Escaping the Sandbox on Windows

Chrome & Adobe Pdf Reader

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Whoami

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Principal Architect at Sangfor

PhD in Cryptography, interested in all areas of Computer Science

Work in Defensive & Offensive security

Published many research in both Industry & Academia

More about me: https://sites.google.com/site/zhiniangpeng

some of my bugs

CVE-2018-20694,CVE-2018-20746,CVE-2018-20693,CVE-2018-20692,CVE-2018-20696,CVE-2018-20689,CVE-2018-20690,CVE-2018-10812,CVE-2019-6184,CVE-2019-6186,CVE-2019-6487,CVE-2019-1253,CVE-2019-1292,CVE-2019-1317,CVE-2019-1340,CVE-2019-1342,CVE-2019-1374,CVE-2019-8162,CVE-2019-1474,CVE-2019-18371,CVE-2019-18370,CVE-2020-0616,CVE-2020-0635,CVE-2020-0636,CVE-2020-0638,CVE-2020-0641,CVE-2020-0648,CVE-2020-0697,CVE-2020-0730,CVE-2020-3808,CVE-2020-0747,CVE-2020-0753,CVE-2020-0754,CVE-2020-0777,CVE-2020-0780,CVE-2020-0785,CVE-2020-0786,CVE-2020-0789,CVE-2020-0794,CVE-2020-0797,CVE-2020-0800,CVE-2020-0805,CVE-2020-0808,CVE-2020-0819,CVE-2020-0822,CVE-2020-0835,CVE-2020-0841,CVE-2020-0844,CVE-2020-0849,CVE-2020-0854,CVE-2020-0858,CVE-2020-0863,CVE-2020-0864,CVE-2020-0865,CVE-2020-0868,CVE-2020-0871,CVE-2020-0896,CVE-2020-0897,CVE-2020-0899,CVE-2020-0900,CVE-2020-0934,CVE-2020-0935,CVE-2020-0936,CVE-2020-0942,CVE-2020-0944,CVE-2020-0983,CVE-2020-0985,CVE-2020-0989,CVE-2020-1000,CVE-2020-1002,CVE-2020-1010,CVE-2020-1011,CVE-2020-1029,CVE-2020-1068,CVE-2020-1077,CVE-2020-1084,CVE-2020-1086,CVE-2020-1090,CVE-2020-1094,CVE-2020-1109,CVE-2020-1120,CVE-2020-1121,CVE-2020-1123,CVE-2020-1124,CVE-2020-1125,CVE-2020-1131,CVE-2020-1134,CVE-2020-1137,CVE-2020-1139,CVE-2020-1144,CVE-2020-1146,CVE-2020-1151,CVE-2020-1155,CVE-2020-1156,CVE-2020-1157,CVE-2020-1158,CVE-2020-1163,CVE-2020-1164,CVE-2020-1165,CVE-2020-1166,CVE-2020-1184,CVE-2020-1185,CVE-2020-1186,CVE-2020-1187,CVE-2020-1188,CVE-2020-1189,CVE-2020-1190,CVE-2020-1191,CVE-2020-1196,CVE-2020-1199,CVE-2020-1201,CVE-2020-1204,CVE-2020-1209,CVE-2020-1211,CVE-2020-1217,CVE-2020-1222,CVE-2020-1231,CVE-2020-1233,CVE-2020-1235,CVE-2020-1244,CVE-2020-1257,CVE-2020-1264,CVE-2020-1269,CVE-2020-1270,CVE-2020-1273,CVE-2020-1274,CVE-2020-1276,CVE-2020-1277,CVE-2020-1278,CVE-2020-1282,CVE-2020-1283,CVE-2020-1304,CVE-2020-1305,CVE-2020-1306,CVE-2020-1307,CVE-2020-1309,CVE-2020-1312,CVE-2020-1317,CVE-2020-1337,CVE-2020-1344,CVE-2020-1346,CVE-2020-1347,CVE-2020-1352,CVE-2020-1356,CVE-2020-1357,CVE-2020-1360,CVE-2020-1361,CVE-2020-1362,CVE-2020-1364,CVE-2020-5957,CVE-2020-1366,CVE-2020-1372,CVE-2020-1373,CVE-2020-1375,CVE-2020-1385,CVE-2020-1392,CVE-2020-1393,CVE-2020-1394,CVE-2020-1399,CVE-2020-1404,CVE-2020-1405,CVE-2020-1424,CVE-2020-1427,CVE-2020-1441,CVE-2020-0518,CVE-2020-1461,CVE-2020-1465,CVE-2020-1472,CVE-2020-1474,CVE-2020-1475,CVE-2020-1484,CVE-2020-1485,CVE-2020-1511,CVE-2020-1512,CVE-2020-0516,CVE-2020-1516,CVE-2020-1517,CVE-2020-1518,CVE-2020-1519,CVE-2020-1521,CVE-2020-1522,CVE-2020-1524,CVE-2020-1528,CVE-2020-1538,CVE-2020-8741,CVE-2020-1548,CVE-2020-1549,CVE-2020-1550,CVE-2020-1552,CVE-2020-1590,CVE-2020-1130,CVE-2020-16851,CVE-2020-16852,CVE-2020-1122,CVE-2020-1038,CVE-2020-17089,CVE-2020-16853,CVE-2020-16879,CVE-2020-16900,CVE-2020-16980,CVE-2020-17014,CVE-2020-17070,CVE-2020-17073,CVE-2020-17074,CVE-2020-17075,CVE-2020-17076,CVE-2020-17077,CVE-2020-17092,CVE-2020-17097,CVE-2020-17120,CVE-2021-1649,CVE-2021-1650,CVE-2021-1651,CVE-2021-1659,CVE-2021-1680,CVE-2021-1681,CVE-2021-1686,CVE-2021-1687,CVE-2021-1688,CVE-2021-1689,CVE-2021-1690,CVE-2021-1718,CVE-2021-1722,CVE-2021-24072,CVE-2021-24077,CVE-2021-3750,CVE-2021-24088,CVE-2021-26869,CVE-2021-26870,CVE-2021-26871,CVE-2021-26885,CVE-2021-28347,CVE-2021-28351,CVE-2021-28436,CVE-2021-28450,CVE-2021-31966,CVE-2021-34527,CVE-2021-42321,CVE-2021-36970,CVE-2021-38657,CVE-2021-40485,CVE-2021-41366,CVE-2021-42294,CVE-2021-42297,CVE-2021-43216,CVE-2021-43223,CVE-2021-43248,CVE-2022-21835,CVE-2022-21837,CVE-2022-21878,CVE-2022-21881,CVE-2022-21888,CVE-2022-21971,CVE-2022-21974,CVE-2022-21992,CVE-2022-23285,CVE-2022-23290,CVE-2022-24454,CVE-2022-29108,CVE-2022-24547,CVE-2022-23270,CVE-2022-26930,CVE-2022-29103,CVE-2022-29113,CVE-2022-38036,CVE-2022-35793,CVE-2022-35755,CVE-2022-35749,CVE-2022-35746,CVE-2022-34690,CVE-2022-21980,CVE-2022-22050,CVE-2022-22024,CVE-2022-22022,CVE-2022-30226,CVE-2022-30157,CVE-2022-29108,CVE-2022-21999,CVE-2023-21683,CVE-2023-21684,CVE-2023-21693,CVE-2023-21801,CVE-2023-23403,CVE-2023-23406,CVE-2023-23413,CVE-2023-24856,CVE-2023-24857,CVE-2023-24858,CVE-2023-24863,CVE-2023-24865,CVE-2023-24866,CVE-2023-24867,CVE-2023-24907,CVE-2023-24868,CVE-2023-24909,CVE-2023-24870,CVE-2023-24872,CVE-2023-24913,CVE-2023-24876,CVE-2023-24924,CVE-2023-24883,CVE-2023-24925,CVE-2023-24884,CVE-2023-24926,CVE-2023-24885,CVE-2023-24927,CVE-2023-24886,CVE-2023-24928,CVE-2023-24887,CVE-2023-24929,CVE-2023-28243,CVE-2023-28296,CVE-2023-29366,CVE-2023-29367,CVE-2023-32017,CVE-2023-32039,CVE-2023-32040,CVE-2023-32041,CVE-2023-32042,CVE-2023-32085,CVE-2023-35296,CVE-2023-35302,CVE-2023-35306,CVE-2023-35313,CVE-2023-35323,CVE-2023-35324,CVE-2023-36898,CVE-2023-36792,CVE-2023-36704,CVE-2023-36418,CVE-2023-36395,CVE-2023-36393,CVE-2023-35624,CVE-2023-21683,CVE-2023-29366,CVE-2023-46138,CVE-2023-42820,CVE-2023-42819,CVE-2024-21426,CVE-2024-29156,CVE-2024-26198,CVE-2024-21435,CVE-2024-21329,CVE-2024-21384,CVE-2024-20691,CVE-2024-21433,CVE-2024-20694,CVE-2024-0087,CVE-2024-0088,CVE-2024-30060,CVE-2024-29989

Whoami

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Q4n is a security researcher, his research focus on binary exploitation and artificial intelligence.

Whoami

R4nger

R4nger is a security researcher, his research focus on reverse engineering and artificial intelligence.

Agenda

- ➢ Introduction
- ➢ Attack Surface of Different Sandboxes on Windows
- ➢ Exploiting the Chrome GPU Process
- ➢ Exploiting a Windows Kernel Vulnerability
- ➢ Summary

Introduction

Background

- ➢ Modern desktop application become more secure
  - SDLC, Mitigations, Security Architecture, ……
- ➢ Chrome and Adobe pdf Reader are still the main targets
  - 0day exploitation still in the wild.
  - Commercial Surveillance Vendors and Governments.

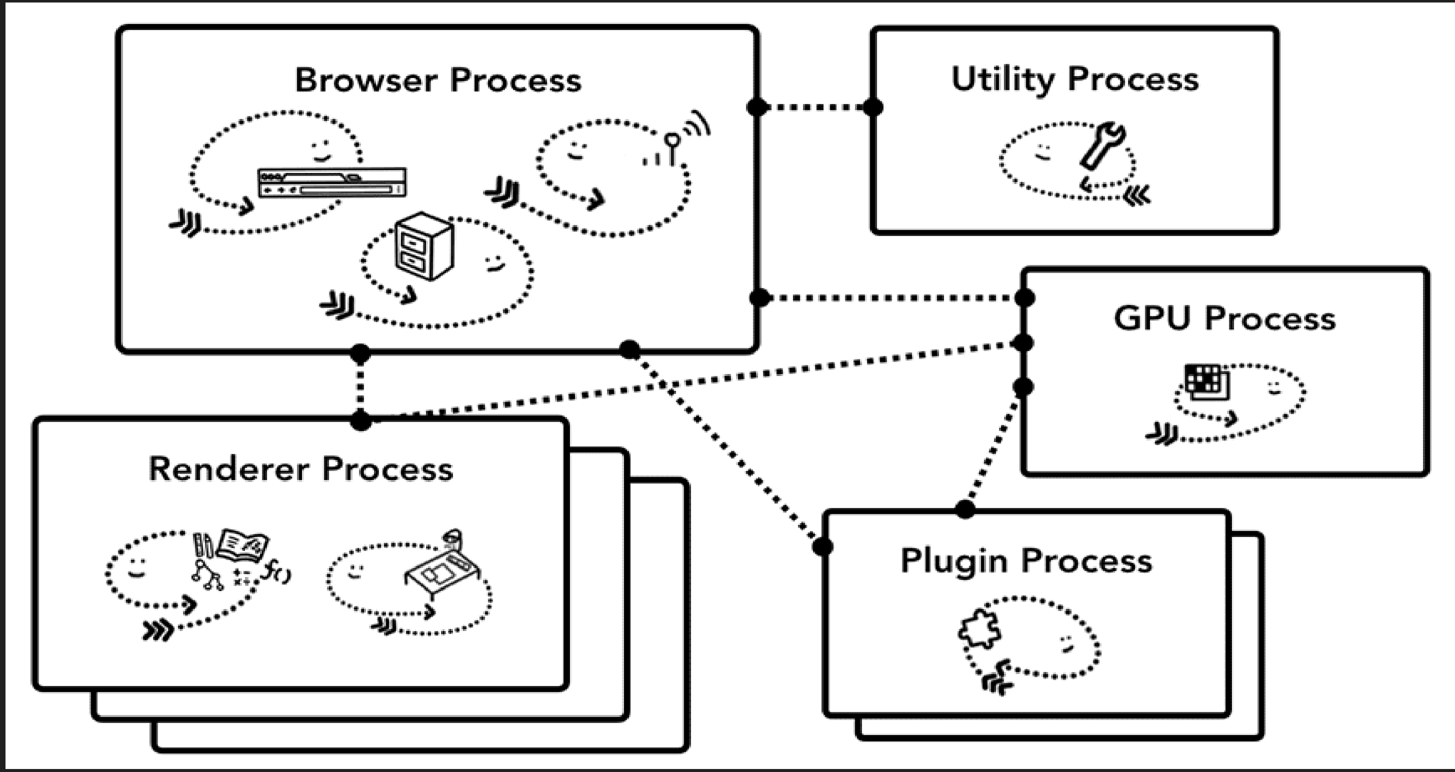
Motivation

- ➢ Offensive research drive defense
  - ○ Defense and detection
  - ○ Attack simulation (BAS)
- ➢ Build a full chain exploit for Chrome and Adobe pdf Reader
  - ○ No Experience on Chrome and Adobe before
  - ○ On PC (Windows)
  - ○ Sandbox escape is the main obstacle
  - ○ In this talk: our journey of research on sandbox escape

Attack Surface of Different Sandboxes

Chrome Process Architecture

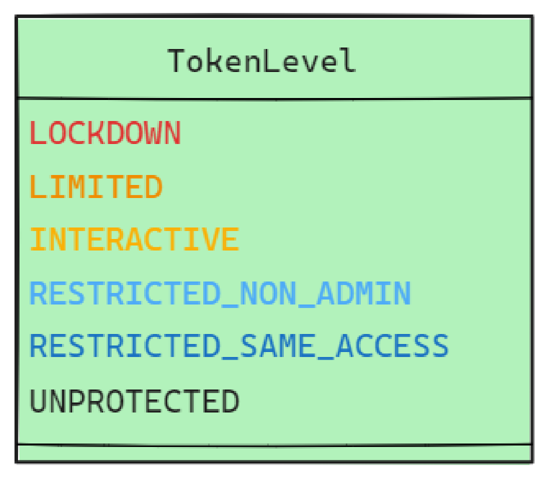
- ➢ Multi-process architecture.
- ➢ Different kind of process for different features.
- ➢ Talk to each other using Inter Process Communication (IPC).
- ➢ Sandbox restrict processes.



https://developer.chrome.com/blog/inside-browser-part1

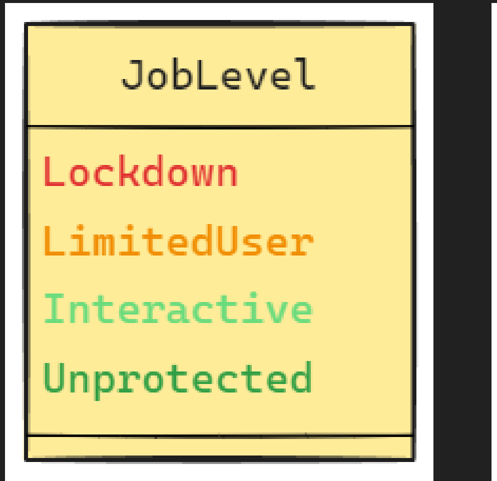
How Sandbox Restrict Process on Windows

- Restricted Token, Job Level.
  - Restricted privileges, protecting securable resources.
- Integrity Levels.
  - Enforce mandatory access control.
- Mitigations.
  - Setup various security enforcing policies.
- Alternate Desktop.
  - Restrict sandbox to interact with user desktop.



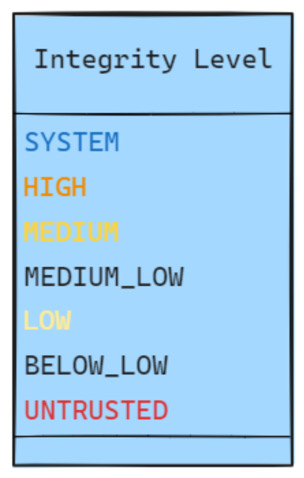
TokenLevel

LOCKDOWN
LIMITED
INTERACTIVE
RESTRICTED_NON_ADMIN
RESTRICTED_SAME_ACCESS
UNPROTECTED



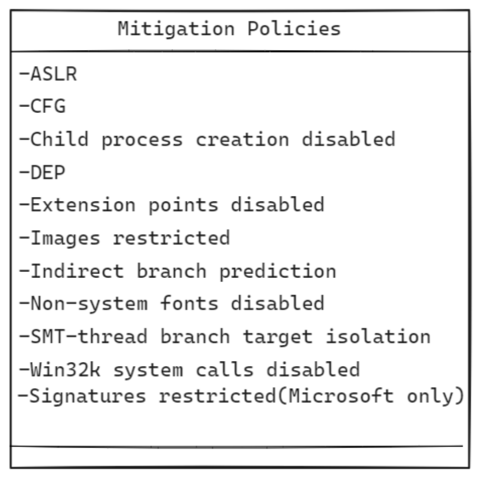
JobLevel

Lockdown
LimitedUser
Interactive
Unprotected



Integrity Level

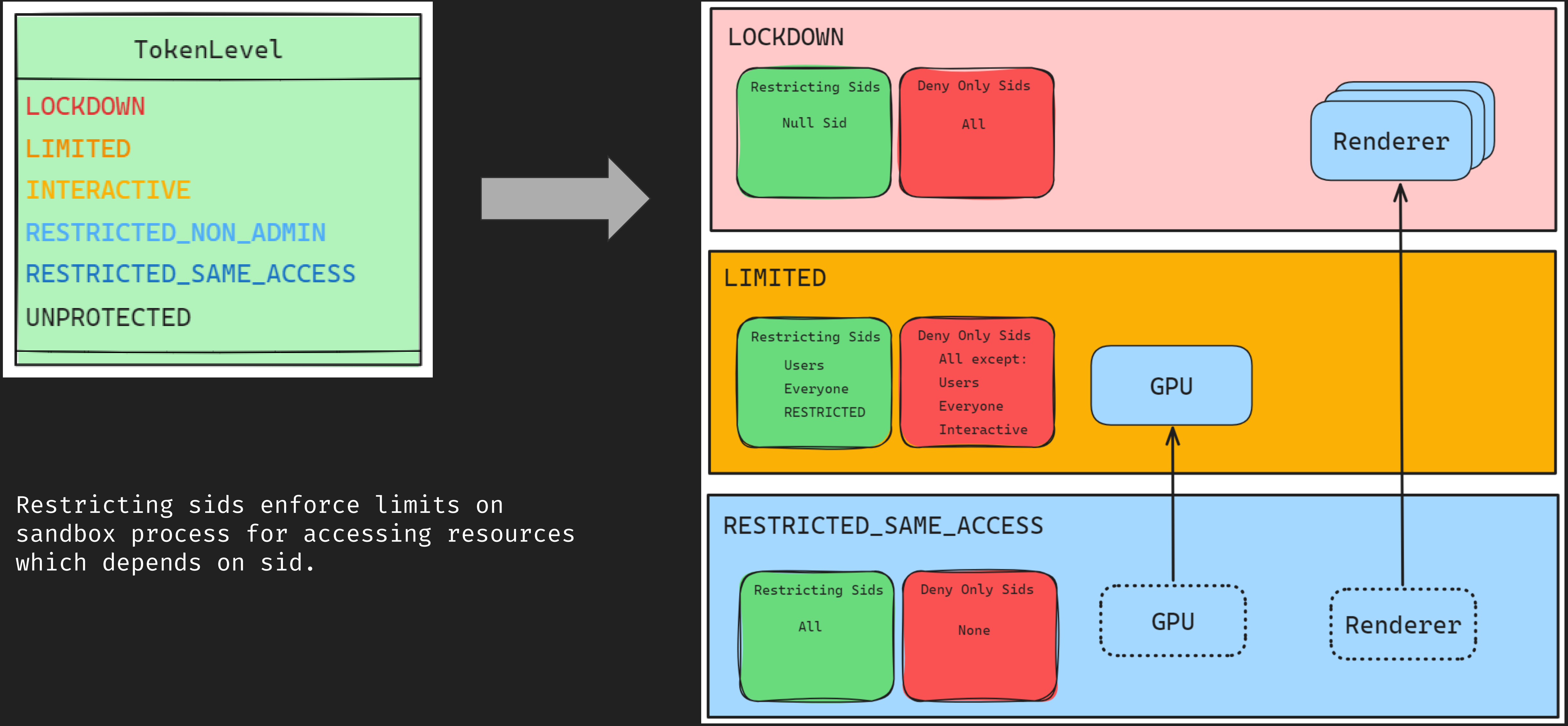
SYSTEM
HIGH
MEDIUM
MEDIUM_LOW
LOW
BELOW_LOW
UNTRUSTED



Mitigation Policies

-ASLR
-CFG
-Child process creation disabled
-DEP
-Extension points disabled
-Images restricted
-Indirect branch prediction
-Non-system fonts disabled
-SMT-thread branch target isolation
-Win32k system calls disabled
-Signatures restricted(Microsoft only)

