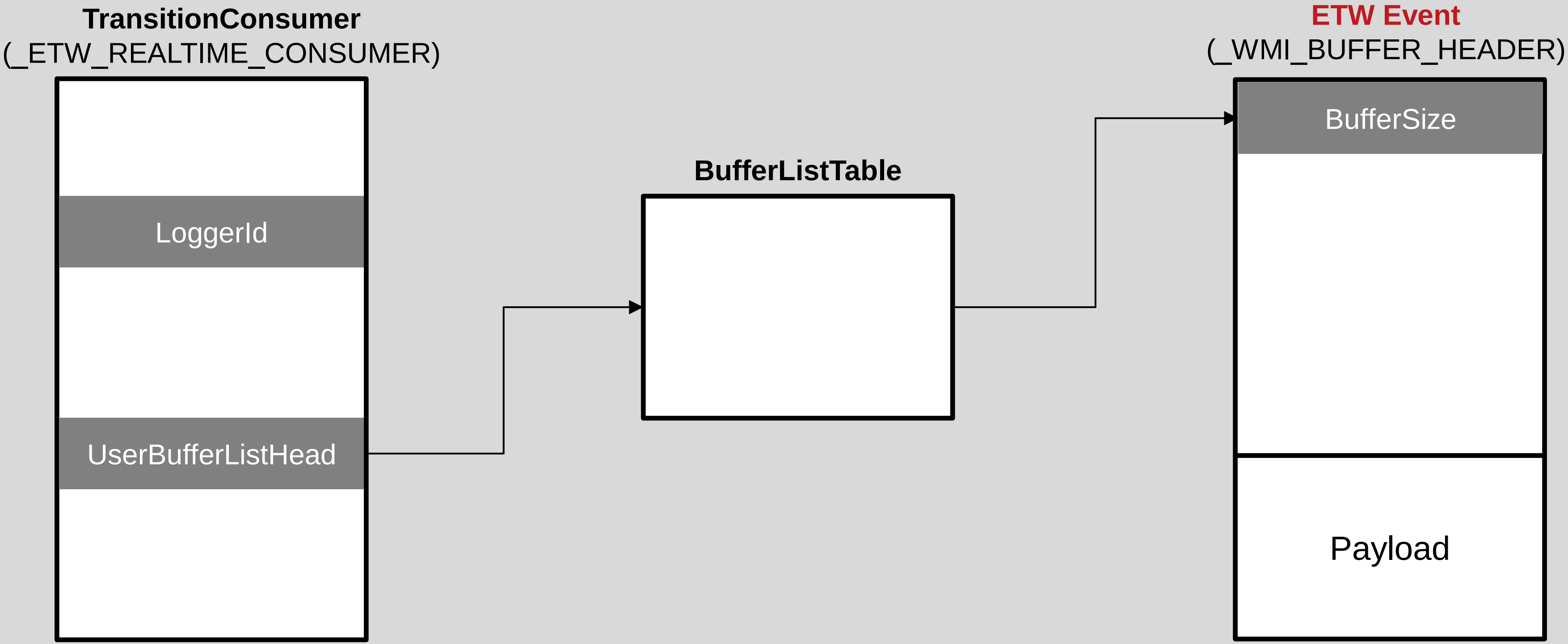
Trace ETW Data from the Structure



Trace ETW Data from the Structure



Trace ETW Data from the Structure



What is the difference between GlobalList and BufferQueue?

GlobalList _WMI_LOGGER_CONTEXT

- All cached ETW events.

BufferQueue _WMI_LOGGER_CONTEXT

- Queue of ETW events to be written to the ETL file.
  - **Stream mode: File**
- If ETW events are not saved in the ETL file, the BufferQueue is not used.

UserBufferListHead _ETW_REALTIME_CONSUMER

- Tracing ETW events to Consumers in real time.
  - **Stream mode: Real time**

What is the difference between GlobalList and BufferQueue?

