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Proxying to Kernel : Streaming vulnerabilities from the Windows Kernel

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Who am I

- Angelboy (@scwuaptx)
- Senior Security of DEVCORE
- MSRC 2024 MVR Top 100
- Speaker at
  - CODE BLUE, HITCON, HITB GSEC, HEXACON
- Master of Pwn of Pwn2Own Toronto 2022


Looking at historical vulnerabilities is indispensable
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Pwn2Own Vancouver 2024

Target	Prize	Master of Pwn Points
Ubuntu Desktop	$20,000	2
Microsoft Windows 11	$30,000	3
Apple macOS	$40,000	4

https://www.zerodayinitiative.com/blog/2024/1/16/pwn2own-vancouver-2024-bring-cloud-nativecontainer-security-to-pwn2own

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In-the-wild

- Win32k
  - GDI (Graphics Device Interface) and UI functions
    - Windows drawing, font management …
  - Complexity of Code
  - It has been a popular target for attackers over the past decade.

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In-the-wild

- CLFS
  - Common Log File System
  - Handles log-based transaction processing
    - Complexity of Code
  - It has been a popular target for attackers over the past six years.

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In-the-wild

- MSKSSRV
  - Microsoft Kernel Streaming Service
  - Handles synchronization of multimedia streams
  - Very small

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In-the-wild

- MSKSSRV
  - Microsoft Kernel Streaming Service
  - Handles synchronization of multimedia streams
  - Very small
  - Last year it became a very popular target, with 2 ITW exploits in just a few month.

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In-the-wild

- ~~Win32k~~
- ~~CLFS~~
- MSKSSRV
- ...

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Let's take a look at MSKSSRV

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MSKSSRV

- CVE-2023-29360 – logical bug (found by @masthoon)
  - MmProbeAndLockPages invalid AccessMode
    - No check if access mode is KernelMode (0)

```
__int64 __fastcall FsAllocAndLockMdl(void *user_addr, ULONG size, struct _MDL **a3)
{
  ...
  if ( user_addr && size && a3 )
  {
    Mdl = IoAllocateMdl(user_addr, size, 0, 0, 0LL);
    v6 = Mdl;
    if ( Mdl )
    {
      MmProbeAndLockPages(Mdl, 0, IoWriteAccess);
      *a3 = v6;
    }
```

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MSKSSRV

- CVE-2023-29360 – logical bug (found by @masthoon)
  - MmProbeAndLockPages invalid AccessMode
    - No check if access mode is KernelMode (0)
      - Mapping arbitrary kernel memory to user space
        - Arbitrary memory writing

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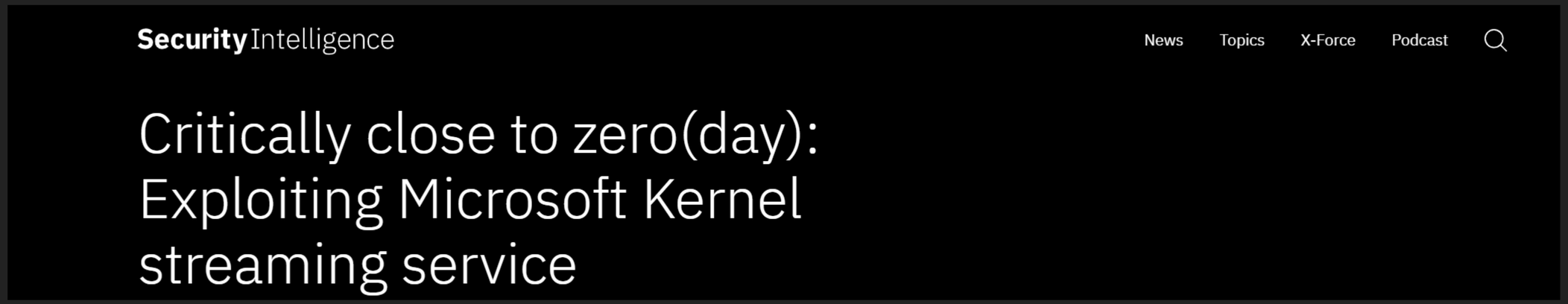
MSKSSRV

- CVE-2023-36802 – Type Confusion
  - No any check for FileObject->FsContext2
    - Context Object & Stream Object type confusion



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MSKSSRV

- CVE-2024-30089 (found by chompie)

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But is that the end of it ?

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Actually ...

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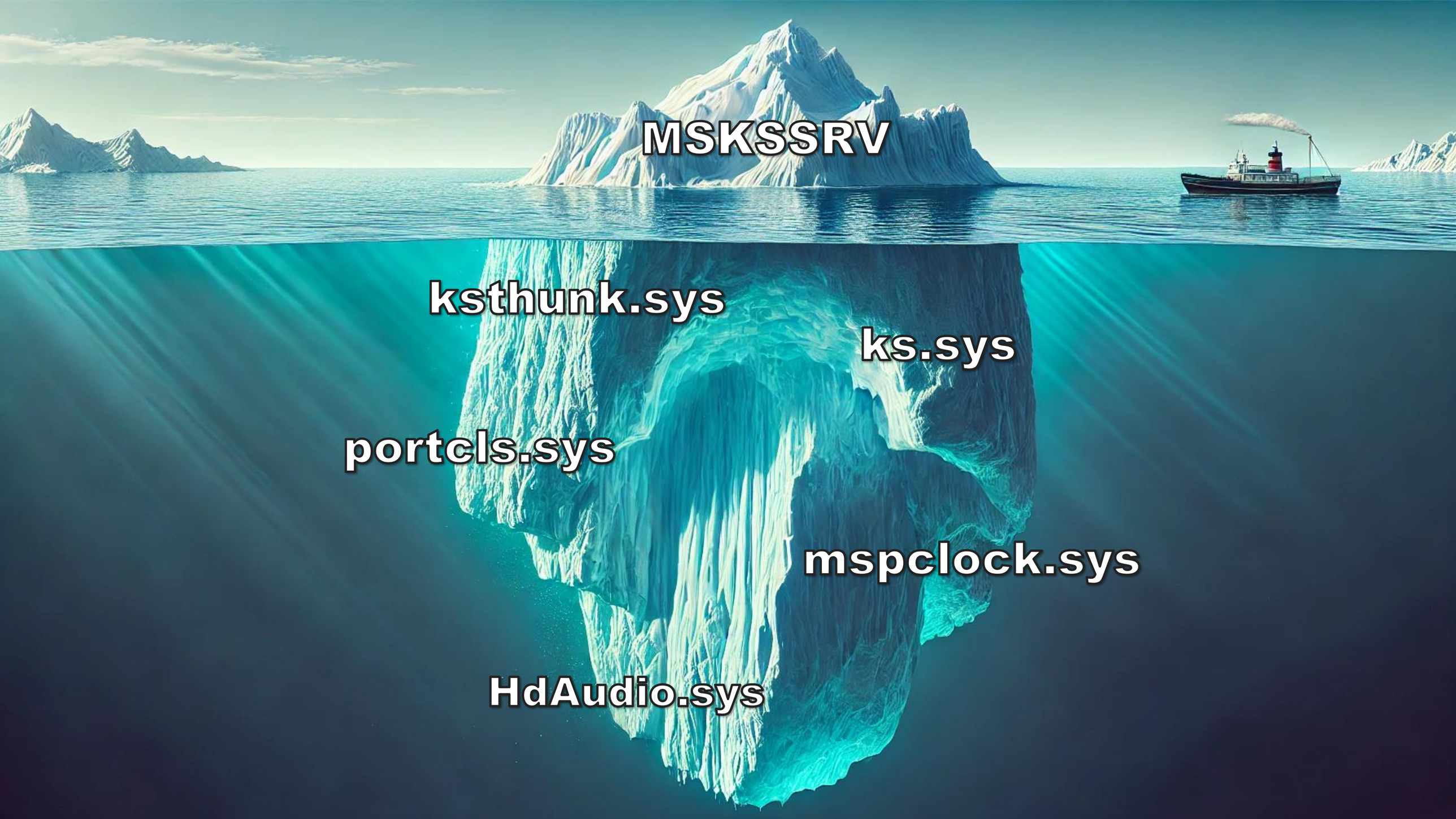
MSKSSRV
ksthunk.sys
ks.sys
portcls.sys
mspclock.sys
HdAudio.sys

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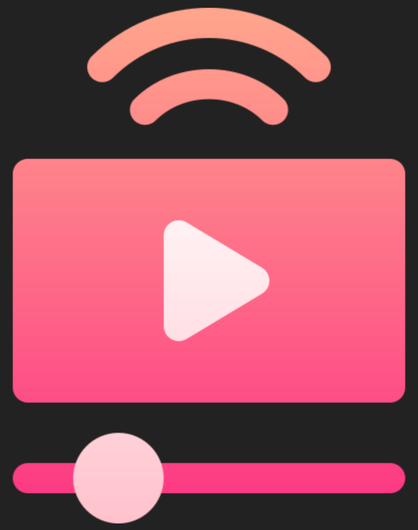
CVE-2024-38054
CVE-2024-30084
CVE-2024-35250
CVE-2024-30090
CVE-2024-38057



Brief overview of Kernel Streaming

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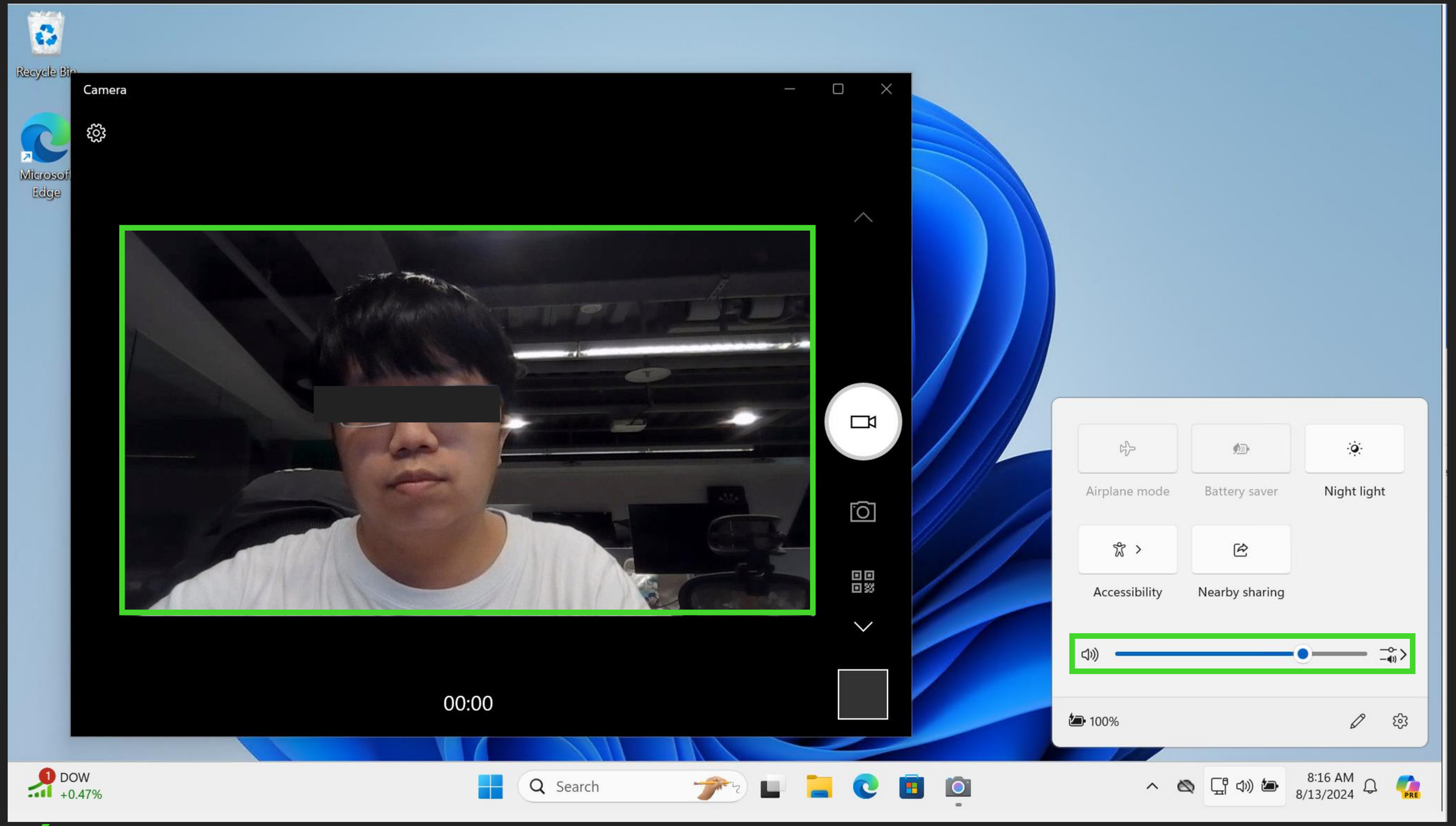
Recycle Bin
Microsoft Edge
Camera
00:00
Airplane mode
Battery saver
Night light
Accessibility
Nearby sharing
100%
DOW
+0.47%
Search
8:16 AM
8/13/2024

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What is Kernel Streaming ?

- Microsoft-provided services that support kernel-mode processing of streamed data
  - Low Latency
  - Efficient Data Processing
  - Unified Interface
  - High Extensibility

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What is Kernel Streaming ?

- Microsoft provides 3 multimedia class driver models
  - Port class
    - Audio device
  - AVStream
    - integrated audio/video streaming
  - Stream class

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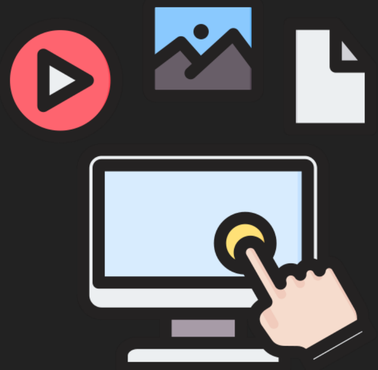
How to interact with Device?



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Enumerate Device

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Enumerate KS Device

- You can use SetupDiGetClassDevs with class GUID to emulate device

```
\\?\hdaudio#subfunc_01&ven_8086&dev_2812&nid_0001&subsys_00000000&rev_1000#6&2f1f346a&0&0002&0000001d#{6994ad04-93ef-11d0-a3cc-00a0c9223196}\ehdmiouttopo
```

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Enumerate KS Device

- KsOpenDefaultDevice
  - Opens a handle to the first device that is listed in the specified Plug and Play (PnP) category

```
hr = KsOpenDefaultDevice(KSCATEGORY_VIDEO_CAMERA,
    GENERIC_READ | GENERIC_WRITE, &g_hDevice);
```

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KS Object

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KS Object

- After we open these Devices, Kernel Streaming will establish some Kernel Streaming related instance
  - KS Filter
  - KS Pin
  - …
- Encapsulate hardware function

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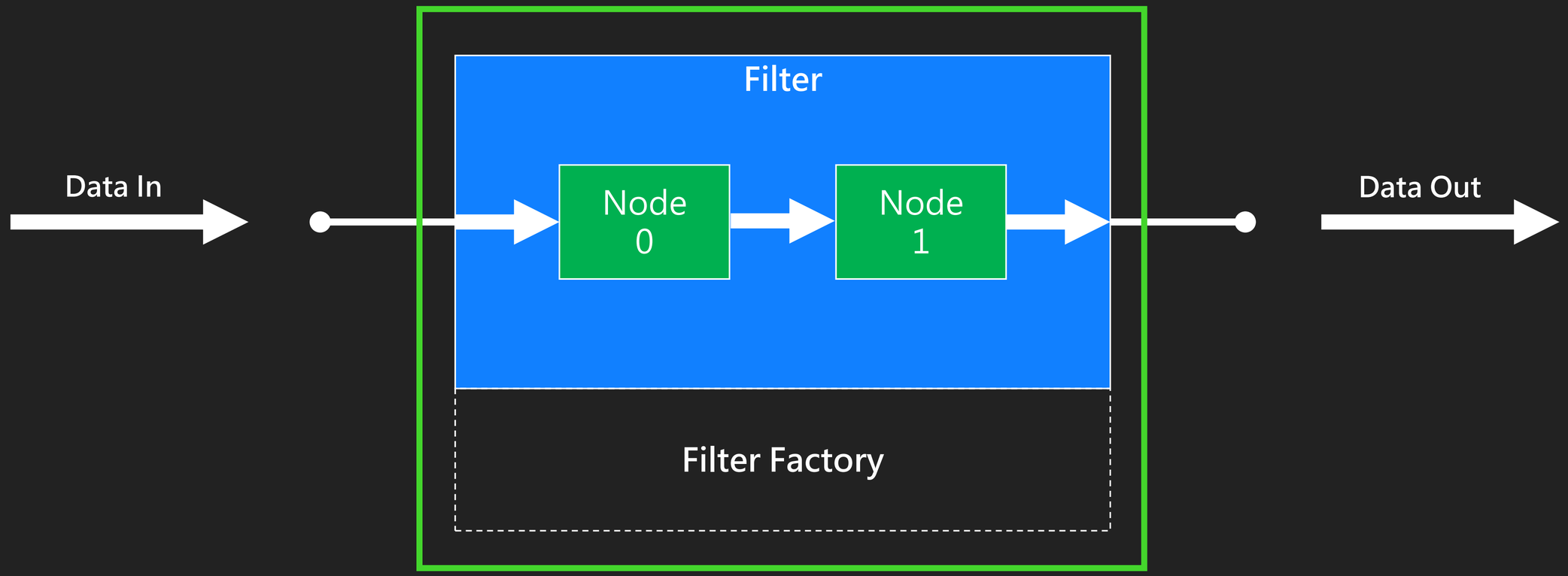
KS Filter



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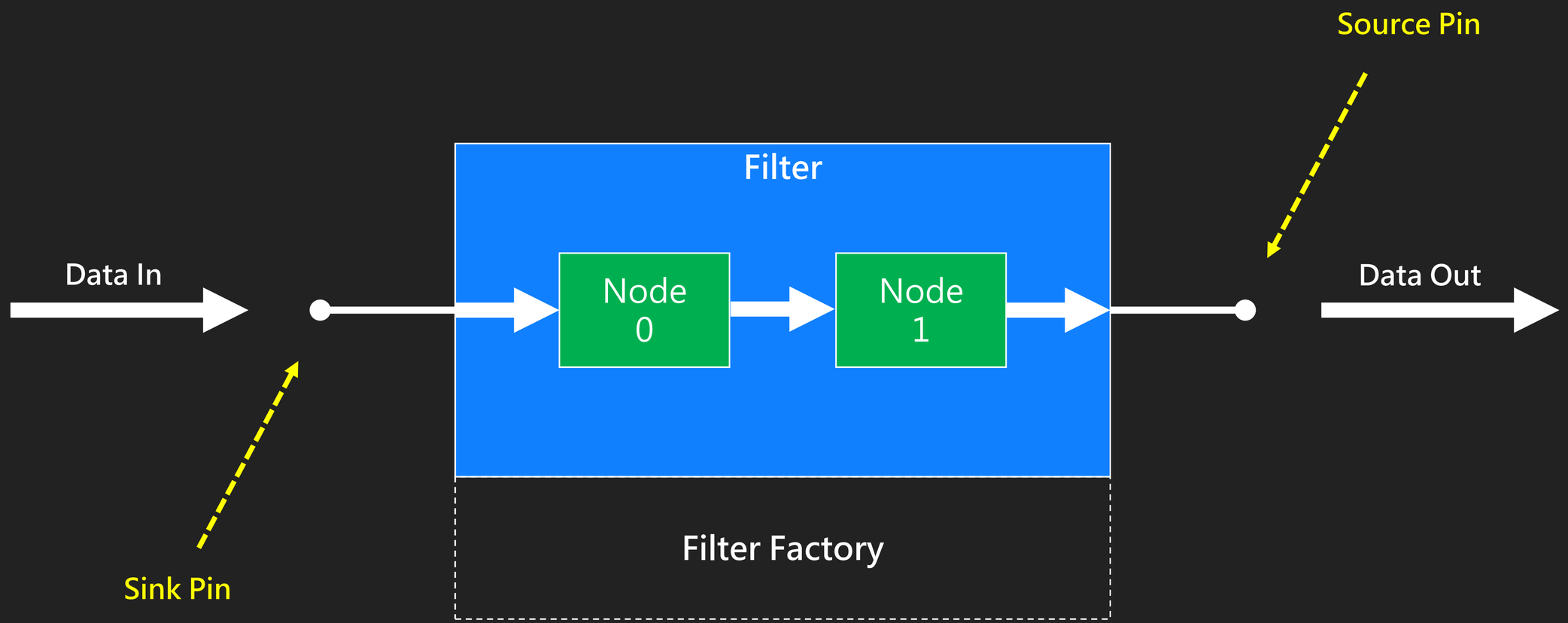
https://learn.microsoft.com/en-us/windows-hardware/drivers/audio/audio-filters

KS Pin



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https://learn.microsoft.com/en-us/windows-hardware/drivers/audio/audio-filters

KS Property

- A Property represents a capability or control-state setting that belongs to a kernel streaming object
- Client can set or get property to KS Object with GUID
  - Device State
  - Data format
  - Volume Level

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KS Property

- Device State is a KS property
- Through IOCTL_KS_PROPERTY to get or set it

```
DeviceIoControl(hPin, IOCTL_KS_PROPERTY, &pinProp, sizeof(pinProp),
    &state, sizeof(state), &cbReturned, NULL);
```

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Kernel Streaming Architecture

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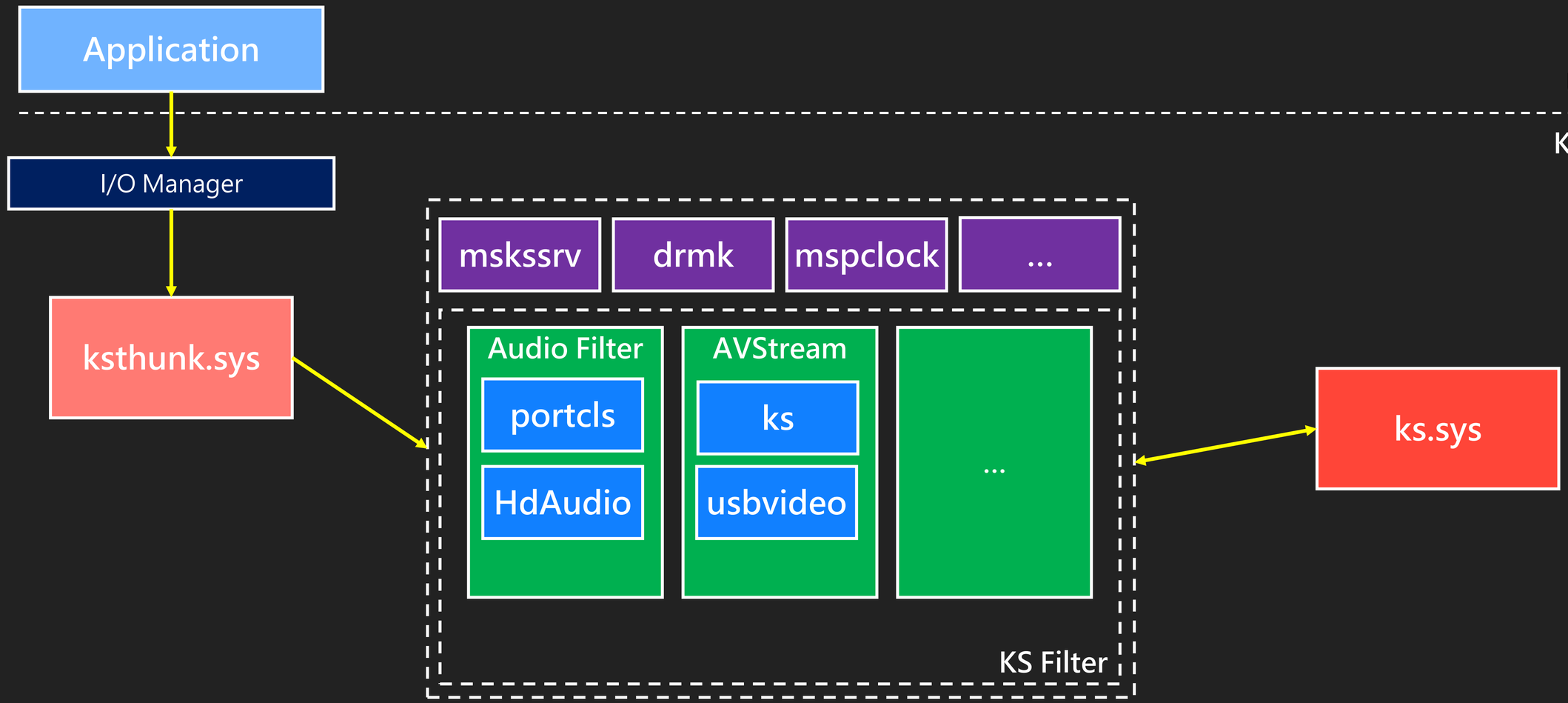
Kernel Streaming Architecture



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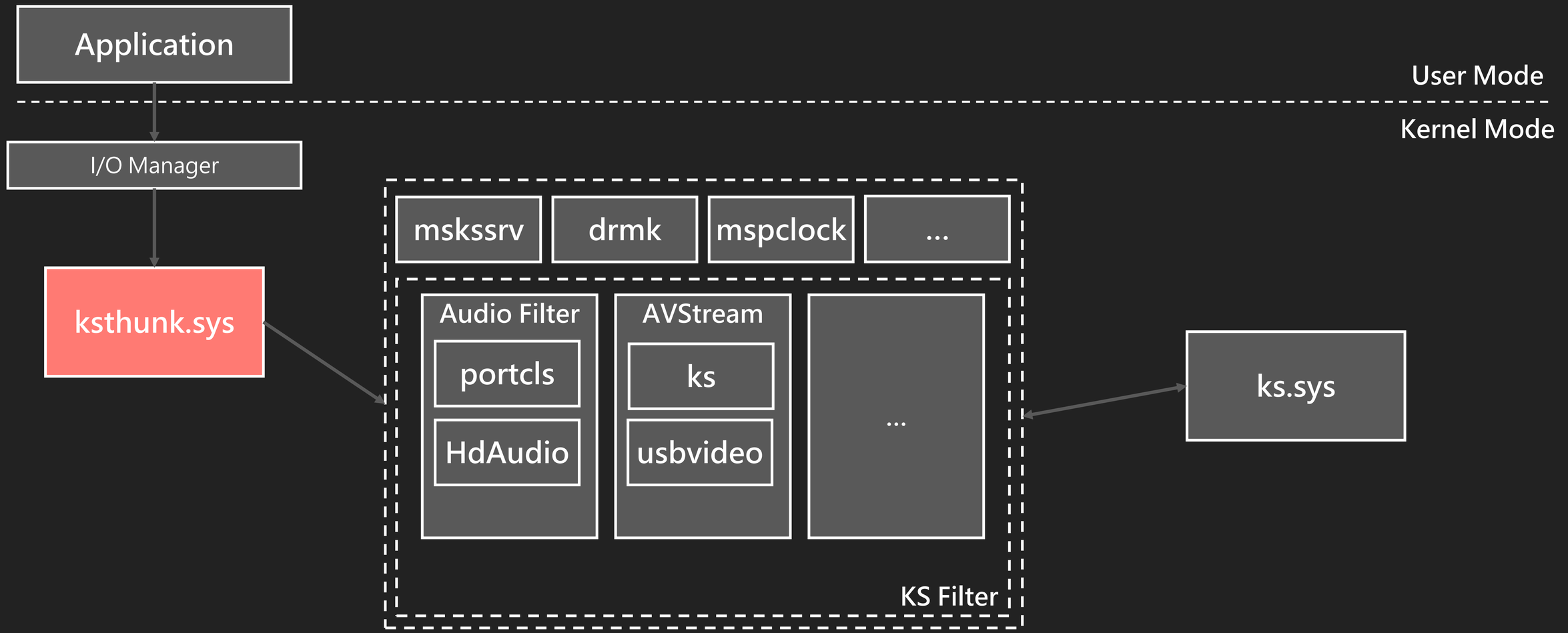
Kernel Streaming Architecture