Restricted Token



TokenLevel

- LOCKDOWN
- LIMITED
- INTERACTIVE
- RESTRICTED_NON_ADMIN
- RESTRICTED_SAME_ACCESS
- UNPROTECTED

LOCKDOWN

Restricting Sids: Null Sid

Deny Only Sids: All

Renderer

LIMITED

Restricting Sids: Users, Everyone, RESTRICTED

Deny Only Sids: All except: Users, Everyone, Interactive

GPU

RESTRICTED_SAME_ACCESS

Restricting Sids: All

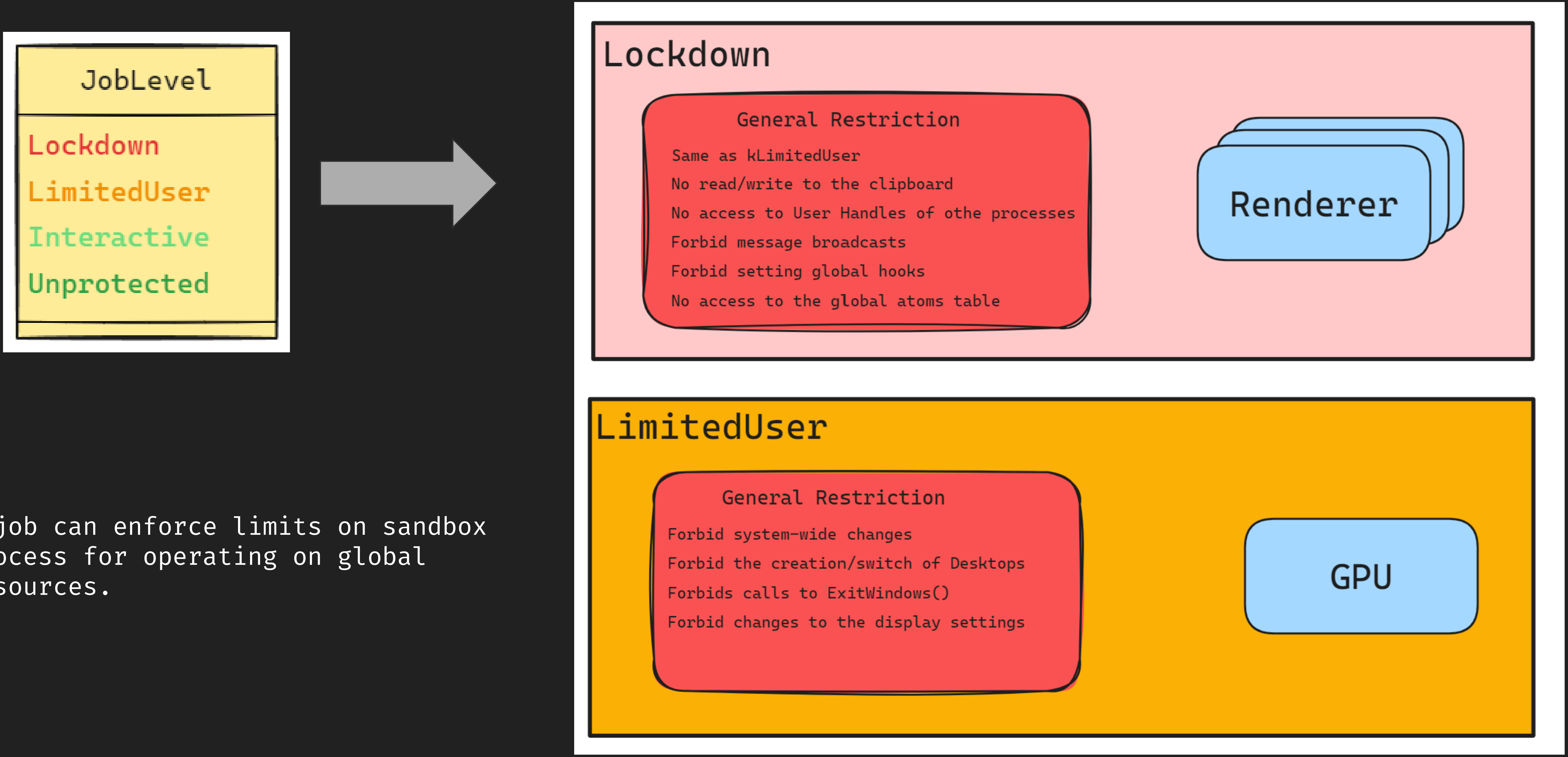
Deny Only Sids: None

GPU

Renderer

Restricting sids enforce limits on sandbox process for accessing resources which depends on sid.

Job Level



JobLevel

- Lockdown
- LimitedUser
- Interactive
- Unprotected

Lockdown

General Restriction

Same as kLimitedUser

No read/write to the clipboard

No access to User Handles of othe processes

Forbid message broadcasts

Forbid setting global hooks

No access to the global atoms table

LimitedUser

General Restriction

Forbid system-wide changes

Forbid the creation/switch of Desktops

Forbids calls to ExitWindows()

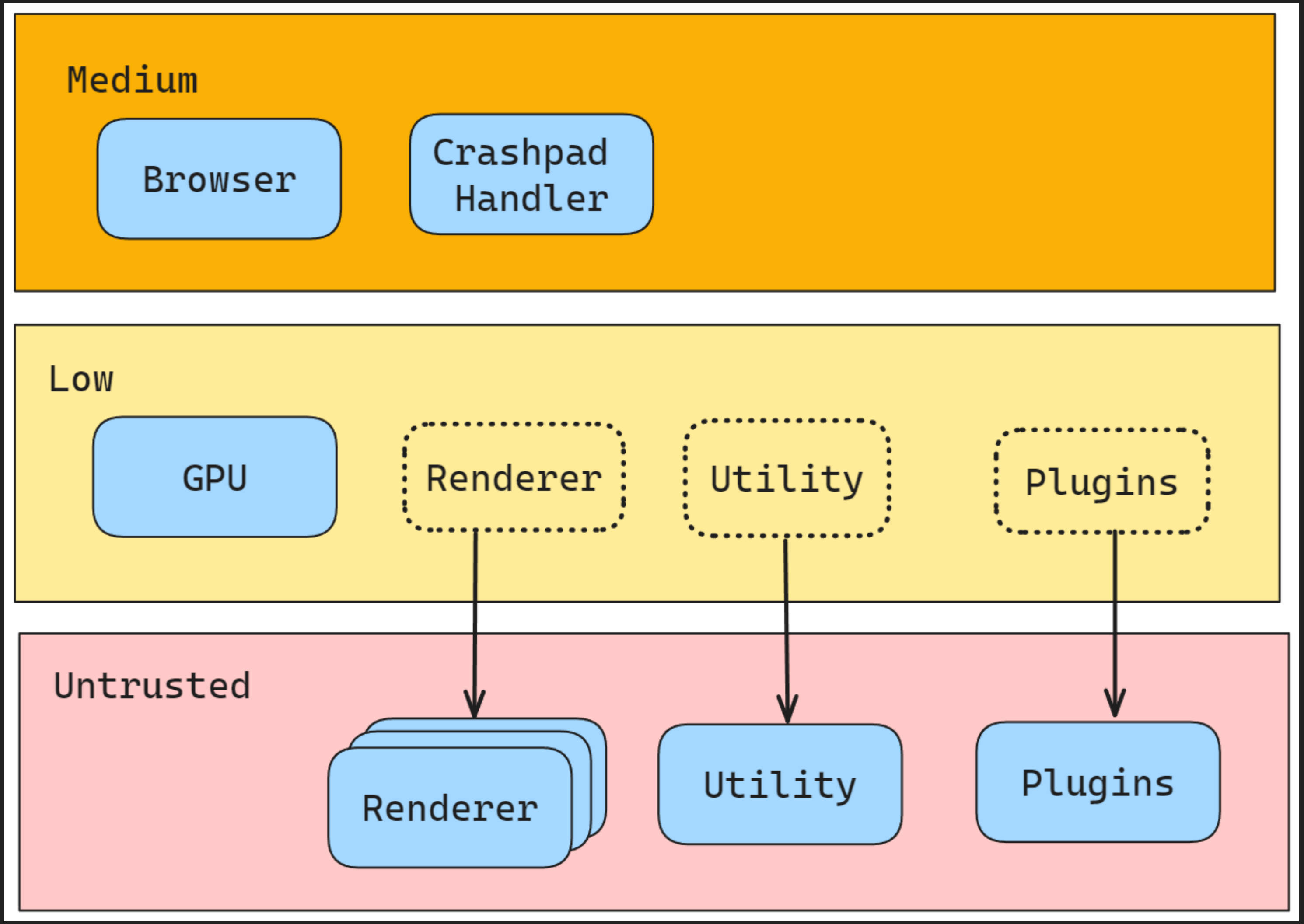
Forbid changes to the display settings

A job can enforce limits on sandbox process for operating on global resources.

Integrity Level

Integrity Level

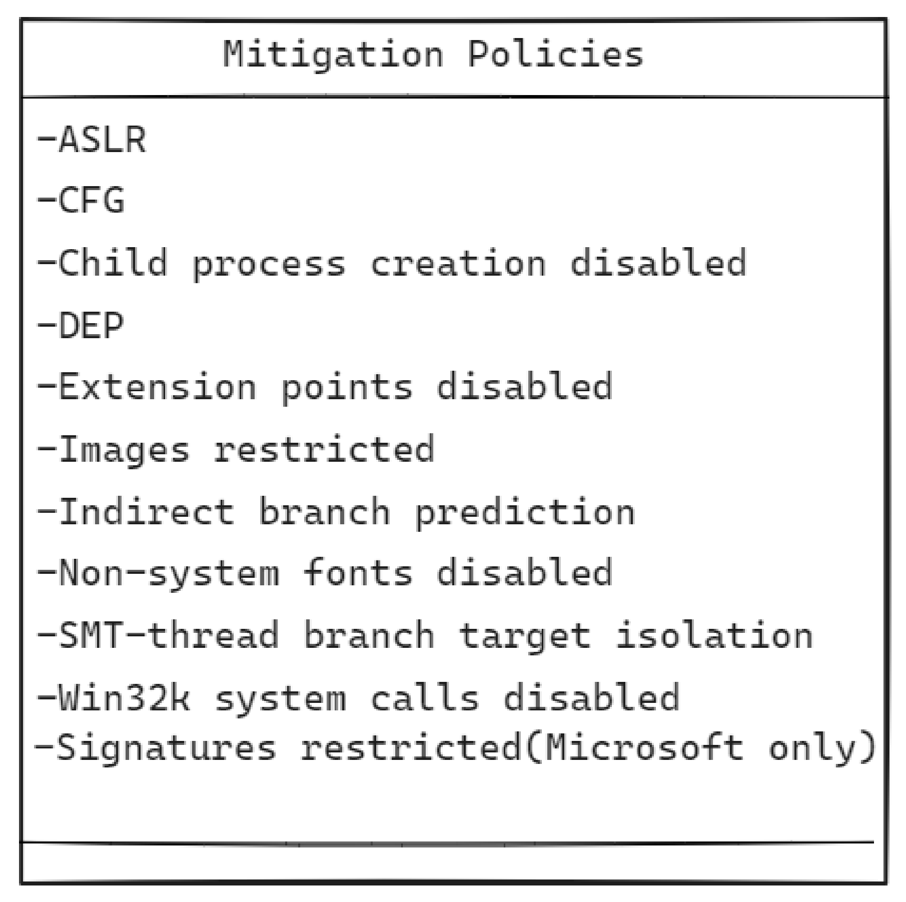
SYSTEM
HIGH
MEDIUM
MEDIUM_LOW
LOW
BELOW_LOW
UNTRUSTED



Integrity level enforce mandatory access control

Mitigation Policies

- ➢ Security enforcing policies to sandbox.
  - ○ Most can be applied via SetProcessMitigationPolicy.



Mitigation Policies

-ASLR

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-Images restricted

-Indirect branch prediction

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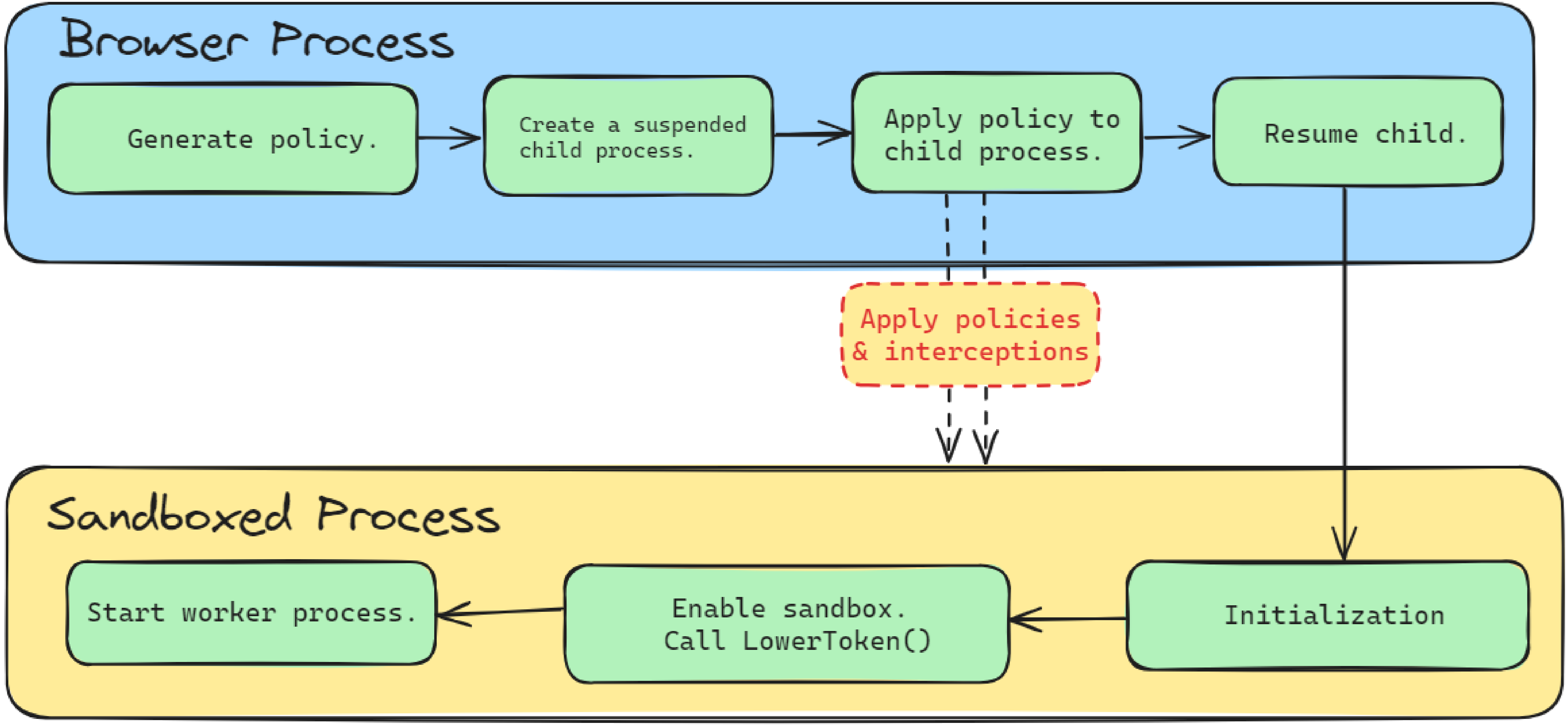
-SMT-thread branch target isolation

-Win32k system calls disabled

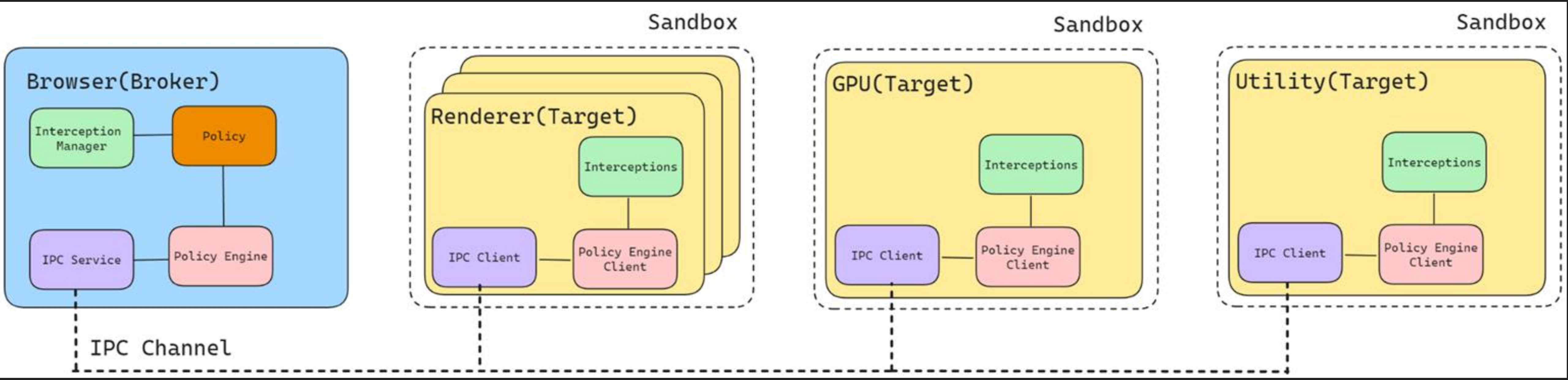
-Signatures restricted(Microsoft only)