GlobalList _WMI_LOGGER_CONTEXT

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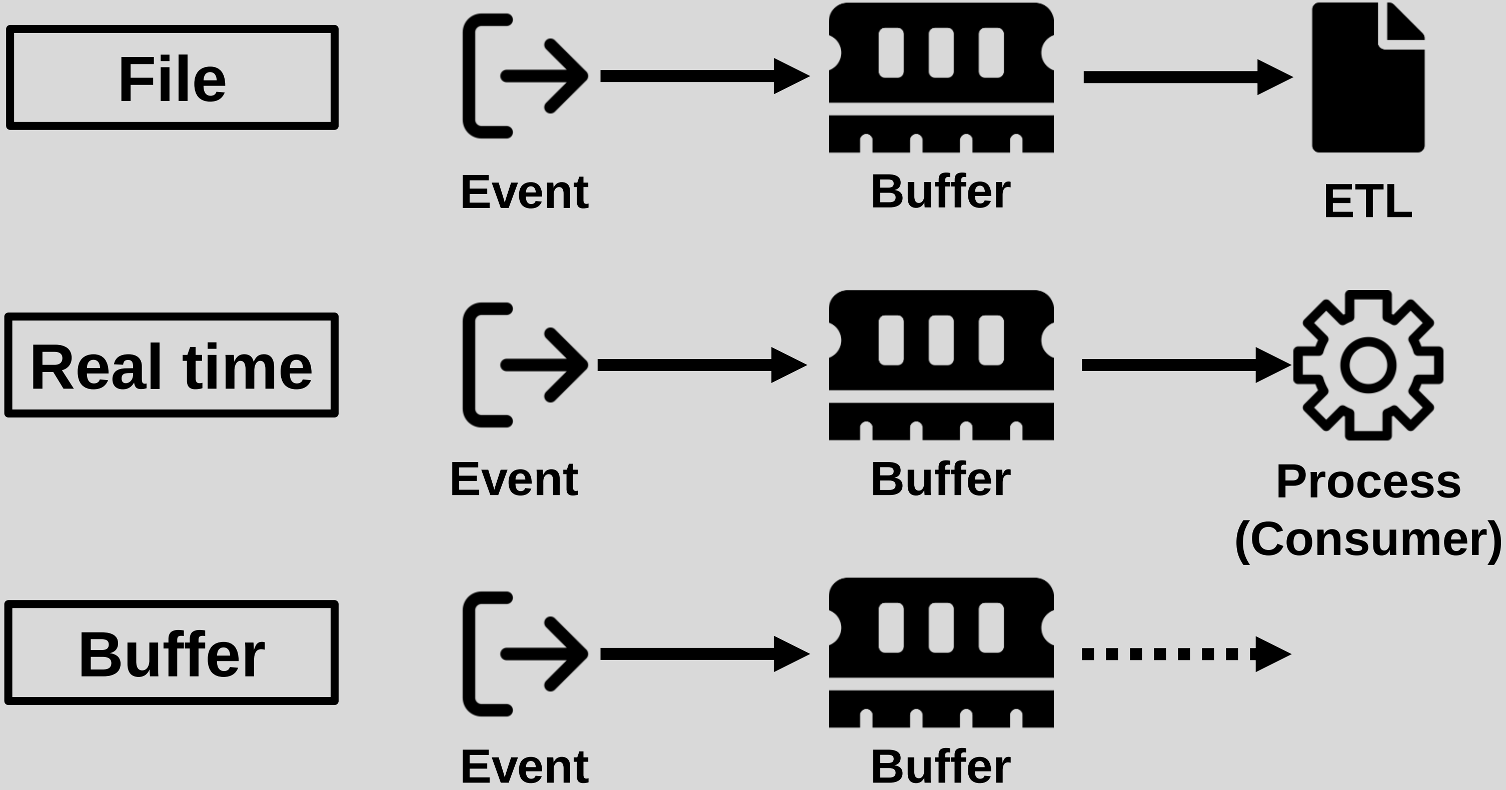
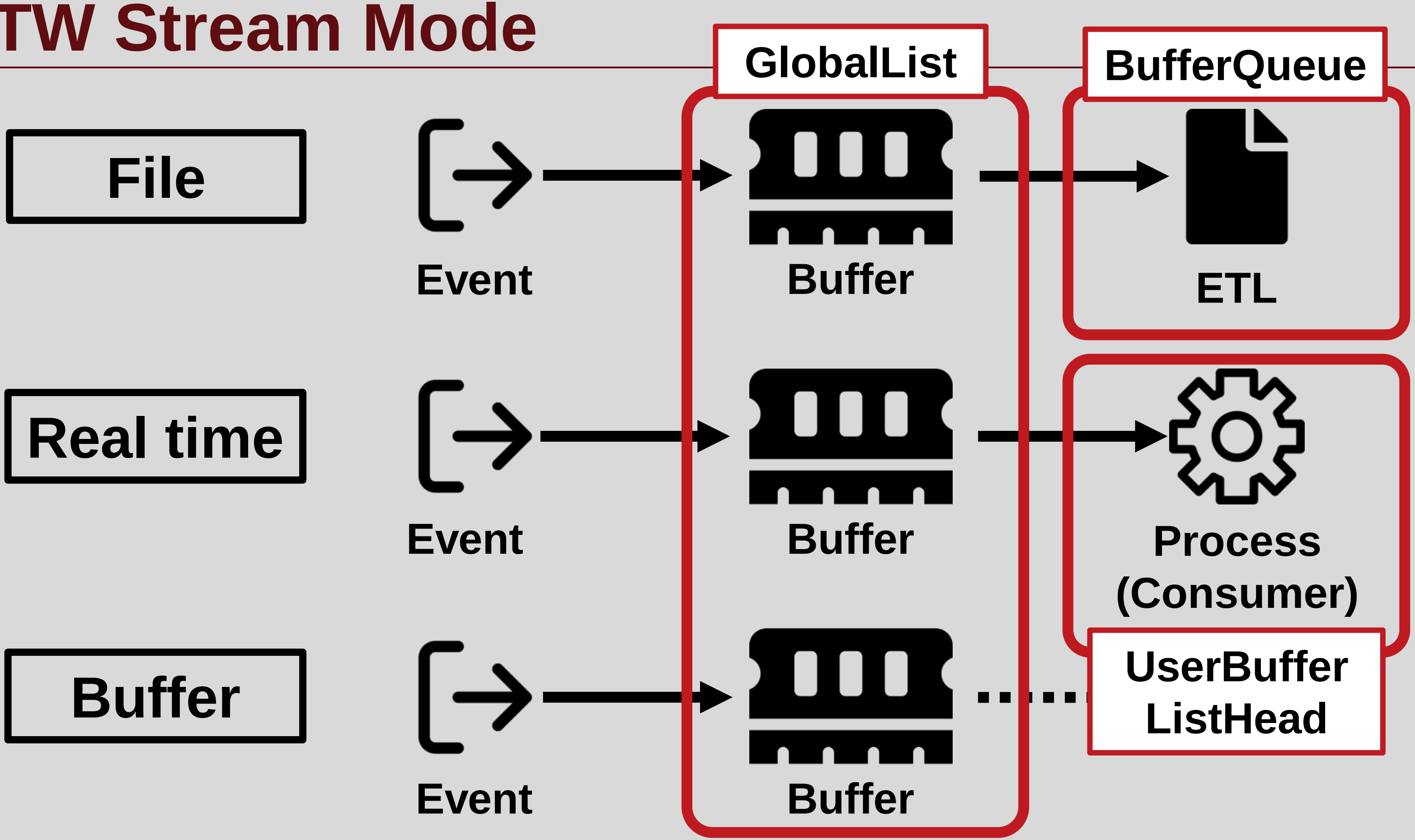
UserBufferListHead _ETW_REALTIME_CONSUMER