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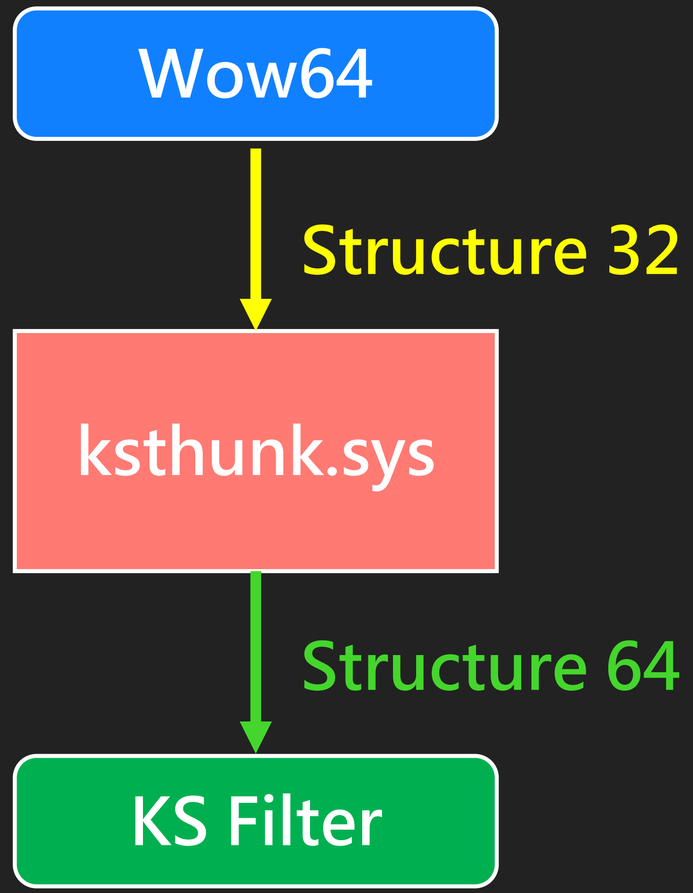
ksthunk

- Kernel Streaming WOW Thunk Service Driver
- Entry point of Kernel Streaming
- For backward compatibility
  - If the request process is WoW64
    - Transfer 32-bits to 64-bit request



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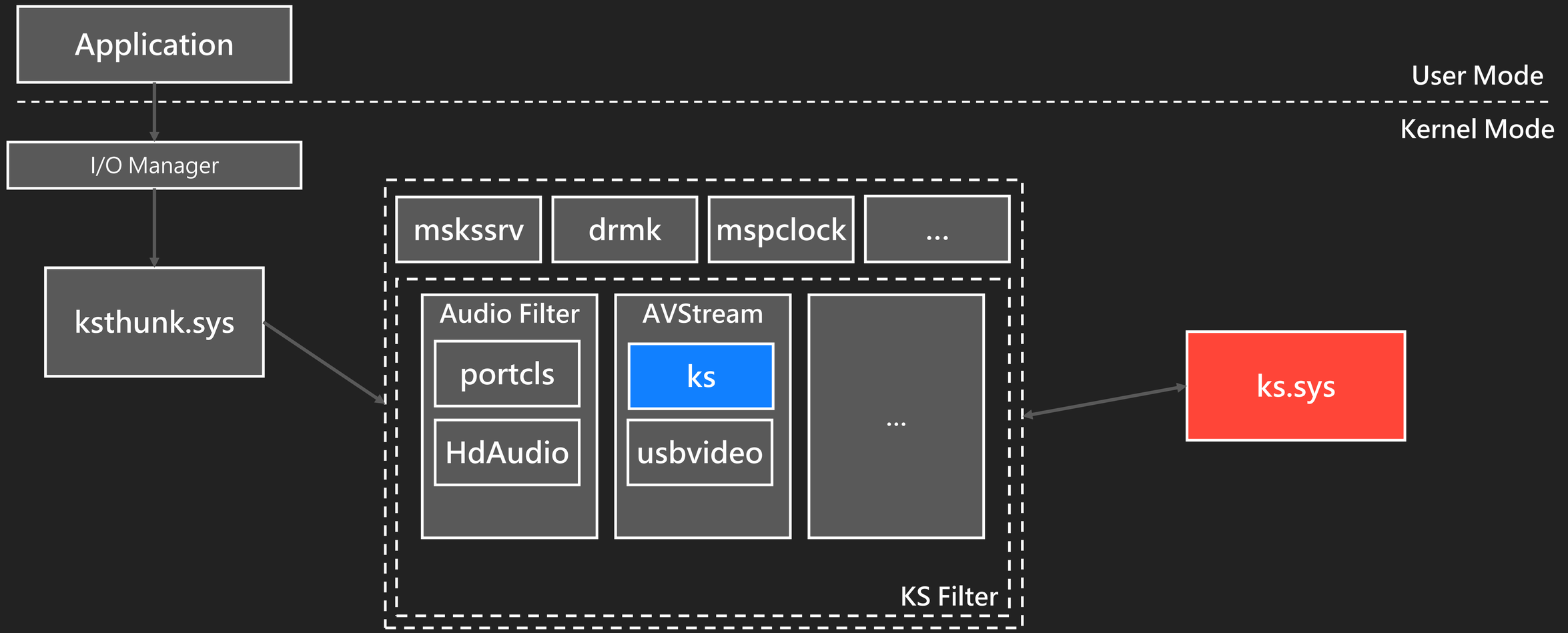
Kernel Streaming Architecture



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ks.sys

- Kernel CSA Library
- One of the main components of Kernel Streaming
- Provide interface for Kernel Stream
  - Property
  - Event
  - …

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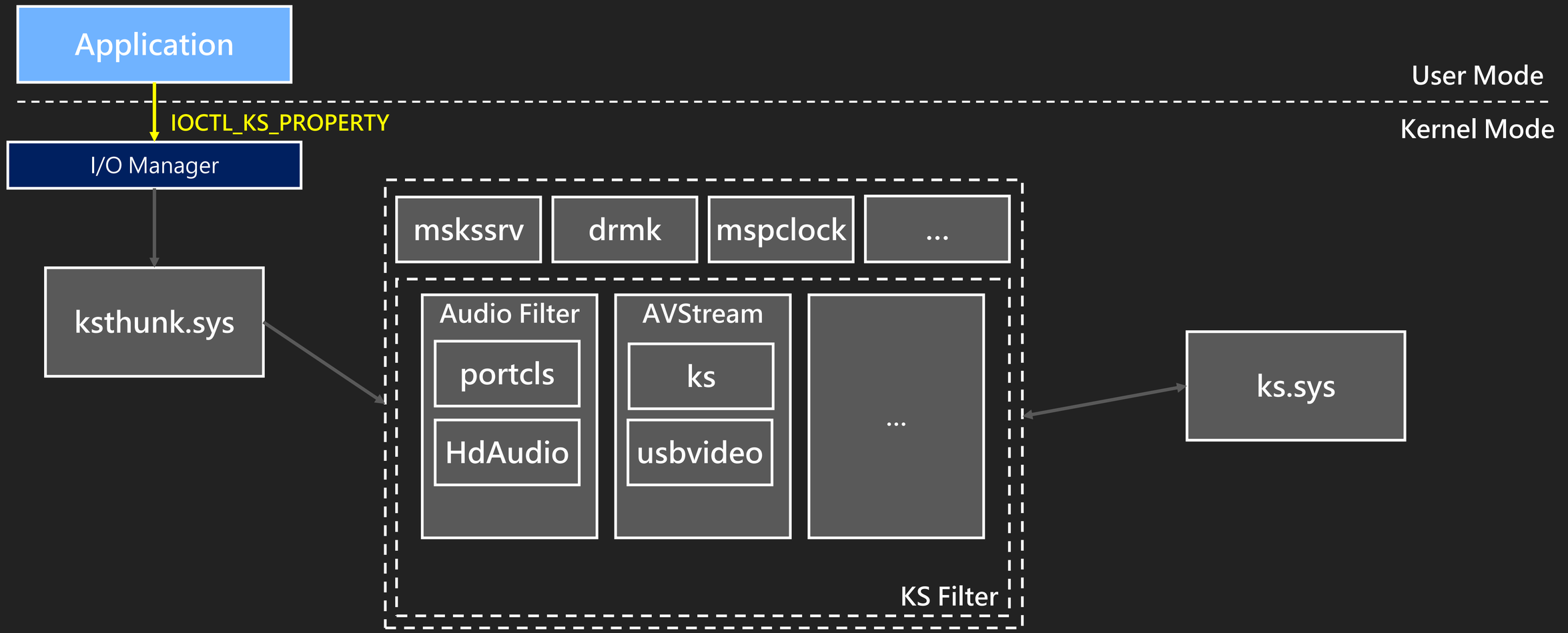
The work flow of set pin state



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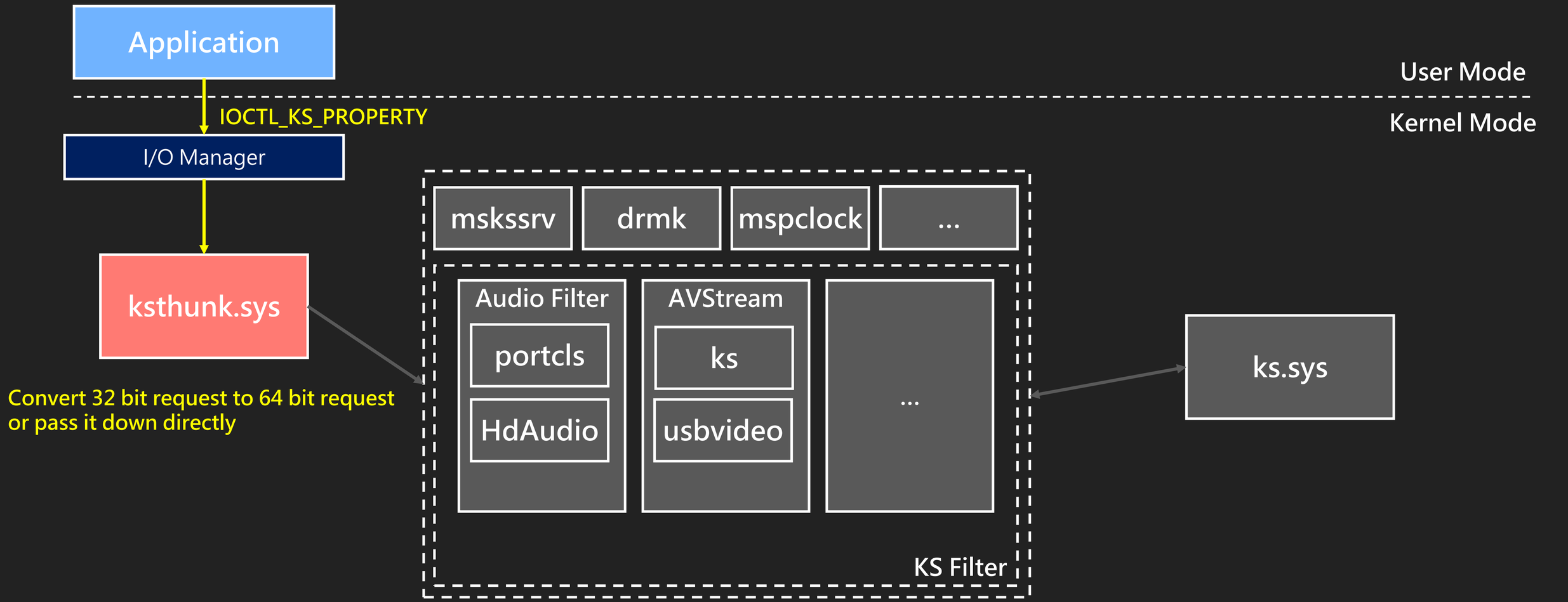
The work flow of set pin state



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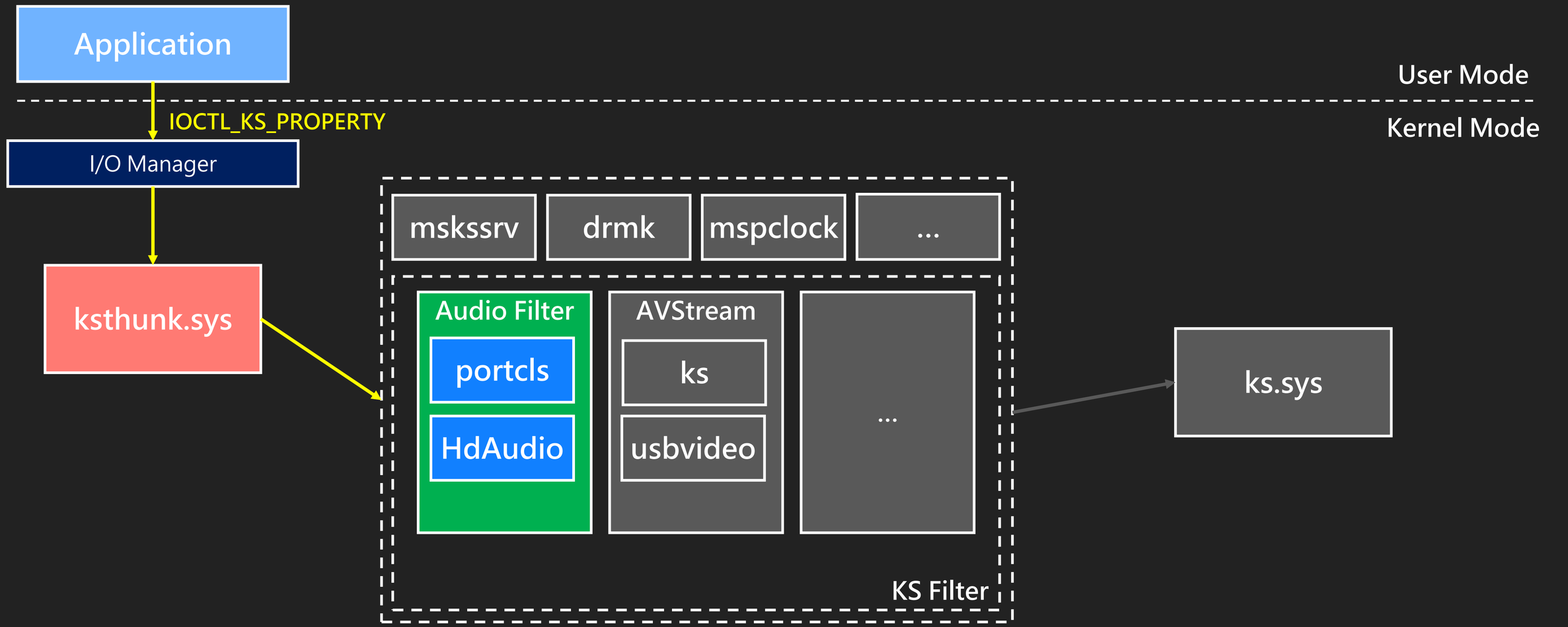
The work flow of set pin state



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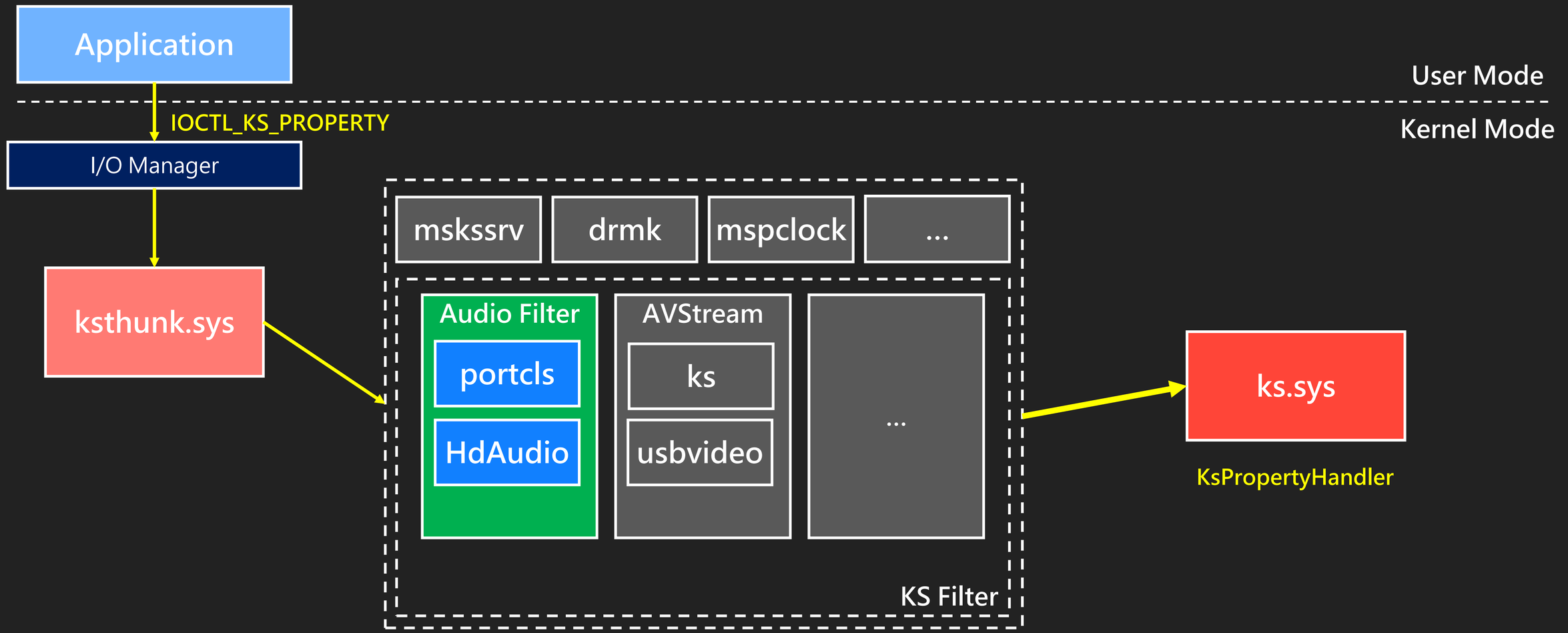
The work flow of set pin state



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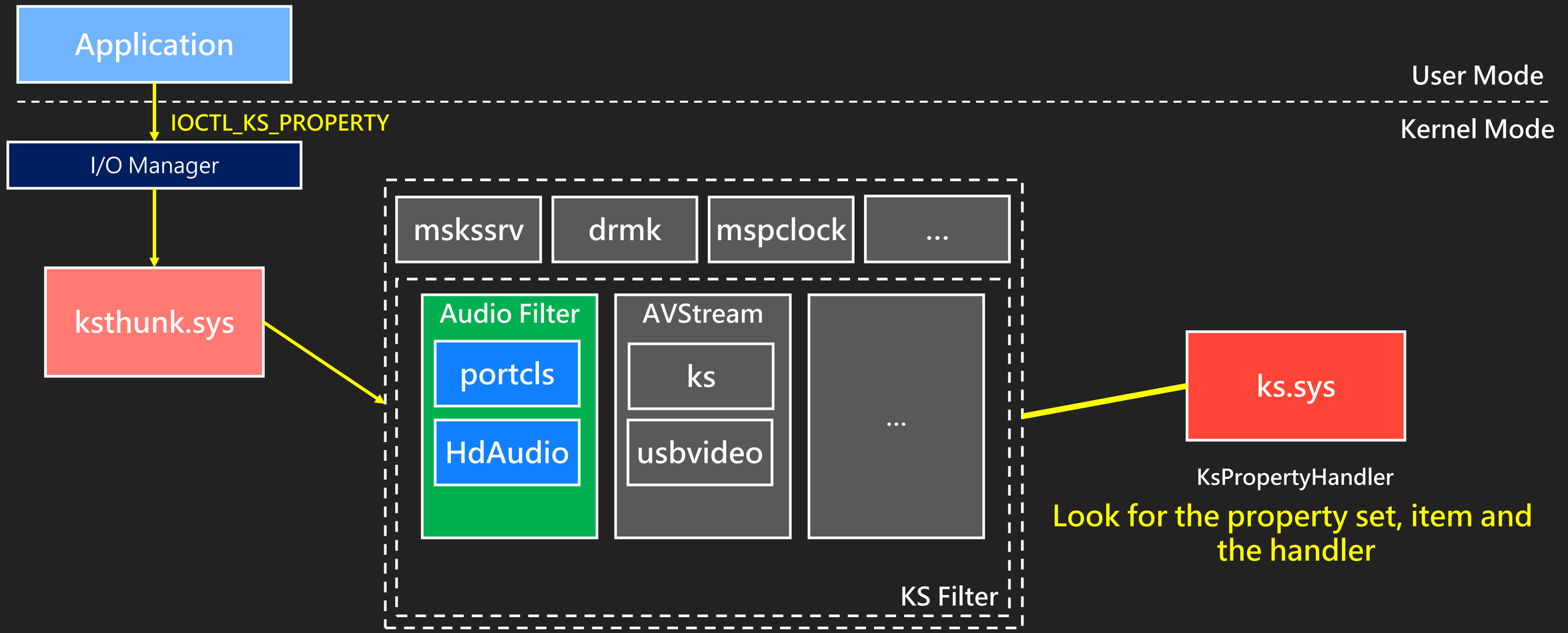
The work flow of set pin state



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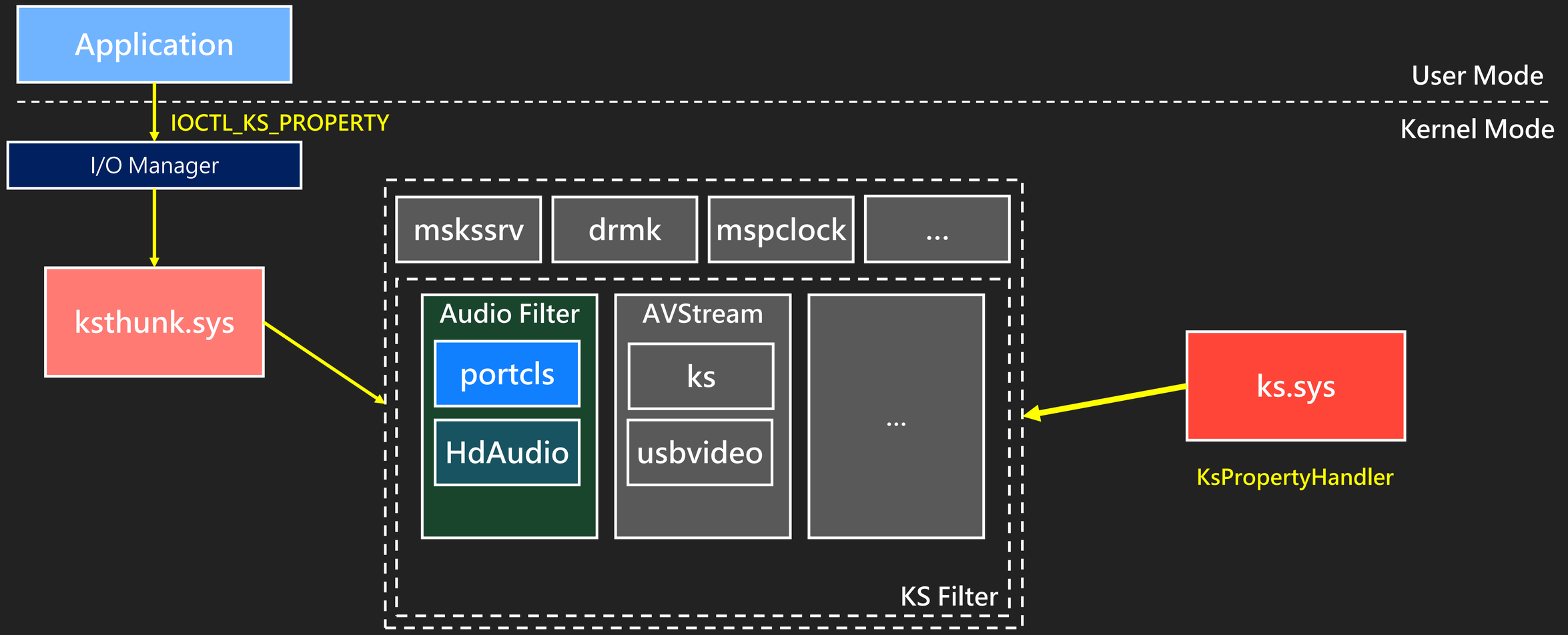
The work flow of set pin state



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portcls! PinPropertyDeviceState

From attacker's view

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From attacker's view

- There are many properties for each device
  - individual implementation

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From attacker's view

- There are many properties for each device
  - individual implementation
- No vulnerabilities in ks and ksthunk for a long time
  - **CVE-2020-16889 (found by @nghiadt1098)**
  - **CVE-2020-17045 (found by @nghiadt1098)**

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From attacker's view

- There are many properties for each device
  - individual implementation
- No vulnerabilities in ks and ksthunk for a long time
  - CVE-2020-16889 (found by @nghiadt1098)
  - CVE-2020-17045 (found by @nghiadt1098)
- **Each driver handles part of the content individually, which may lead to inconsistencies.**

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We found some trivial vulnerabilities in few days ...

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Vulnerabilities

- Portcls.sys
  - CVE-2024-38055 (OOB)
  - CVE-2024-38056
- Ksthunk
  - CVE-2024-38054 (OOB)
  - CVE-2024-38057
  - CVE-2024-38144

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CVE-2024-38144

```
__int64 __fastcall CKSAutomationThunk::ThunkEnableEventIrp(...)
{
  outbuflen = CurrentStackLocation->Parameters.DeviceIoControl.OutputBufferLength;
  NewSize = (outbuflen + 0x17) & 0xFFFFFFF8;
  if ( NewSize < (int)outbuflen + 0x10 || NewSize + inputbuflen < NewSize )
    ExRaiseStatus(-1073741306);
  newsysbuf = (PVOID)ExAllocatePool2(..., NewSize + inputbuflen ,...);
  ...
  memmove((void *)(newsysbuf + 0x20), (char *)irp->UserBuffer + 0x10, outbuflen - 0x10);
  ...

}
```

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CVE-2024-38144

```
__int64 __fastcall CKSAutomationThunk::ThunkEnableEventIrp(...)
{
  outbuflen = CurrentStackLocation->Parameters.DeviceIoControl.OutputBufferLength;
  NewSize = (outbuflen + 0x17) & 0xFFFFFFF8;
  if ( NewSize < (int)outbuflen + 0x10 || NewSize + inputbuflen < NewSize )
    ExRaiseStatus(-1073741306);
  newsysbuf = (PVOID)ExAllocatePool2(..., NewSize + inputbuflen ,...);
  ...
  memmove((void *)(newsysbuf + 0x20), (char *)irp->UserBuffer + 0x10, outbuflen - 0x10);
  ...

}
```

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We found some interesting things

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Is really safe ?

```
if ( irp->RequestorMode )
{
  v14 = 0xC0000010;
}
else
{
  UserBuffer = (unsigned int *)irp->UserBuffer;
  v19[0] = 0LL;
  v19[1] = v9;
  FileObject = CurrentStackLocation->FileObject;
  v21 = FileObject;
  v14 = (*(__int64 (__fastcall **)(_QWORD, _QWORD, __int64 *))(Type3InputBuffer + 0x38))(
          *UserBuffer,
          0LL,
          v19);
}
```

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Is really safe ?