Renderer

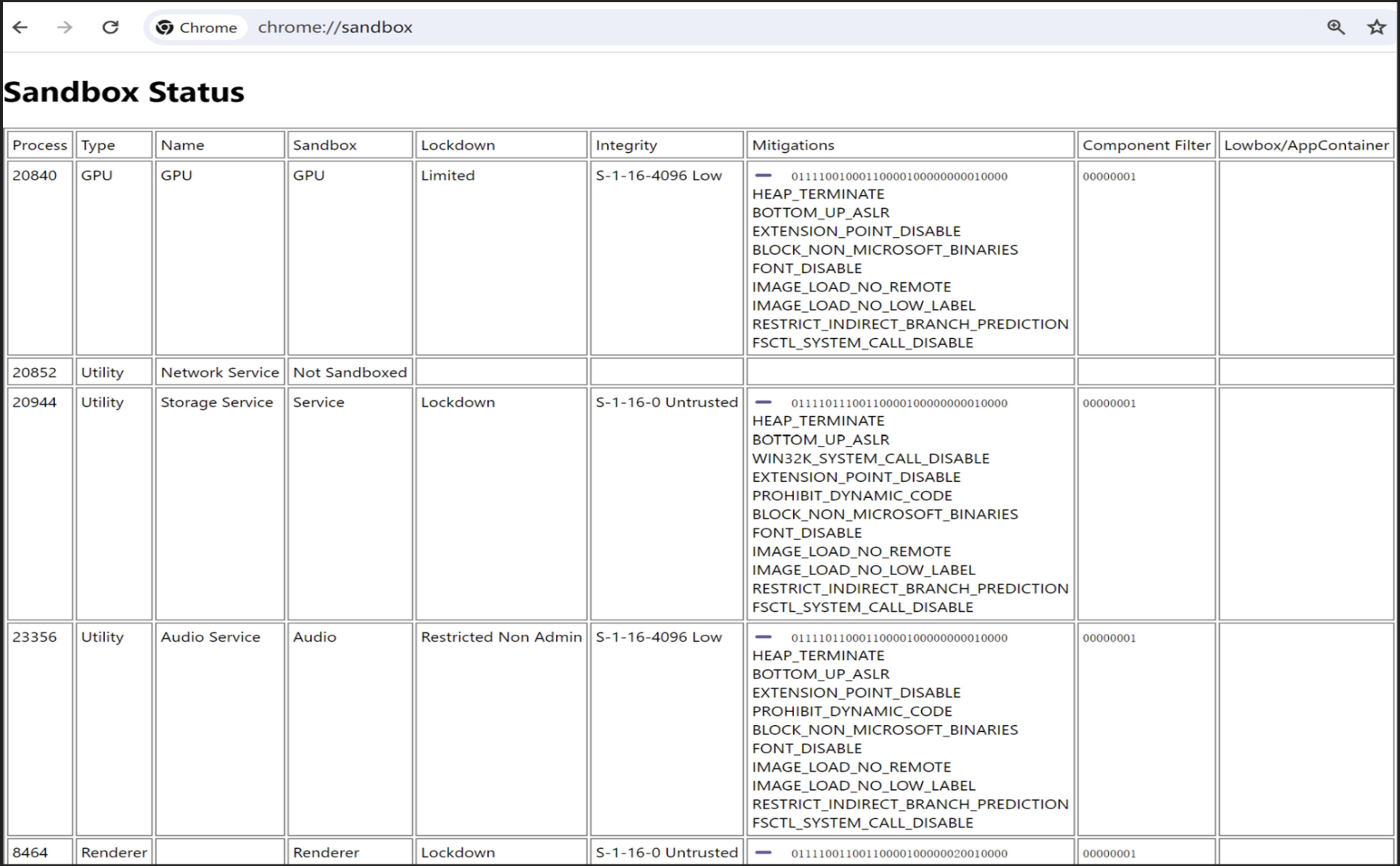
Chrome Sandbox Startup Flow on Windows


Browser Process
Generate policy.
Create a suspended child process.
Apply policy to child process.
Resume child.
Apply policies & interceptions
Sandboxed Process
Start worker process.
Enable sandbox. Call LowerToken()
Initialization

Chrome Sandbox Architecture



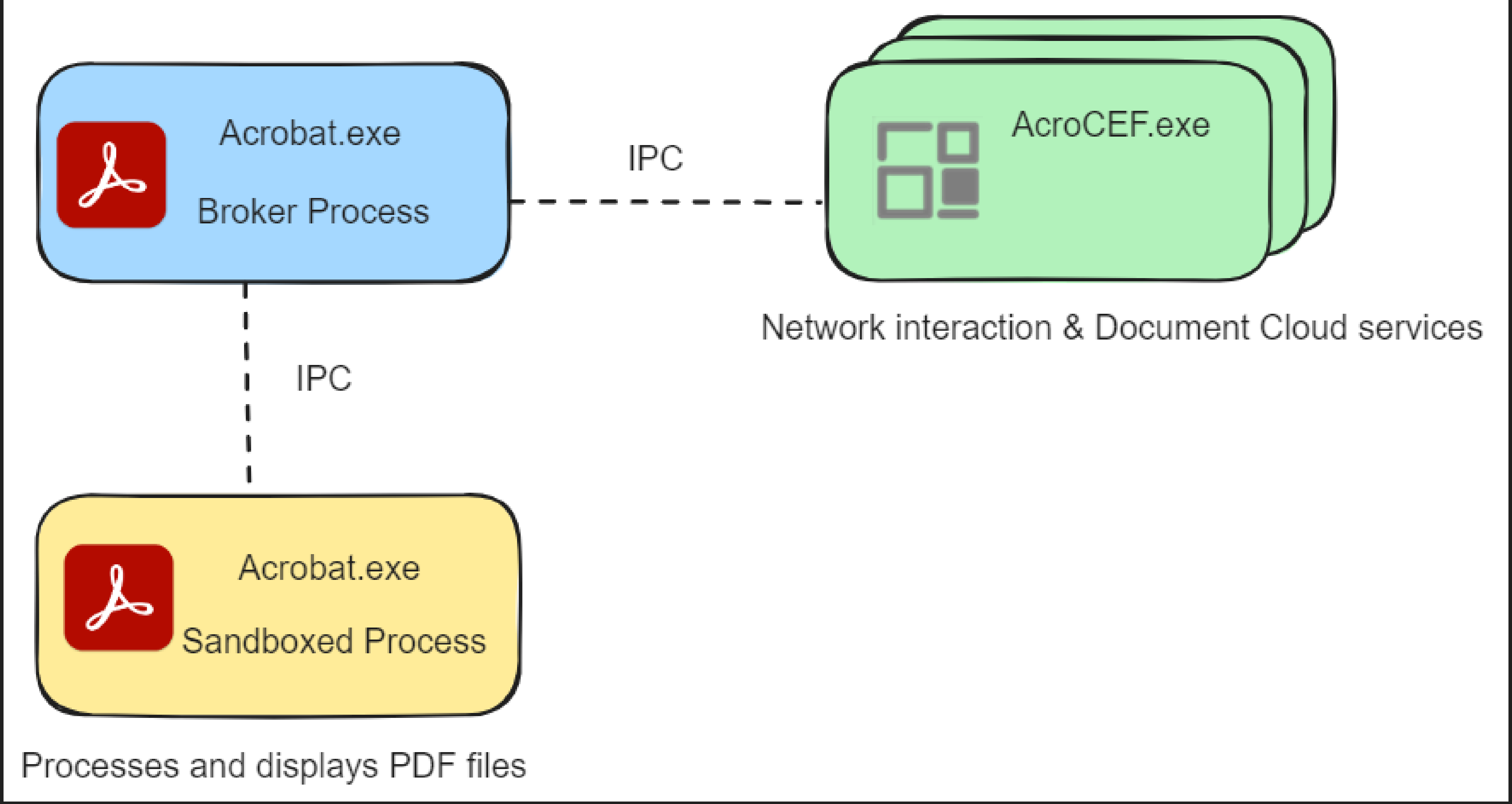
➢ chrome://sandbox



Sandbox Status

Process	Type	Name	Sandbox	Lockdown	Integrity	Mitigations	Component Filter	Lowbox/AppContainer
20840	GPU	GPU	GPU	Limited	S-1-16-4096 Low	— 01111001000110000100000000010000 HEAP_TERMINATE BOTTOM_UP_ASLR EXTENSION_POINT_DISABLE BLOCK_NON_MICROSOFT_BINARIES FONT_DISABLE IMAGE_LOAD_NO_REMOTE IMAGE_LOAD_NO_LOW_LABEL RESTRICT_INDIRECT_BRANCH_PREDICTION FSCTL_SYSTEM_CALL_DISABLE	00000001	
20852	Utility	Network Service	Not Sandboxed					
20944	Utility	Storage Service	Service	Lockdown	S-1-16-0 Untrusted	— 01111011100110000100000000010000 HEAP_TERMINATE BOTTOM_UP_ASLR WIN32K_SYSTEM_CALL_DISABLE EXTENSION_POINT_DISABLE PROHIBIT_DYNAMIC_CODE BLOCK_NON_MICROSOFT_BINARIES FONT_DISABLE IMAGE_LOAD_NO_REMOTE IMAGE_LOAD_NO_LOW_LABEL RESTRICT_INDIRECT_BRANCH_PREDICTION FSCTL_SYSTEM_CALL_DISABLE	00000001	
23356	Utility	Audio Service	Audio	Restricted Non Admin	S-1-16-4096 Low	— 01111011000110000100000000010000 HEAP_TERMINATE BOTTOM_UP_ASLR EXTENSION_POINT_DISABLE PROHIBIT_DYNAMIC_CODE BLOCK_NON_MICROSOFT_BINARIES FONT_DISABLE IMAGE_LOAD_NO_REMOTE IMAGE_LOAD_NO_LOW_LABEL RESTRICT_INDIRECT_BRANCH_PREDICTION FSCTL_SYSTEM_CALL_DISABLE	00000001	
8464	Renderer		Renderer	Lockdown	S-1-16-0 Untrusted	— 01111001100110000100000020010000	00000001	

Adobe Process Architecture



Acrobat.exe

Broker Process

IPC

AcroCEF.exe

Network interaction & Document Cloud services

IPC

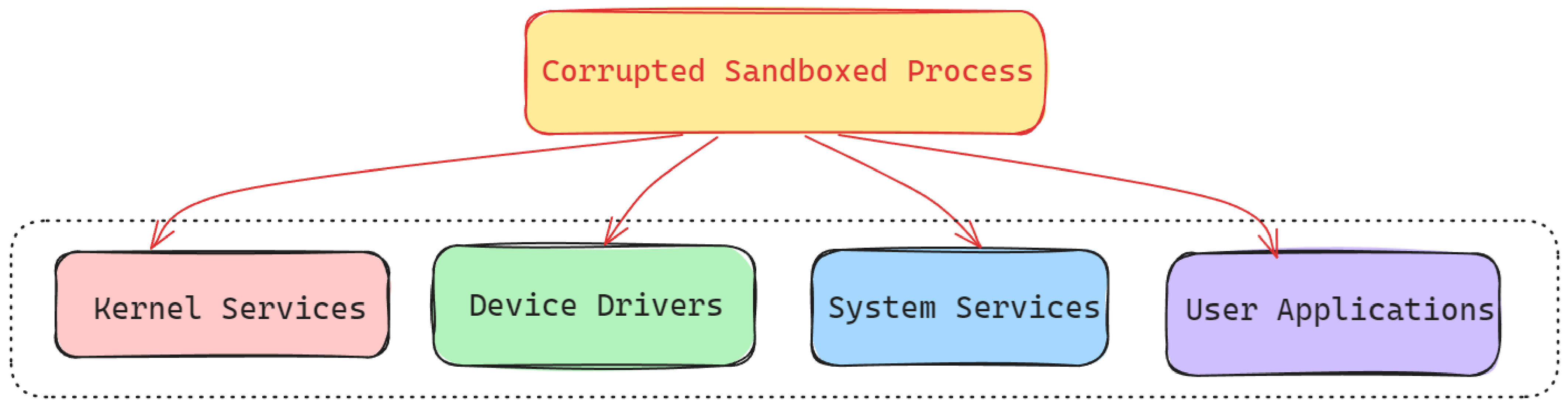
Acrobat.exe

Sandboxed Process

Processes and displays PDF files

Sandbox Escape Methodology

- Resources accessible inside the sandbox.
  - Configuration Issues may lead to direct sandbox escape.
  - Policy auditing.
- Code that can interactive inside the sandbox.
  - Vulnerability in these code might cause a sandbox escape.
  - The more resources you can access, the more code you can interact with.



Resources Accessible inside Sandbox

Depends on three factors :

- Token/Job/Mitigations: Chrome uses Mitigation Policy, Token, Job, Desktop to restrict the behavior of sandbox on Windows

- Pre-opened Objects: Sandboxed process has pre-opened objects which are necessary for the sandbox to run normally

- Policy Rules: Chrome provides the Policy Rule to allow the sandbox to access extra system resources

Accessible Resources by Token/Job

Get Writable Directories

```
Get-AccessibleFile -Win32Path "C:\" -Recurse -ProcessIds 1234 -DirectoryAccessRights AddFile -CheckMode
DirectoriesOnly -FormatWin32Path | Select-Object Name
```

Get Accessible ALPC Port

```
Get-AccessibleAlpcPort -ProcessIds 1234
```

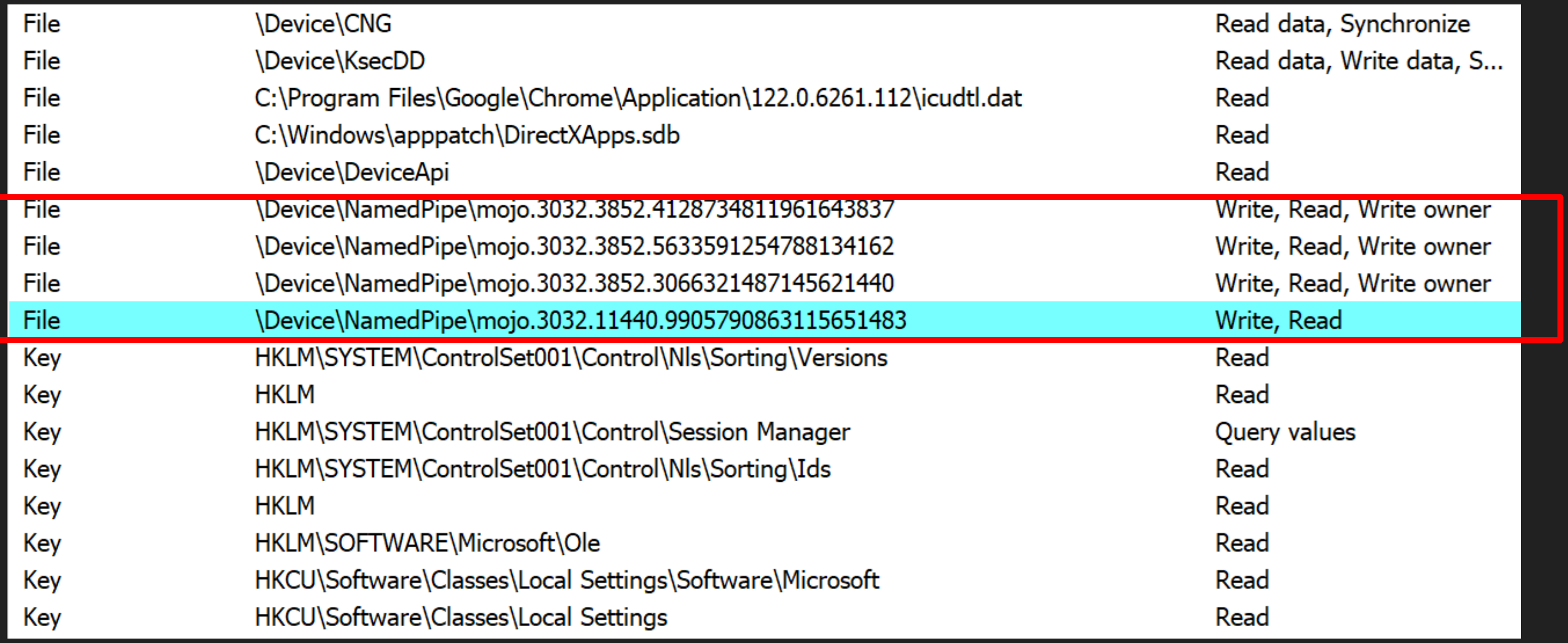
Get Accessible Device Object

```
Get-AccessibleDevice \Device -ProcessIds 1234
```