- Tracing ETW events to Consumers in real time.
  - **Stream mode: Real time**

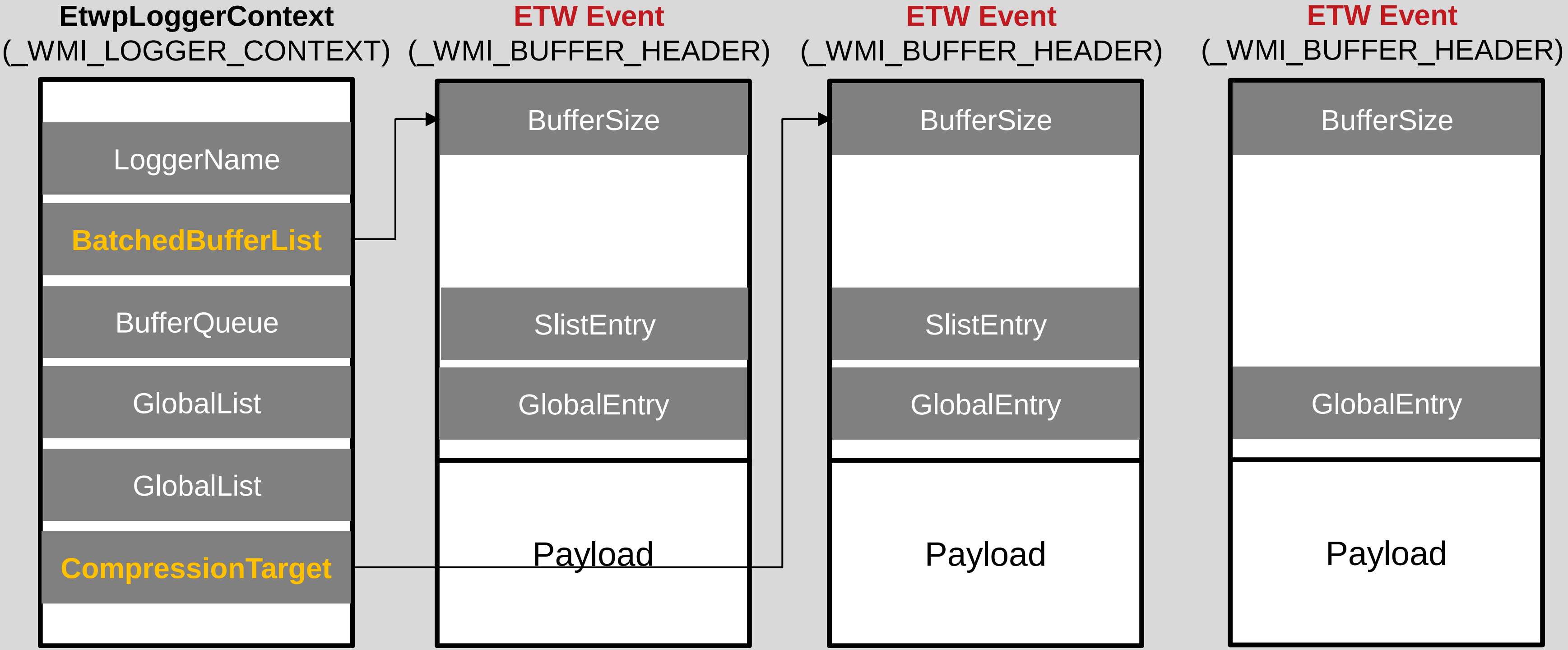
ETW Stream Mode



ETW Stream Mode

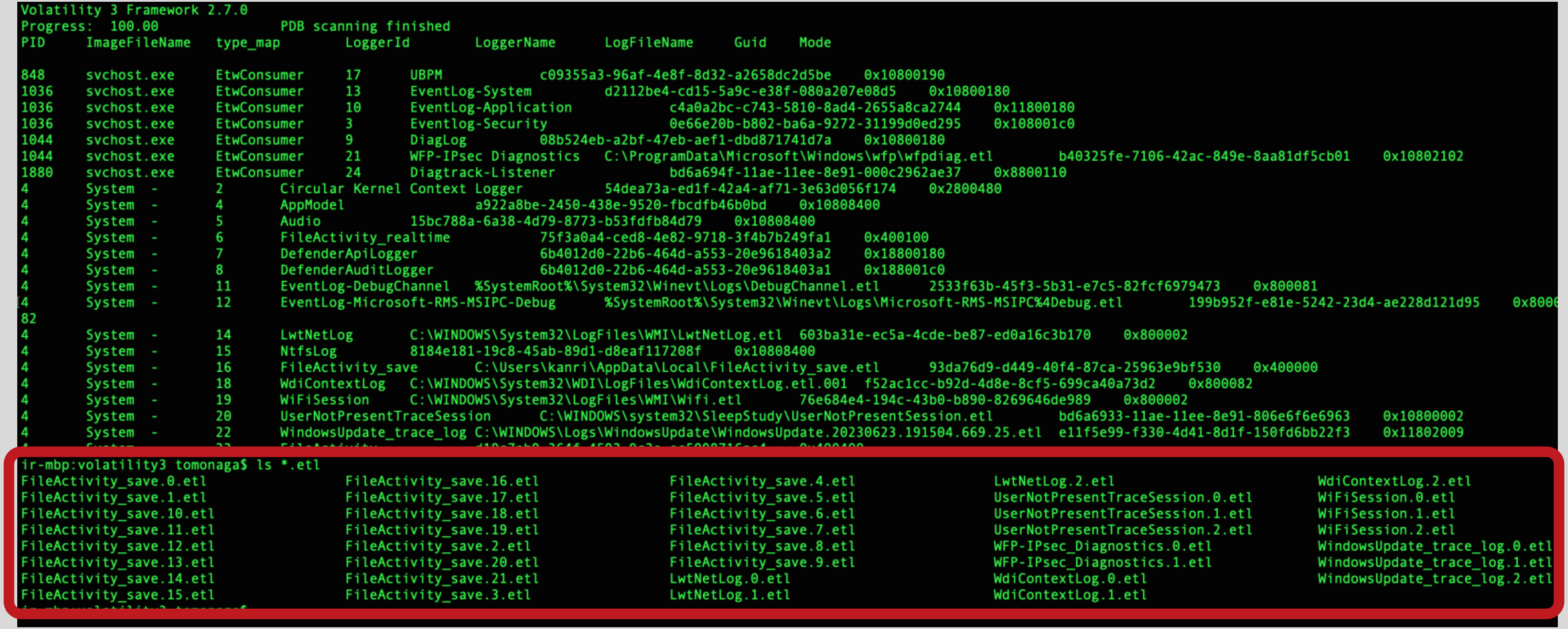


Trace ETW Data from the Structure



Dump ETW from Memory

Volatility3 plugin

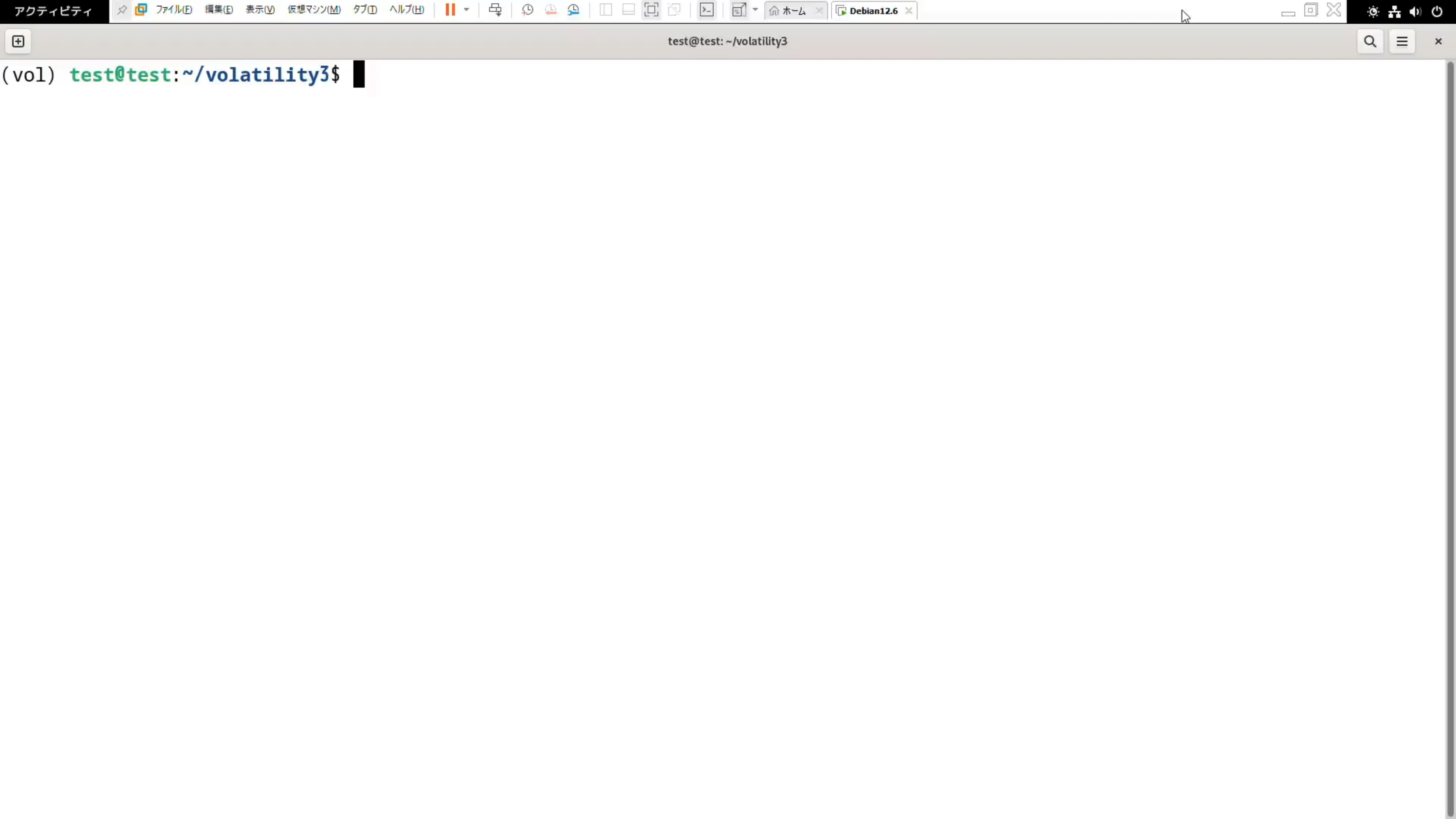


```
Volatility 3 Framework 2.7.0
Progress:  100.00               PDB scanning finished
PID     ImageFileName   type_map        LoggerId        LoggerName      LogFileName     Guid    Mode

848     svchost.exe     EtwConsumer     17      UBPM            c09355a3-96af-4e8f-8d32-a2658dc2d5be    0x10800190
1036    svchost.exe     EtwConsumer     13      EventLog-System         d2112be4-cd15-5a9c-e38f-080a207e08d5    0x10800180
1036    svchost.exe     EtwConsumer     10      EventLog-Application            c4a0a2bc-c743-5810-8ad4-2655a8ca2744    0x11800180
1036    svchost.exe     EtwConsumer     3       Eventlog-Security               0e66e20b-b802-ba6a-9272-31199d0ed295    0x108001c0
1044    svchost.exe     EtwConsumer     9       DiagLog         08b524eb-a2bf-47eb-aef1-dbd871741d7a    0x10800180
1044    svchost.exe     EtwConsumer     21      WFP-IPsec Diagnostics   C:\ProgramData\Microsoft\Windows\wfp\wfpdiag.etl        b40325fe-7106-42ac-849e-8aa81df5cb01    0x10802102
1880    svchost.exe     EtwConsumer     24      Diagtrack-Listener              bd6a694f-11ae-11ee-8e91-000c2962ae37    0x8800110
4       System  -       2       Circular Kernel Context Logger          54dea73a-ed1f-42a4-af71-3e63d056f174    0x2800480
4       System  -       4       AppModel                a922a8be-2450-438e-9520-fbcdfb46b0bd    0x10808400
4       System  -       5       Audio           15bc788a-6a38-4d79-8773-b53fdfb84d79    0x10808400