UserMode(1)

```
if ( irp->RequestorMode )
{
  v14 = 0xC0000010;
}
else
{
  UserBuffer = (unsigned int *)irp->UserBuffer;
  v19[0] = 0LL;
  v19[1] = v9;
  FileObject = CurrentStackLocation->FileObject;
  v21 = FileObject;
  v14 = (*(__int64 (__fastcall **)(_QWORD, _QWORD, __int64 *))(Type3InputBuffer + 0x38))(
          *UserBuffer,
          0LL,
          v19);
}
```

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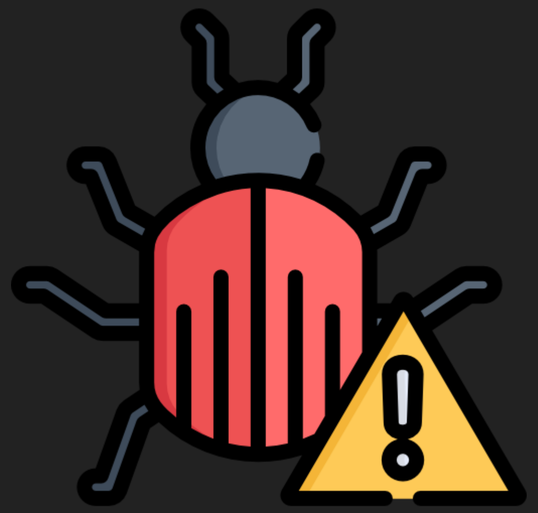

The Overlooked Bug Class

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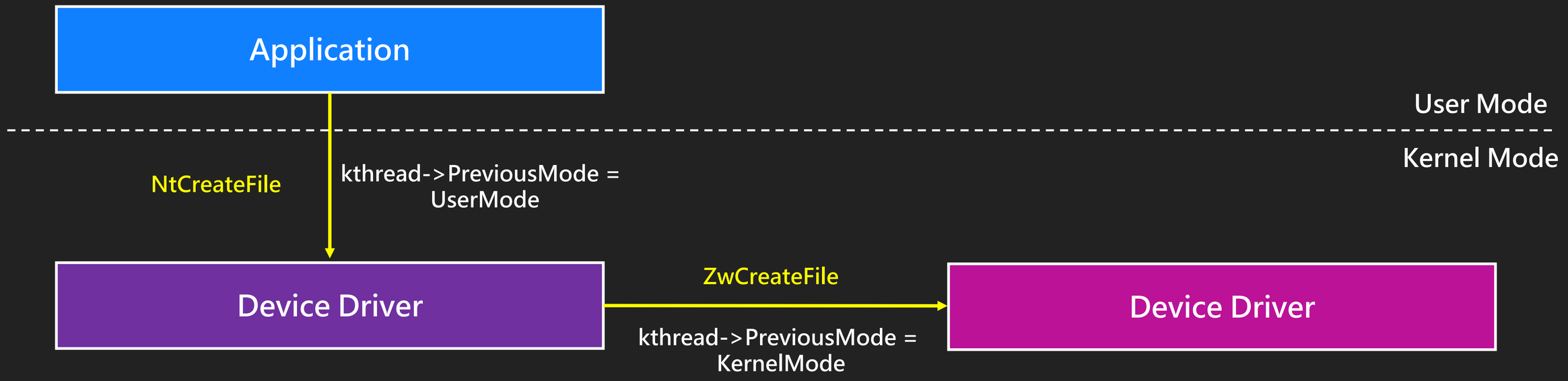
PreviousMode

- A field in the thread object that indicates whether the parameters for a System Service Call originated in user mode or kernel mode.



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IRP RequestorMode

- IRP->RequestorMode
  - the execution mode of the original requester of the operation
  - A copy of the PreviousMode value from the thread object

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IRP RequestorMode

```
if ( Irp->RequestorMode )
{
  ProbeForRead(CurrentStackLocation->Parameters.DeviceIoControl.Type3InputBuffer, InputBufferLength, 1u);
  a4 = callback;
  outputLength = outlen;
}
```

```
MmProbeAndLockPages(Irp->MdlAddress, Irp->RequestorMode, IoWriteAccess);
RequestorMode = Irp->RequestorMode;
v16 = (unsigned __int8)HIBYTE(*(_WORD *)(a2 + 24)) >> 6;
Object = 0LL;
v14 = ObReferenceObjectByHandle(v8, v16, (POBJECT_TYPE)IoFileObjectType, RequestorMode, &Object, 0LL);
```

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But there are some issues in some cases ...

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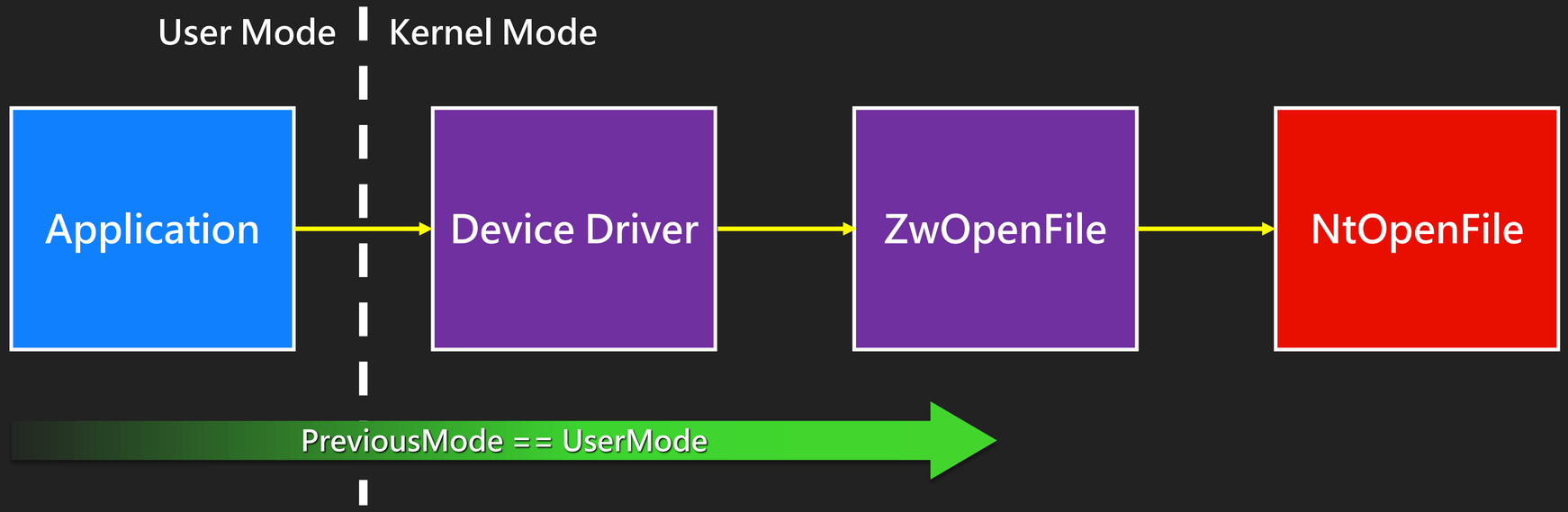
A logical bug class

- Windows Kernel Logic Bug Class: Access Mode Mismatch in IO Manager by James Forshaw



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https://googleprojectzero.blogspot.com/2019/03/windows-kernel-logic-bug-class-access.html

A logical bug class

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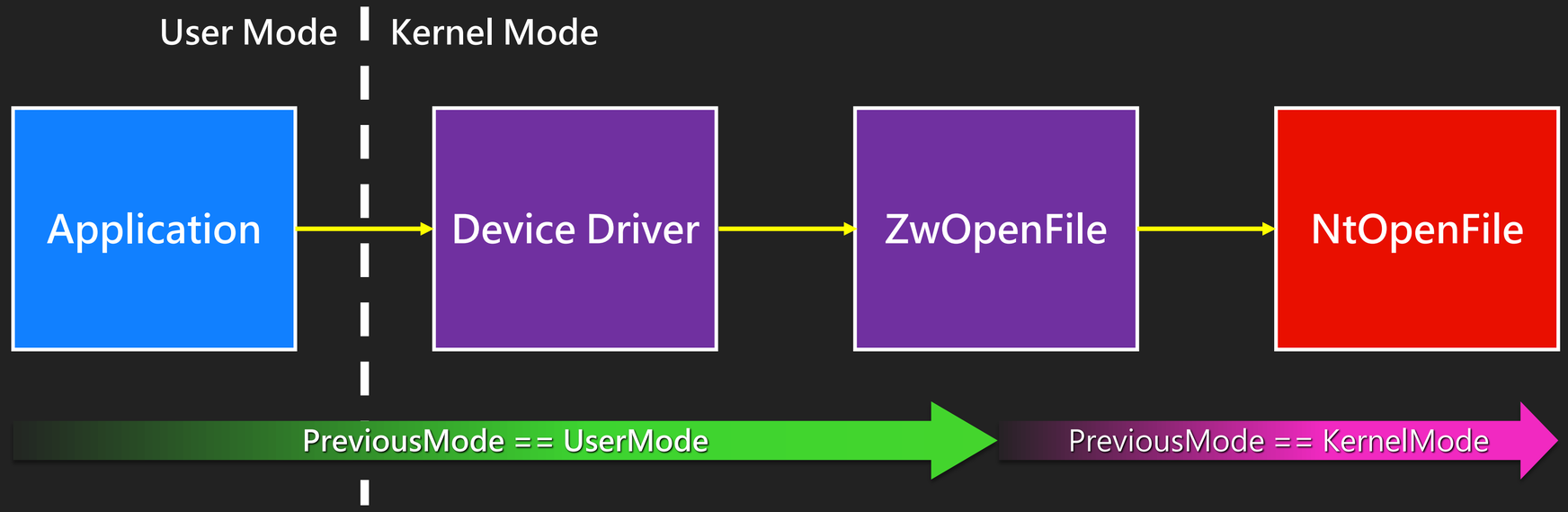

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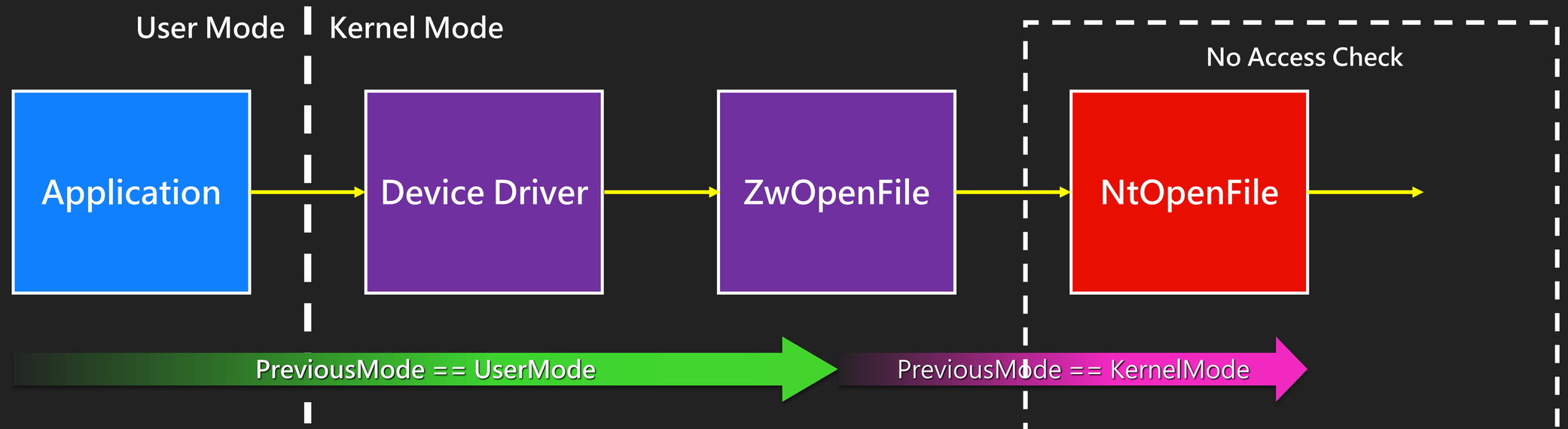
https://googleprojectzero.blogspot.com/2019/03/windows-kernel-logic-bug-class-access.html

A logical bug class

- What happens if kernel call OpenFile and solely relies on RequestorMode for validation ?



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https://googleprojectzero.blogspot.com/2019/03/windows-kernel-logic-bug-class-access.html

A logical bug class

- What happens if kernel call OpenFile and solely relies on RequestorMode for validation ?
  - Bypass
    - Security Access Check
    - Memory Access Check

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https://googleprojectzero.blogspot.com/2019/03/windows-kernel-logic-bug-class-access.html

It focuses on Zw* system service call

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Are there other potential causes for this bug class?

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Are there other potential causes for this bug class?

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The Bug Pattern

- IoBuildDeviceIoControlRequest

The **IoBuildDeviceIoControlRequest** routine allocates and sets up an IRP for a synchronously processed device control request.

Syntax

C++ Copy

```
__drv_aliasesMem PIRP IoBuildDeviceIoControlRequest(
  [in]             ULONG            IoControlCode,
  [in]             PDEVICE_OBJECT   DeviceObject,
  [in, optional]   PVOID            InputBuffer,
  [in]             ULONG            InputBufferLength,
  [out, optional] PVOID             OutputBuffer,
  [in]             ULONG            OutputBufferLength,
  [in]             BOOLEAN          InternalDeviceIoControl,
  [in, optional]   PKEVENT          Event,
  [out]            PIO_STATUS_BLOCK IoStatusBlock
);
```

https://learn.microsoft.com/en-us/windows-hardware/drivers/ddi/wdm/nf-wdm-iobuilddeviceiocontrolrequest

The Bug Pattern

- IoBuildDeviceIoControlRequest

If the caller supplies an InputBuffer or OutputBuffer parameter, this parameter must point to a buffer that resides in system memory. The caller is responsible for validating any parameter values that it copies into the input buffer from a user-mode buffer. The input buffer might contain parameter values that are interpreted differently depending on whether the originator of the request is a user-mode application or a kernel-mode driver. In the IRP that **IoBuildDeviceIoControlRequest** returns, the **RequestorMode** field is always set to **KernelMode.** This value indicates that the request, and any information contained in the request, is from a trusted, kernel-mode component.

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After quick review of this bug pattern in KS

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```
NTSTATUS __stdcall KsSynchronousIoControlDevice(
    PFILE_OBJECT FileObject,
    KPROCESSOR_MODE RequestorMode,
    ULONG IoControl,
    PVOID InBuffer,
    ULONG InSize,
    PVOID OutBuffer,
    ULONG OutSize,
    PULONG BytesReturned)
{

    KeInitializeEvent(&Event, NotificationEvent, 0);
    NewIrp = IoBuildDeviceIoControlRequest(
        IoControl,
        RelatedDeviceObject,
        InBuffer,
        InSize,
        OutBuffer,
        OutSize,
        0,
        &Event,
        &IoStatusBlock);
    ...
    NewIrp->RequestorMode = RequestorMode;
    ...
    Status = IofCallDriver(RelatedDeviceObject, NewIrp);
}
```

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But ...

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CKsPin::GetState

KernelMode

```
BytesReturned = 0;
v5 = KsSynchronousIoControlDevice(m_Worker, 0, 0x2F0003u, &InBuffer, 0x18u, OutBuffer,
if ( v5 >= 0 && BytesReturned != 4 )
  v5 = -1073741306;
```

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CKsPin::GetState

```
BytesReturned = 0;
v5 = KsSynchronousIoControlDevice(m_Worker, 0, 0x2F0003u, &InBuffer, 0x18u, OutBuffer,
if ( v5 >= 0 && BytesReturned != 4 )
  v5 = -1073741306;
```

SerializePropertySet

```
if ( SerialSize )
{
  v19 = KsSynchronousIoControlDevice(
          CurrentStackLocation->FileObject,
          0,
          CurrentS                rameters.DeviceIoControl.IoControlCode,
          PoolWithTag,
          InSize,
          (v16 + 0x20),
          SerialSize,
          &BytesReturned);
```

KernelMode

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CKsPin::GetState

UnserializePropertySet

```
if ( OutSize > v13 )
  goto error2;
= KsSynchronousIoControlDevice(
    CurrentStackLocation->FileObject,
    0,
    CurrentStackLocation->Parameters.DeviceIoControl.IoControlCode,
    New_KsProperty_req,
    InSize,
    OutBuffer,
    OutSize,
    &BytesReturned);
```

KernelMode

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Look for the bug pattern in KS

1. KsSynchronousIoControlDevice
2. Controllable
   - InputBuffer
   - OutputBuffer
3. IOCTL relies on RequestorMode for security checks

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Look for the bug pattern in KS

1. KsSynchronousIoControlDevice
2. Controllable
   - InputBuffer
   - OutputBuffer

```
KsSynchronousIoControlDevice(
  CurrentStackLocation->FileObject,
  0,
  CurrentStackLocation->Parameters.DeviceIoControl.IoControlCode,
  New_KsProperty_req,
  InSize,
  OutBuffer,
  OutSize,
  &BytesReturned);
```

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Look for the bug pattern in KS

1. KsSynchronousIoControlDevice
2. Controllable
   - InputBuffer
   - OutputBuffer
3. IOCTL relies on RequestorMode for security checks

```
MmProbeAndLockPages(mdl, irp->RequestorMode, IoWriteAccess);
```

```
if ( irp->RequestorMode )
  ProbeForRead(CurrentStackLocation->Parameters.DeviceIoControl.Type3InputBuffer, inputbuf, 1u);
```

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The Vulnerability & Exploitation

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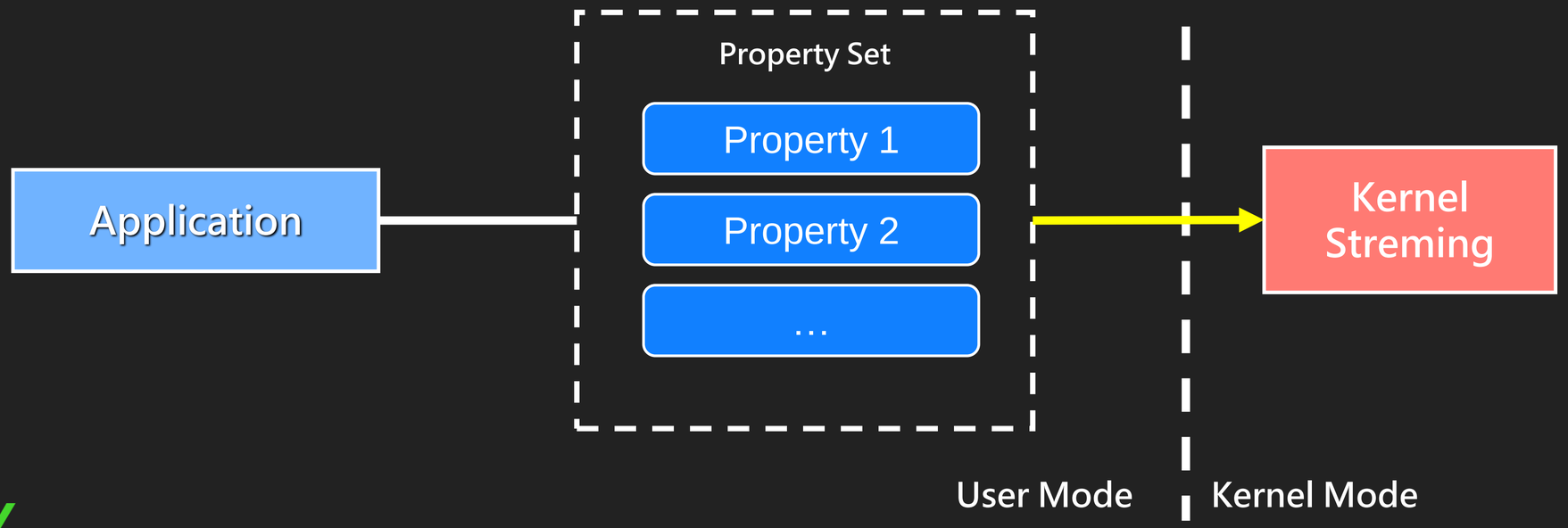
CVE-2024-35250

Unserialize the property set

- KSPROPERTY_TYPE_UNSERIALIZESET
  - Interaction with multiple properties with a single call



DEVCORE

UnserializePropertySet

```
NTSTATUS __fastcall KspPropertyHandler(
        PIRP Irp,
        unsigned int propertysetscnt,
        KSPROPERTY_SET *propertyset,
        __int64 (__fastcall *a4)(_QWORD, _QWORD, _QWORD),
        int a5,
        __int64 NodeAutomationTable,
        unsigned int NodeCnt){

        // check if the UserProvideProperty->Set is in the propertyset

        ...
        if ( KsProperty_flag == KSPROPERTY_TYPE_UNSERIALIZESET )
          return UnserializePropertySet(Irp, sysbuf_, propertyset_);
        ...

}
```

UnserializePropertySet

```
unsigned __int64 __fastcall UnserializePropertySet(
    PIRP irp,
    KSIDENTIFIER* UserProvideProperty,
    KSPROPERTY_SET* propertyset_)
{
    ...
    New_KsProperty_req = ExAllocatePoolWithTag(NonPagedPoolNx, InSize, 0x7070534Bu);
    ...
    memmove(New_KsProperty_req, CurrentStackLocation->Parameters.DeviceIoControl.Type3InputBuffer, InSize);
    ...
    status = KsSynchronousIoControlDevice(
            CurrentStackLocation->FileObject,
            0,
            CurrentStackLocation->Parameters.DeviceIoControl.IoControlCode,
            New_KsProperty_req,
            InSize,
            OutBuffer,
            OutSize,
            &BytesReturned);
    ...
}
```

UnserializePropertySet

```
unsigned __int64 __fastcall UnserializePropertySet(
    PIRP irp,
    KSIDENTIFIER* UserProvideProperty,
    KSPROPERTY_SET* propertyset_)
{
    ...
    New_KsProperty_req = ExAllocatePoolWithTag(NonPagedPoolNx, InSize, 0x7070534Bu);
    ...
    memmove(New_KsProperty_req, CurrentStackLocation->Parameters.DeviceIoControl.Type3InputBuffer, InSize);
    ...
    status = KsSynchronousIoControlDevice(
            CurrentStackLocation->FileObject,
            0,
            CurrentStackLocation->Parameters.DeviceIoControl.IoControlCode,
            New_KsProperty_req,
            InSize,
            OutBuffer,
            OutSize,
            &BytesReturned);
    ...
}
```

UnserializePropertySet

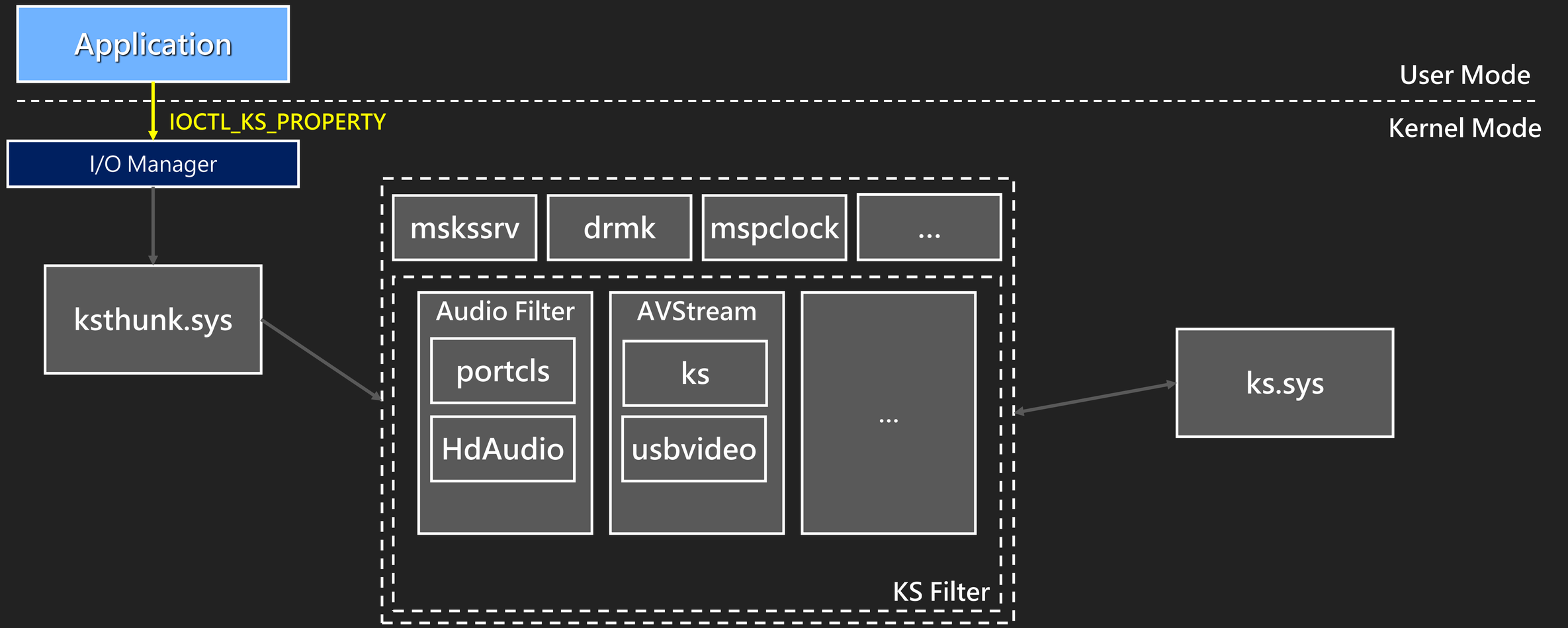
```
unsigned __int64 __fastcall UnserializePropertySet(
    PIRP irp,
    KSIDENTIFIER* UserProvideProperty,
    KSPROPERTY_SET* propertyset_)
{
    ...
    New_KsProperty_req = ExAllocatePoolWithTag(NonPagedPoolNx, InSize, 0x7070534Bu);
    ...
    memmove(New_KsProperty_req, CurrentStackLocation->Parameters.DeviceIoControl.Type3InputBuffer, InSize);
    ...
    status = KsSynchronousIoControlDevice(
            CurrentStackLocation->FileObject,
            0,    KernelMode
            CurrentStackLocation->Parameters.DeviceIoControl.IoControlCode,
            New_KsProperty_req,
            InSize,
            OutBuffer,
            OutSize,
            &BytesReturned);
    ...
}
```

UnserializePropertySet