`Install-Module -Name NtObjectManager`

Pre-opened object in Renderer

Get pre-opened object by System Informer

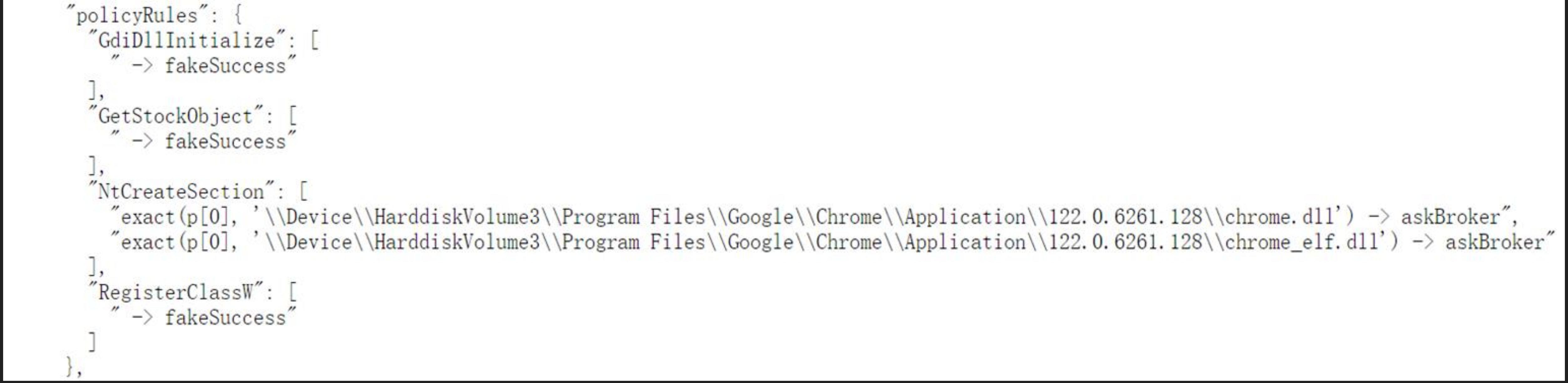


File	\Device\CNG	Read data, Synchronize
File	\Device\KsecDD	Read data, Write data, S...
File	C:\Program Files\Google\Chrome\Application\122.0.6261.112\icudtl.dat	Read
File	C:\Windows\apppatch\DirectXApps.sdb	Read
File	\Device\DeviceApi	Read
File	\Device\NamedPipe\mojo.3032.3852.4128734811961643837	Write, Read, Write owner
File	\Device\NamedPipe\mojo.3032.3852.5633591254788134162	Write, Read, Write owner
File	\Device\NamedPipe\mojo.3032.3852.3066321487145621440	Write, Read, Write owner
File	\Device\NamedPipe\mojo.3032.11440.9905790863115651483	Write, Read
Key	HKLM\SYSTEM\ControlSet001\Control\Nls\Sorting\Versions	Read
Key	HKLM	Read
Key	HKLM\SYSTEM\ControlSet001\Control\Session Manager	Query values
Key	HKLM\SYSTEM\ControlSet001\Control\Nls\Sorting\Ids	Read
Key	HKLM	Read
Key	HKLM\SOFTWARE\Microsoft\Ole	Read
Key	HKCU\Software\Classes\Local Settings\Software\Microsoft	Read
Key	HKCU\Software\Classes\Local Settings	Read

IPC based on named pipe

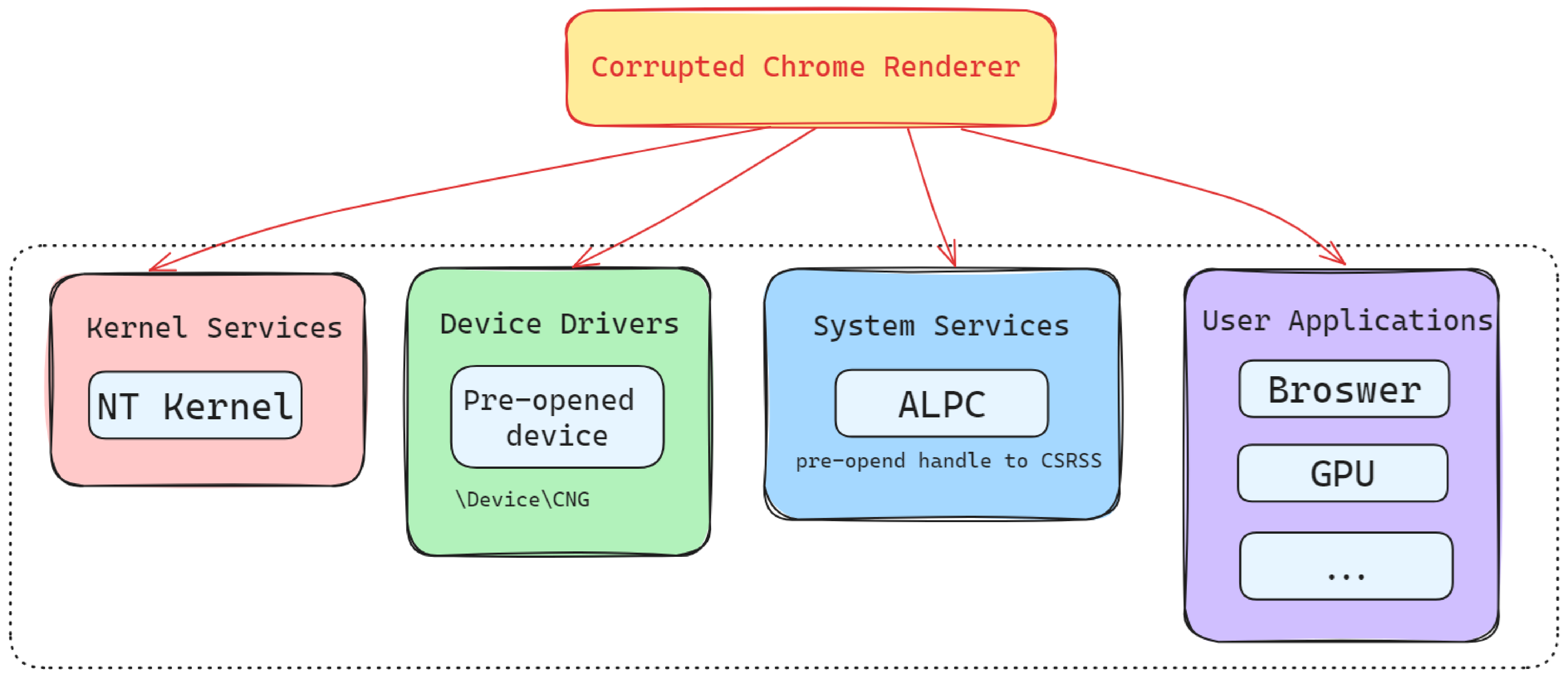
Extra Resources

- ➢ Ask broker process for the extra resources
    - ○ Crosscall answers are rule-based.
    - ○ Get policy rules from chrome://sandbox.



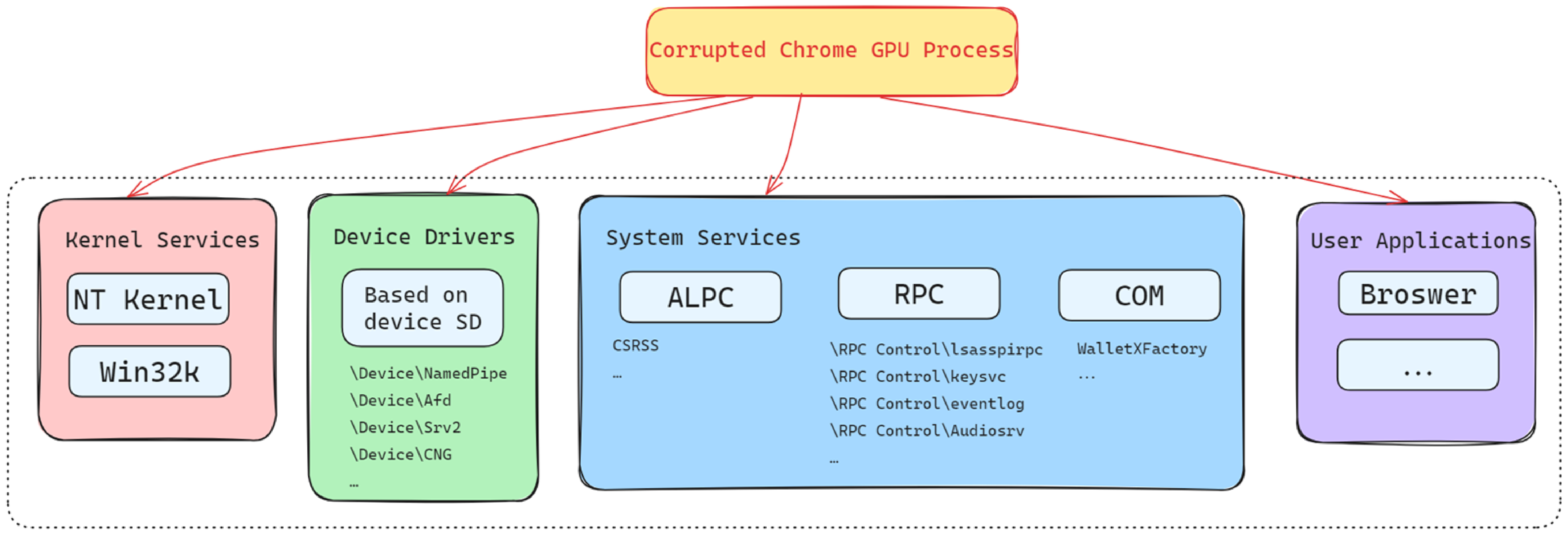
```
"policyRules": {
  "GdiDllInitialize": [
    " -> fakeSuccess"
  ],
  "GetStockObject": [
    " -> fakeSuccess"
  ],
  "NtCreateSection": [
    "exact(p[0], '\\Device\\HarddiskVolume3\\Program Files\\Google\\Chrome\\Application\\122.0.6261.128\\chrome.dll') -> askBroker",
    "exact(p[0], '\\Device\\HarddiskVolume3\\Program Files\\Google\\Chrome\\Application\\122.0.6261.128\\chrome_elf.dll') -> askBroker"
  ],
  "RegisterClassW": [
    " -> fakeSuccess"
  ]
},
```

Code You Can Interact With (Attack Surface)



Every attack surface listed here has vulnerabilities exploited in the wild before.

Attack Surface of Chrome GPU Process

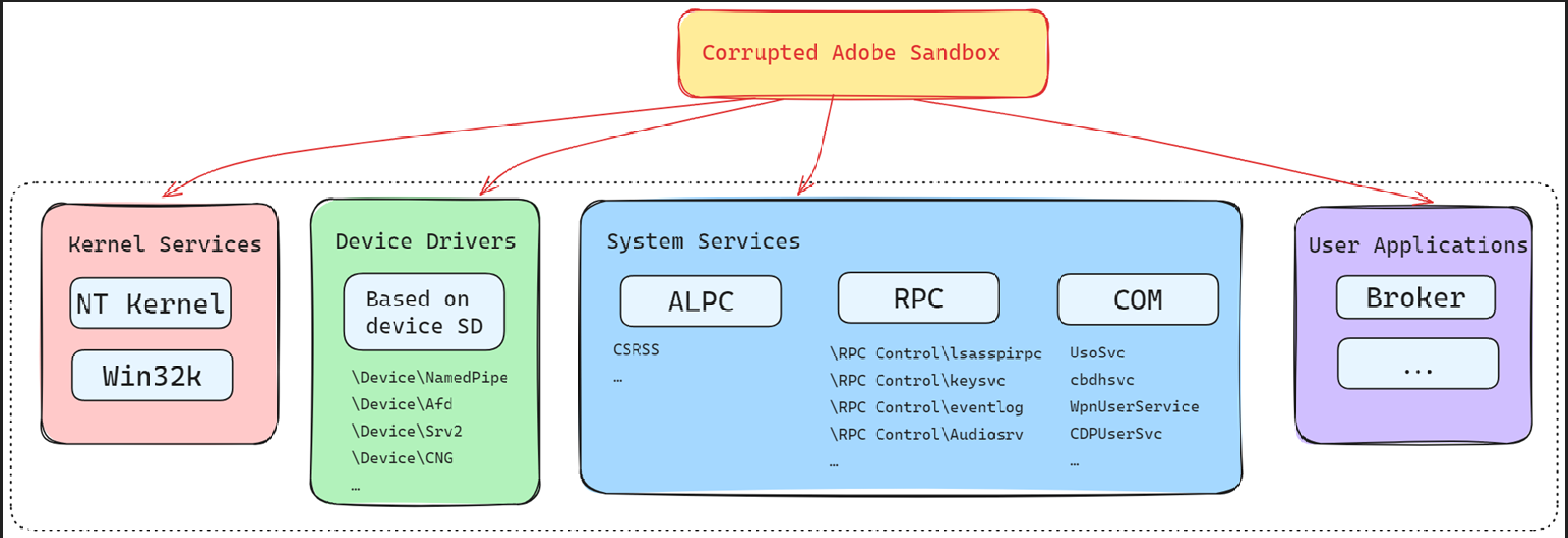


Comparing with renderer:

having the same syscall in NT kernel, but you can interact with more code.

Easier to escape.

Attack Surface of Adobe Sandboxed Process



Corrupted Adobe Sandbox

Kernel Services

NT Kernel

Win32k

Device Drivers

Based on device SD

\Device\NamedPipe

\Device\Afd

\Device\Srv2

\Device\CNG

…

System Services

ALPC

CSRSS

…

RPC

\RPC Control\lsasspirpc

\RPC Control\keysvc

\RPC Control\eventlog

\RPC Control\Audiosrv

…

COM

UsoSvc

cbdhsvc

WpnUserService

CDPUserSvc

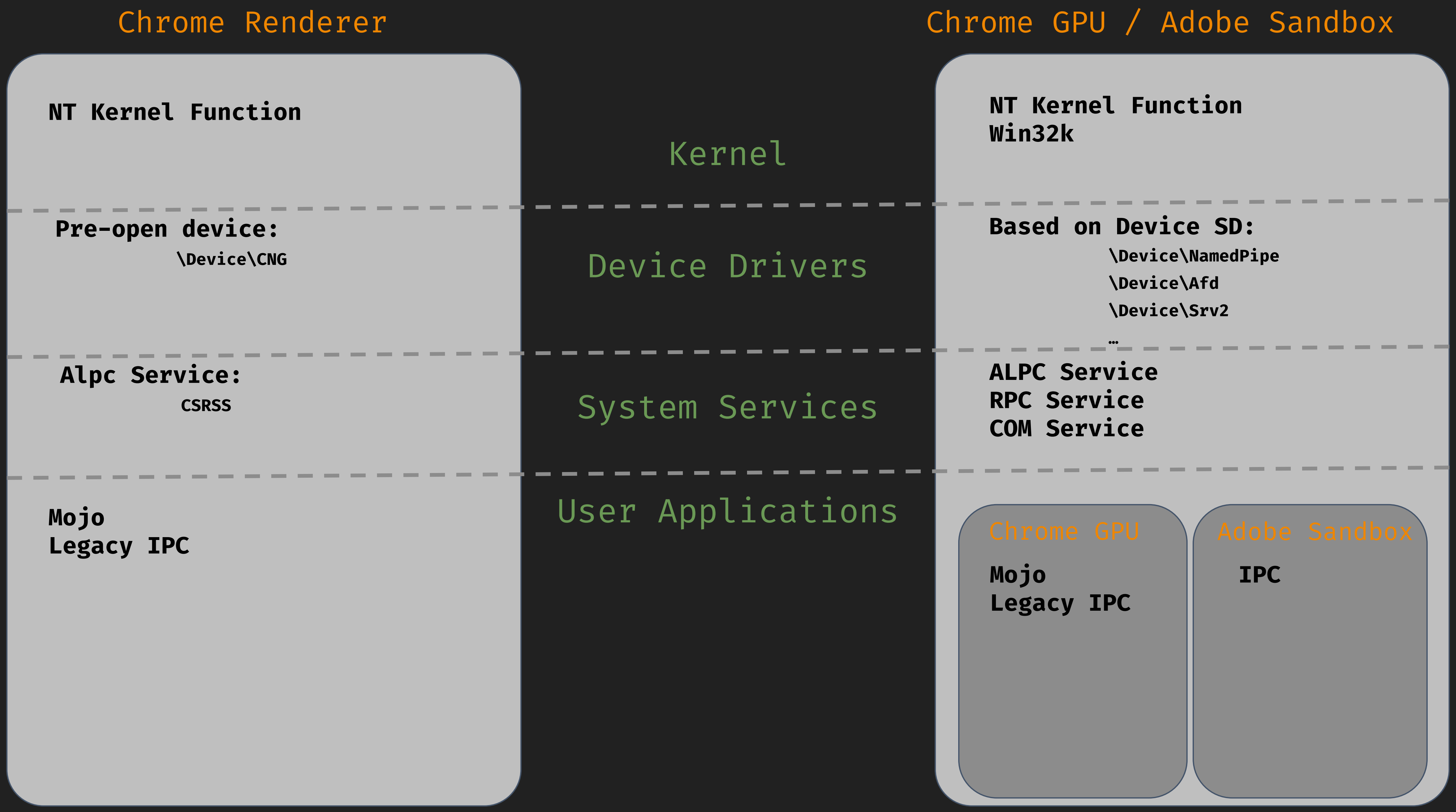
…

User Applications

Broker

...

Comparison



Chrome Renderer

Chrome GPU / Adobe Sandbox

Kernel

NT Kernel Function

NT Kernel Function
Win32k

Device Drivers

Pre-open device:
\Device\CNG

Based on Device SD:
\Device\NamedPipe
\Device\Afd
\Device\Srv2
…

System Services

Alpc Service:
CSRSS

ALPC Service
RPC Service
COM Service

User Applications

Mojo
Legacy IPC

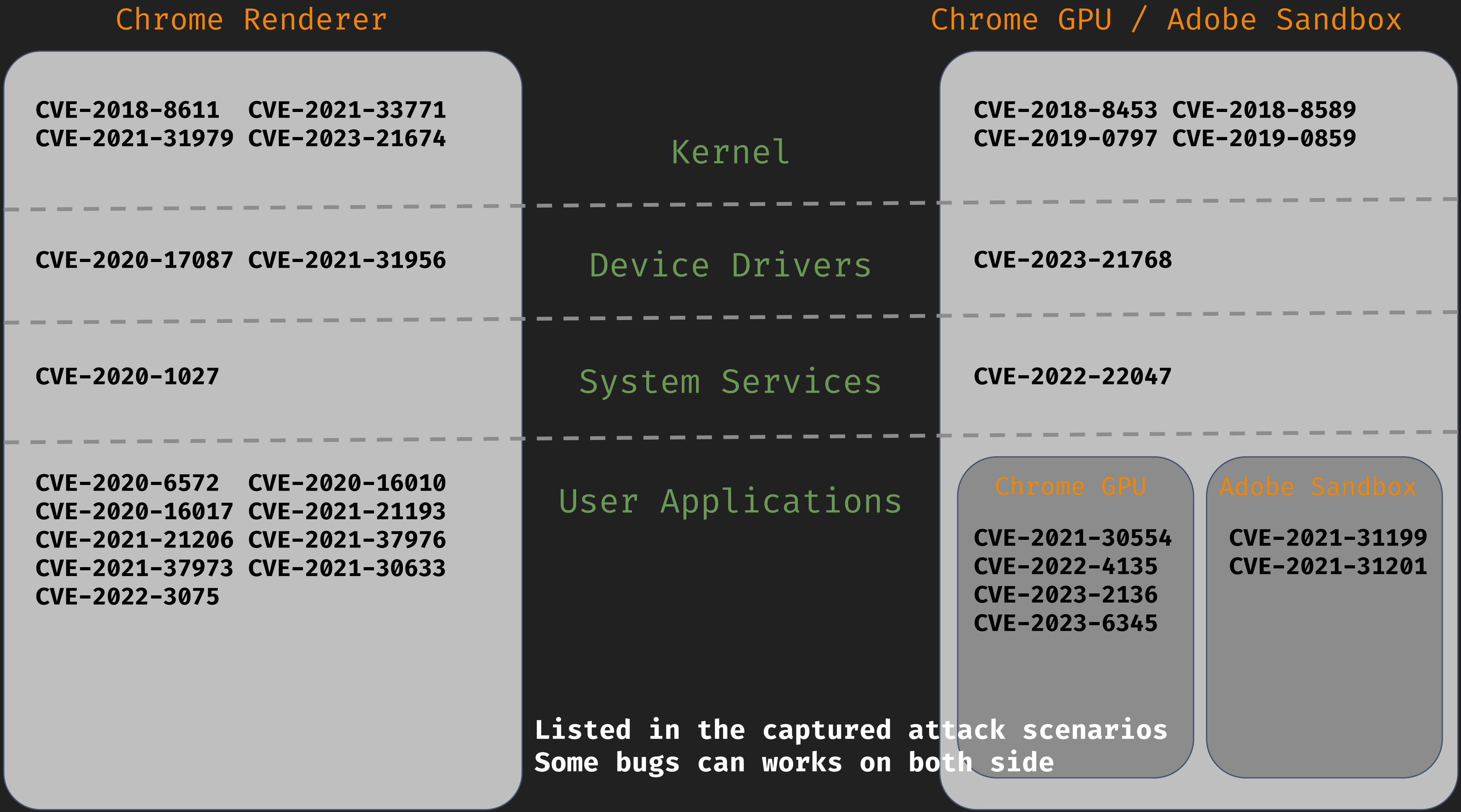
Chrome GPU

Mojo
Legacy IPC

Adobe Sandbox

IPC

In-the-wild Exploits



Chrome Renderer		Chrome GPU / Adobe Sandbox
CVE-2018-8611 CVE-2021-33771 CVE-2021-31979 CVE-2023-21674	Kernel	CVE-2018-8453 CVE-2018-8589 CVE-2019-0797 CVE-2019-0859
CVE-2020-17087 CVE-2021-31956	Device Drivers	CVE-2023-21768
CVE-2020-1027	System Services	CVE-2022-22047
CVE-2020-6572 CVE-2020-16010 CVE-2020-16017 CVE-2021-21193 CVE-2021-21206 CVE-2021-37976 CVE-2021-37973 CVE-2021-30633 CVE-2022-3075	User Applications	Chrome GPU CVE-2021-30554 CVE-2022-4135 CVE-2023-2136 CVE-2023-6345 Adobe Sandbox CVE-2021-31199 CVE-2021-31201