4       System  -       6       FileActivity_realtime           75f3a0a4-ced8-4e82-9718-3f4b7b249fa1    0x400100
4       System  -       7       DefenderApiLogger               6b4012d0-22b6-464d-a553-20e9618403a2    0x18800180
4       System  -       8       DefenderAuditLogger             6b4012d0-22b6-464d-a553-20e9618403a1    0x188001c0
4       System  -       11      EventLog-DebugChannel   %SystemRoot%\System32\Winevt\Logs\DebugChannel.etl      2533f63b-45f3-5b31-e7c5-82fcf6979473    0x800081
4       System  -       12      EventLog-Microsoft-RMS-MSIPC-Debug      %SystemRoot%\System32\Winevt\Logs\Microsoft-RMS-MSIPC%4Debug.etl        199b952f-e81e-5242-23d4-ae228d121d95    0x8000
82
4       System  -       14      LwtNetLog       C:\WINDOWS\System32\LogFiles\WMI\LwtNetLog.etl  603ba31e-ec5a-4cde-be87-ed0a16c3b170    0x800002
4       System  -       15      NtfsLog         8184e181-19c8-45ab-89d1-d8eaf117208f    0x10808400
4       System  -       16      FileActivity_save       C:\Users\kanri\AppData\Local\FileActivity_save.etl      93da76d9-d449-40f4-87ca-25963e9bf530    0x400000
4       System  -       18      WdiContextLog   C:\WINDOWS\System32\WDI\LogFiles\WdiContextLog.etl.001  f52ac1cc-b92d-4d8e-8cf5-699ca40a73d2    0x800082
4       System  -       19      WiFiSession     C:\WINDOWS\System32\LogFiles\WMI\Wifi.etl       76e684e4-194c-43b0-b890-8269646de989    0x800002
4       System  -       20      UserNotPresentTraceSession      C:\WINDOWS\system32\SleepStudy\UserNotPresentSession.etl        bd6a6933-11ae-11ee-8e91-806e6f6e6963    0x10800002
4       System  -       22      WindowsUpdate_trace_log C:\WINDOWS\Logs\WindowsUpdate\WindowsUpdate.20230623.191504.669.25.etl  e11f5e99-f330-4d41-8d1f-150fd6bb22f3    0x11802009
```