```
unsigned __int64 __fastcall UnserializePropertySet(
    PIRP irp,
    KSIDENTIFIER* UserProvideProperty,
    KSPROPERTY_SET* propertyset_)
{
    ...
    New_KsProperty_req = ExAllocatePoolWithTag(NonPagedPoolNx, InSize, 0x7070534Bu);
    ...
    memmove(New_KsProperty_req, CurrentStackLocation->Parameters.DeviceIoControl.Type3InputBuffer, InSize);
    ...
    status = KsSynchronousIoControlDevice(
            CurrentStackLocation->FileObject,
            0,
            CurrentStackLocation->Parameters.DeviceIoControl.IoControlCode,
            New_KsProperty_req,
            InSize,
            OutBuffer,
            OutSize,
            &BytesReturned);
    ...
}
```

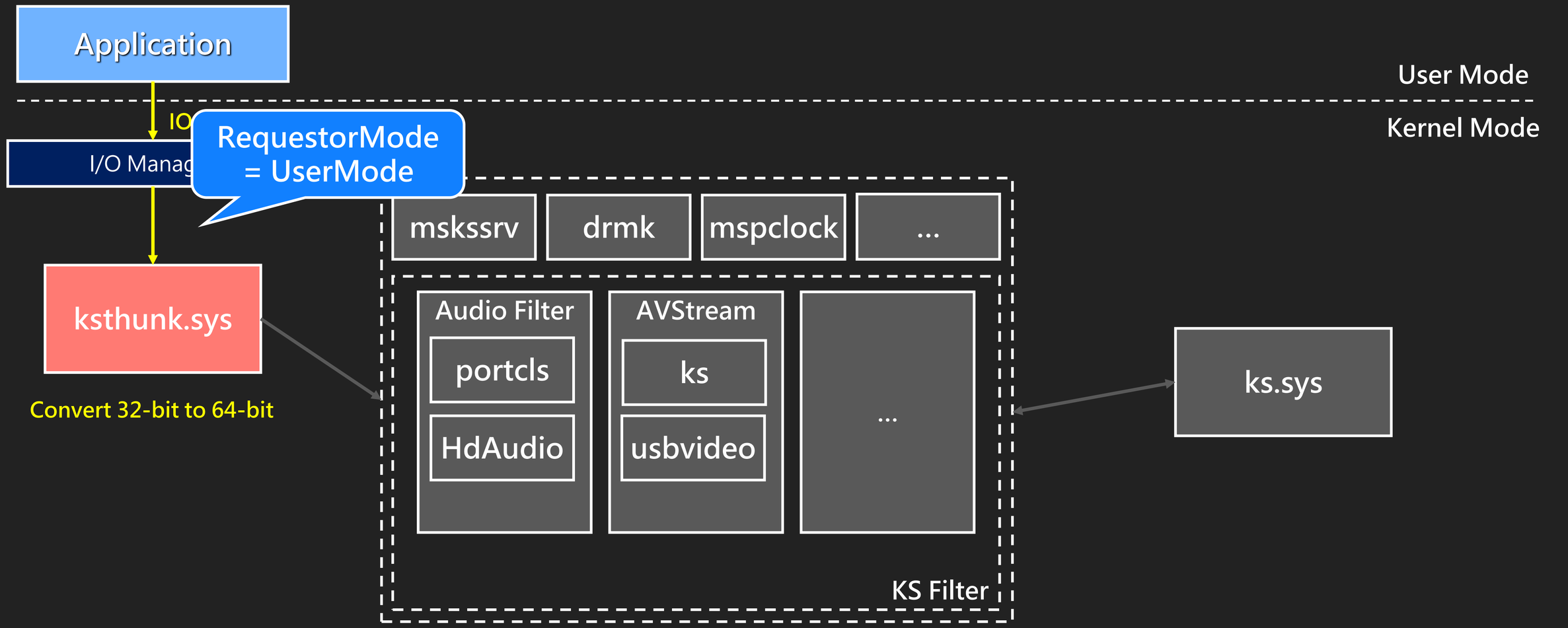
User Control

UnserializePropertySet



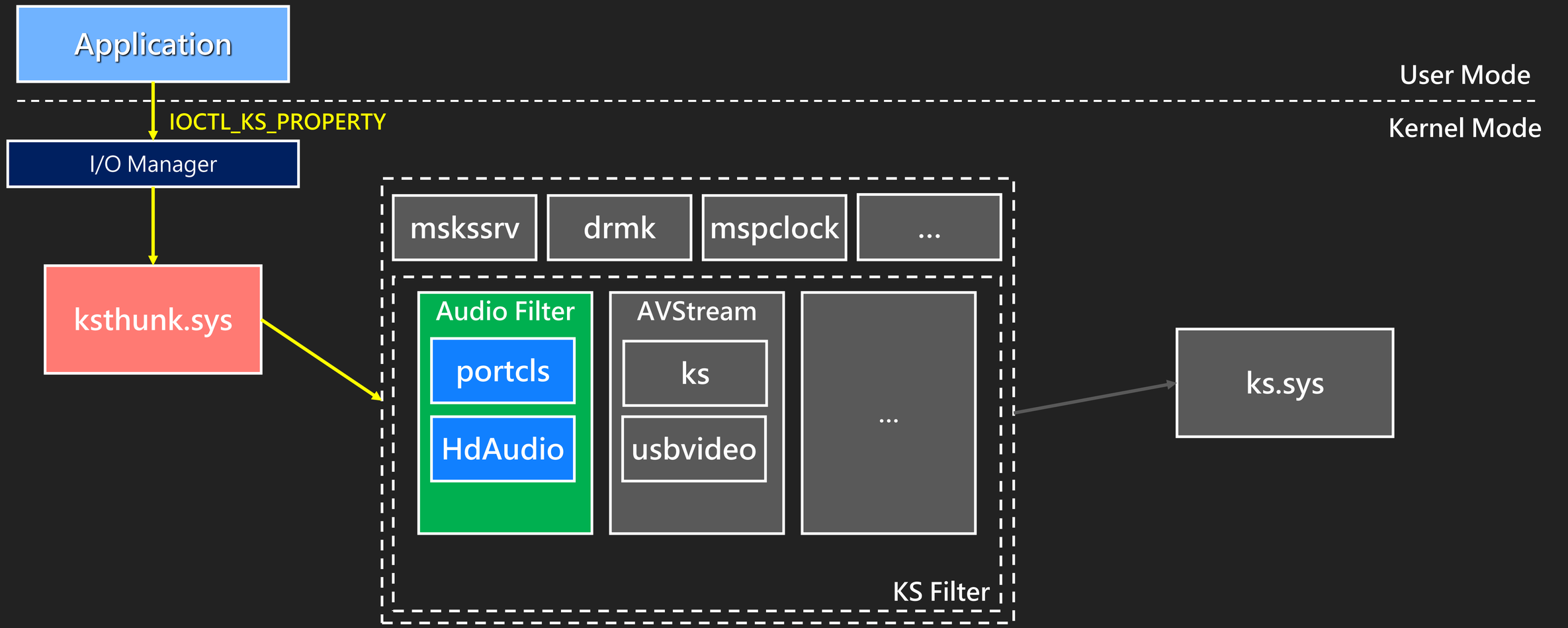
DEVCORE

UnserializePropertySet



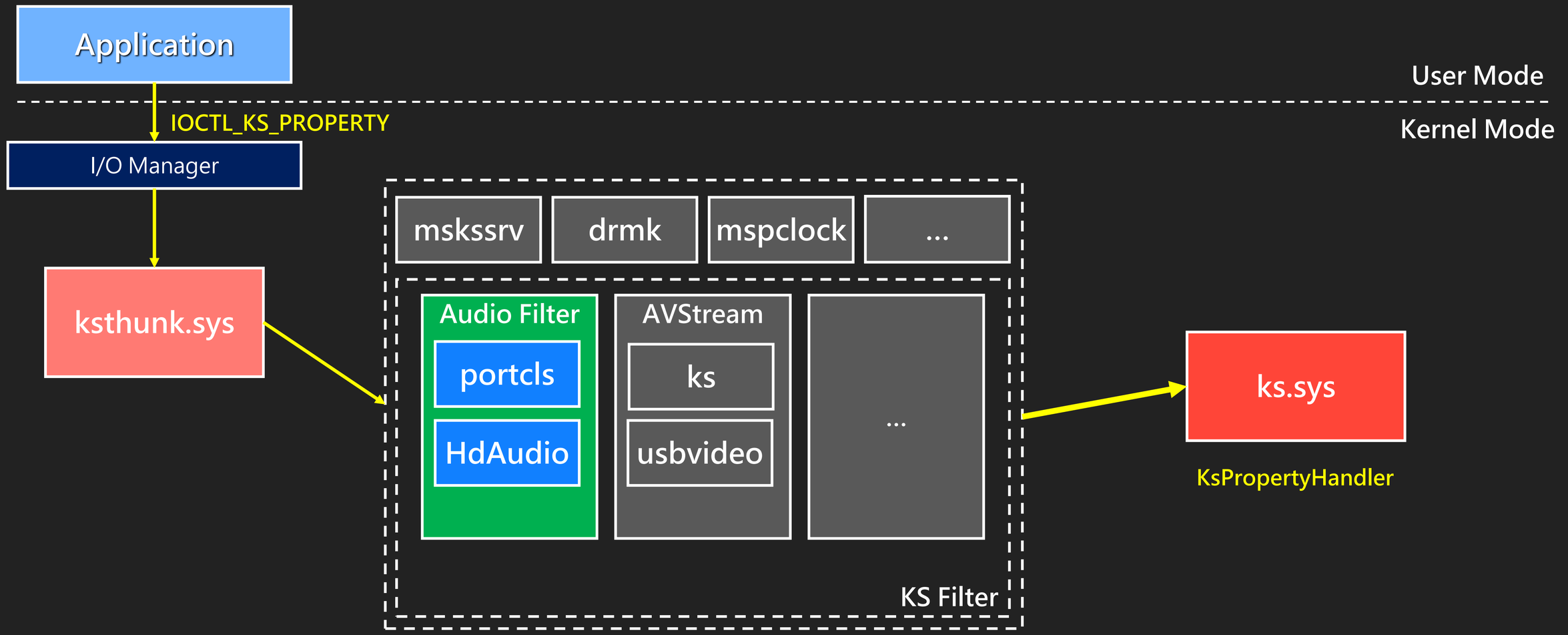
DEVCORE

UnserializePropertySet



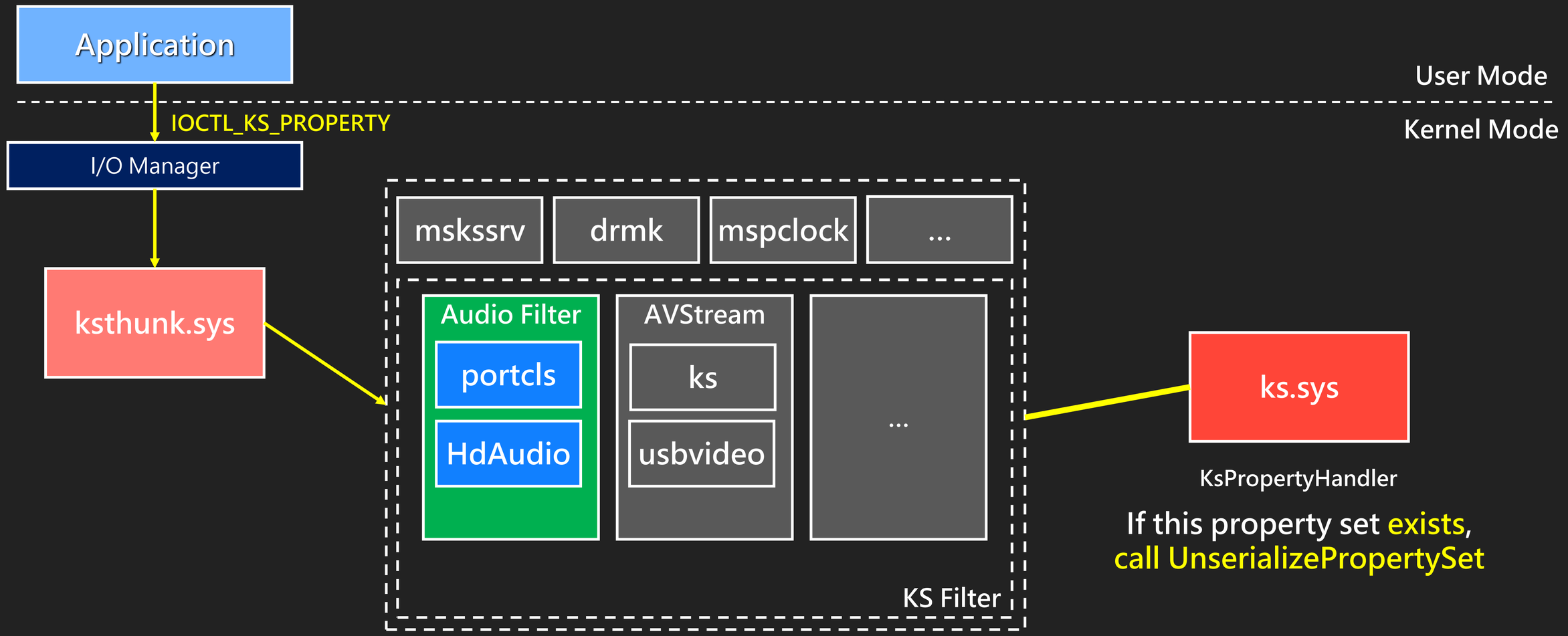
DEVCORE

UnserializePropertySet



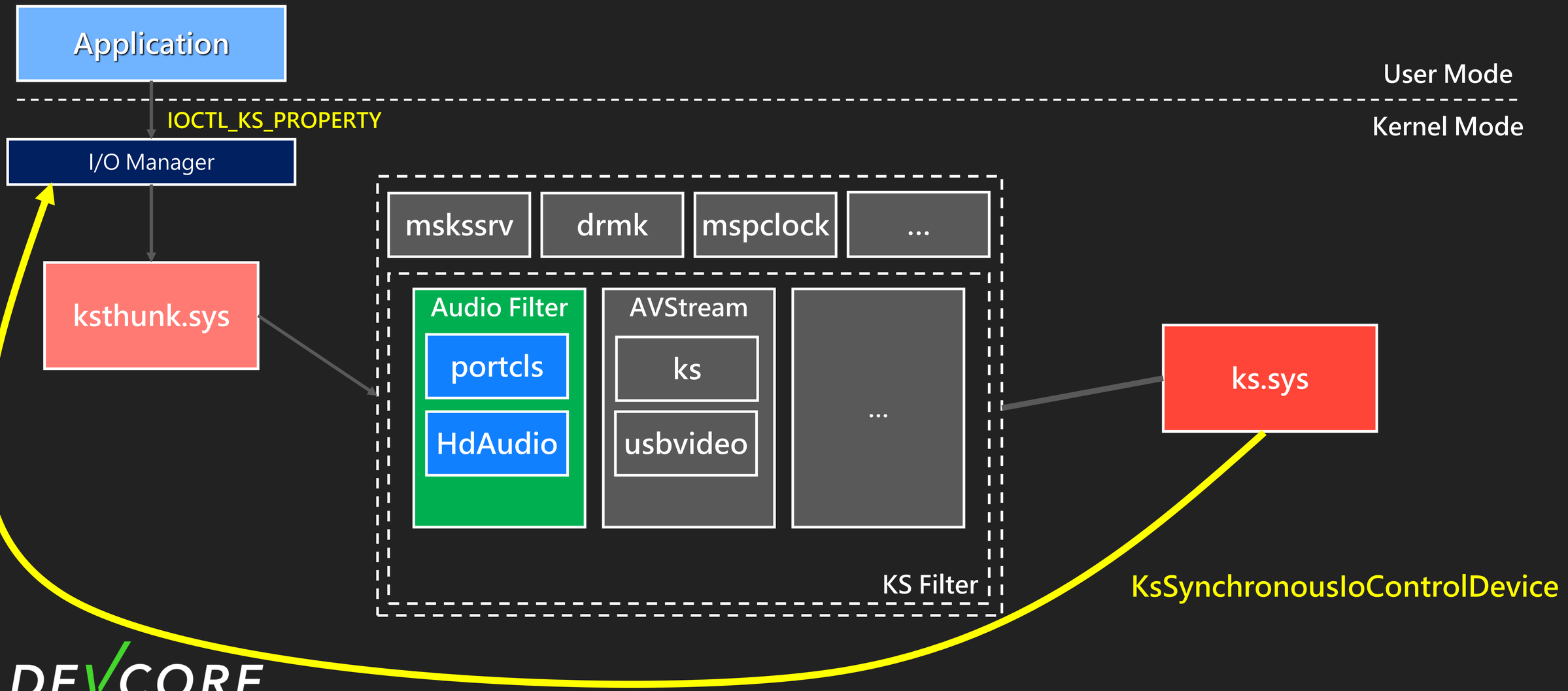
DEVCORE

UnserializePropertySet



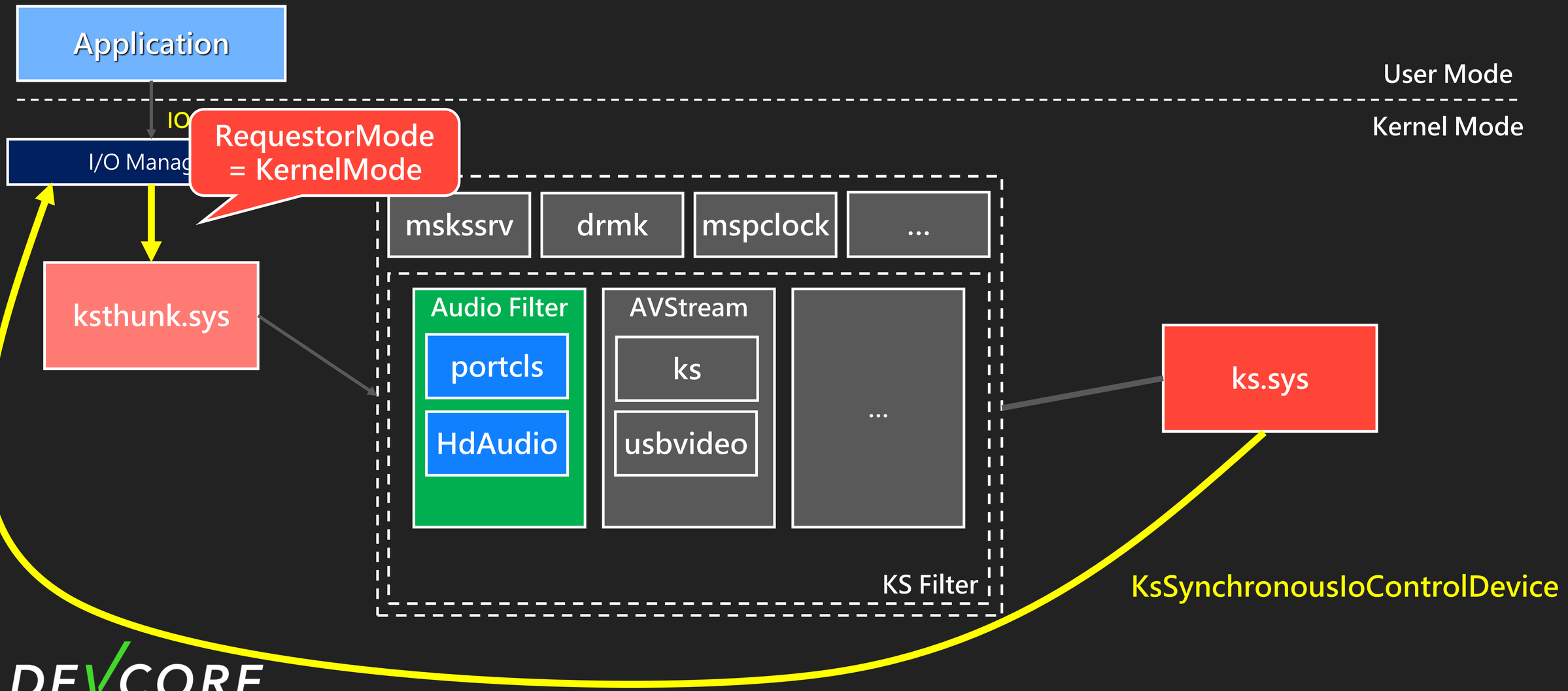
DEVCORE

UnserializePropertySet



DEVCORE

UnserializePropertySet



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We can do arbitrary IOCTL_KS_PROPERTY with KernelMode now

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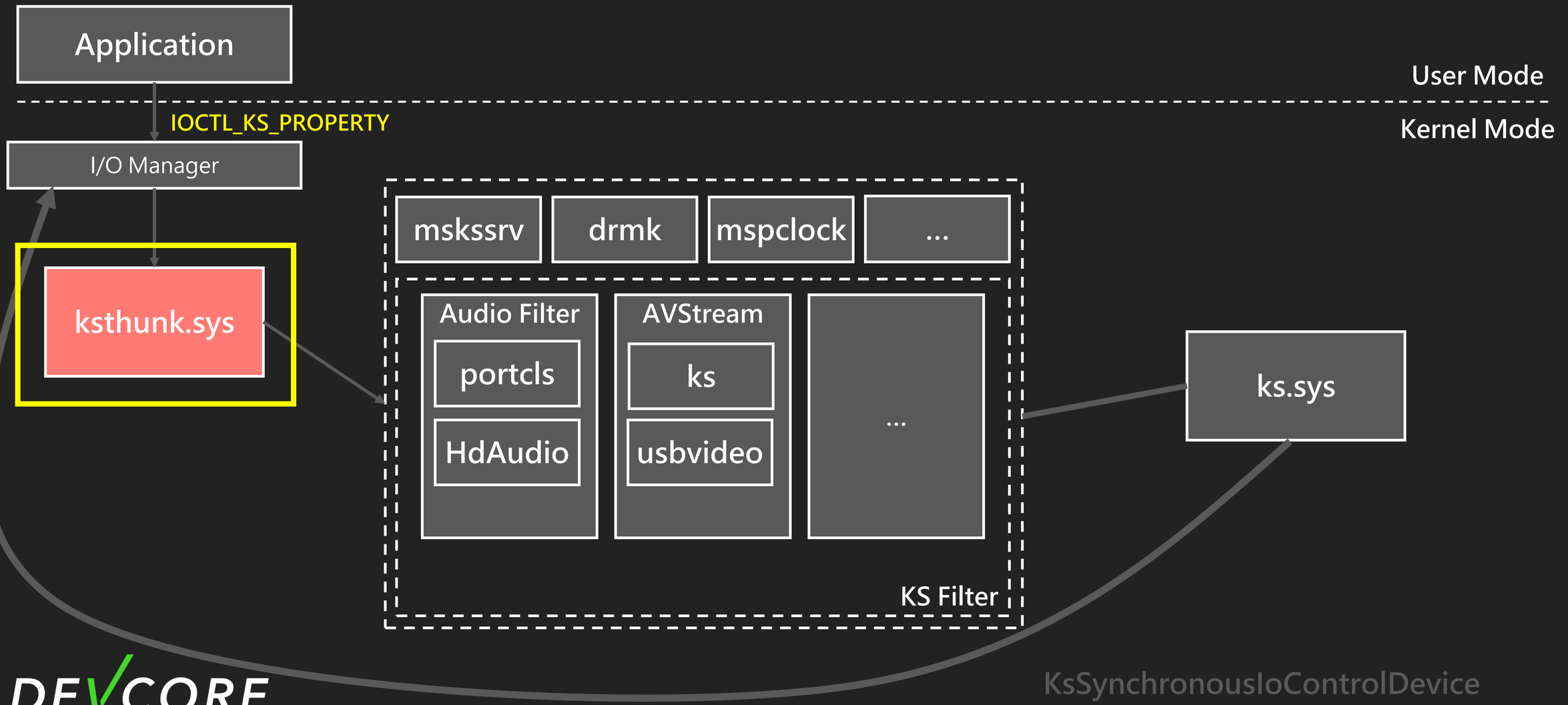
We need to find a target to EoP

DEVCORE

UnserializePropertySet



DEVCORE

ksthunk! DispatchIoctl

```
__int64 __fastcall CKSThunkDevice::CheckIrpForStackAdjustmentNative(__int64 a1, struct _IRP *irp, __int64 a3, int *a4)
{
  ...
    if ( *(_OWORD *)&Type3InputBuffer->Set == *(_OWORD *)&KSPROPSETID_DrmAudioStream
        && !type3inputbuf.Id
        && (type3inputbuf.Flags & 2) != 0 )       // KSPROPERTY_TYPE_SET
    {
        if ( irp->RequestorMode )
        {
        v14 = 0xC0000010;
        }
        else
        {
        UserBuffer = (unsigned int *)irp->UserBuffer;
        ...
        v14 = (*(__int64 (__fastcall **)(_QWORD, _QWORD, __int64 *))(Type3InputBuffer + 0x38))(// call Type3InputBuffer+0x38
                *UserBuffer,
                0LL,
                v19);
        }
    }
}
```

ksthunk! DispatchIoctl

```
__int64 __fastcall CKSThunkDevice::CheckIrpForStackAdjustmentNative(__int64 a1, struct _IRP *irp, __int64 a3, int *a4)
{
  ...
    if ( *(_OWORD *)&Type3InputBuffer->Set == *(_OWORD *)&KSPROPSETID_DrmAudioStream
        && !type3inputbuf.Id
        && (type3inputbuf.Flags & 2) != 0 )       // KSPROPERTY_TYPE_SET
    {
        if ( irp->RequestorMode )
        {
        v14 = 0xC0000010;
        }
        else
        {
        UserBuffer = (unsigned int *)irp->UserBuffer;
        ...
        v14 = (*(__int64 (__fastcall **)(_QWORD, _QWORD, __int64 *))(Type3InputBuffer + 0x38))(// call Type3InputBuffer+0x38
                *UserBuffer,
                0LL,
                v19);
        }
    }
}
```

ksthunk! DispatchIoctl

```
__int64 __fastcall CKSThunkDevice::CheckIrpForStackAdjustmentNative(__int64 a1, struct _IRP *irp, __int64 a3, int *a4)
{
  ...
    if ( *(_OWORD *)&Type3InputBuffer->Set == *(_OWORD *)&KSPROPSETID_DrmAudioStream
        && !type3inputbuf.Id
        && (type3inputbuf.Flags & 2) != 0 )       // KSPROPERTY_TYPE_SET
    {
        if ( irp->RequestorMode )
        {
        v14 = 0xC0000010;
        }
        else
        {
        UserBuffer = (unsigned int *)irp->UserBuffer;
        ...
        v14 = (*(__int64 (__fastcall **)(_QWORD, _QWORD, __int64 *))(Type3InputBuffer + 0x38))(// call Type3InputBuffer+0x38
                *UserBuffer,
                0LL,
                v19);
        }
    }
}
```

RequestorMode == KernelMode (0)

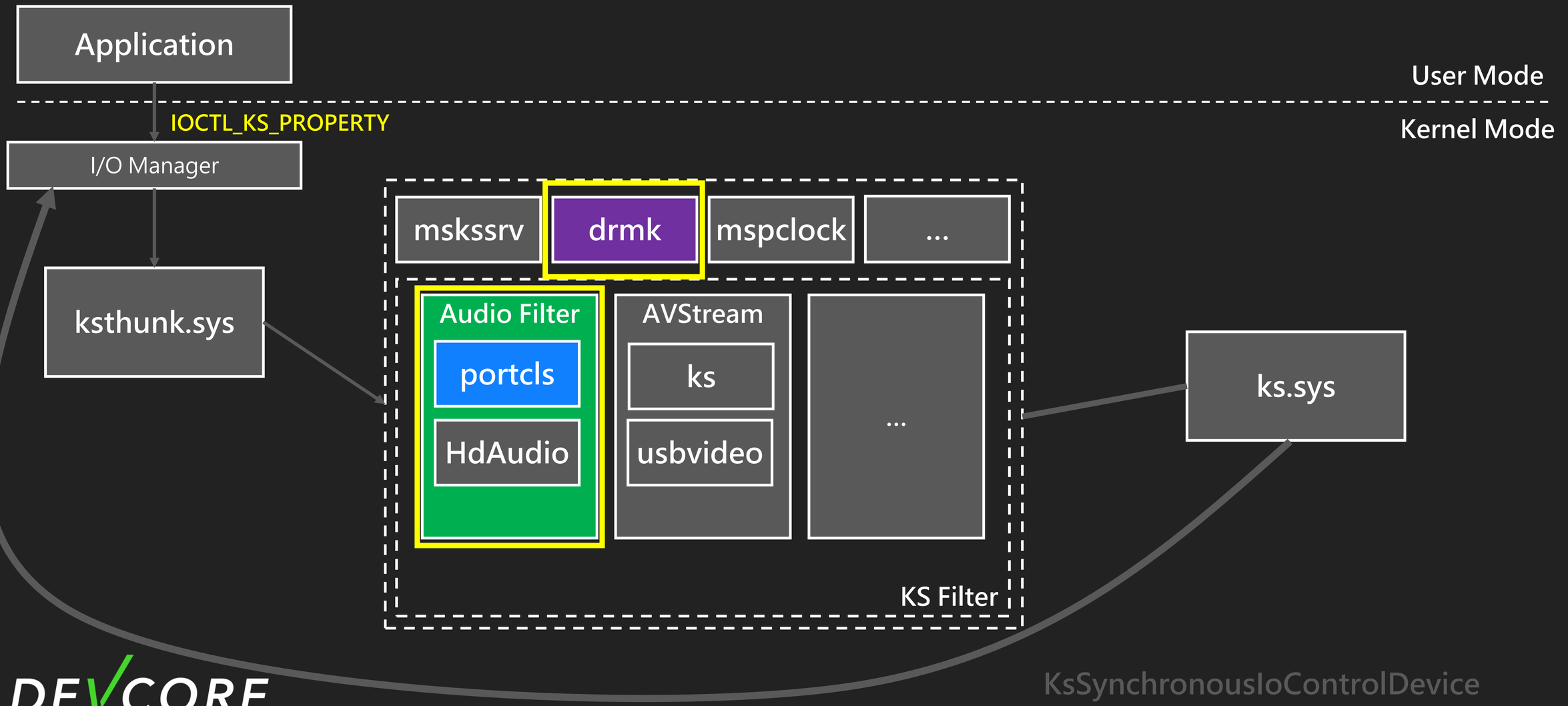
ksthunk! DispatchIoctl