Listed in the captured attack scenarios
Some bugs can works on both side

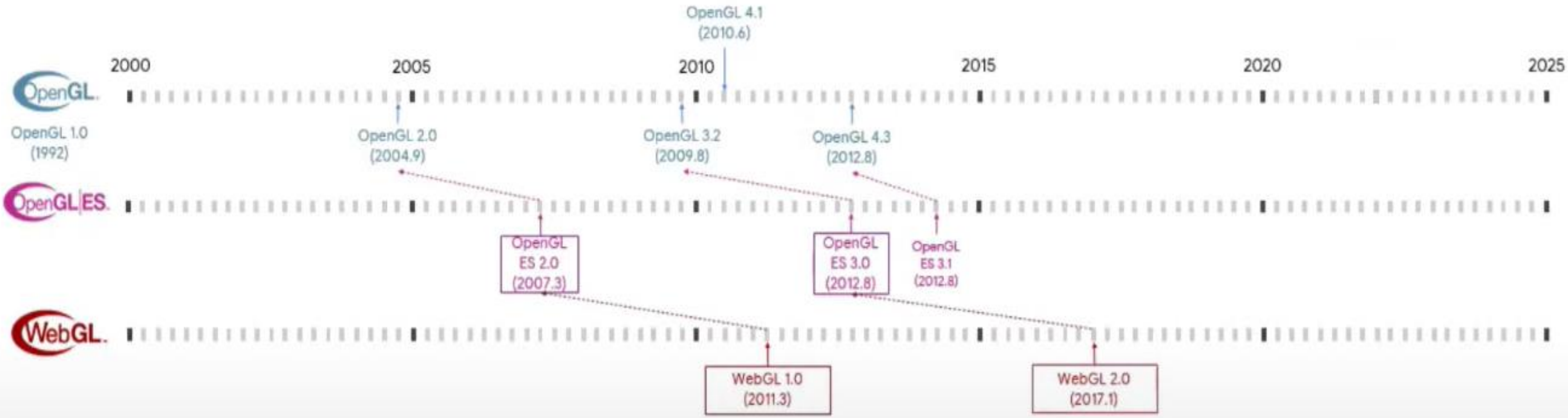
Exploiting the Chrome GPU Process

Introduction to WebGL

- ➢ Web standard for a low-level 3D graphics API.
- ➢ Browser-compatible JavaScript API.
- ➢ WebGL stays very close to the related OpenGL ES specification.
- ➢ …

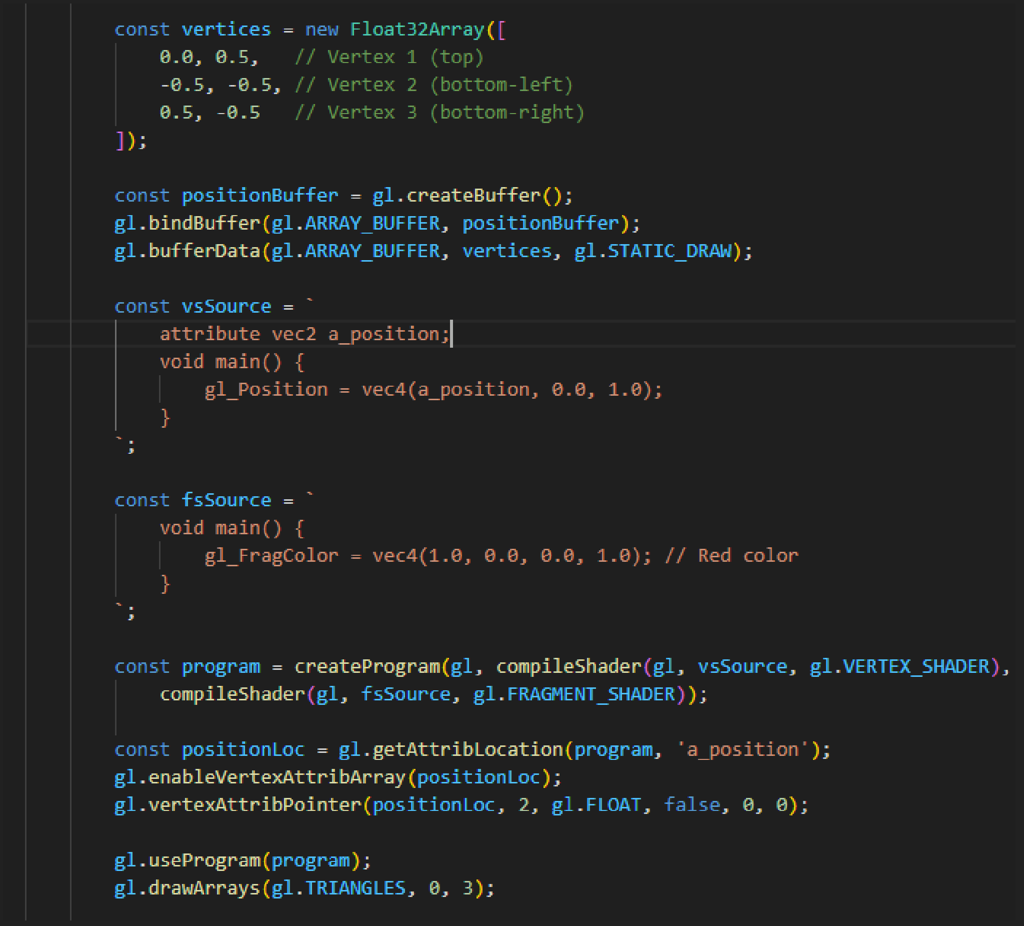
History of WebGL

- ➢ WebGL 1.0 was released in 2011.
  - ○ Based on OpenGL ES 2.0(2007).
- ➢ WebGL 2.0 was released in 2017.
  - ○ Based on OpenGL ES 3.0(2012).

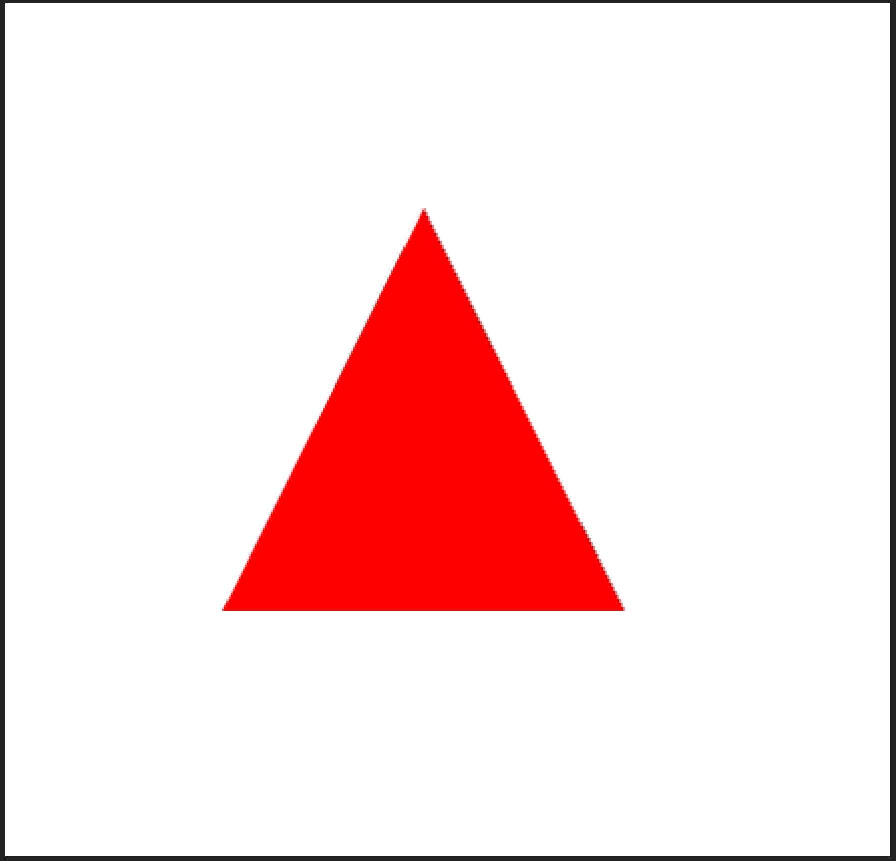


WebGL Demo

➢ Simple webgl2 code drawing a triangle

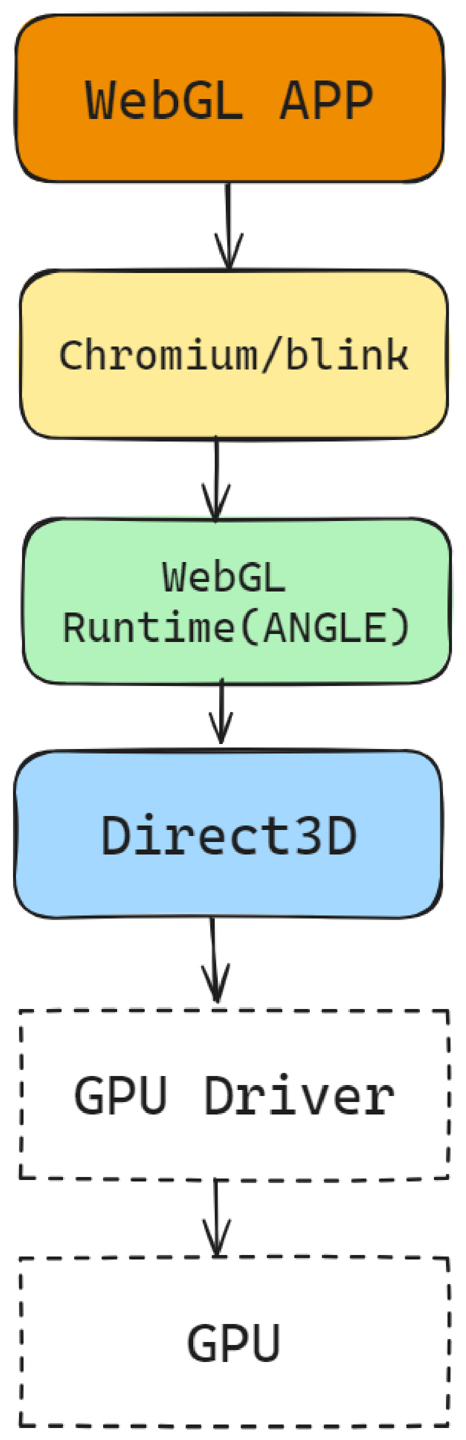


```
const vertices = new Float32Array([
    0.0, 0.5,    // Vertex 1 (top)
    -0.5, -0.5, // Vertex 2 (bottom-left)
    0.5, -0.5   // Vertex 3 (bottom-right)
]);

const positionBuffer = gl.createBuffer();
gl.bindBuffer(gl.ARRAY_BUFFER, positionBuffer);
gl.bufferData(gl.ARRAY_BUFFER, vertices, gl.STATIC_DRAW);

const vsSource = `
    attribute vec2 a_position;
    void main() {
        gl_Position = vec4(a_position, 0.0, 1.0);
    }
`;

const fsSource = `
    void main() {
        gl_FragColor = vec4(1.0, 0.0, 0.0, 1.0); // Red color
    }
`;

const program = createProgram(gl, compileShader(gl, vsSource, gl.VERTEX_SHADER),
    compileShader(gl, fsSource, gl.FRAGMENT_SHADER));

const positionLoc = gl.getAttribLocation(program, 'a_position');
gl.enableVertexAttribArray(positionLoc);
gl.vertexAttribPointer(positionLoc, 2, gl.FLOAT, false, 0, 0);

gl.useProgram(program);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```



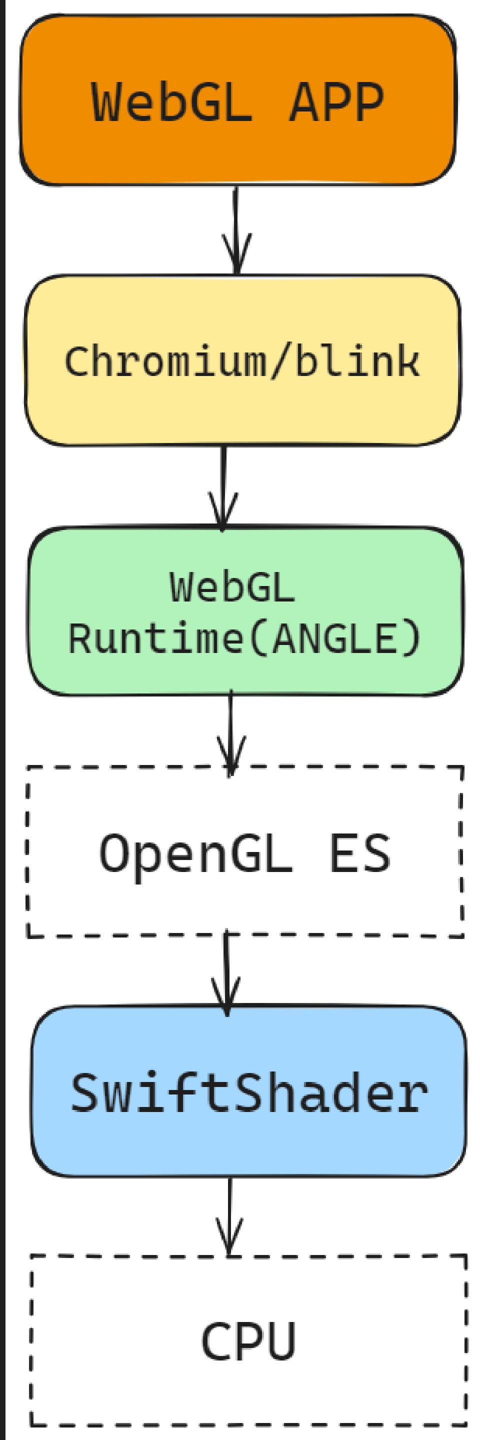
Chrome GPU Architecture on Windows

- ➢ Using Hardware Acceleration.
- ➢ ANGLE calls the D3D API directly.



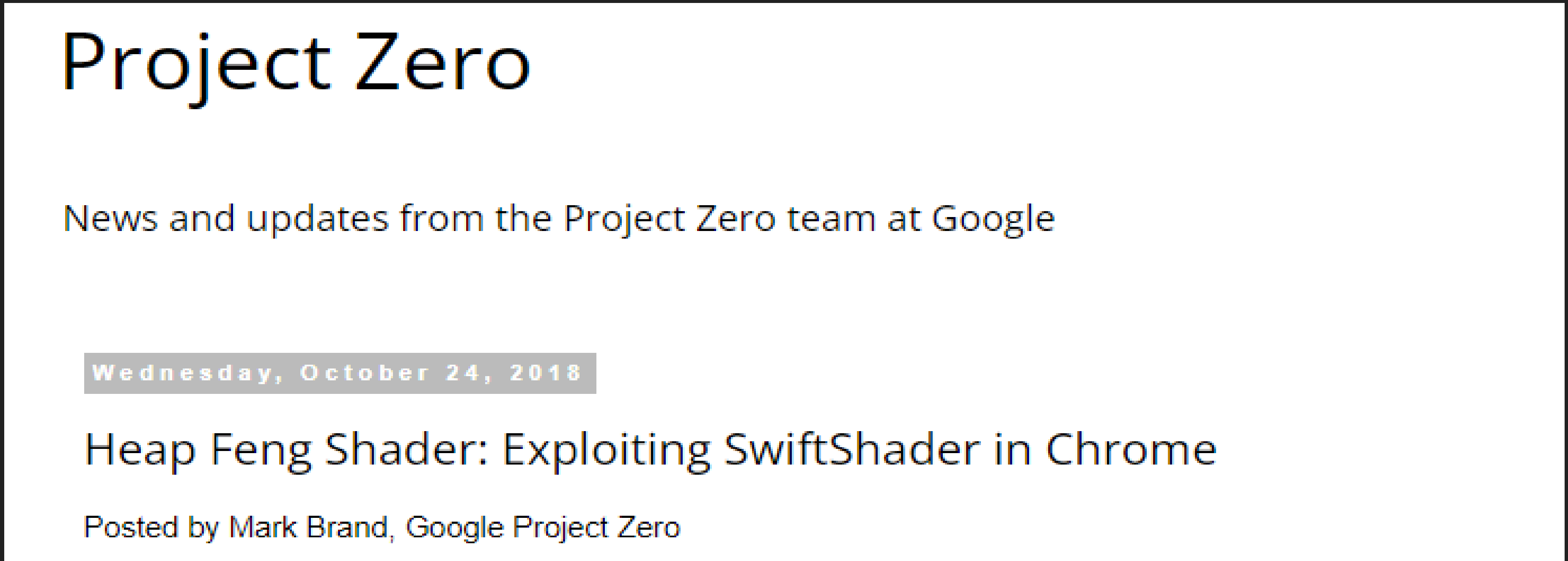
Chrome GPU Architecture on Windows

- With SwiftShader enabled.
  - Pure software implementation.
  - Running on devices that do not support hardware acceleration.
  - Cross-platform features.



What does swiftshader bring us?

- ➢ Attack surface from render to GPU process.



Project Zero

News and updates from the Project Zero team at Google

Wednesday, October 24, 2018

Heap Feng Shader: Exploiting SwiftShader in Chrome

Posted by Mark Brand, Google Project Zero

https://googleprojectzero.blogspot.com/2018/10/heap-feng-shader-exploiting-swiftshader.html

Check swiftshader exists