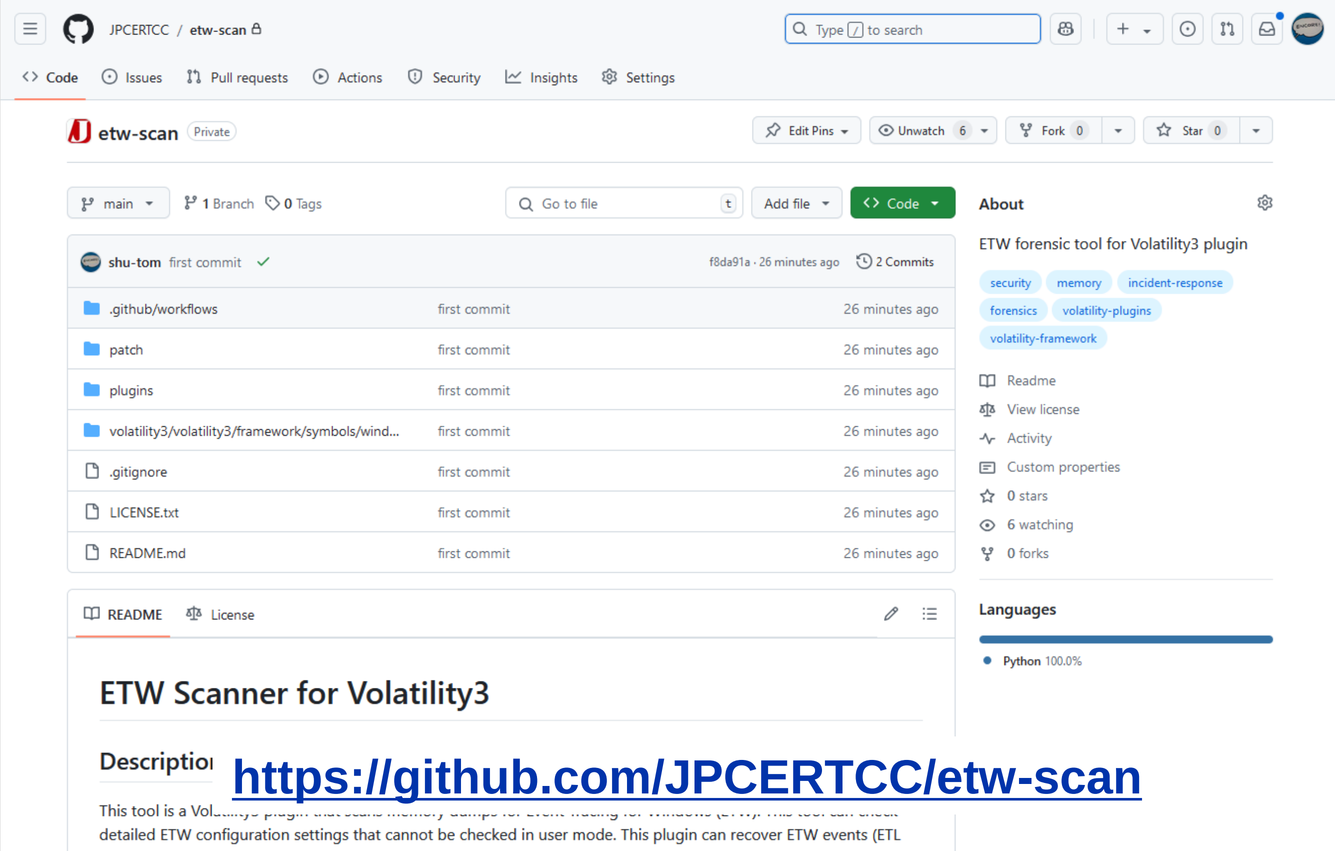
```
ir-mbp:volatility3 tomonaga$ ls *.etl
FileActivity_save.0.etl          FileActivity_save.16.etl         FileActivity_save.4.etl          LwtNetLog.2.etl                  WdiContextLog.2.etl
FileActivity_save.1.etl          FileActivity_save.17.etl         FileActivity_save.5.etl          UserNotPresentTraceSession.0.etl WiFiSession.0.etl
FileActivity_save.10.etl         FileActivity_save.18.etl         FileActivity_save.6.etl          UserNotPresentTraceSession.1.etl WiFiSession.1.etl
FileActivity_save.11.etl         FileActivity_save.19.etl         FileActivity_save.7.etl          UserNotPresentTraceSession.2.etl WiFiSession.2.etl
FileActivity_save.12.etl         FileActivity_save.2.etl          FileActivity_save.8.etl          WFP-IPsec_Diagnostics.0.etl      WindowsUpdate_trace_log.0.etl
FileActivity_save.13.etl         FileActivity_save.20.etl         FileActivity_save.9.etl          WFP-IPsec_Diagnostics.1.etl      WindowsUpdate_trace_log.1.etl
FileActivity_save.14.etl         FileActivity_save.21.etl         LwtNetLog.0.etl                  WdiContextLog.0.etl              WindowsUpdate_trace_log.2.etl
FileActivity_save.15.etl         FileActivity_save.3.etl          LwtNetLog.1.etl                  WdiContextLog.1.etl
```