```
__int64 __fastcall CKSThunkDevice::CheckIrpForStackAdjustmentNative(__int64 a1, struct _IRP *irp, __int64 a3, int *a4)
{
  ...
    if ( *(_OWORD *)&Type3InputBuffer->Set == *(_OWORD *)&KSPROPSETID_DrmAudioStream
        && !type3inputbuf.Id
        && (type3inputbuf.Flags & 2) != 0 )       // KSPROPERTY_TYPE_SET
    {
        if ( irp->RequestorMode )
        {
        v14 = 0xC0000010;
        }
        else
        {
        UserBuffer = (unsigned int *)irp->UserBuffer;
        ...
        v14 = (*(__int64 (__fastcall **)(_QWORD, _QWORD, __int64 *))(Type3InputBuffer + 0x38))(// call Type3InputBuffer+0x38
                *UserBuffer,
                0LL,
                v19);
        }
    }
}
```

ksthunk! DispatchIoctl

```
__int64 __fastcall CKSThunkDevice::CheckIrpForStackAdjustmentNative(__int64 a1, struct _IRP *irp, __int64 a3, int *a4)
{
  ...
    if ( *(_OWORD *)&Type3InputBuffer->Set == *(_OWORD *)&KSPROPSETID_DrmAudioStream
        && !type3inputbuf.Id
        && (type3inputbuf.Flags & 2) != 0 )       // KSPROPERTY_TYPE_SET
    {
        if ( irp->RequestorMode )
        {
        v14 = 0xC0000010;
        }
        else
        {
        UserBuffer = (unsigned int *)irp->UserBuffer;
        ...
        v14 = (*(__int64 (__fastcall **)(_QWORD, _QWORD, __int64 *))(Type3InputBuffer + 0x38))(// call Type3InputBuffer+0x38
                *UserBuffer,
                0LL,
                v19);
        }
    }
}
```

UnserializePropertySet



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ksthunk! DispatchIoctl

```
BUGCHECK_CODE:  3b

BUGCHECK_P1: c0000005

BUGCHECK_P2: fffff80173333380

BUGCHECK_P3: ffffaa88a40de100

BUGCHECK_P4: 0

CONTEXT:  ffffaa88a40de100 -- (.cxr 0xffffaa88a40de100)
rax=ffff404040404040 rbx=ffff838a3cef5b20 rcx=00000000deadbee0
rdx=0000000000000000 rsi=ffff838a3cef5da0 rdi=0000000000000001
rip=fffff80173333380 rsp=ffffaa88a40deb28 rbp=ffff838a3d45e0a0
 r8=ffffaa88a40deb78  r9=ffffaa88a40dec80 r10=fffff8016aa26e90
r11=0000000000000000 r12=ffffaa88a40dec80 r13=ffff838a3df23de0
r14=4fac41982f2c8ddd r15=ffff838a3d45e0a0
iopl=0         nv up ei pl zr na po nc
cs=0010  ss=0018  ds=002b  es=002b  fs=0053  gs=002b             efl=00050246
ksthunk!guard_dispatch_icall_nop:
fffff801`73333380 ffe0            jmp     rax {ffff4040`40404040}
Resetting default scope
```

We have an arbitrary call with one argument now

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Exploitation

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Mitigation on Win11

- kCFG
- kASLR
- SMEP
- …

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Mitigation on Win11

- kCFG
- kASLR ✓
  - NtQuerySystemInformation
- SMEP ✓
  - Reuse Kernel Code
- …

DEVCORE

Bypass kCFG

- Find a valid function in Windows Kernel
  - Our goal is turn arbitrary call to arbitrary memory write

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Bypass kCFG

- Find a valid function in Windows Kernel
  - Our goal is turn arbitrary call to arbitrary memory write
    - Search *Set* function export from ntoskrnl.exe

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Bypass kCFG

Name	Address	Ordinal
RtlNumberOfSetBitsInRangeEx	00000001405A7080	2441
RtlNumberOfSetBitsUlongPtr	**00000001403B0490**	**2442**
RtlSetActiveConsoleId	0000000140758470	2505
RtlSetAllBits	**000000014024EE60**	**2506**
RtlSetAllBitsEx	00000001403B3240	2507
RtlSetBit	**000000014029A5F0**	**2508**
RtlSetBitEx	000000014029D810	2509
RtlSetBits	**000000014024D8B0**	**2510**
RtlSetBitsEx	0000000140355B70	2511
RtlSetConsoleSessionForegroundProcessId	00000001407574E0	2512
RtlSetControlSecurityDescriptor	0000000140852320	2513
RtlSetDaclSecurityDescriptor	**0000000140697010**	**2514**
RtlSetDynamicTimeZoneInformation	00000001409BBA60	2515

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Two hours later ...

DEVCORE

Bypass kCFG

```
void __stdcall RtlSetAllBits(PRTL_BITMAP BitMapHeader)
{
  unsigned int *Buffer; // r8
  unsigned __int64 v2; // rdx

  Buffer = BitMapHeader->Buffer;
  v2 = (unsigned __int64)(4 * (((BitMapHeader->SizeOfBitMap & 0x1F) != 0) + (BitMapHeader->SizeOfBitMap >> 5))) >> 2;
  if ( v2 )
  {
    ...
    memset(Buffer, 0xFFu, 8 * (v2 >> 1));
    if ( (v2 & 1) != 0 )
      Buffer[v2 - 1] = -1;
  }
}
```

DEVCORE

Bypass kCFG

- RtlSetAllBits
  - The RtlSetAllBits routine sets all bits in a given bitmap variable.

```
NTSYSAPI VOID RtlSetAllBits(
  [in] PRTL_BITMAP BitMapHeader
);
```

```
struct _RTL_BITMAP
{
    ULONG SizeOfBitMap;
    ULONG* Buffer;
};
```

DEVCORE

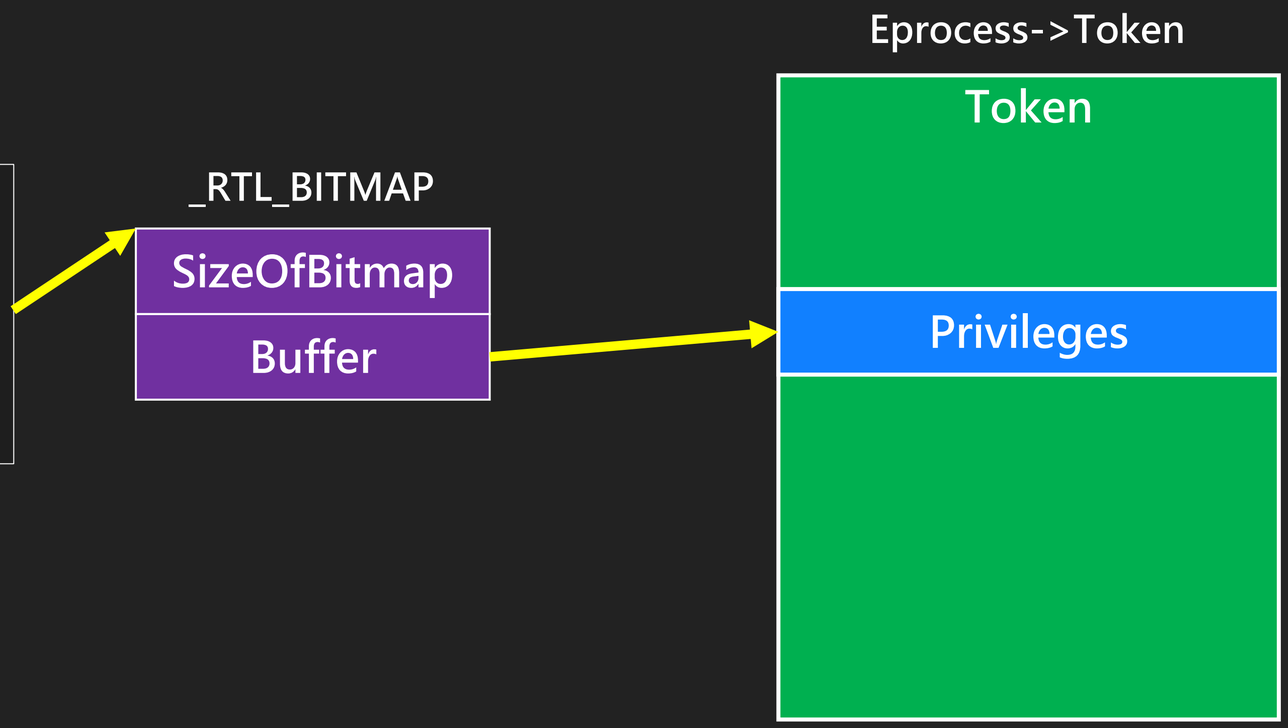
We can set all bits in arbitrary memory

DEVCORE

Abuse token privilege

- We can use the primitive to
  - Enable all privilege in current process token

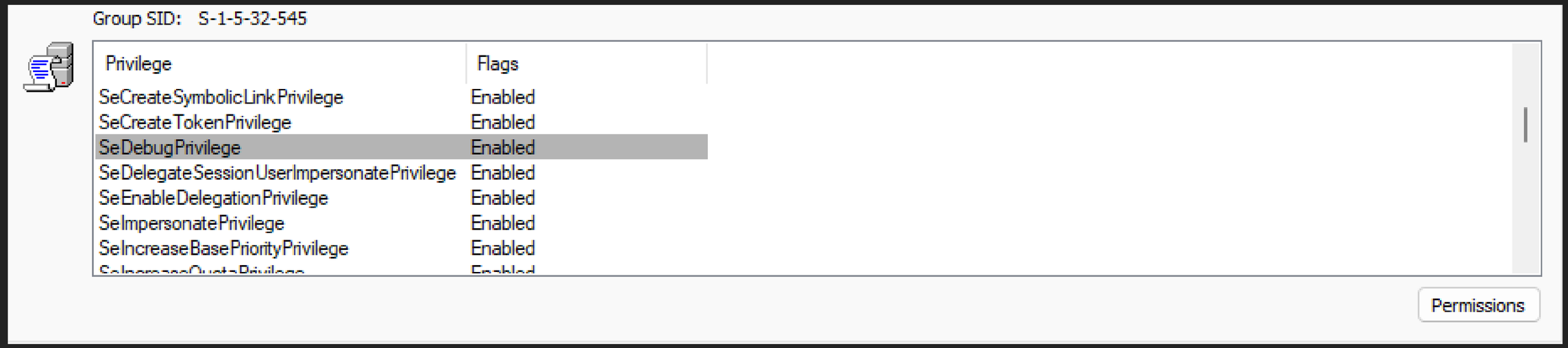
```
NTSYSAPI VOID RtlSetAllBits(
  [in] PRTL_BITMAP BitMapHeader
);
```



DEVCORE

Abuse token privilege

- We can use the primitive to
  - Enable all privilege in current process token



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The Last Step

- Well-known EoP method with SeDebugPrivilege
  - Open process of winlogon.exe
  - Set thread attribute to PROC_THREAD_ATTRIBUTE_PARENT_PROCESS
  - Spawn cmd.exe

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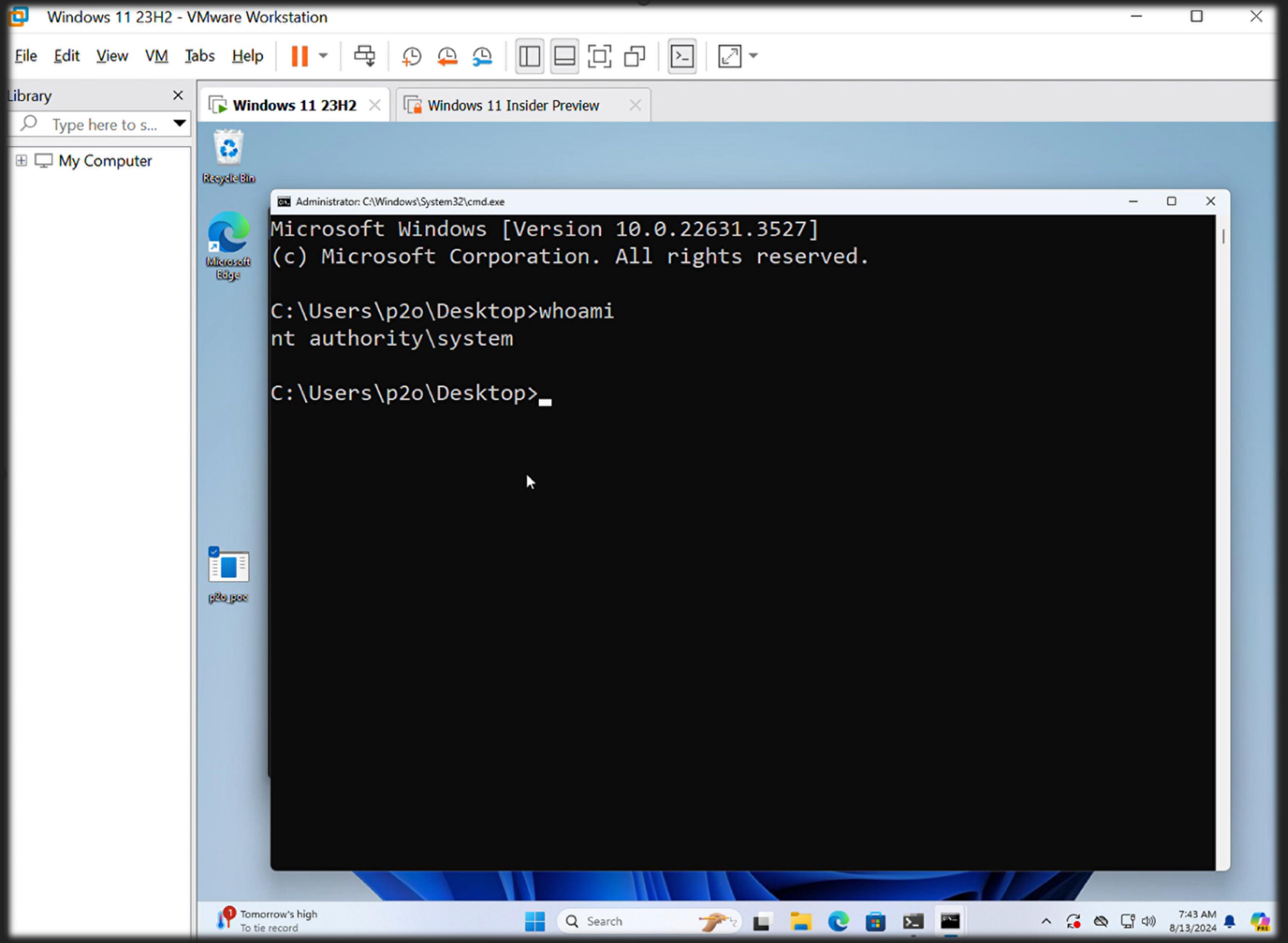
Windows 11 23H2 - VMware Workstation
File Edit View VM Tabs Help
Library
Type here to s...
My Computer
Windows 11 23H2
Windows 11 Insider Preview
Recycle Bin
Microsoft Edge
Administrator: C:\Windows\System32\cmd.exe
Microsoft Windows [Version 10.0.22631.3527]
(c) Microsoft Corporation. All rights reserved.
C:\Users\p2o\Desktop>whoami
nt authority\system
C:\Users\p2o\Desktop>
Tomorrow's high
To tie record
Search
7:43 AM
8/13/2024

It's like a Proxy to Kernel !

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However ...

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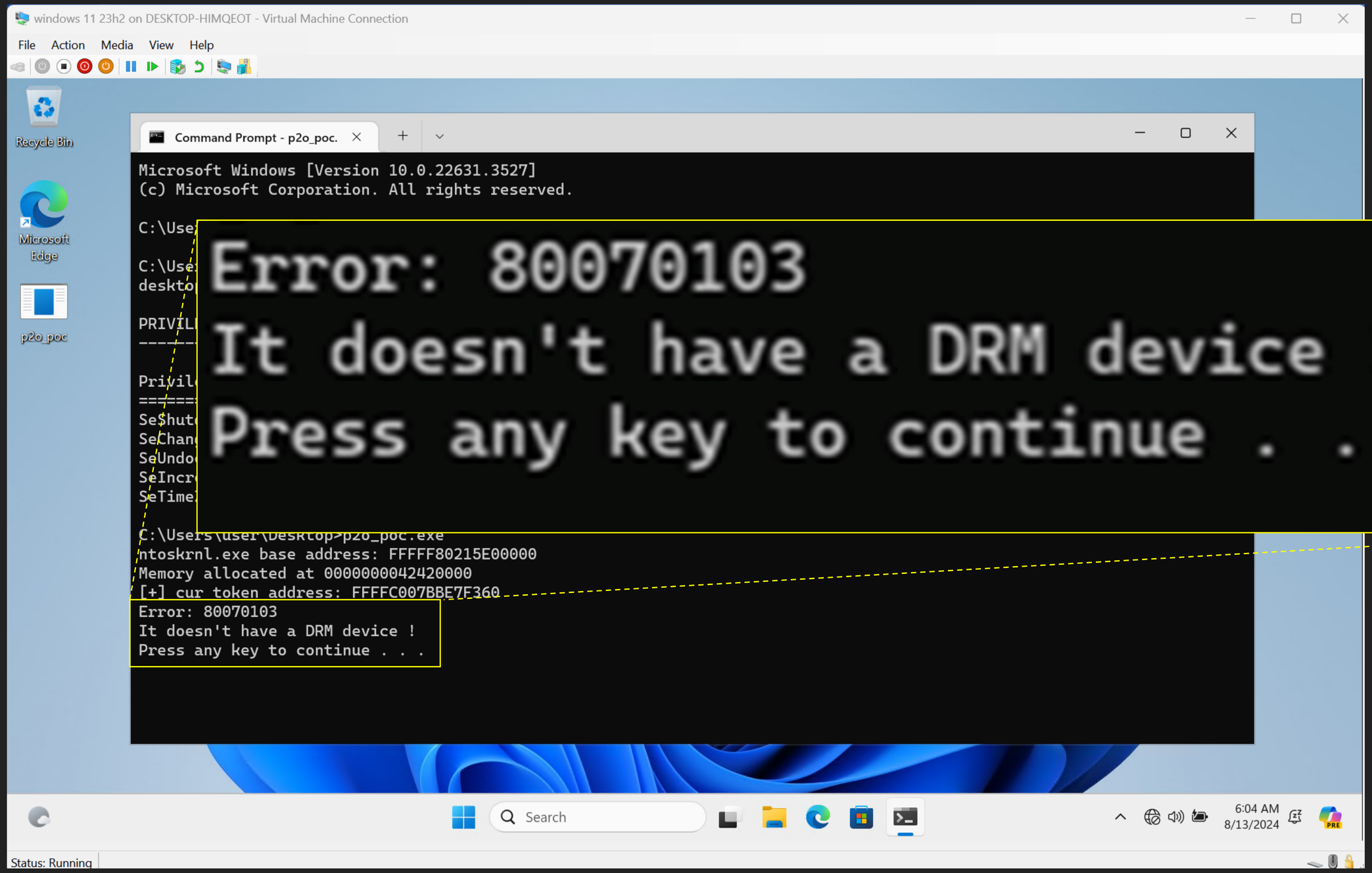
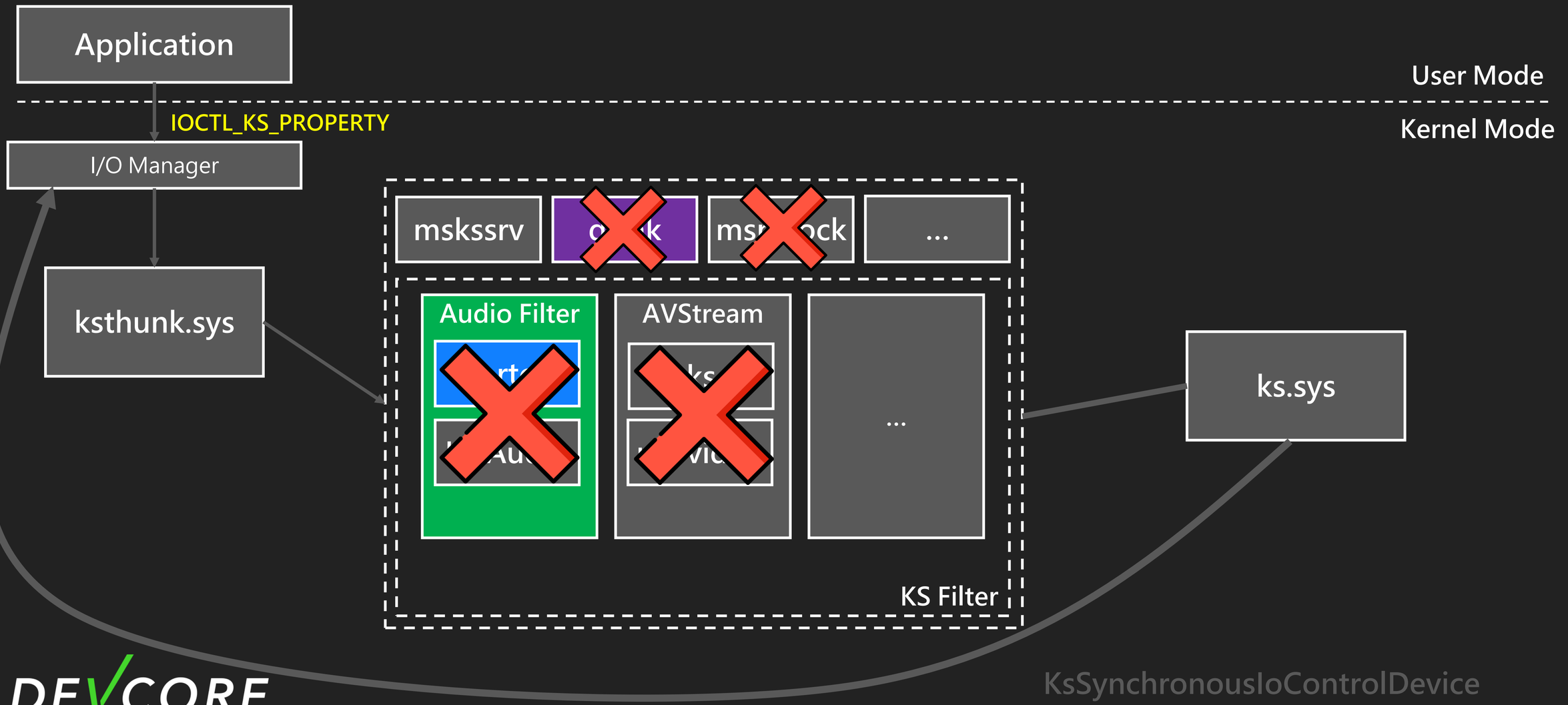

windows 11 23h2 on DESKTOP-HIMQEOT - Virtual Machine Connection
File Action Media View Help
Recycle Bin
Microsoft Edge
p2o_poc
Command Prompt - p2o_poc.
Microsoft Windows [Version 10.0.22631.3527]
(c) Microsoft Corporation. All rights reserved.
C:\Users\user\Desktop>p2o_poc.exe
ntoskrnl.exe base address: FFFFF80215E00000
Memory allocated at 0000000042420000
[+] cur token address: FFFFC007BBE7F360
Error: 80070103
It doesn't have a DRM device !
Press any key to continue . . .
Search
6:04 AM
8/13/2024
Status: Running

KS Device in Hyper-V



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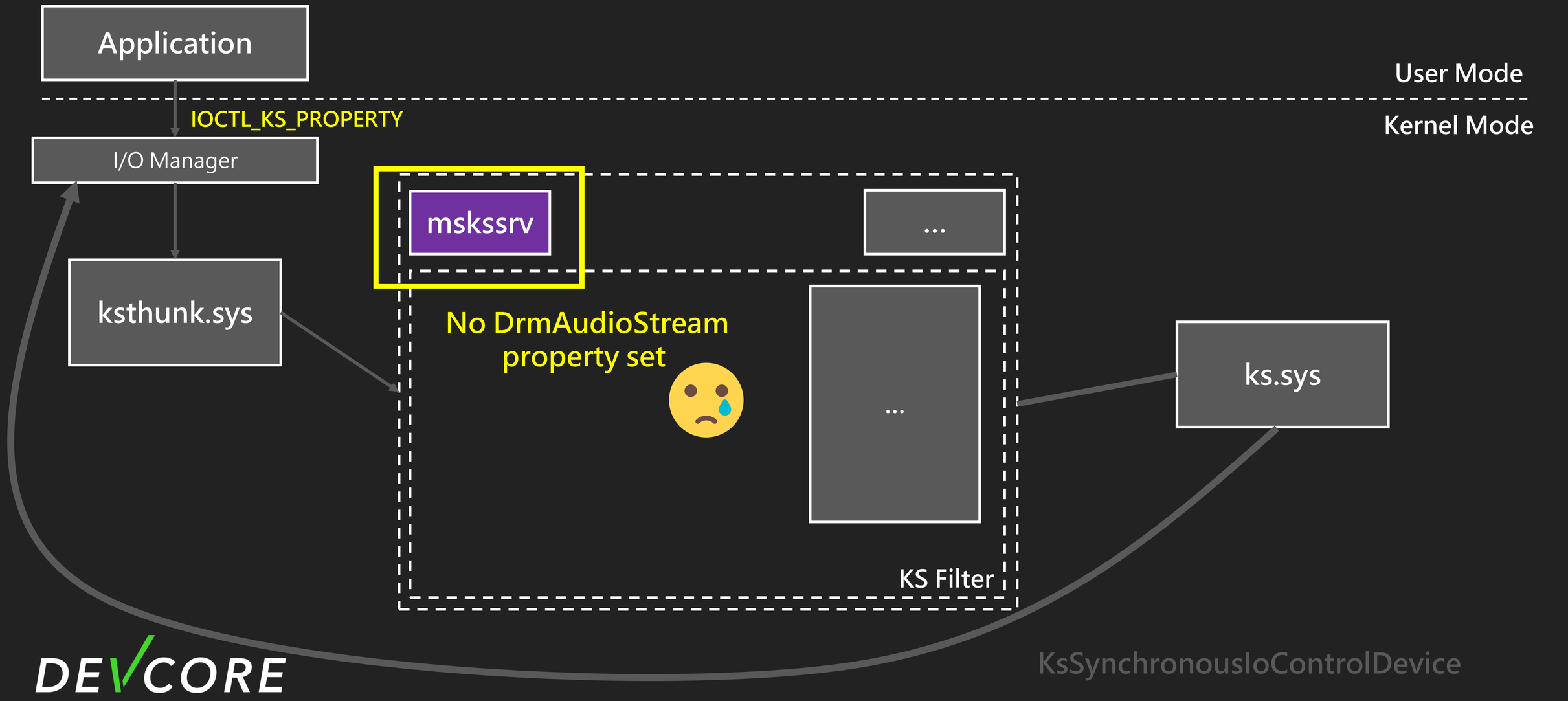
KS Device in Hyper-V



DEVCORE

CVE-2024-30084

IOCTL_KS_PROPERTY

- Neither I/O
  - Using user input buffer directly
- Inputbuffer = Parameters.DeviceIoControl.Type3InputBuffer
- Outputbuffer = Irp->UserBuffer

DEVCORE

KspPropertyHandler

User input buffer

```
NTSTATUS __fastcall KspPropertyHandler(
        PIRP Irp,
        unsigned int propertysetscnt,
        KSPROPERTY_SET *propertyset,
        ...){

        memmove(SystemBuffer[outlen_padding],
        CurrentStackLocation->Parameters.DeviceIoControl.Type3InputBuffer,
        InputBufferLength);
        ...
        Guid = *&SystemBuffer[outlen_padding];
        // Check if the Guid is in the property set

        ...
        if ( KsProperty_flag == KSPROPERTY_TYPE_UNSERIALIZESET )
          return UnserializePropertySet(Irp, sysbuf_, propertyset_);
        ...