```
const canvas = document.createElement('canvas');
const gl = canvas.getContext('webgl2');
const debugInfo = gl.getExtension("WEBGL_debug_renderer_info");
const renderer = gl.getParameter(debugInfo.UNMASKED_RENDERER_WEBGL);
console.log(renderer);
```

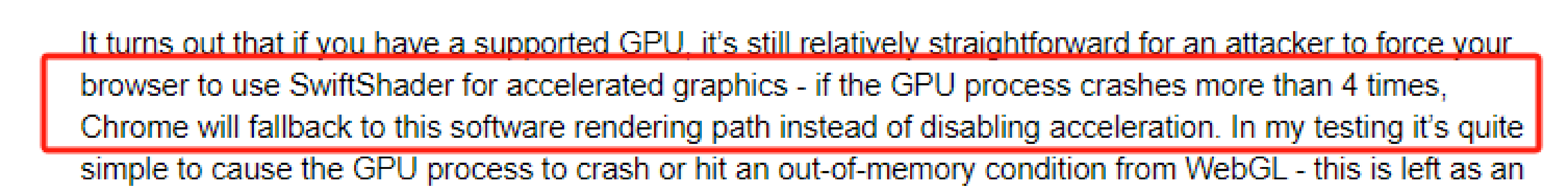
```
> ANGLE (Intel, Intel(R) UHD Graphics 630 (0x00003E92) Direct3D11
vs_5_0 ps_5_0, D3D11)
// without swiftshader


> ANGLE (Google, Vulkan 1.3.0 (SwiftShader Device (Subzero)
(0x0000C0DE)), SwiftShader driver)
// with swiftshader
```

How to Enable Swiftshader

- Adding --disable-gpu to the chrome startup command line.
  - Not the default.
- Or turning off 3D acceleration in virtual machines.
  - Common in cloud platform, but not universal for physical machines.
- In other cases, the swiftshader backend is disabled.

So how can we enable swiftshader by default in stable chrome?

Enable Swiftshader



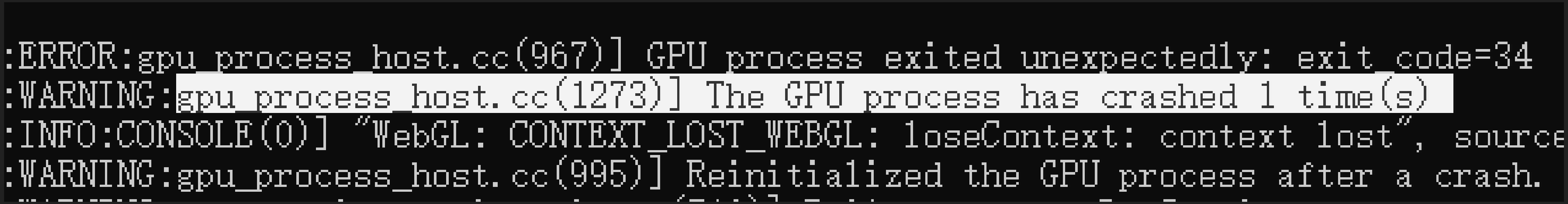
It turns out that if you have a supported GPU, it's still relatively straightforward for an attacker to force your browser to use SwiftShader for accelerated graphics - if the GPU process crashes more than 4 times, Chrome will fallback to this software rendering path instead of disabling acceleration. In my testing it's quite simple to cause the GPU process to crash or hit an out-of-memory condition from WebGL - this is left as an

- Crash the gpu process more than 4 times.
  - However, it didn't work… 🧐

```
for (let i = 0; i < 4; i++)
{
    gpuKiller(gl);
}
```

Crash GPU Process 4 times

0: gpuKiller() -> Crashed



```
:ERROR:gpu_process_host.cc(967)] GPU process exited unexpectedly: exit_code=34
:WARNING:gpu_process_host.cc(1273)] The GPU process has crashed 1 time(s)
:INFO:CONSOLE(0)] "WebGL: CONTEXT_LOST_WEBGL: loseContext: context lost", source
:WARNING:gpu_process_host.cc(995)] Reinitialized the GPU process after a crash.
```

1: gpuKiller() -> Failed

2: gpuKiller() -> Failed

3: gpuKiller() -> Failed

```
    canvas.addEventListener("webglcontextcreationerror",
(event) => {console.log(`${event.statusMessage}`);});
```

```
js> Web page caused context loss and was
blocked
js> Failed to create a WebGL2 context.
```

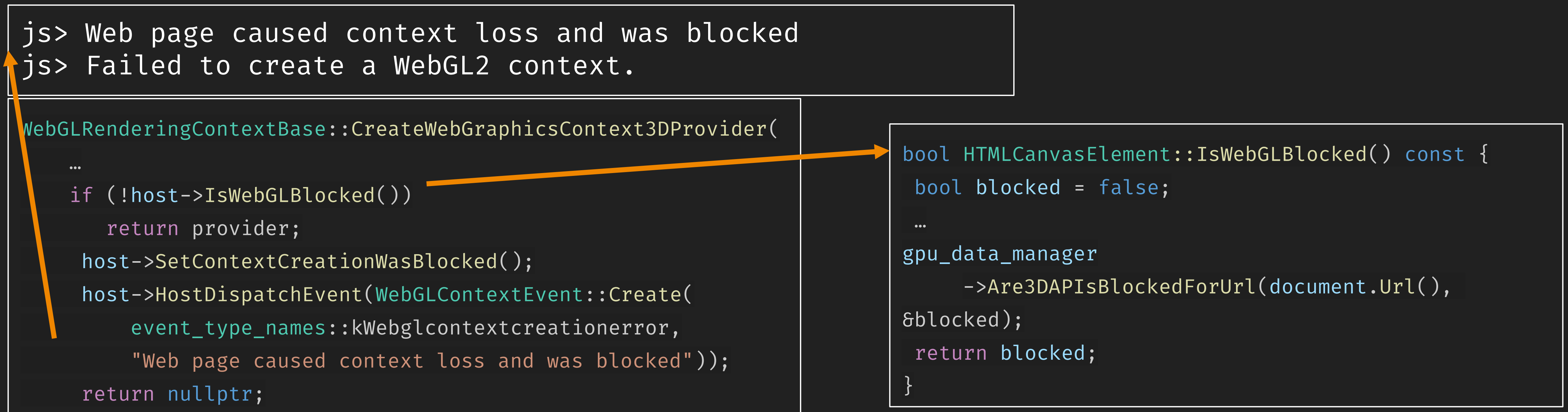
GPU Fallback

```
void GpuProcessHost::RecordProcessCrash() {
…
if (recent_crash_count_ >= GetFallbackCrashLimit() && !disable_crash_limit) {
   base::UmaHistogramEnumeration(kFallbackEventCause,
                                 GPUFallbackEventCauseType::kCrashLimit);
   GpuDataManagerImpl::GetInstance()->FallBackToNextGpuMode();
 }
```

https://source.chromium.org/chromium/chromium/src/+/c7c5bedfc6c313826cb8cfa884dc3a3b20831311:content/browser/gpu/gpu_process_host.cc;l=1452;bpv=0;bpt=0

- ➢ The GetFallbackCrashLimit() function returns constant 3 on windows.
  - o If gpu process crashes more than 3 times, it tries to fallback to the next GPU mode.
  - o After gpu mode switched, recent_crash_count_ will be reset.
- ➢ There are 2 gpu fallbacks on windows.
  - o gpu::GpuMode::SWIFTSHADER
  - o gpu::GpuMode::DISPLAY_COMPOSITOR

IsWebGLBlocked



```
js> Web page caused context loss and was blocked
js> Failed to create a WebGL2 context.
```

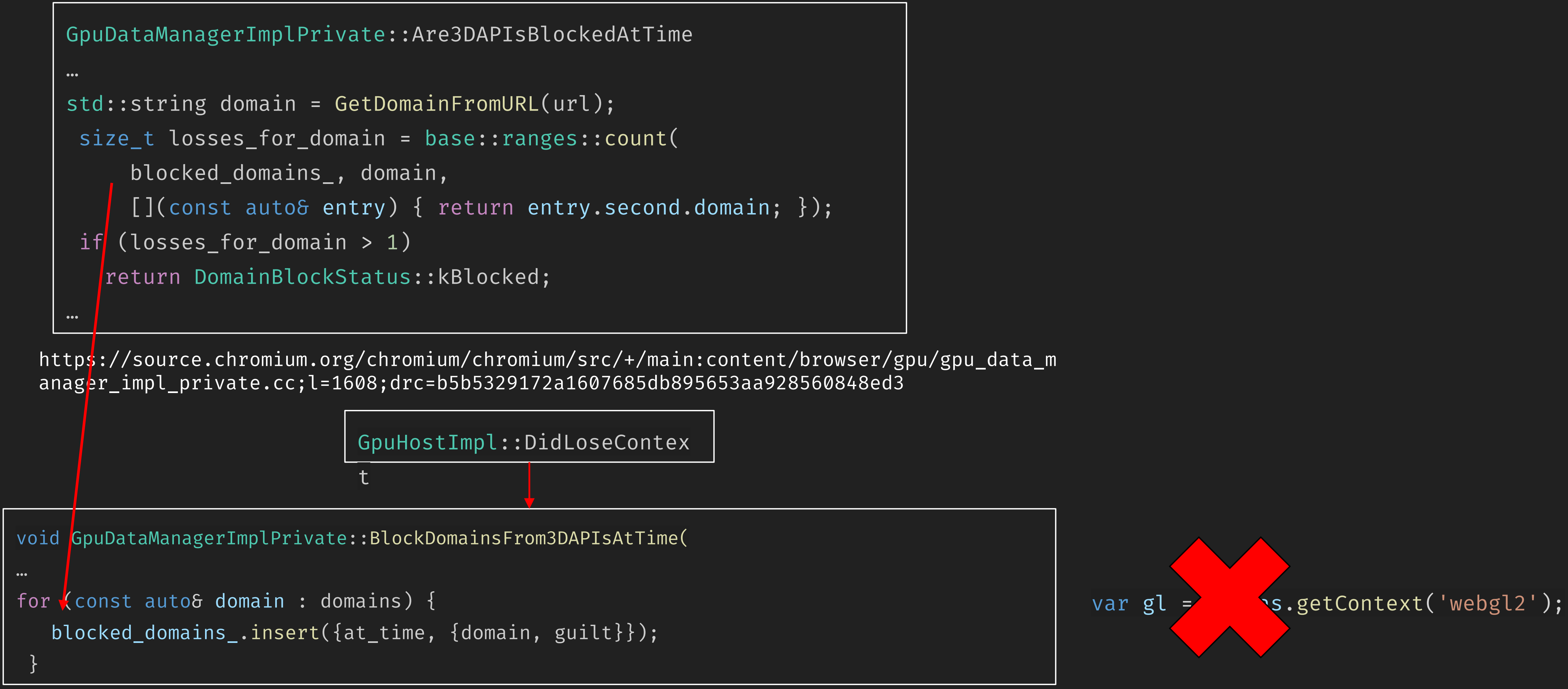
```
WebGLRenderingContextBase::CreateWebGraphicsContext3DProvider(
    …
    if (!host->IsWebGLBlocked())
       return provider;
     host->SetContextCreationWasBlocked();
     host->HostDispatchEvent(WebGLContextEvent::Create(
         event_type_names::kWebglcontextcreationerror,
         "Web page caused context loss and was blocked"));
     return nullptr;
    }
```

https://source.chromium.org/chromium/chromium/src/+/main:third_party/blink/renderer/modules/webgl/webgl_rendering_context_base.cc;l=688;drc=79fd5d71c46d0e6ecd842867bc1c787fae68e218;bpv=1;bpt=1

```
bool HTMLCanvasElement::IsWebGLBlocked() const {
 bool blocked = false;
 …
gpu_data_manager
     ->Are3DAPIsBlockedForUrl(document.Url(),
&blocked);
 return blocked;
}
```

https://source.chromium.org/chromium/chromium/src/+/main:third_party/blink/renderer/core/html/canvas/html_canvas_element.cc;l=579;drc=79fd5d71c46d0e6ecd842867bc1c787fae68e218;bpv=1;bpt=1?q=iswebglblock&ss=chromium%2Fchromium%2Fsrc

Are3DAPIsBlockedAtTime



```
GpuDataManagerImplPrivate::Are3DAPIsBlockedAtTime
…
std::string domain = GetDomainFromURL(url);
 size_t losses_for_domain = base::ranges::count(
      blocked_domains_, domain,
      [](const auto& entry) { return entry.second.domain; });
 if (losses_for_domain > 1)
   return DomainBlockStatus::kBlocked;
…
```

https://source.chromium.org/chromium/chromium/src/+/main:content/browser/gpu/gpu_data_manager_impl_private.cc;l=1608;drc=b5b5329172a1607685db895653aa928560848ed3

```
GpuHostImpl::DidLoseContext
```

```
void GpuDataManagerImplPrivate::BlockDomainsFrom3DAPIsAtTime(
…
for (const auto& domain : domains) {
   blocked_domains_.insert({at_time, {domain, guilt}});
 }
```

https://source.chromium.org/chromium/chromium/src/+/main:content/browser/gpu/gpu_data_manager_impl_private.cc;l=1567;drc=b5b5329172a1607685db895653aa928560848ed3;bpv=1;bpt=1

```
var gl = s.getContext('webgl2');
```

3 Domains to Enable Swiftshader

- Attacker need more than 3 different domains to deploy exploits.
  - Noisy and not OPSEC.
  - Inconvenient in the restricted scenarios.

🤔

Patch the Renderer

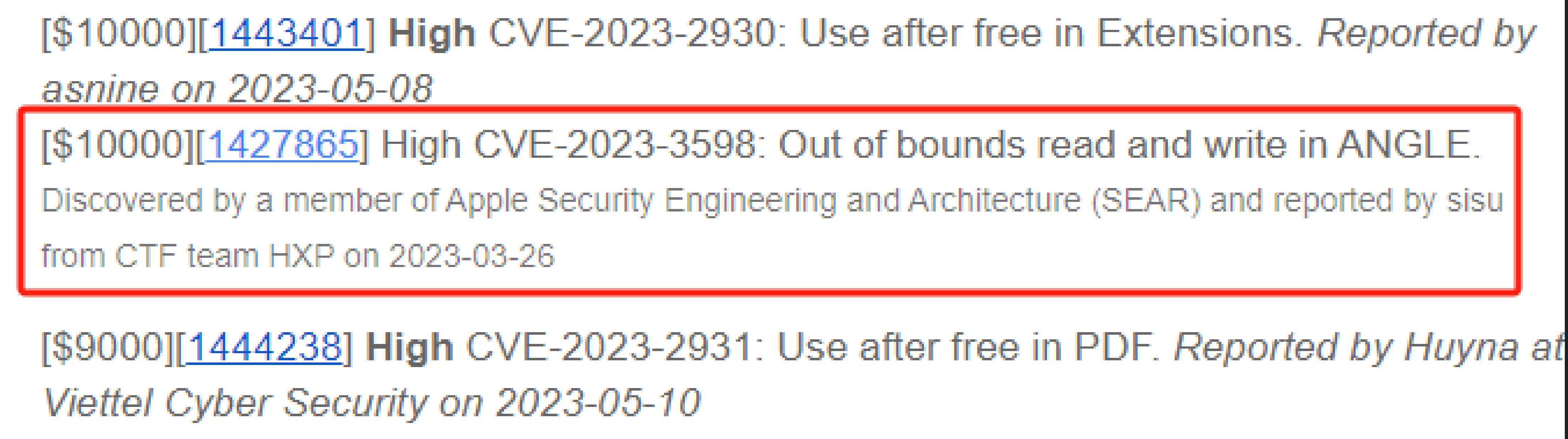
```
WebGLRenderingContextBase::CreateWebGraphicsContext3DProvider(
…
if (!host->IsWebGLBlocked())
   return provider;
 host->SetContextCreationWasBlocked();
 host->HostDispatchEvent(WebGLContextEvent::Create(
     event_type_names::kWebglcontextcreationerror,
     "Web page caused context loss and was blocked"));
 return nullptr;
}
```

- IsWebGLBlocked() simply returns true or false.
- No side effect in browser process.

====> 1 assembly instruction patch to renderer process to bypass Webgl block checking.

CVE-2023-3598: Out of Bounds Read and Write in ANGLE

- CVE-2023-3598 was discovered and exploited in hxpCTF
- Organizers caught the traffic and reported it to vender



[$10000][1443401] **High** CVE-2023-2930: Use after free in Extensions. *Reported by asnine on 2023-05-08*

[$10000][1427865] High CVE-2023-3598: Out of bounds read and write in ANGLE. Discovered by a member of Apple Security Engineering and Architecture (SEAR) and reported by sisu from CTF team HXP on 2023-03-26

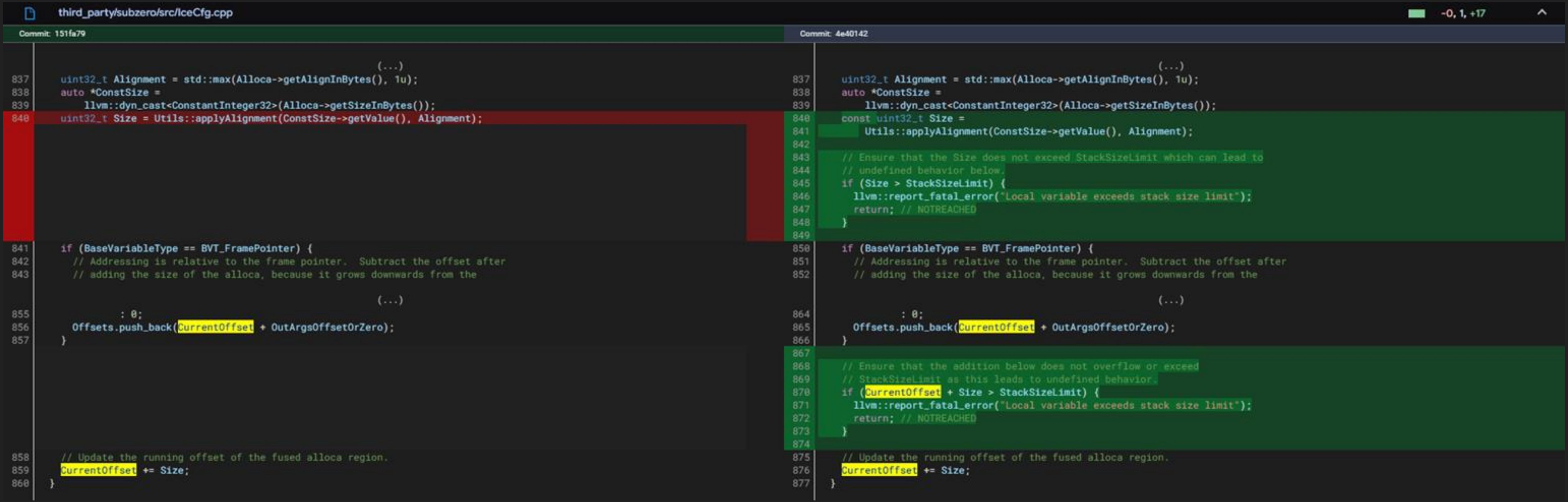
[$9000][1444238] **High** CVE-2023-2931: Use after free in PDF. *Reported by Huyna at Viettel Cyber Security on 2023-05-10*

Analysis of CVE-2023-3598

- Vulnerability
  - Implement of merging allocas in SUBZERO JIT
    - Alloca
      - An instruction to allocate memory on stack.
      - Storing local variables and temporary data.
    - Integer overflow in Cfg::sortAndCombineAllocas.
      - Causes arbitrary code execution in GPU process.

- More details
  - https://issues.chromium.org/issues/40065276

Patch Analysis of CVE-2023-3598



third_party/subzero/src/IceCfg.cpp

-0, 1, +17

Commit: 151fa79