Demo



```
(vol) test@test:~/volatility3$ 
```

ETW Scanner for Volatility3



etw-scan Private

shu-tom first commit ✓ f8da91a · 26 minutes ago 2 Commits

.github/workflows	first commit	26 minutes ago
patch	first commit	26 minutes ago
plugins	first commit	26 minutes ago
volatility3/volatility3/framework/symbols/wind...	first commit	26 minutes ago
.gitignore	first commit	26 minutes ago
LICENSE.txt	first commit	26 minutes ago
README.md	first commit	26 minutes ago

About

ETW forensic tool for Volatility3 plugin

security memory incident-response forensics volatility-plugins volatility-framework

- Readme
- View license
- Activity
- Custom properties
- 0 stars
- 6 watching
- 0 forks

Languages

● Python 100.0%

ETW Scanner for Volatility3

Descriptio

This tool is a Volatility3 plugin that scans memory dumps for Event Tracing for Windows (ETW). This tool can check detailed ETW configuration settings that cannot be checked in user mode. This plugin can recover ETW events (ETL

https://github.com/JPCERTCC/etw-scan

1 What is ETW?

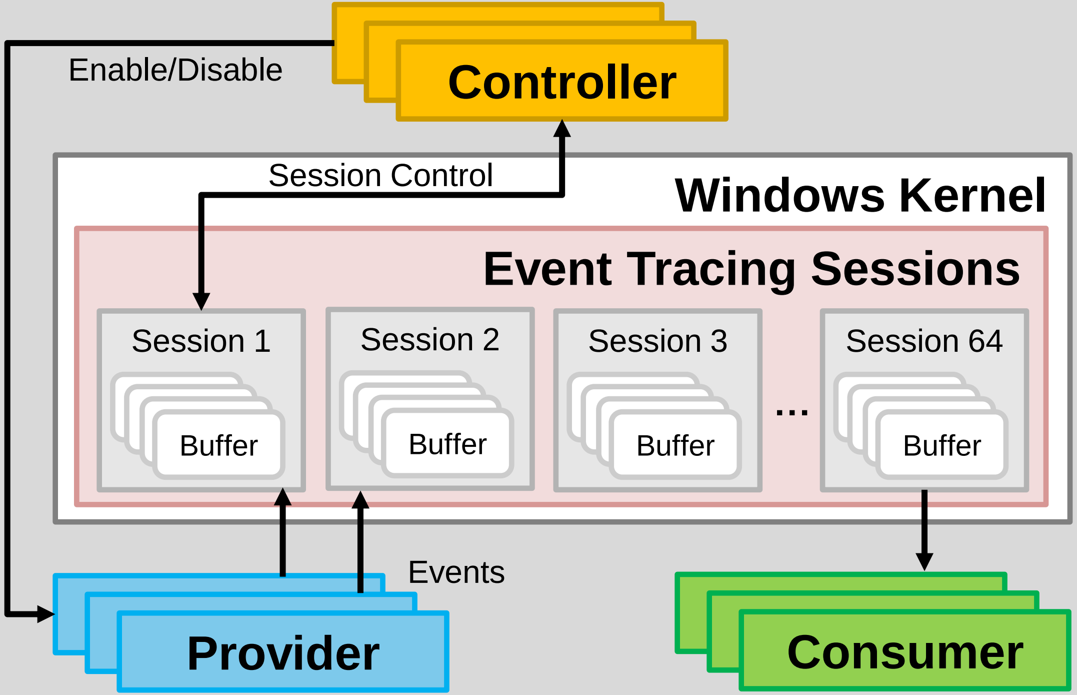
2 ETW Internals

3 ETW using Incident Response

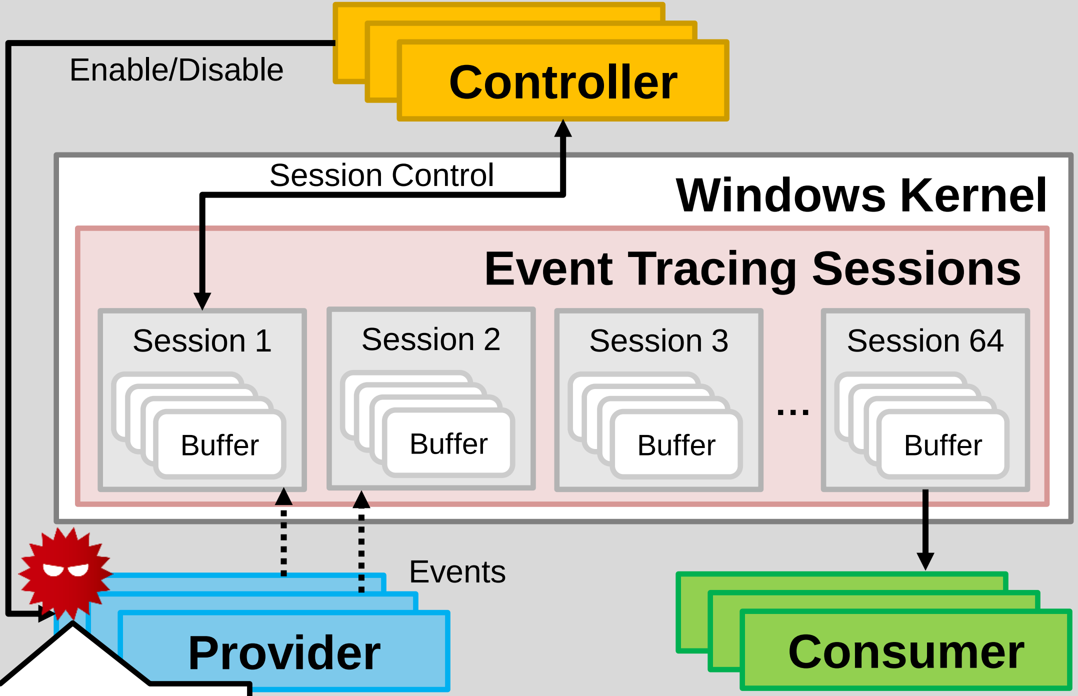
4 Attack Surface

5 Mitigation and Detection

Attack Surface for ETW

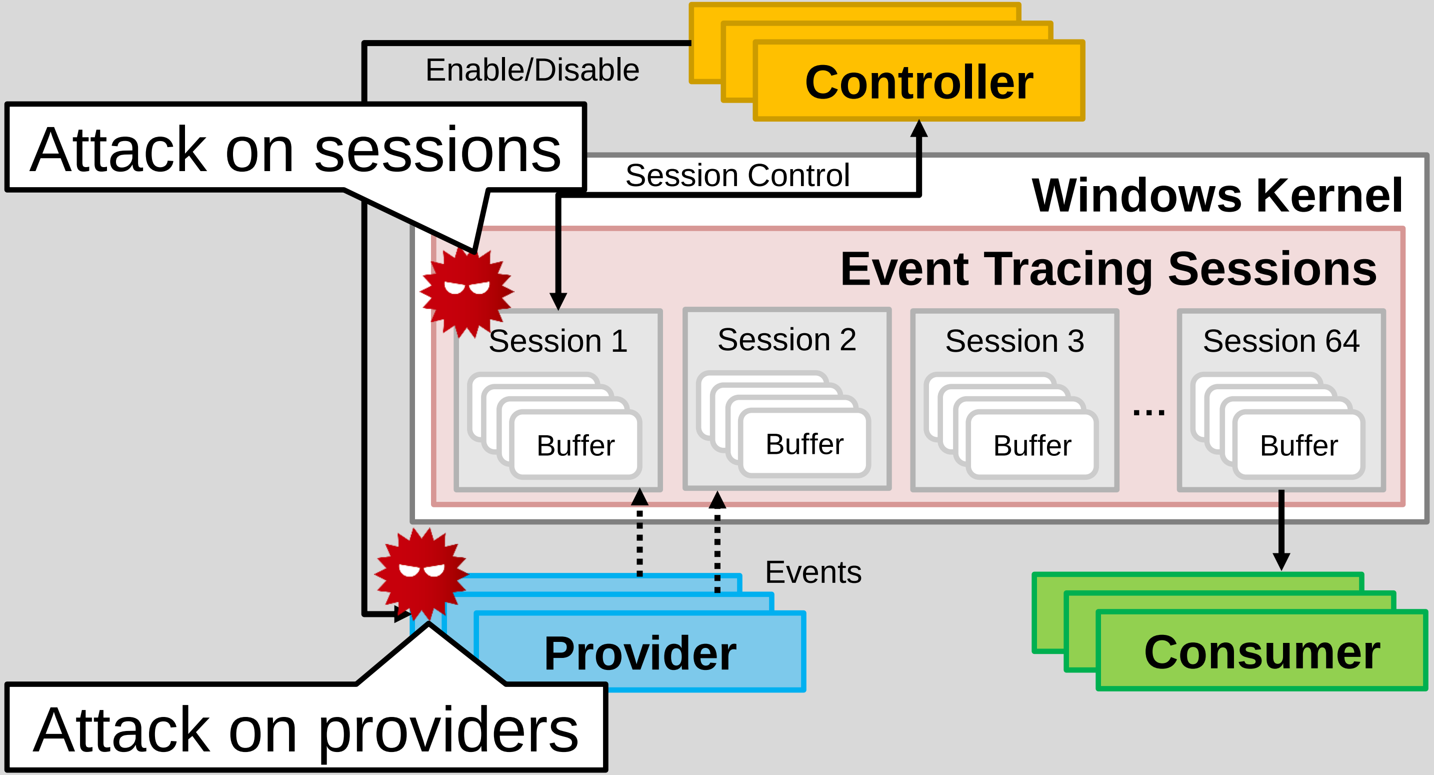


Attack Surface for ETW



Attack on providers

Attack Surface for ETW



ETW Bypass Technique

Attack on providers

- Block or delete the writing of events by ETW providers.

Attack on sessions

- Stop or delete sessions.

Block Event Writing of Providers using API Hook

Intercept the ETW API and disallow the API to execute.