}
```

KspPropertyHandler

```
NTSTATUS __fastcall KspPropertyHandler(
        PIRP Irp,
        unsigned int propertysetscnt,
        KSPROPERTY_SET *propertyset,
        ...){

        memmove(SystemBuffer[outlen_padding],
        CurrentStackLocation->Parameters.DeviceIoControl.Type3InputBuffer,
        InputBufferLength);
        ...
        Guid = *&SystemBuffer[outlen_padding];
        // Check if the Guid is in the property set

        ...
        if ( KsProperty_flag == KSPROPERTY_TYPE_UNSERIALIZESET )
          return UnserializePropertySet(Irp, sysbuf_, propertyset_);
        ...

}
```

Let's take a look at UnserializePropertySet again

DEVCORE

UnserializePropertySet

```
unsigned __int64 __fastcall UnserializePropertySet(
    PIRP irp,
    KSIDENTIFIER* UserProvideProperty,
    KSPROPERTY_SET* propertyset_)
{
    ...
    New_KsProperty_req = ExAllocatePoolWithTag(NonPagedPoolNx, InSize, 0x7070534Bu);
    ...
    memmove(New_KsProperty_req, CurrentStackLocation->Parameters.DeviceIoControl.Type3InputBuffer, InSize);
    ...
    status = KsSynchronousIoControlDevice(
            CurrentStackLocation->FileObject,
            0,
            CurrentStackLocation->Parameters.DeviceIoControl.IoControlCode,
            New_KsProperty_req,
            InSize,
            OutBuffer,
            OutSize,
            &BytesReturned);
    ...
}
```

Copy User input again ! ?

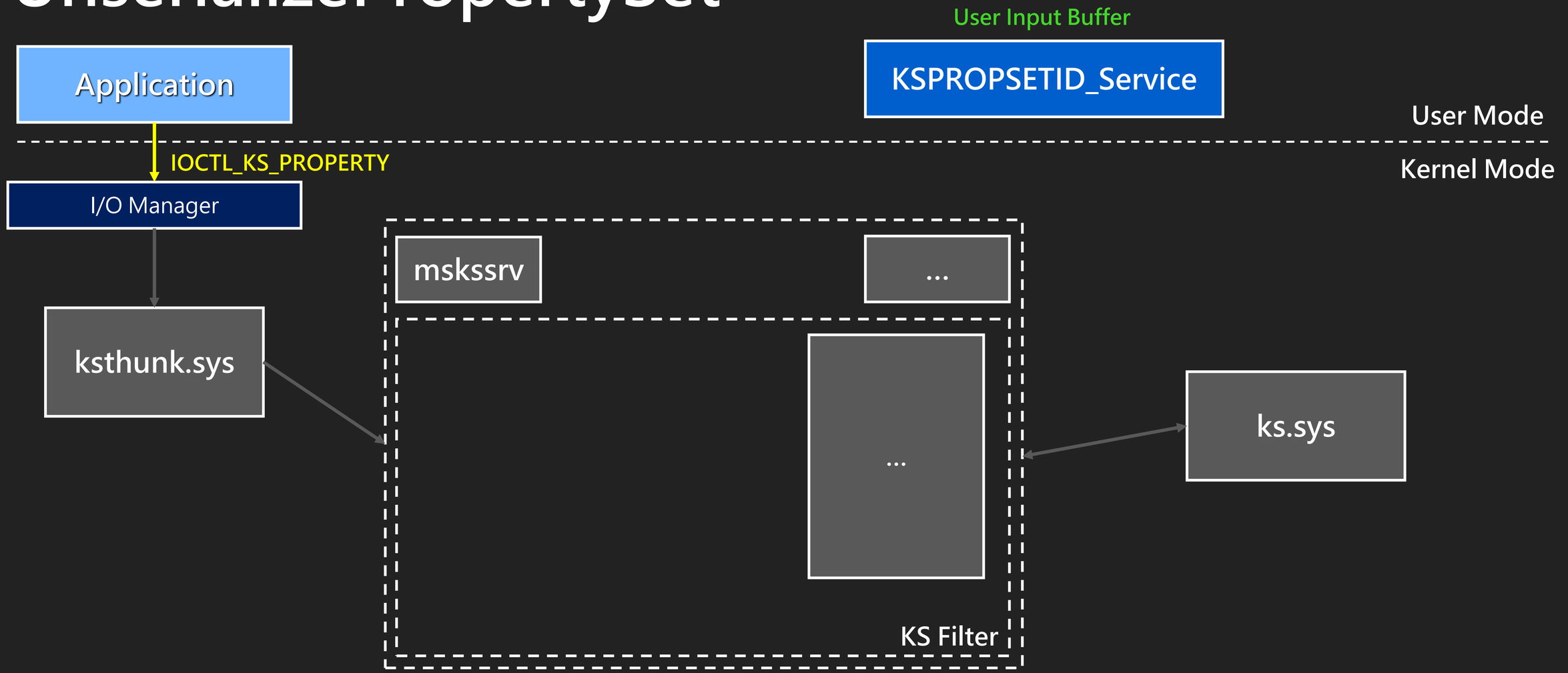
UnserializePropertySet

```
unsigned __int64 __fastcall UnserializePropertySet(
    PIRP irp,
    KSIDENTIFIER* UserProvideProperty,
    KSPROPERTY_SET* propertyset_)
{
    ...
    New_KsProperty_req = ExAllocatePoolWithTag(NonPa
    ...
    memmove(New_KsProperty_req, CurrentS
    ...
    status = KsSynchronousIoControlDevice(
            CurrentSt
            0,
            CurrentStackLocation->Parameters.Device
            New_KsProperty_req,
            InSize,
            OutBuffer,
            OutSize,
            &Bytes
    ...
}
```

Double Fetch

Copy User input again !?

UnserializePropertySet



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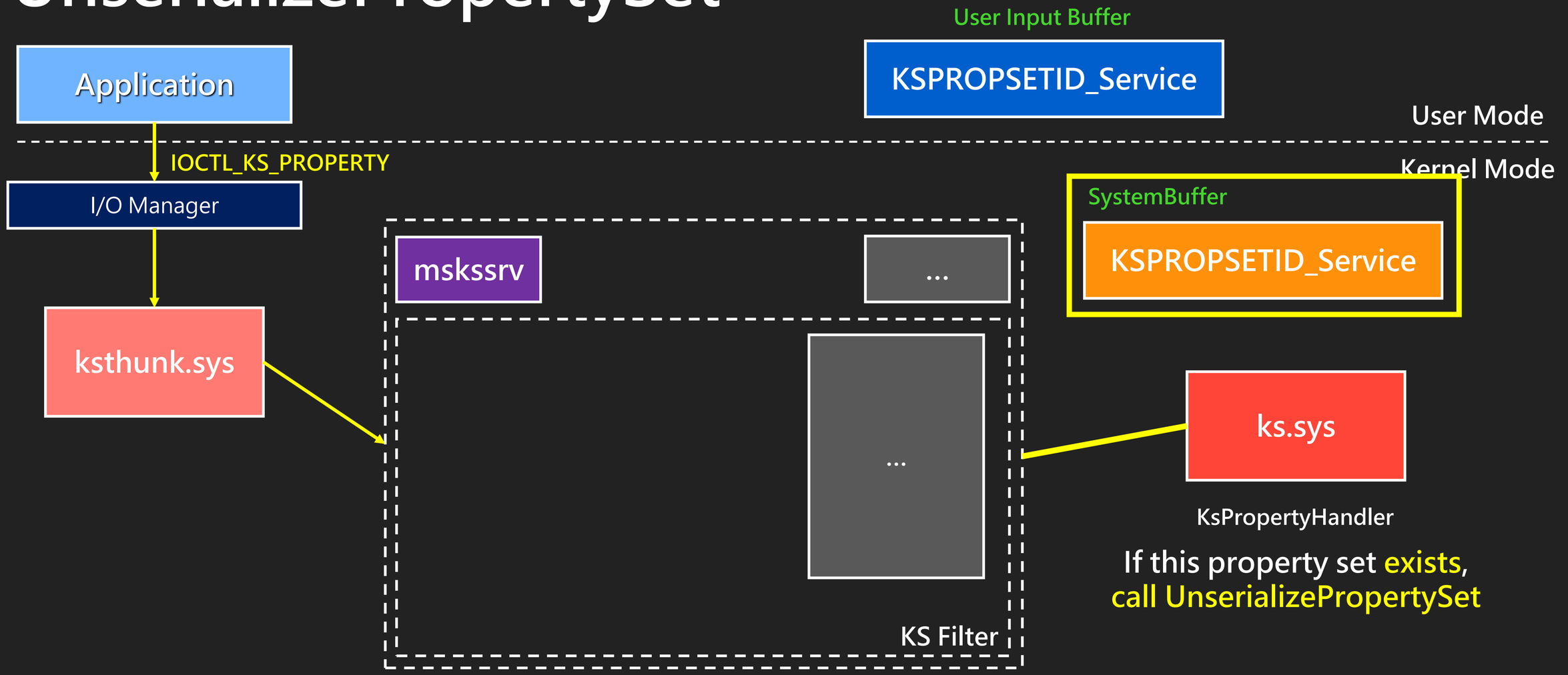
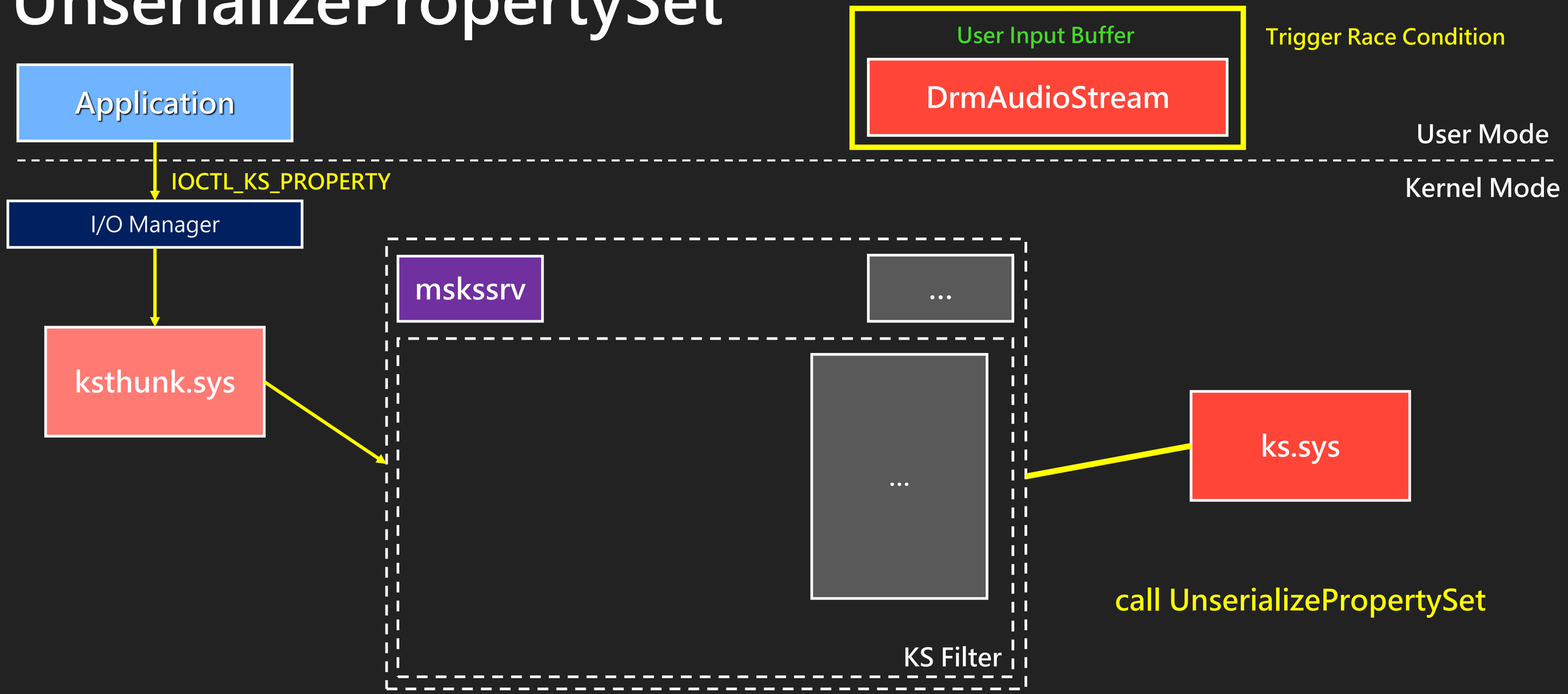
UnserializePropertySet



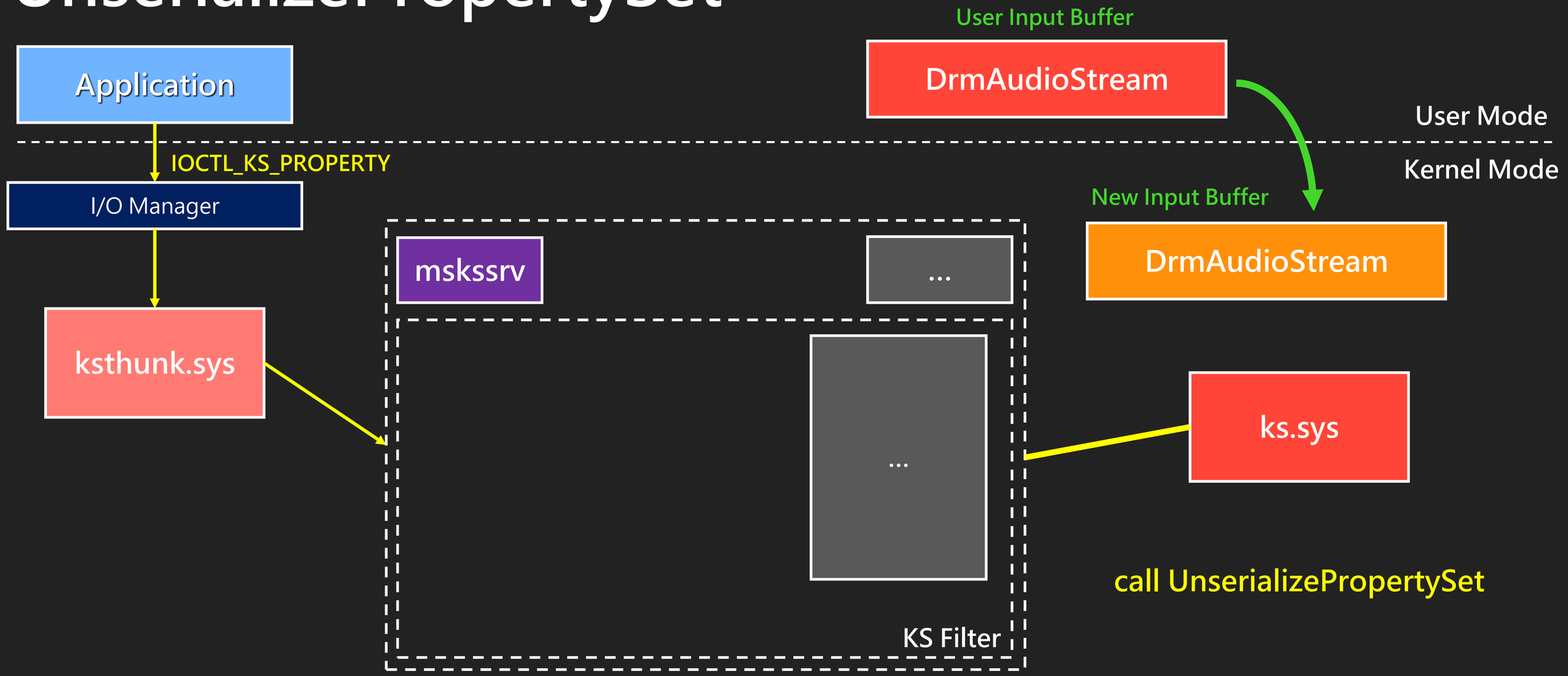
DEVCORE

UnserializePropertySet



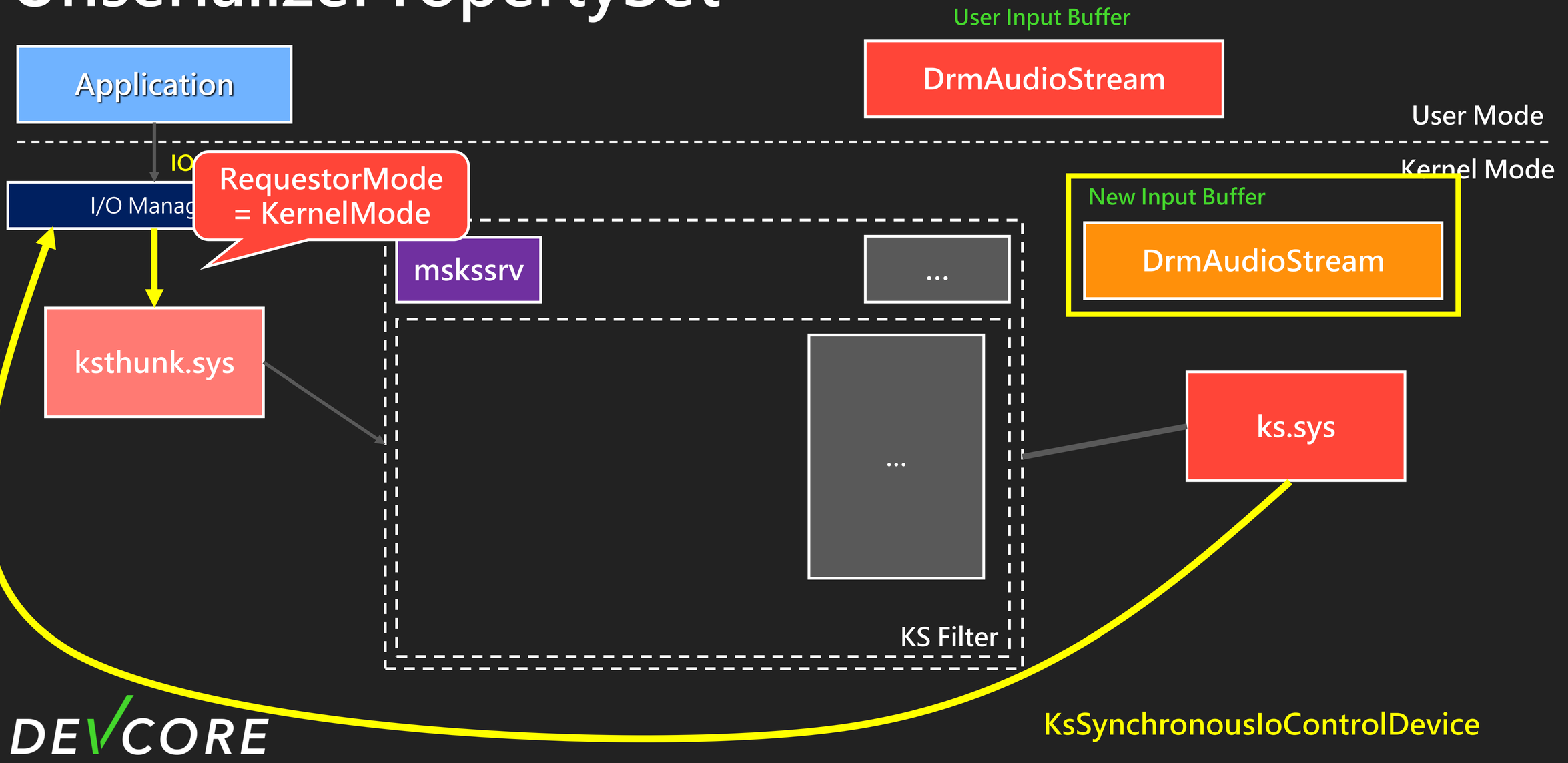
DEVCORE

UnserializePropertySet

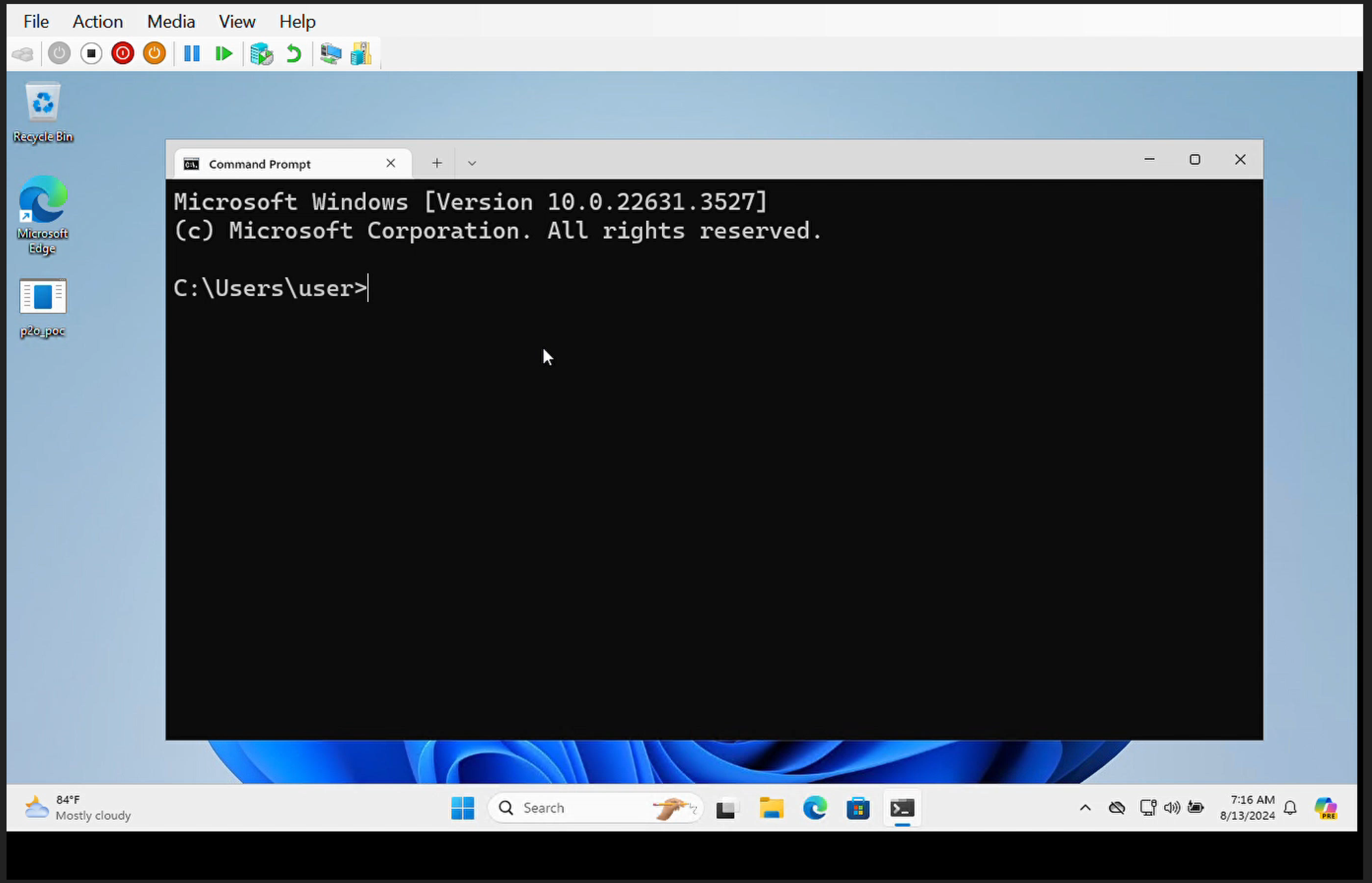


DEVCORE

UnserializePropertySet



DEVCORE


File
Action
Media
View
Help
Recycle Bin
Microsoft Edge
p2o_poc
Command Prompt
Microsoft Windows [Version 10.0.22631.3527]
(c) Microsoft Corporation. All rights reserved.
C:\Users\user>
84°F
Mostly cloudy
Search
7:16 AM
8/13/2024

Zero Day Initiative @thezdi · 3月21日

Confirmed! The DEVCORE Team used a couple of bugs, including a somewhat risky TOCTAU race condition, to get their LPE on #Windows 11. They earn $30,000 and 3 Master of Pwn points. #Pwn2Own

11 63 7,650

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Is that the end of it ?

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CVE-2024-30090

KS Event

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KS Event

- Event sets are groups of related events for which a listener can request notification.
- Client can register event for
  - Device State Change
  - Time interval
  - ...

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KS Event

- Use IOCTL_KS_ENABLE_EVENT to register
  - EVENT_HANDLE
  - SEMAPHORE_HANDLE

```
typedef struct {
  ULONG NotificationType;
  union {
    struct {
      HANDLE    Event;
      ...
    } EventHandle;
    struct {
      HANDLE Semaphore;
      ...
    } SemaphoreHandle;
  }
  ...
} KSEVENTDATA, *PKSEVENTDATA;
```

DEVCORE

kstunk! ThunkEnableEventIrp

- Transfer 32-bit IOCTL_KS_ENABLE_EVENT requests to 64-bit requests

```
__int64 __fastcall CKSThunkDevice::DispatchIoctl(CKernelFilterDevice *a1, IRP *irp, unsigned int a3, NTSTATUS *a4)
{
  ...
  if ( IoIs32bitProcess(irp) && irp->RequestorMode )
  {
    ...
    if ( CurrentStackLocation->Parameters.DeviceIoControl.IoControlCode == IOCTL_KS_ENABLE_EVENT )
      return CKSAutomationThunk::ThunkEnableEventIrp(v12, a2, v11, a4);
    ...
  }
  else if ( CurrentStackLocation->Parameters.DeviceIoControl.IoControlCode == IOCTL_KS_PROPERTY )
  {
    //Pass down
    return CKSThunkDevice::CheckIrpForStackAdjustmentNative((__int64)a1, irp, v11, a4);
  }
}
```

ThunkEnableEventIrp

```
__int64 __fastcall CKSAutomationThunk::ThunkEnableEventIrp(__int64 ioctlcode_d, PIRP irp, __int64 a3, int *a4)
{
  ...
  if ( (v25->Parameters.DeviceIoControl.Type3InputBuffer->Flags & 0xEFFFFFFF) == KSEVENT_TYPE_ENABLE
    || (v25->Parameters.DeviceIoControl.Type3InputBuffer->Flags & 0xEFFFFFFF) == KSEVENT_TYPE_ONESHOT
    || (v25->Parameters.DeviceIoControl.Type3InputBuffer->Flags & 0xEFFFFFFF) == KSEVENT_TYPE_ENABLEBUFFERED )
  {
    // Convert 32-bit requests and pass down directly
  }
  else if ( (v25->Parameters.DeviceIoControl.Type3InputBuffer->Flags & 0xEFFFFFFF) == KSEVENT_TYPE_QUERYBUFFER )
  {
    ...
    newinputbuf = (KSEVENT *)ExAllocatePoolWithTag((POOL_TYPE)0x600, (unsigned int)(inputbuflen + 8), 'bqSK');
    ...
    memcpy(newinputbuf,Type3InputBuffer,0x28);
    ...
    v18 = KsSynchronousIoControlDevice(
            v25->FileObject,
            0,
            IOCTL_KS_ENABLE_EVENT,
            newinputbuf,
            inputbuflen + 8,
            OutBuffer,
            outbuflen,
            &BytesReturned);
    ...
  }
  ...
}
```

User input

ThunkEnableEventIrp

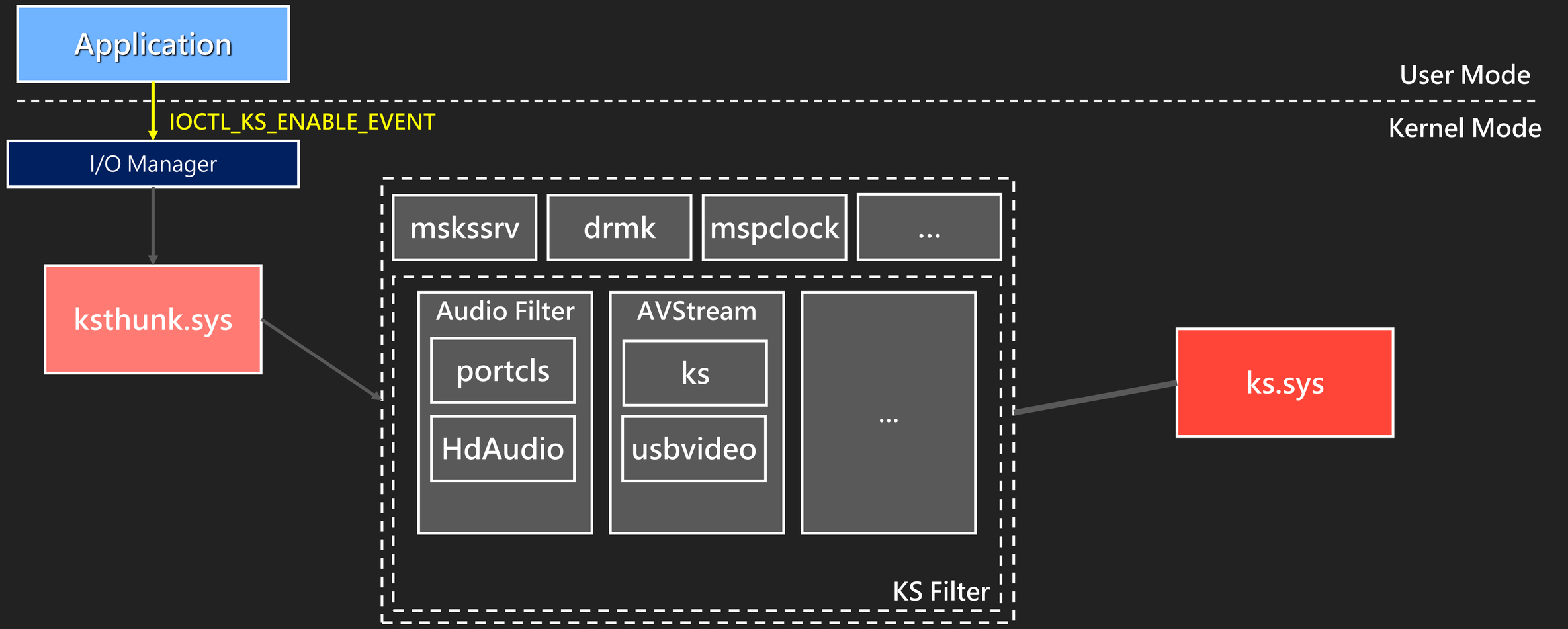
```
__int64 __fastcall CKSAutomationThunk::ThunkEnableEventIrp(__int64 ioctlcode_d, PIRP irp, __int64 a3, int *a4)
{
  ...
  if ( (v25->Parameters.DeviceIoControl.Type3InputBuffer->Flags & 0xEFFFFFFF) == KSEVENT_TYPE_ENABLE
    || (v25->Parameters.DeviceIoControl.Type3InputBuffer->Flags & 0xEFFFFFFF) == KSEVENT_TYPE_ONESHOT
    || (v25->Parameters.DeviceIoControl.Type3InputBuffer->Flags & 0xEFFFFFFF) == KSEVENT_TYPE_ENABLEBUFFERED )
  {
    // Convert 32-bit requests and pass down directly
  }
  else if ( (v25->Parameters.DeviceIoControl.Type3InputBuffer->Flags & 0xEFFFFFFF) == KSEVENT_TYPE_QUERYBUFFER )
  {
    ...
    newinputbuf = (KSEVENT *)ExAllocatePoolWithTag((POOL_TYPE)0x600, (unsigned int)(inputbuflen + 8), 'bqSK');
    ...
    memcpy(newinputbuf,Type3InputBuffer,0x28);
    ...
    v18 = KsSynchronousIoControlDevice(
            v25->FileObject,
            0,
            IOCTL_KS_ENABLE_EVENT,
            newinputbuf,
            inputbuflen + 8,
            OutBuffer,
            outbuflen,
            &BytesReturned);
    ...
  }
  ...
}
```

ThunkEnableEventIrp

```
__int64 __fastcall CKSAutomationThunk::ThunkEnableEventIrp(__int64 ioctlcode_d, PIRP irp, __int64 a3, int *a4)
{
  ...
  if ( (v25->Parameters.DeviceIoControl.Type3InputBuffer->Flags & 0xEFFFFFFF) == KSEVENT_TYPE_ENABLE
    || (v25->Parameters.DeviceIoControl.Type3InputBuffer->Flags & 0xEFFFFFFF) == KSEVENT_TYPE_ONESHOT
    || (v25->Parameters.DeviceIoControl.Type3InputBuffer->Flags & 0xEFFFFFFF) == KSEVENT_TYPE_ENABLEBUFFERED )
  {
    // Convert 32-bit requests and pass down directly
  }
  else if ( (v25->Parameters.DeviceIoControl.Type3InputBuffer->Flags & 0xEFFFFFFF) == KSEVENT_TYPE_QUERYBUFFER )
  {
    ...
    newinputbuf = (KSEVENT *)ExAllocatePoolWithTag((POOL_TYPE)0x600, (unsigned int)(inputbuflen + 8), 'bqSK');
    ...
    memcpy(newinputbuf,Type3InputBuffer,0x28);
    ...
    v18 = KsSynchronousIoControlDevice(
            v25->FileObject,
            0,
            IOCTL_KS_ENABLE_EVENT,
            newinputbuf,
            inputbuflen + 8,
            OutBuffer,
            outbuflen,
            &BytesReturned);
    ...
  }
  ...
}
```

KernelMode

ThunkEnableEventIrp



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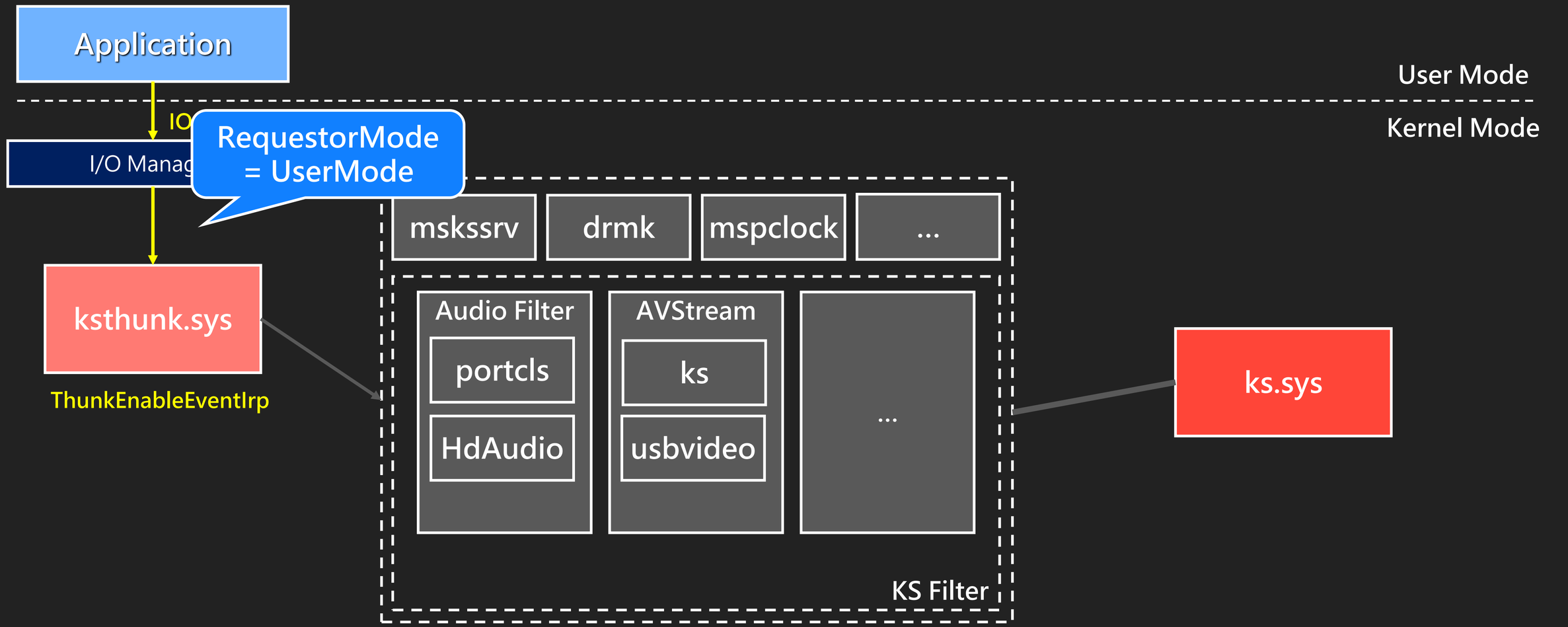
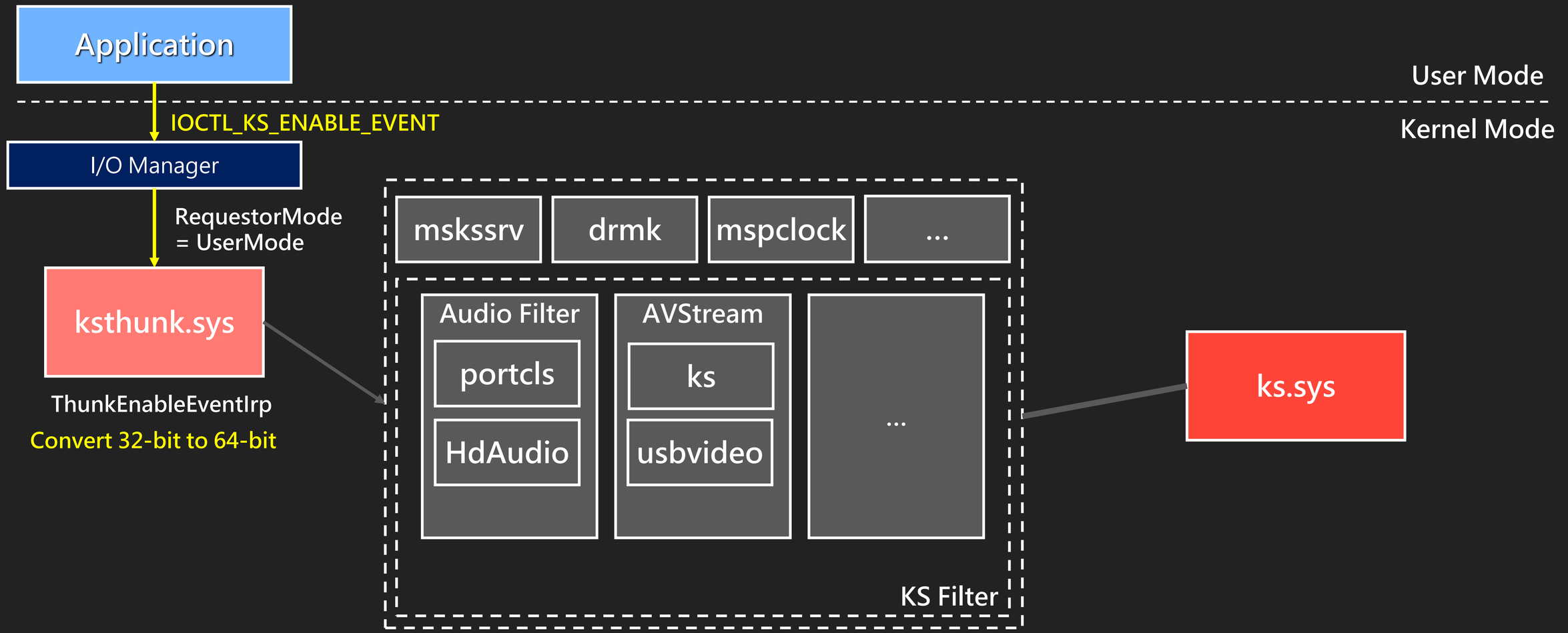
ThunkEnableEventIrp



DEVCORE

ThunkEnableEventIrp



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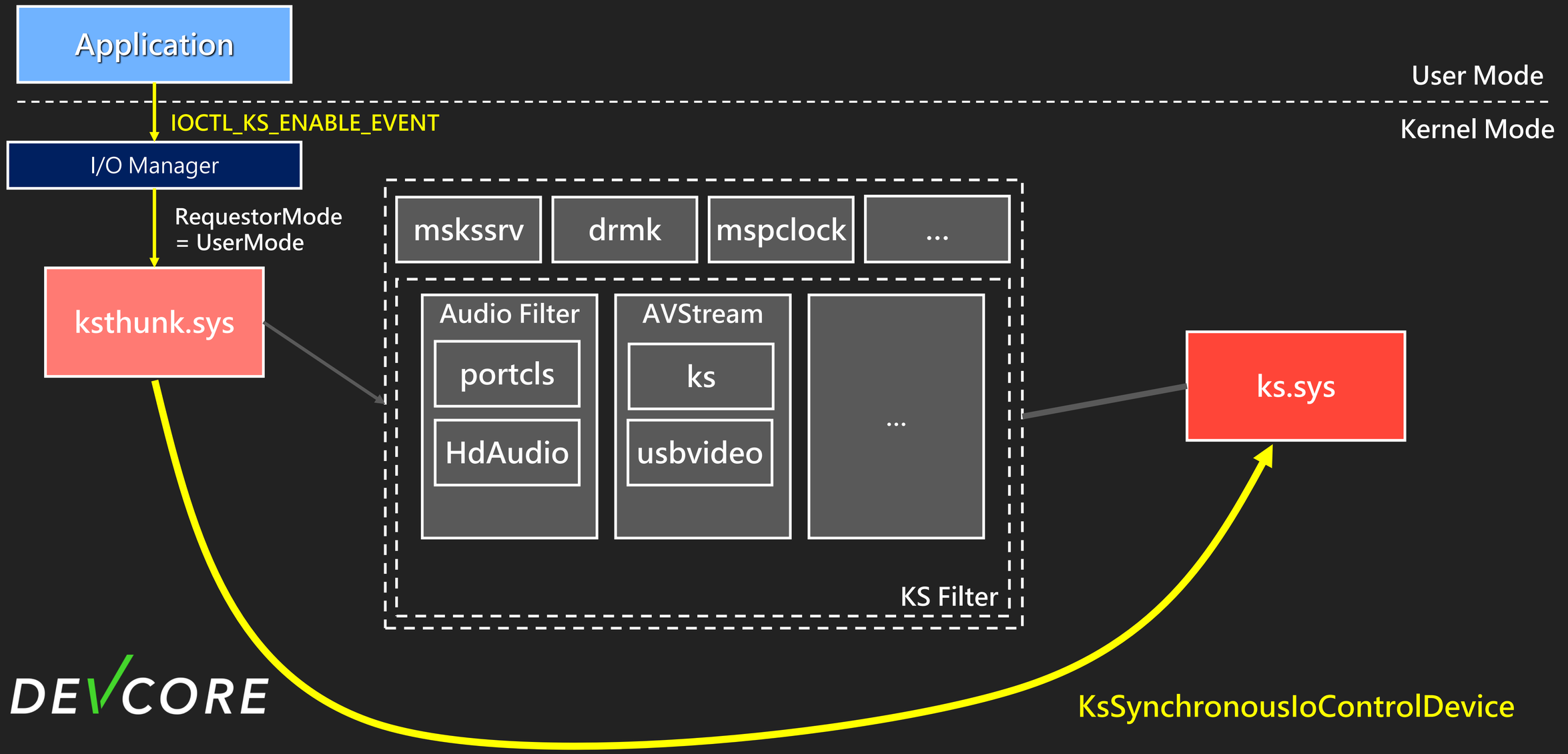
ThunkEnableEventIrp



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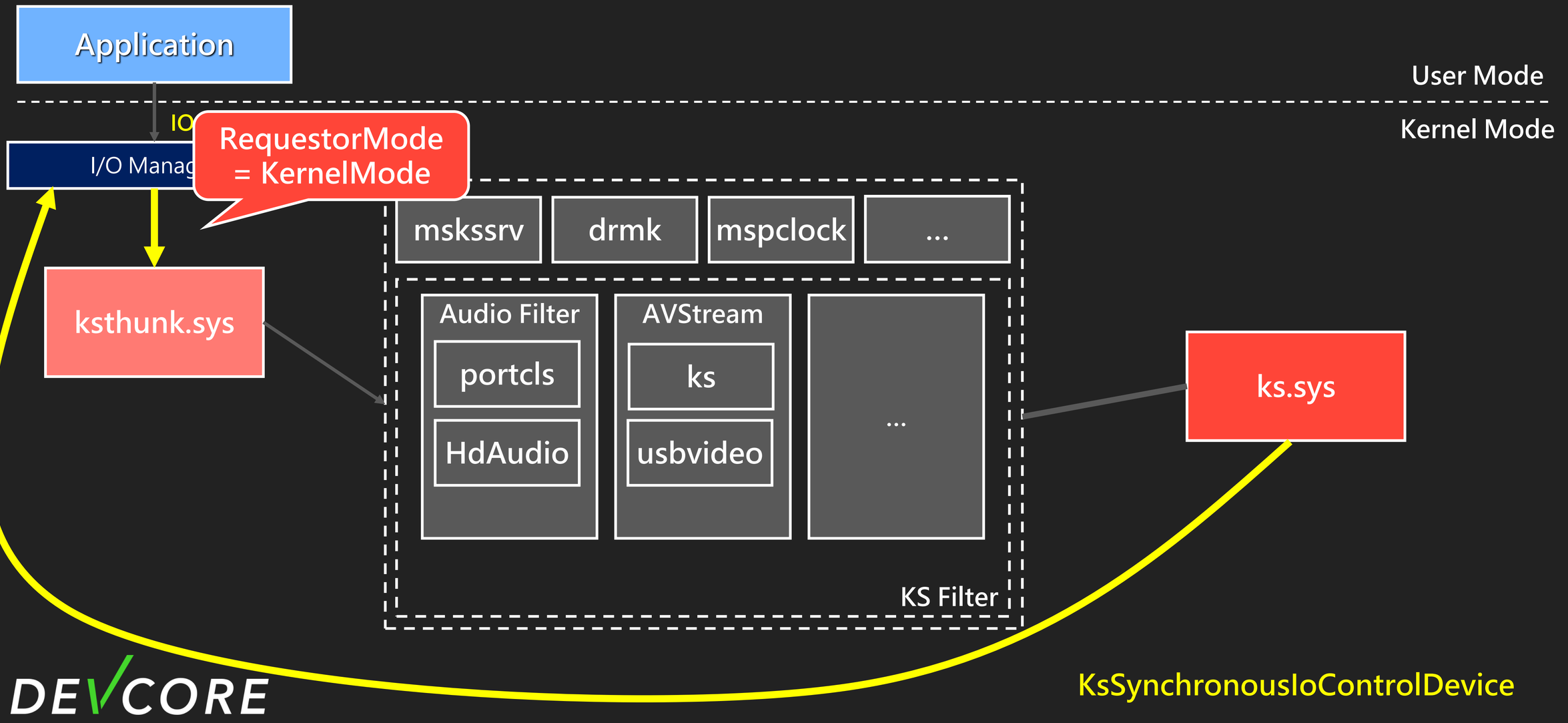
ThunkEnableEventIrp



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We can do arbitrary IOCTL_KS_ENABLE_EVENT with KernelMode now

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We need to find a target to EoP

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But we didn't find a suitable target in ksthunk

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We decide to pass it down to look for target

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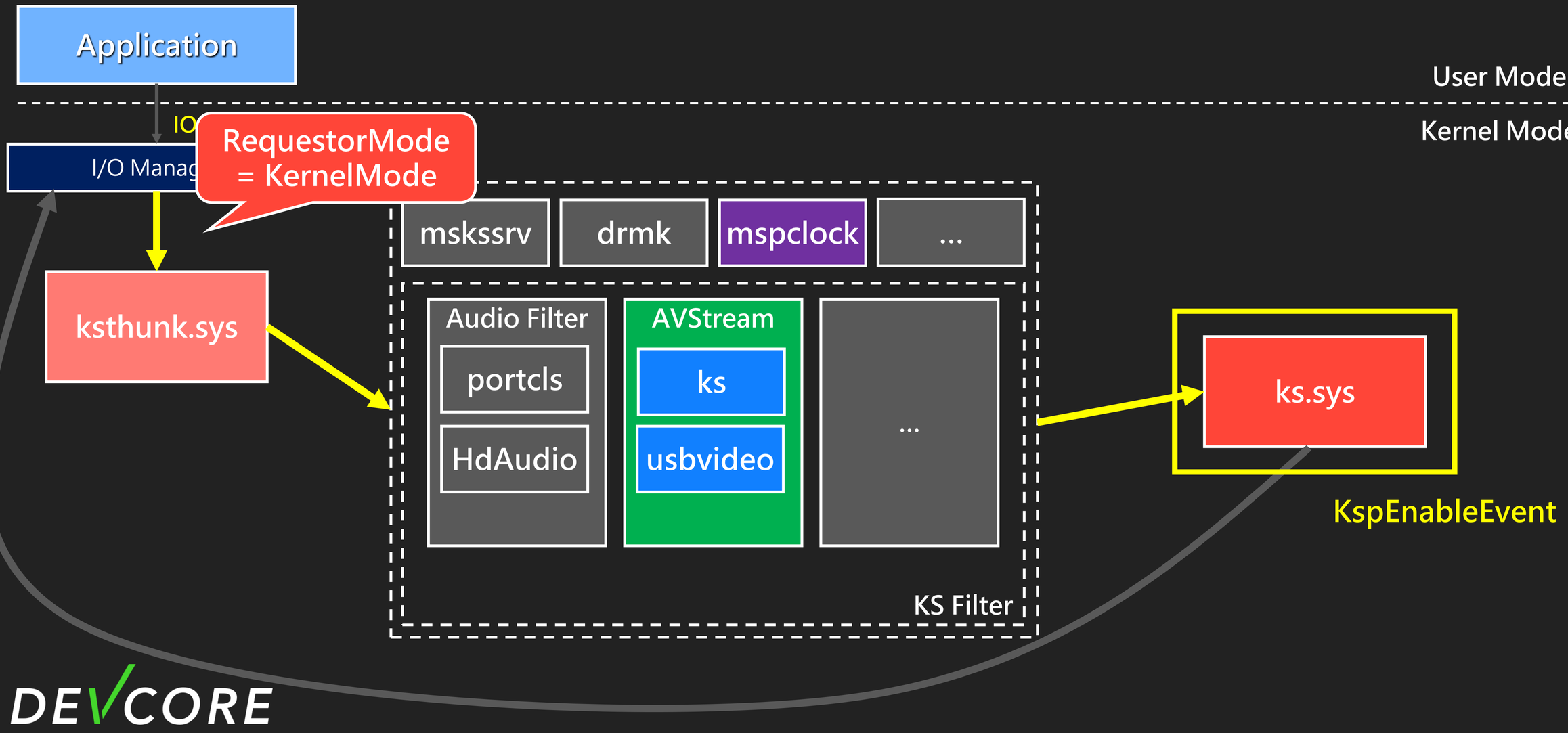
ThunkEnableEventIrp



DEVCORE

We found some interesting ...

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KspEnableEvent

```
__int64 __fastcall KspEnableEvent(
        ...)
{
    ...
    EventData = ExAllocatePoolWithTag(...);
    memcpy(EventData,Irp->UserBuffer,...);
    ...
    EventEntryEx->EventEntry.NotificationType = EventData->NotificationType;
    switch ( EventEntryEx_->EventEntry.NotificationType )
   {
      case KSEVENTF_EVENT_HANDLE:
          ...
          break;
      case KSEVENTF_EVENT_OBJECT:
      case DPC:
      case KSEVENTF_KSWORKITEM:
        if(Irp->RequestorMode)
          goto error;
      ...
   }
   Eventitem->AddEventHandler(Irp, EventData, PEventEntry);
}
```

KS Event

- The output buffer is a KSEVENTDATA structure used to specify a notification method.
  - Call from kernel driver
    - EVENT_OBJECT
    - DPC
    - KSWORKITEM
    - …

```
typedef struct {
  ULONG NotificationType;
    struct {
      PVOID     Event;
      ...
    } EventObject;
    struct {
      PKDPC     Dpc;
      ...
    } Dpc;
  ...
} KSEVENTDATA, *PKSEVENTDATA;
```

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We can provide arbitrary kernel object to it !

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If we trigger the event, it would call
KsGenerateEvent

DEVCORE

KsGenerateEvent

```
NTSTATUS __stdcall KsGenerateEvent(PKSEVENT_ENTRY EventEntry)
{

  switch ( EventEntry->NotificationType )
  {
    case KSEVENTF_DPC:
      ...
      if ( !KeInsertQueueDpc(EventEntry->EventData->Dpc.Dpc, EventEntry->EventData, 0LL) )
        _InterlockedAdd(&EventEntry->EventData->EventObject.Increment, 0xFFFFFFFF);
      ...
    case KSEVENTF_KSWORKITEM:
      ...
      KsIncrementCountedWorker(eventdata->KsWorkItem.KsWorkerObject);

  }
}
```

KsIncrementCountedWorker

```
ULONG __stdcall KsIncrementCountedWorker(__int64 Worker)
{
  ULONG v1; // ebx

  v1 = _InterlockedIncrement((Worker + 0x5C));
  if ( v1 == 1 )
    KsQueueWorkItem(Worker, *(Worker + 96));
  return v1;
}
```

Arbitrary memory increment

We have arbitrary increment primitive now

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Arbitrary increment primitive to EoP

- There are many well-known method
  - Abuse token privilege
  - IoRing
  - ...

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It seems trivial, but ...

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Arbitrary increment primitive to EoP

- Abuse token privilege
  - Need to overwrite Privileges.Enable and Privileges.Present
    - Need to trigger the bug multiple times
    - It may take a long time

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Arbitrary increment primitive to EoP

- IoRing
  - Need to overwrite IoRing->RegBuffersCount and IoRing->RegBuffers
    - Good Candidate
    - Only need to trigger the bug twice

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KsIncrementCountedWorker

```
ULONG __stdcall KsIncrementCountedWorker(__int64 Worker)
{
  ULONG v1; // ebx

  v1 = _InterlockedIncrement((Worker + 0x5C));
  if ( v1 == 1 )
    KsQueueWorkItem(Worker, *(Worker + 96));
  return v1;
}
```

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Let's find a new way !

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Arbitrary increment primitive to EoP

- Abuse token privilege
  - The goal is to obtain SeDebugPrivilege
    - Open process of winlogon.exe

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Why does having SeDebugPrivilege allow you to open high-privilege process?

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PsOpenProcess

```
if ( SeSinglePrivilegeCheck(SeDebugPrivilege, AccessMode_) )
{
  if ( (AccessState.RemainingDesiredAccess & MAXIMUM_ALLOWED) != 0 )
    AccessState.PreviouslyGrantedAccess |= PROCESS_ALL_ACCESS;
  else
    AccessState.PreviouslyGrantedAccess |= AccessState.RemainingDesiredAccess;
  AccessState.RemainingDesiredAccess = 0;
}
v20 = ObOpenObjectByPointer(
        Process,
        HandleAttributes,
        &AccessState,
        0,
        (POBJECT_TYPE)PsProcessType,
        AccessMode,
        &Handle);
```

DEVCORE

PsOpenProcess