EventWrite

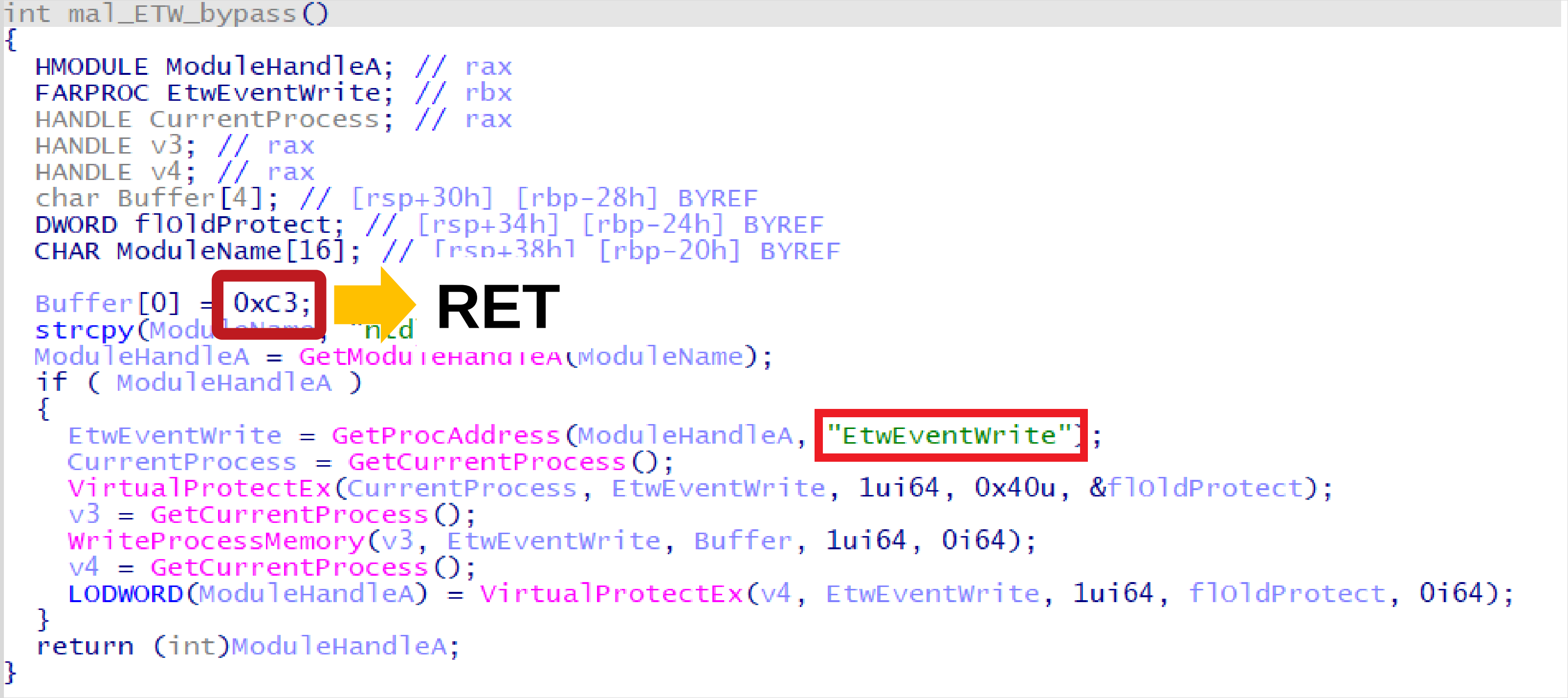
EtwEventWrite

NtTraceEvent

EtwEventWriteFull

ETW Bypass using Malware

HUI Loader using attack providers



```
int mal_ETW_bypass()
{
  HMODULE ModuleHandleA; // rax
  FARPROC EtwEventWrite; // rbx
  HANDLE CurrentProcess; // rax
  HANDLE v3; // rax
  HANDLE v4; // rax
  char Buffer[4]; // [rsp+30h] [rbp-28h] BYREF
  DWORD flOldProtect; // [rsp+34h] [rbp-24h] BYREF
  CHAR ModuleName[16]; // [rsp+38h] [rbp-20h] BYREF

  Buffer[0] = 0xC3;
  strcpy(ModuleName, "ntd
  ModuleHandleA = GetModuleHandleA(ModuleName);
  if ( ModuleHandleA )
  {
    EtwEventWrite = GetProcAddress(ModuleHandleA, "EtwEventWrite");
    CurrentProcess = GetCurrentProcess();
    VirtualProtectEx(CurrentProcess, EtwEventWrite, 1ui64, 0x40u, &flOldProtect);
    v3 = GetCurrentProcess();
    WriteProcessMemory(v3, EtwEventWrite, Buffer, 1ui64, 0i64);
    v4 = GetCurrentProcess();
    LODWORD(ModuleHandleA) = VirtualProtectEx(v4, EtwEventWrite, 1ui64, flOldProtect, 0i64);
  }
  return (int)ModuleHandleA;
}
```

Delete Providers

Using Windows API

- EtwEventUnregister

Overwriting ETW structures

- WMI_LOGGER_CONTEXT
- ETW_GUID_ENTRY
- ETW_REG_ENTRY

Stop or Delete Sessions

Execute ETW API to stop the session.

StopTrace

ControlTrace

NtTraceControl

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Mitigation and Detection

API hook detection

- Check whether ETW API page protections on memory blocks is not **PAGE_EXECUTE_READWRITE**.
- Check whether the top area of the ETW API has not been modified.

- Target ETW API:
  - ✓ EventWrite
  - ✓ EtwEventWrite
  - ✓ NtTraceEvent
  - ✓ EtwEventWriteFull

Mitigation and Detection

Disable ETW detection

- □Block escalation of administrator privileges (like vulnerability exploits).

- □Monitor ETW registry and structure changes.
  - ✓ HKLM¥Software¥Microsoft¥.NETFramework¥ETWEnabled
  - ✓ _WMI_LOGGER_CONTEXT

Takeaways

The internal structure of ETW is difficult to parse, and so it is better to analyze it with PowerShell or convert it to EVTX.

ETW can be used to create custom EDR.

To recover ETW from memory, structure analysis is necessary, and the Volatility3 Plugin that we have created can be helpful.

ETW bypass will be used in many attacks in future, and so mitigation and detection is needed.

Thank you!

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