```
if ( SeSinglePrivilegeCheck(SeDebugPrivilege, AccessMode_) )
{
  if ( (AccessState.RemainingDesiredAccess & MAXIMUM_ALLOWED) != 0 )
    AccessState.PreviouslyGrantedAccess |= PROCESS_ALL_ACCESS;
  else
    AccessState.PreviouslyGrantedAccess |= AccessState.RemainingDesiredAccess;
  AccessState.RemainingDesiredAccess = 0;
}
v20 = ObOpenObjectByPointer(
        Process,
        HandleAttributes,
        &AccessState,
        0,
        (POBJECT_TYPE)PsProcessType,
        AccessMode,
        &Handle);
```

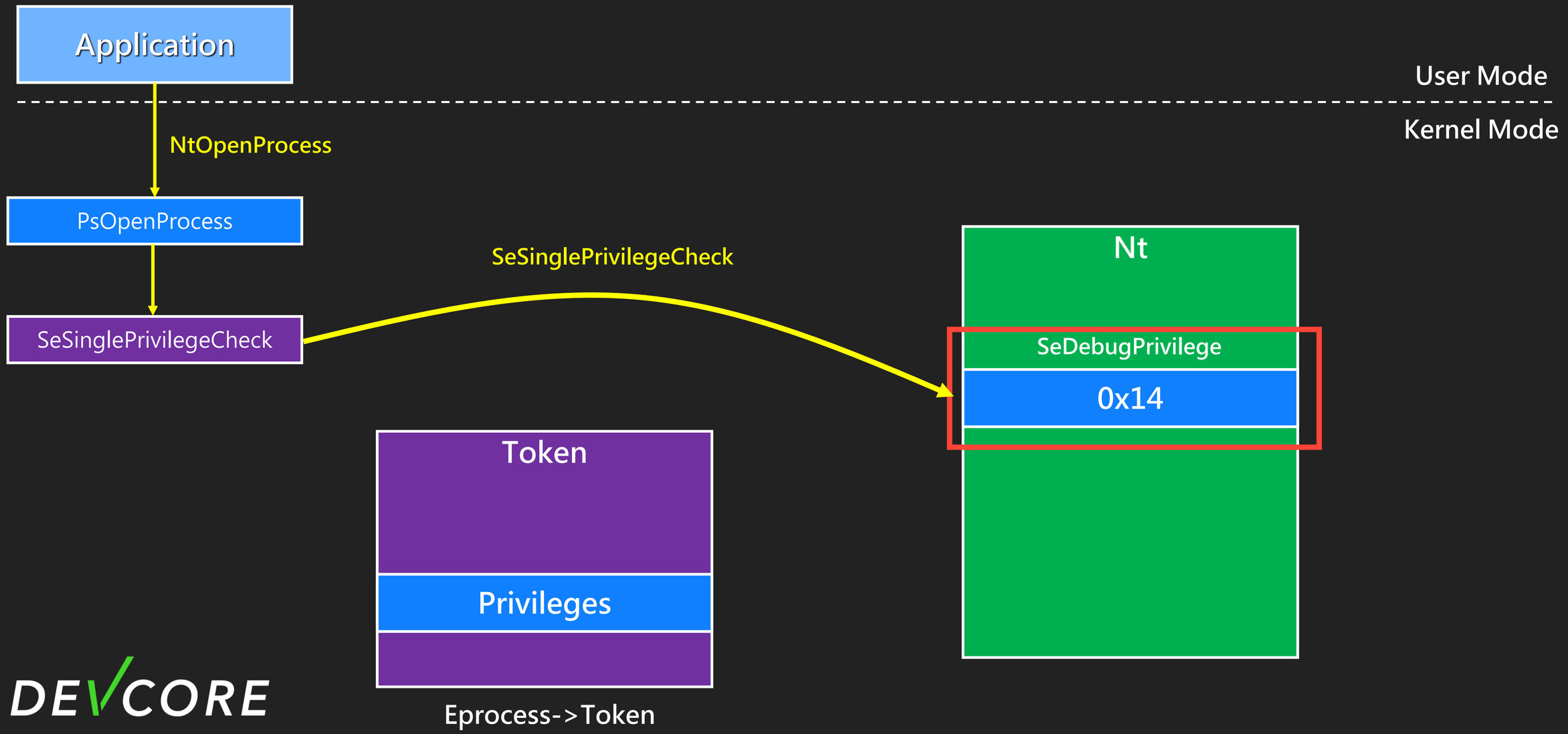
DEVCORE

PsOpenProcess

```
bool SepVariableInitialization()
{
  ...
  SeDebugPrivilege = (LUID)0x14LL;
  v103 = 2LL;
  v60 = (PSID)21;
  v61 = (PSID)0x16;
  Sid = (PSID)0x17;
  SeAuditPrivilege = 21LL;
  SeSystemEnvironmentPrivilege = (LUID)0x16LL;
  SeChangeNotifyPrivilege = 0x17LL;
 ...
}
```

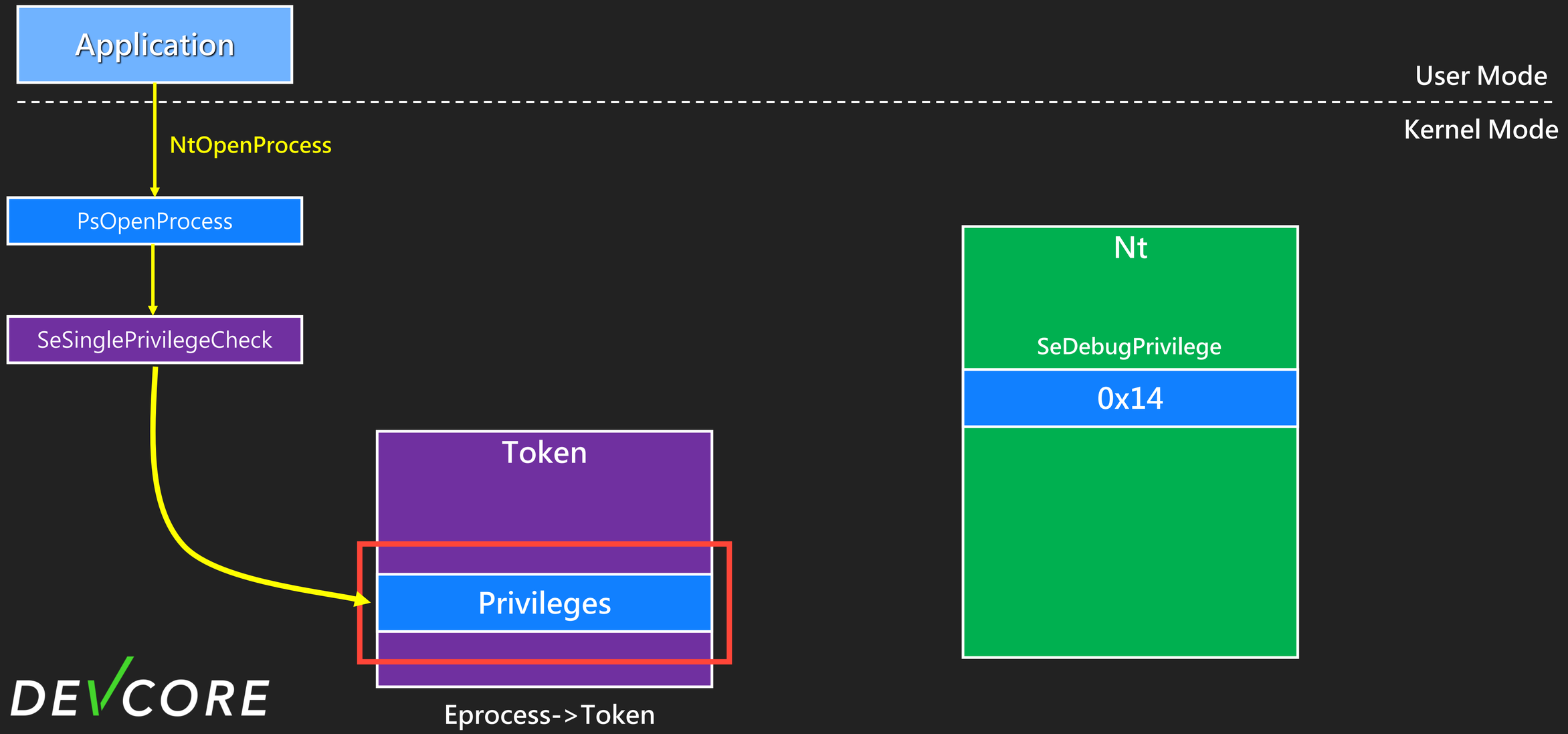
DEVCORE

Make abusing token privilege great again



DEVCORE

Make abusing token privilege great again



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One more interesting ...

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nt! SeDebugPrivilege

```
0000000140D53A10 SeTcbPrivilege  LUID <0>
0000000140D53A10
0000000140D53A18 ; LUID SeDebugPrivilege
0000000140D53A18 SeDebugPrivilege LUID <0>
```

Writable !!!

DEVCORE

Make abusing token privilege great again !

DEVCORE

Make abusing token privilege great again

```
C:\Users\angelboy>whoami /priv

PRIVILEGES INFORMATION
----------------------

Privilege Name                Description                          State
============================= ==================================== ========
SeShutdownPrivilege           Shut down the system                 Disabled
SeChangeNotifyPrivilege       Bypass traverse checking             Enabled
SeUndockPrivilege             Remove computer from docking station Disabled
SeIncreaseWorkingSetPrivilege Increase a process working set       Disabled
SeTimeZonePrivilege           Change the time zone                 Disabled
```

DEVCORE

Make abusing token privilege great again

```
C:\Users\angelboy>whoami /priv

PRIVILEGES INFORMATION
----------------------

Privilege Name                Description                          State
============================= ==================================== ========
SeShutdownPrivilege           Shut down the system                 Disabled
SeChangeNotifyPrivilege       Bypass traverse checking             Enabled
SeUndockPrivilege             Remove computer from docking station Disabled
SeIncreaseWorkingSetPrivilege Increase a process working set       Disabled
SeTimeZonePrivilege           Change the time zone                 Disabled
```

DEVCORE

nt! SeChangeNotifyPrivilege

```
bool SepVariableInitialization()
{
  ...
  SeDebugPrivilege = (LUID)0x14LL;
  v103 = 2LL;
  v60 = (PSID)21;
  v61 = (PSID)0x16;
  Sid = (PSID)0x17;
  SeAuditPrivilege = 21LL;
  SeSystemEnvironmentPrivilege = (LUID)0x16LL;
  SeChangeNotifyPrivilege = 0x17LL;
 ...
}
```

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How about changing the value of
nt! SeDebugPrivilege from 0x14 to 0x17 ?

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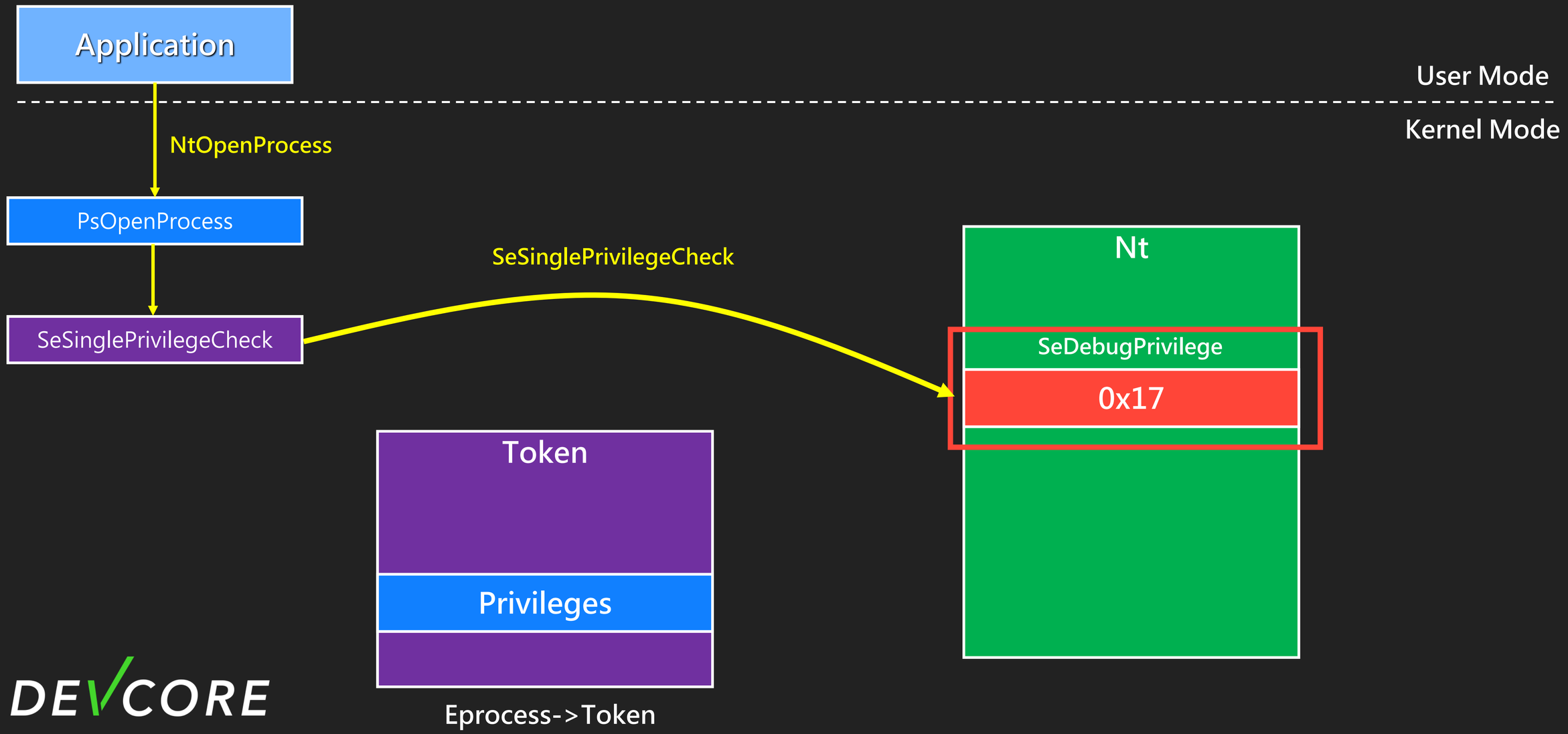
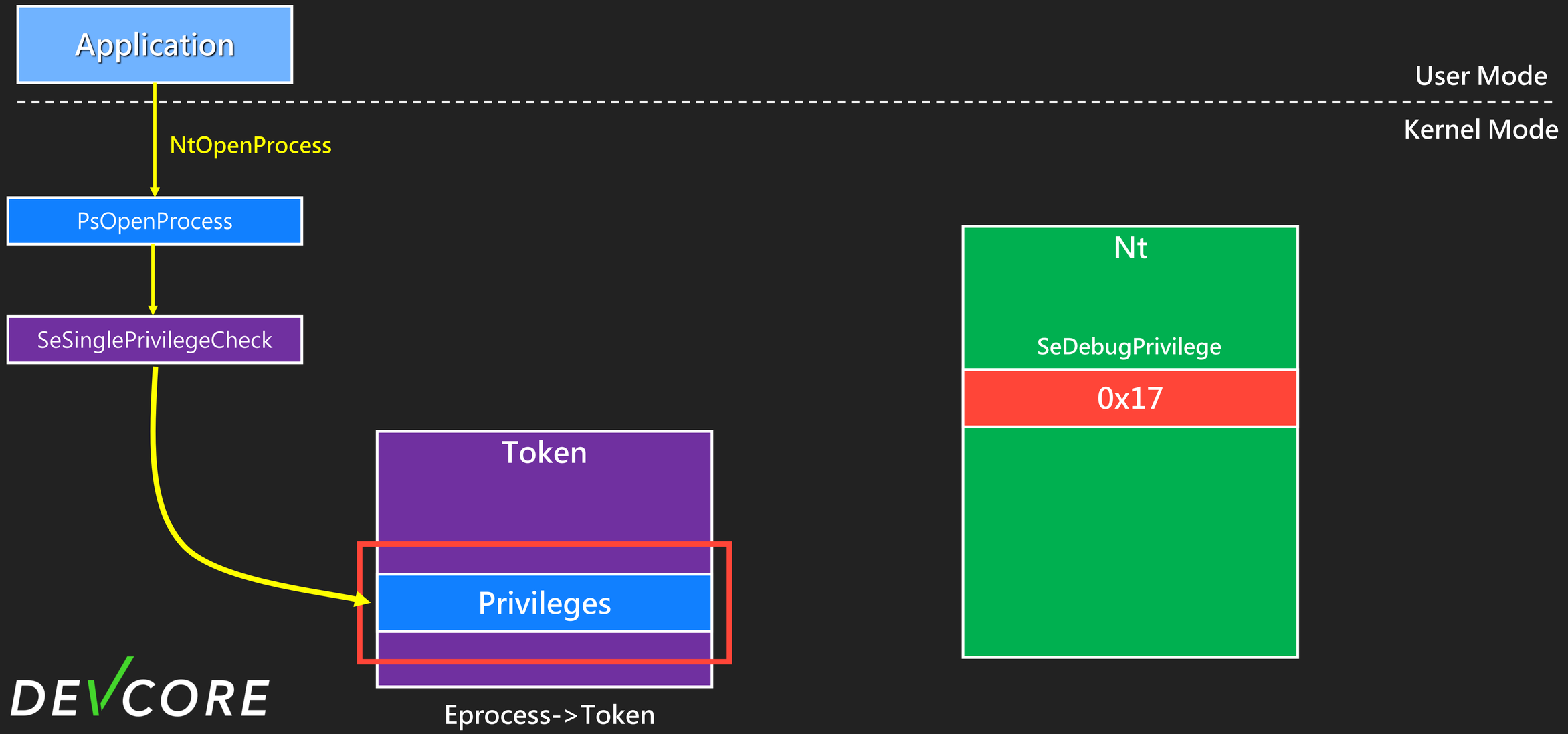
Make abusing token privilege great again



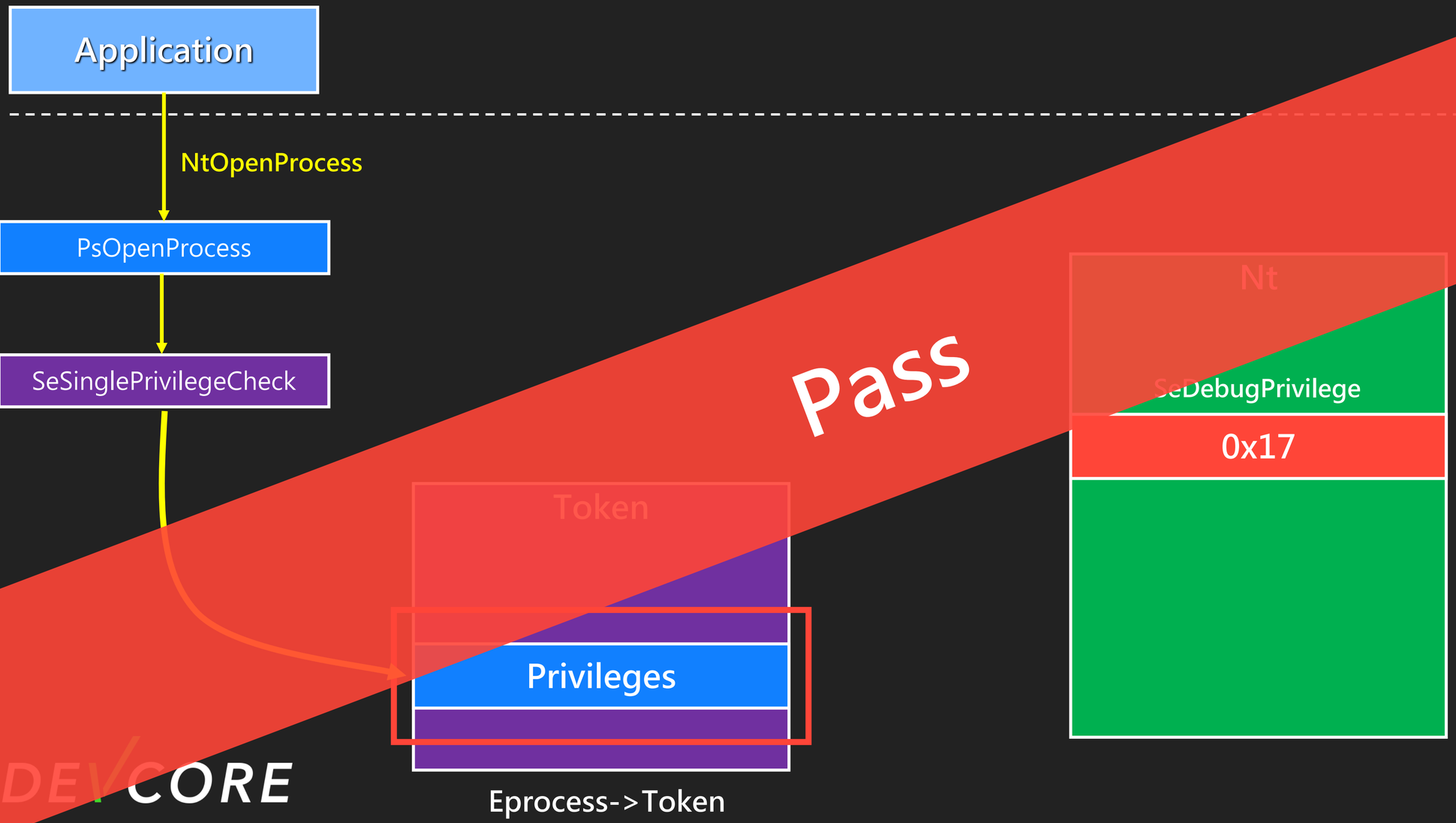
DEVCORE

Make abusing token privilege great again



DEVCORE

Make abusing token privilege great again



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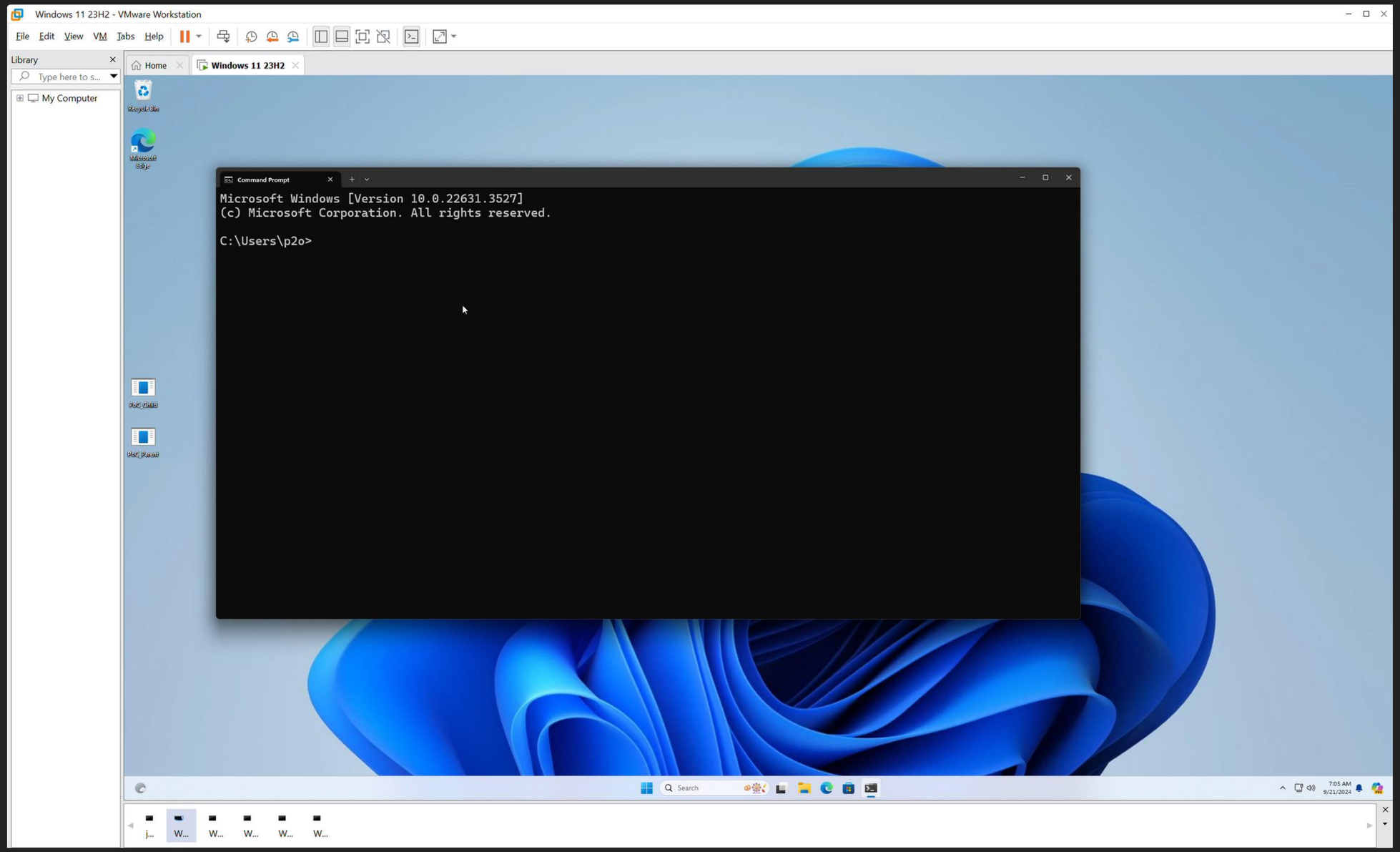
Windows 11 23H2 - VMware Workstation
File Edit View VM Tabs Help
Library
Type here to s...
My Computer
Home
Windows 11 23H2
Recycle Bin
Microsoft Edge
PoC Child
PoC Parent
Command Prompt
Microsoft Windows [Version 10.0.22631.3527]
(c) Microsoft Corporation. All rights reserved.
C:\Users\p2o>
Search
7:05 AM
9/21/2024

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Proxying to Kernel again !

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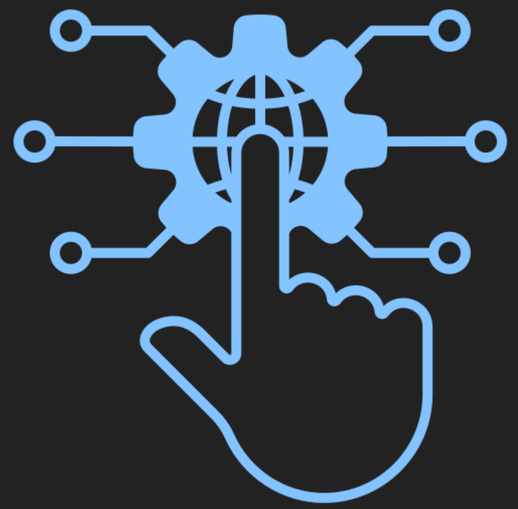
The Patch

```
if ( flag == KSPROPERTY_TYPE_UNSERIALIZESET )
{
  LOBYTE(v20) = (unsigned int)Feature_2849679676__private_IsEnabledDeviceUsage(v11, a2, v63) != 0;
  if ( !v20
    || *(_QWORD *)&KSProperty->Set.Data1 != *(_QWORD *)&KSPROPSETID_DrmAudioStream.Data1
    || *(_QWORD *)KSProperty->Set.Data4 != *(_QWORD *)KSPROPSETID_DrmAudioStream.Data4 )
  {
    return UnserializePropertySet((__int64)Irp, (__int64)KSProperty, v7);
  }
  return STATUS_INVALID_PARAMETER;
}
```

DEVCORE



The Next

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The Next

- The Overlook bug class
  - It may be possible to find more related proxy type bug
    - IoBuildDeviceIoControlRequest
    - IofCallDriver
    - …
  - The timing of setting Irp->RequestorMode to KernelMode is very important.

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The Next

- The Attack Surface
  - kernel streaming has many components
    - Low-hanging fruit
      - Hdaudio.sys
      - Usbvideo.sys
      - …

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Takeaways

- Looking at historical vulnerabilities is indispensable
- When current exploitation methods no longer work, explore the core mechanics - you may discover new approaches.

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Is that the end of it ?

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CVE-2024-38125
CVE-2024-38055
CVE-2024-38056
CVE-2024-38191
CVE-2024-38054
CVE-2024-38144
CVE-2024-30084
CVE-2024-38052
CVE-2024-35250
CVE-2024-38057
CVE-2024-30090

To Be Continued ...

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Thanks!


scwuaptx


angelboy@devco.re