```
                                        (...)
  uint32_t Alignment = std::max(Alloca->getAlignInBytes(), 1u);
  auto *ConstSize =
      llvm::dyn_cast<ConstantInteger32>(Alloca->getSizeInBytes());
  uint32_t Size = Utils::applyAlignment(ConstSize->getValue(), Alignment);
  if (BaseVariableType == BVT_FramePointer) {
    // Addressing is relative to the frame pointer.  Subtract the offset after
    // adding the size of the alloca, because it grows downwards from the
                                        (...)
               : 0;
    Offsets.push_back(CurrentOffset + OutArgsOffsetOrZero);
  }
  // Update the running offset of the fused alloca region.
  CurrentOffset += Size;
}
```

Commit: 4e40142

```
                                        (...)
  uint32_t Alignment = std::max(Alloca->getAlignInBytes(), 1u);
  auto *ConstSize =
      llvm::dyn_cast<ConstantInteger32>(Alloca->getSizeInBytes());
  const uint32_t Size =
      Utils::applyAlignment(ConstSize->getValue(), Alignment);

  // Ensure that the Size does not exceed StackSizeLimit which can lead to
  // undefined behavior below.
  if (Size > StackSizeLimit) {
    llvm::report_fatal_error("Local variable exceeds stack size limit");
    return; // NOTREACHED
  }

  if (BaseVariableType == BVT_FramePointer) {
    // Addressing is relative to the frame pointer.  Subtract the offset after
    // adding the size of the alloca, because it grows downwards from the
                                        (...)
               : 0;
    Offsets.push_back(CurrentOffset + OutArgsOffsetOrZero);
  }

  // Ensure that the addition below does not overflow or exceed
  // StackSizeLimit as this leads to undefined behavior.
  if (CurrentOffset + Size > StackSizeLimit) {
    llvm::report_fatal_error("Local variable exceeds stack size limit");
    return; // NOTREACHED
  }

  // Update the running offset of the fused alloca region.
  CurrentOffset += Size;
}
```

https://source.chromium.org/chromium/_/swiftshader/SwiftShader/+/4e401427f8dd799b17ac6c805391e2da1e017672

Exploitation of CVE-2023-3598 on Windows

- Exploit on macOS does not work on windows.

- But primitives work :)
    - bufAccess
        - oobAccess
            - oobRead
            - oobWrite

- Extremely reduced development time.

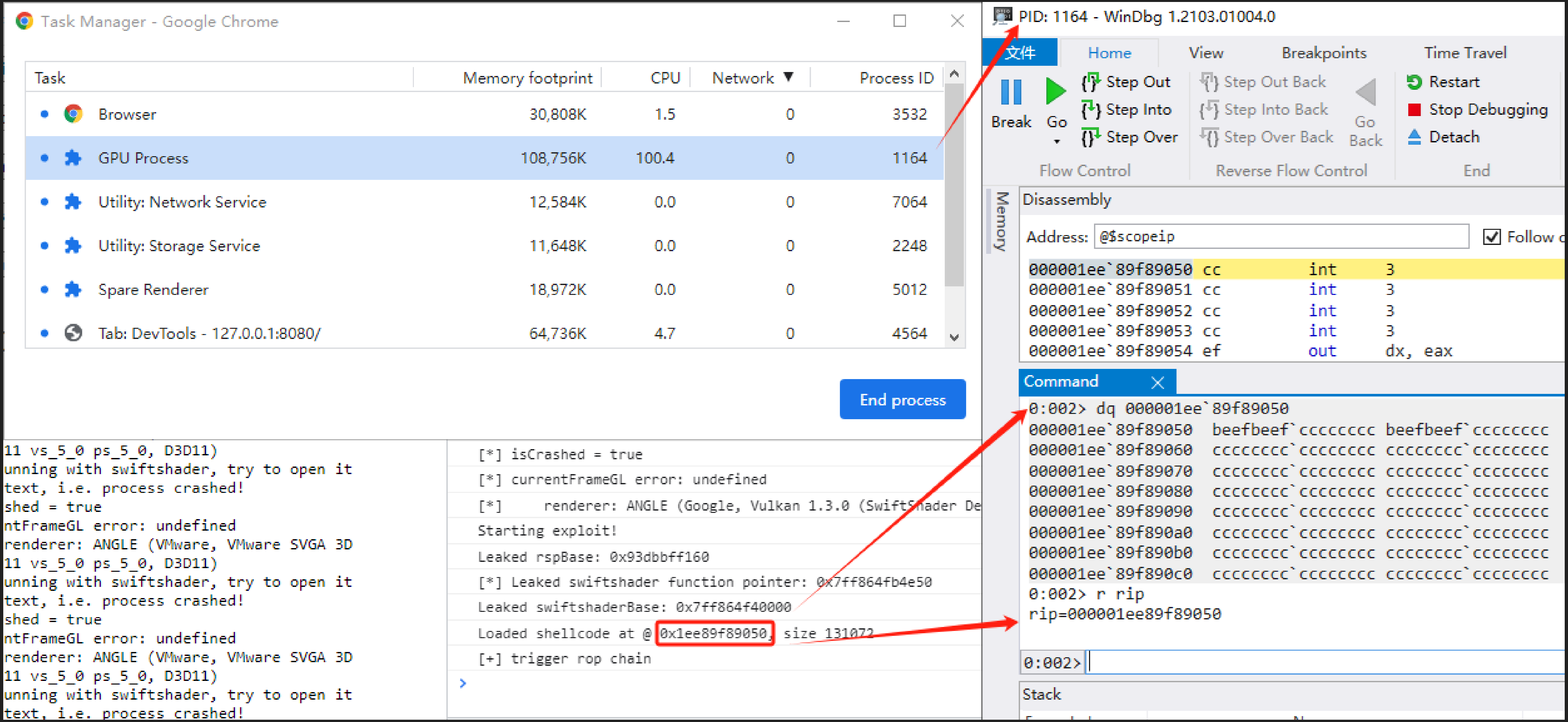
Steps of Exploitation

1. Leak chrome.dll and vk_swiftshader.dll and setup ROP gadgets.
    a. Based on oobRead primitive.

1. Place shellcode at a known address in the GPU process memory.
    a. Create Uniform Buffer Objects(UBOs).
    b. Setup data with shellcode.
    c. Leak heap address based on oobRead.

1. Use oobWrite to execute the ROP chain.
    a. Use vk_swiftshader!rr::protectMemoryPages to modify shellcode permissions to PAGE_EXECUTE_READWRITE.
    b. Jump to shellcode.

Exploitation of CVE-2023-3598 on Windows



Task	Memory footprint	CPU	Network ▼	Process ID
Browser	30,808K	1.5	0	3532
GPU Process	108,756K	100.4	0	1164
Utility: Network Service	12,584K	0.0	0	7064
Utility: Storage Service	11,648K	0.0	0	2248
Spare Renderer	18,972K	0.0	0	5012
Tab: DevTools - 127.0.0.1:8080/	64,736K	4.7	0	4564

```
11 vs_5_0 ps_5_0, D3D11)
unning with swiftshader, try to open it
text, i.e. process crashed!
shed = true
ntFrameGL error: undefined
renderer: ANGLE (VMware, VMware SVGA 3D
11 vs_5_0 ps_5_0, D3D11)
unning with swiftshader, try to open it
text, i.e. process crashed!
shed = true
ntFrameGL error: undefined
renderer: ANGLE (VMware, VMware SVGA 3D
11 vs_5_0 ps_5_0, D3D11)
unning with swiftshader, try to open it
text, i.e. process crashed!
```

```
[*] isCrashed = true
[*] currentFrameGL error: undefined
[*]     renderer: ANGLE (Google, Vulkan 1.3.0 (SwiftShader De
Starting exploit!
Leaked rspBase: 0x93dbbff160
[*] Leaked swiftshader function pointer: 0x7ff864fb4e50
Leaked swiftshaderBase: 0x7ff864f40000
Loaded shellcode at @ 0x1ee89f89050, size 131072
[+] trigger rop chain
>
```

Address: @$scopeip ☑ Follow c

```
000001ee`89f89050 cc              int     3
000001ee`89f89051 cc              int     3
000001ee`89f89052 cc              int     3
000001ee`89f89053 cc              int     3
000001ee`89f89054 ef              out     dx, eax
```

```
0:002> dq 000001ee`89f89050
000001ee`89f89050  beefbeef`cccccccc beefbeef`cccccccc
000001ee`89f89060  cccccccc`cccccccc cccccccc`cccccccc
000001ee`89f89070  cccccccc`cccccccc cccccccc`cccccccc
000001ee`89f89080  cccccccc`cccccccc cccccccc`cccccccc
000001ee`89f89090  cccccccc`cccccccc cccccccc`cccccccc
000001ee`89f890a0  cccccccc`cccccccc cccccccc`cccccccc
000001ee`89f890b0  cccccccc`cccccccc cccccccc`cccccccc
000001ee`89f890c0  cccccccc`cccccccc cccccccc`cccccccc
0:002> r rip
rip=000001ee89f89050
0:002>
```

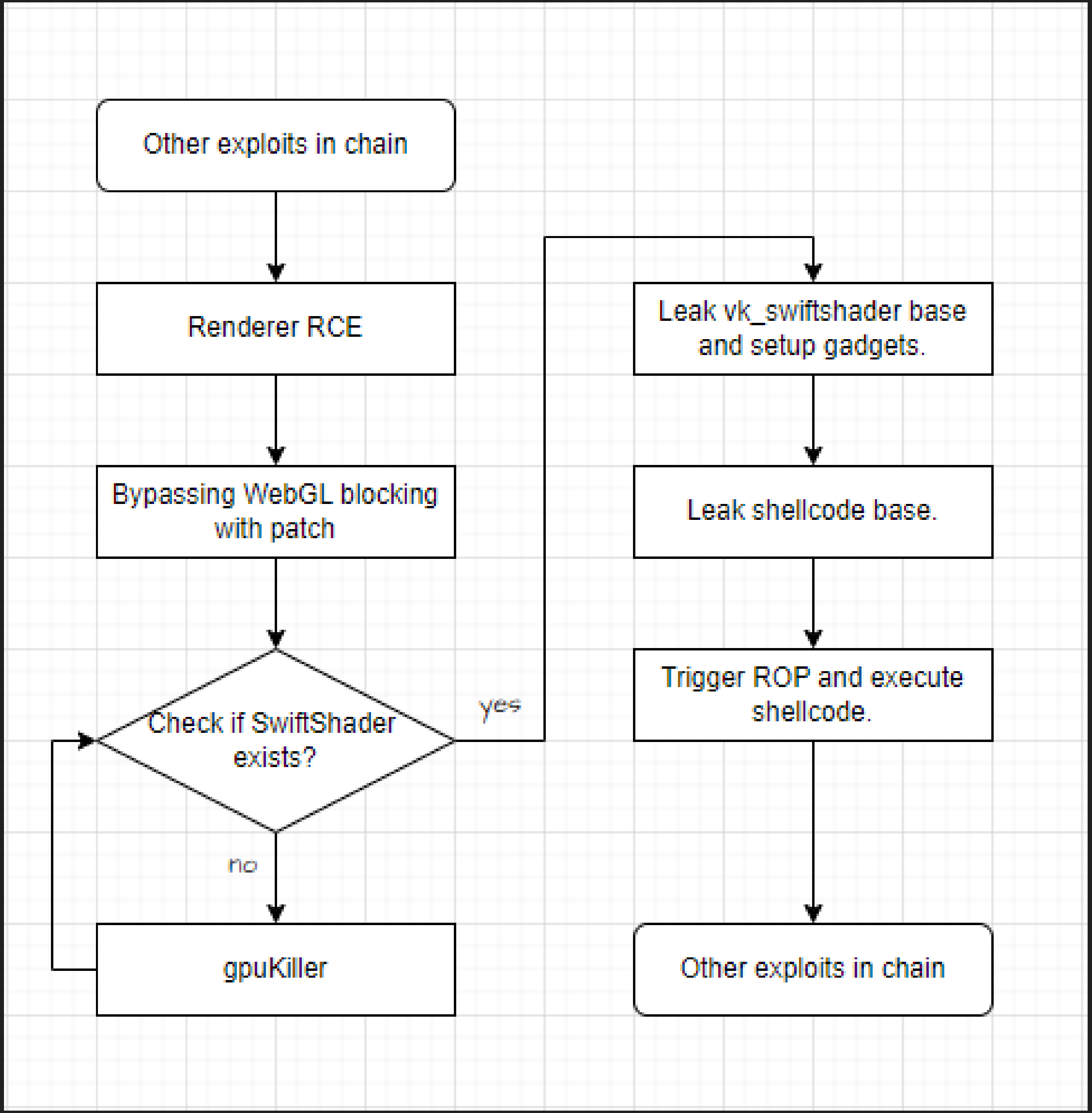
Review Full Exploit Chain

1. Get renderer RCE.
   a. Bypass WebGL blocking

1. Using gpuKiller to enable the swiftshader backend.

1. Leaking addresses and building gadgets.

1. Trigger ROP to execute next stage shellcode.


Other exploits in chain
Renderer RCE
Bypassing WebGL blocking with patch
Check if SwiftShader exists?
yes
no
gpuKiller
Leak vk_swiftshader base and setup gadgets.
Leak shellcode base.
Trigger ROP and execute shellcode.
Other exploits in chain

Exploitation Statistics

- Affected stable versions.
  - [99.0.4844.51-112.0.5615.87]

- Success rate: 100%
  - 1000 times benchmark.
  - No heap feng shui.
  - Just OOB on stack.

Exploiting a Windows Kernel Vulnerability

Escape Chrome GPU/Adobe Sandboxed Process

Find a target -> Afd.sys

- Several bugs in the past few years
- Exploited in the Pwn2Own 2014
- Can be accessed from Chrome GPU/Adobe Sandboxed Process
- CVE-2023-35632 (fixed in 2023.12)

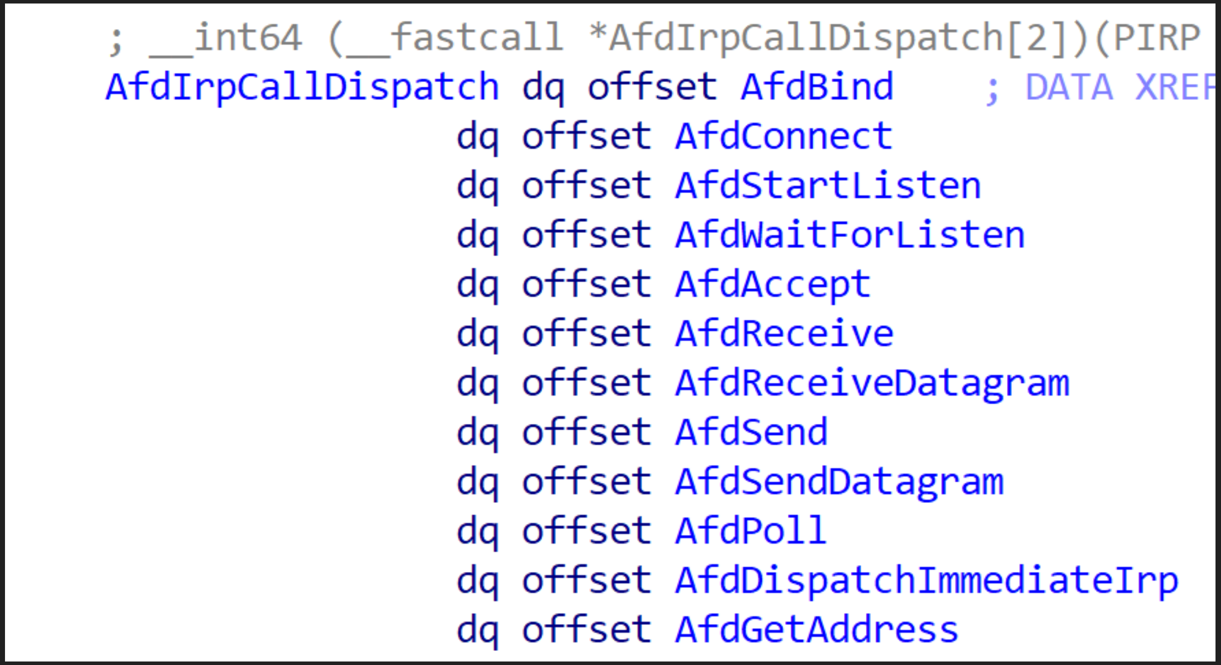
Basic of afd.sys

- Winsock function driver
- Create socket == Open \Device\Afd\Endpoint

User Mode API:

```
socket(...)
connect(...)
listen(...)
send(...)
recv(...)
```

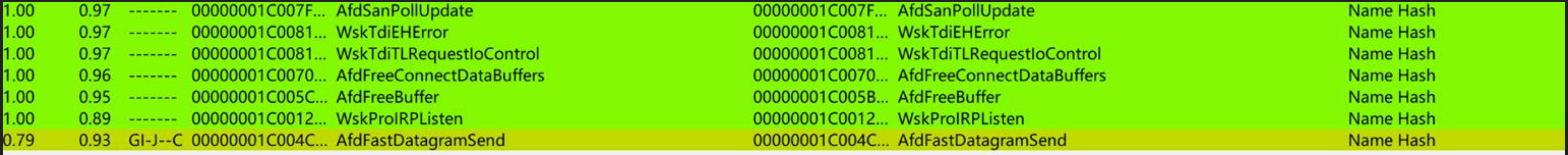
Kernel Mode implementation:



```
; __int64 (__fastcall *AfdIrpCallDispatch[2])(PIRP
AfdIrpCallDispatch dq offset AfdBind     ; DATA XREF
                   dq offset AfdConnect
                   dq offset AfdStartListen
                   dq offset AfdWaitForListen
                   dq offset AfdAccept
                   dq offset AfdReceive
                   dq offset AfdReceiveDatagram
                   dq offset AfdSend
                   dq offset AfdSendDatagram
                   dq offset AfdPoll
                   dq offset AfdDispatchImmediateIrp
                   dq offset AfdGetAddress
```

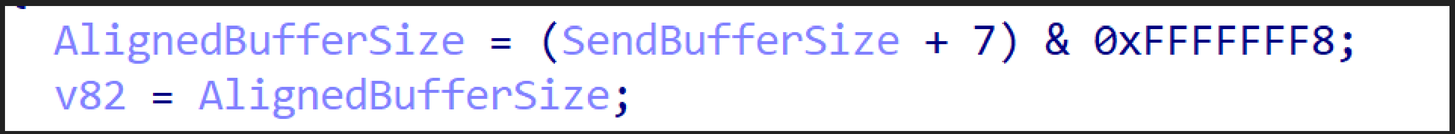
CVE-2023-35632 Patch Analysis

Bindiff results



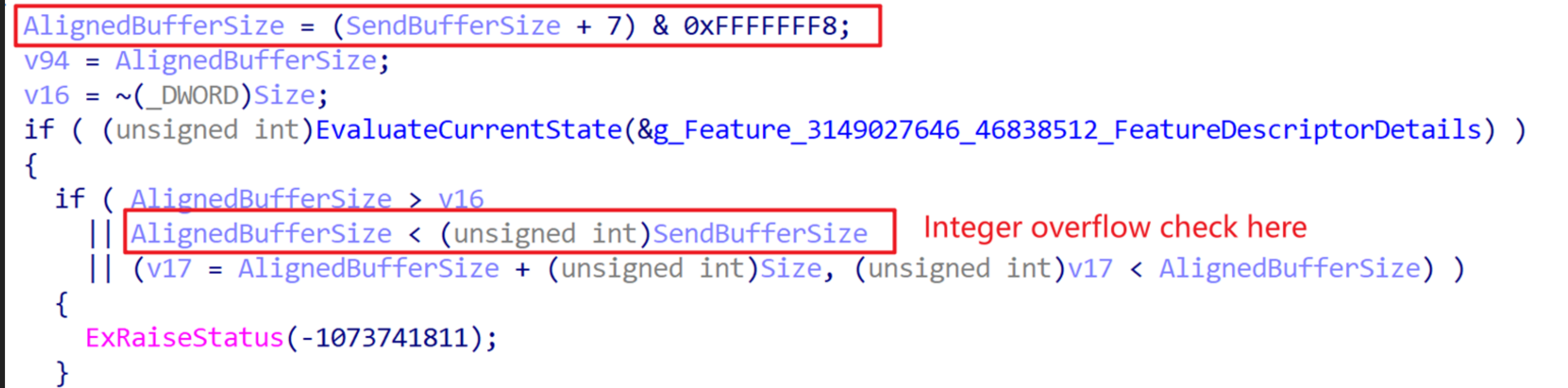
1.00	0.97	-------	00000001C007F...	AfdSanPollUpdate	00000001C007F...	AfdSanPollUpdate	Name Hash
1.00	0.97	-------	00000001C0081...	WskTdiEHError	00000001C0081...	WskTdiEHError	Name Hash
1.00	0.97	-------	00000001C0081...	WskTdiTLRequestIoControl	00000001C0081...	WskTdiTLRequestIoControl	Name Hash
1.00	0.96	-------	00000001C0070...	AfdFreeConnectDataBuffers	00000001C0070...	AfdFreeConnectDataBuffers	Name Hash
1.00	0.95	-------	00000001C005C...	AfdFreeBuffer	00000001C005B...	AfdFreeBuffer	Name Hash
1.00	0.89	-------	00000001C0012...	WskProIRPListen	00000001C0012...	WskProIRPListen	Name Hash
0.79	0.93	GI-J--C	00000001C004C...	AfdFastDatagramSend	00000001C004C...	AfdFastDatagramSend	Name Hash

Before Patching



```
AlignedBufferSize = (SendBufferSize + 7) & 0xFFFFFFF8;
v82 = AlignedBufferSize;
```

After Patching

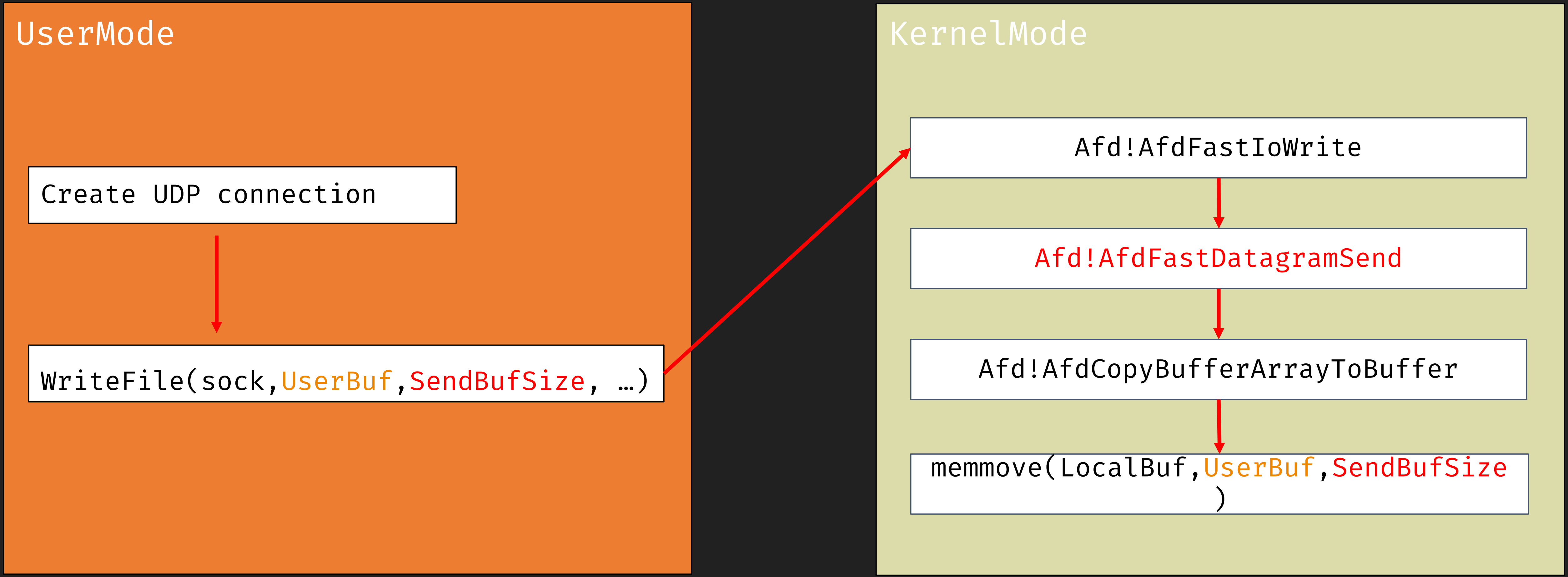


```
AlignedBufferSize = (SendBufferSize + 7) & 0xFFFFFFF8;
v94 = AlignedBufferSize;
v16 = ~(_DWORD)Size;
if ( (unsigned int)EvaluateCurrentState(&g_Feature_3149027646_46838512_FeatureDescriptorDetails) )
{
  if ( AlignedBufferSize > v16
    || AlignedBufferSize < (unsigned int)SendBufferSize
    || (v17 = AlignedBufferSize + (unsigned int)Size, (unsigned int)v17 < AlignedBufferSize) )
  {
    ExRaiseStatus(-1073741811);
  }
```

Integer overflow check here

Only affect windows 10 since the vulnerable code has been removed in windows 11

Call Stack Analysis



UserMode

Create UDP connection

WriteFile(sock,UserBuf,SendBufSize, …)

KernelMode

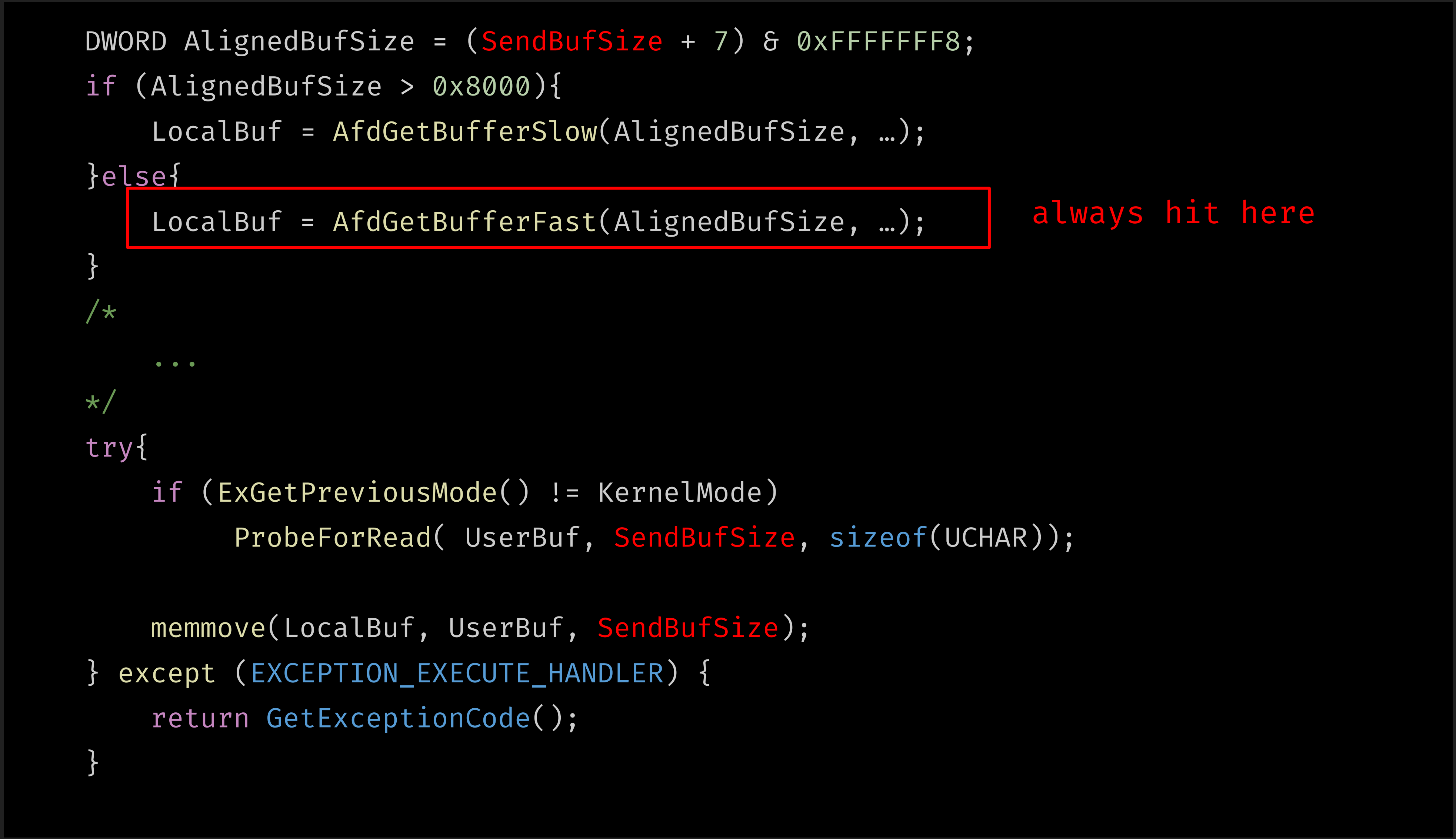
Afd!AfdFastIoWrite

Afd!AfdFastDatagramSend

Afd!AfdCopyBufferArrayToBuffer

memmove(LocalBuf,UserBuf,SendBufSize)

Pseudo Code Snippet



```
DWORD AlignedBufSize = (SendBufSize + 7) & 0xFFFFFFF8;
if (AlignedBufSize > 0x8000){
    LocalBuf = AfdGetBufferSlow(AlignedBufSize, …);
}else{
    LocalBuf = AfdGetBufferFast(AlignedBufSize, …);
}
/*
    ...
*/
try{
    if (ExGetPreviousMode() != KernelMode)
        ProbeForRead( UserBuf, SendBufSize, sizeof(UCHAR));

    memmove(LocalBuf, UserBuf, SendBufSize);
} except (EXCEPTION_EXECUTE_HANDLER) {
    return GetExceptionCode();
}
```

always hit here

if SendBufSize == 0xfffffff9, AlignedBufSize will be 0

Limitations

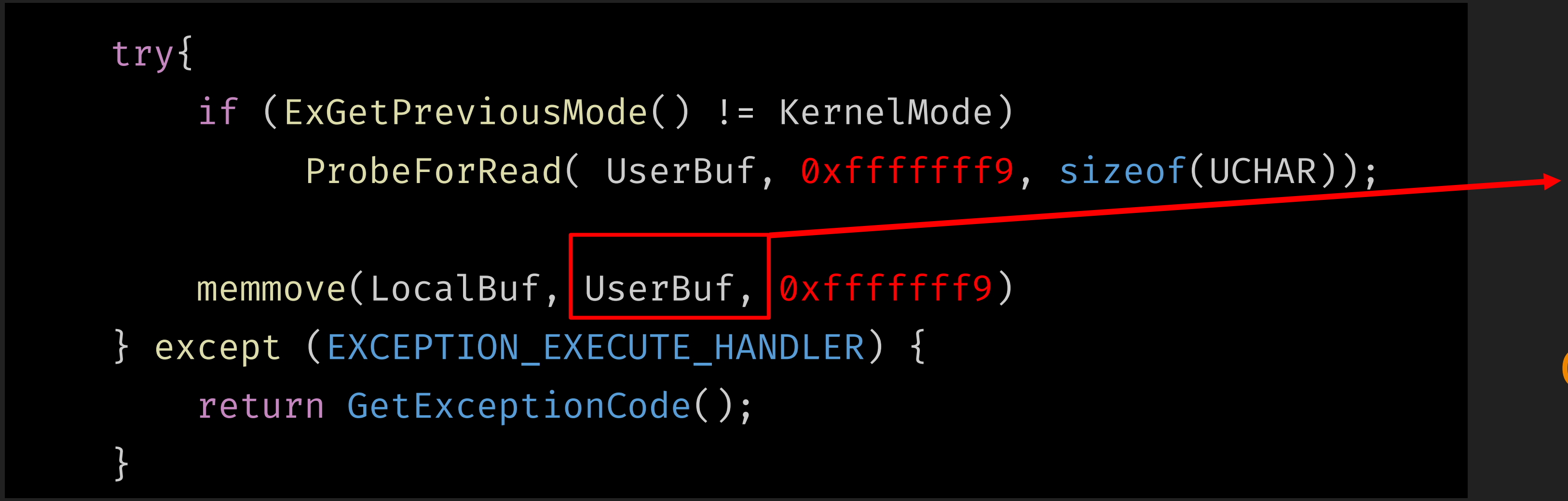
Issues we meet:

1. The OOBW size (0xfffffff9) is too large for exploiting

1. Vuln pool is got from AFD Lookaside List but not directly from system

Bad News

The OOBW size is too large for exploiting



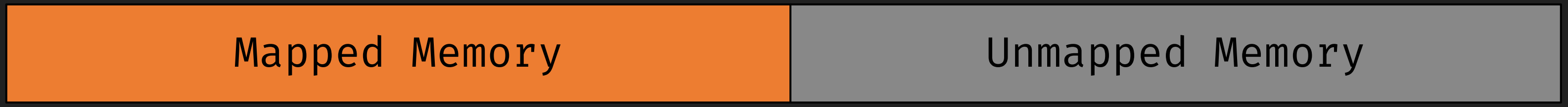
```
try{
    if (ExGetPreviousMode() != KernelMode)
         ProbeForRead( UserBuf, 0xfffffff9, sizeof(UCHAR));

    memmove(LocalBuf, UserBuf, 0xfffffff9)
} except (EXCEPTION_EXECUTE_HANDLER) {
    return GetExceptionCode();
}
```

point to user mode

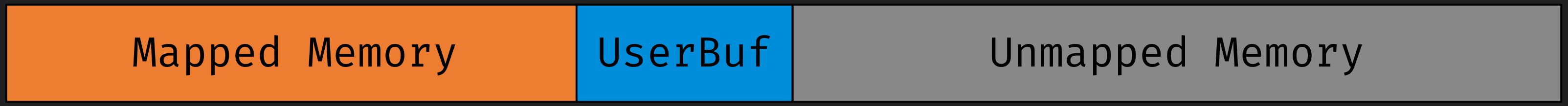
Can we abuse this?

Make OOBW size controllable

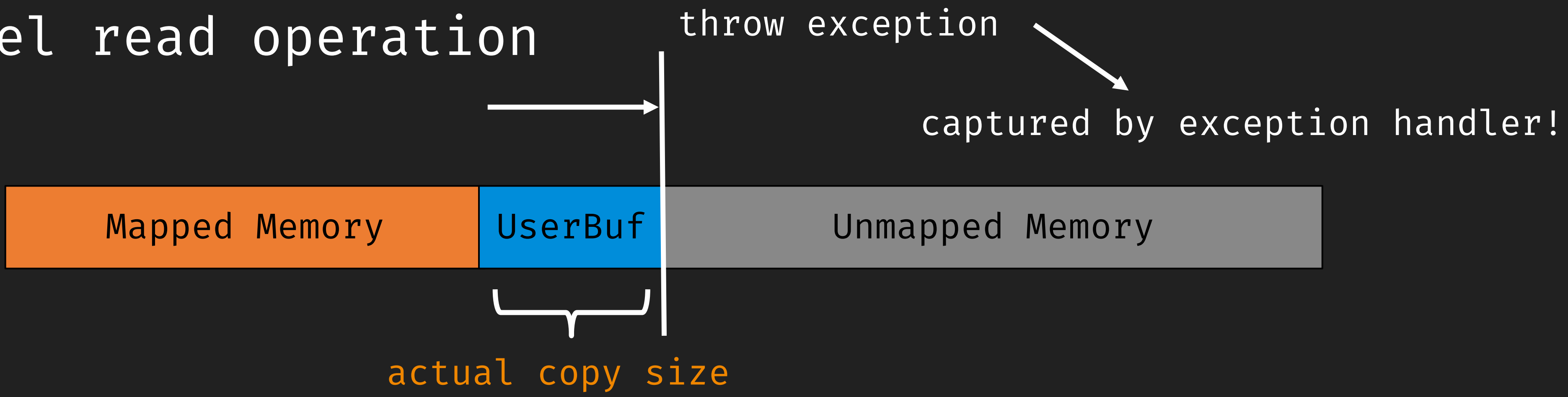
- VirtualAllocEx -> Mapped Memory



- Put UserBuf in the tail



- Break kernel read operation



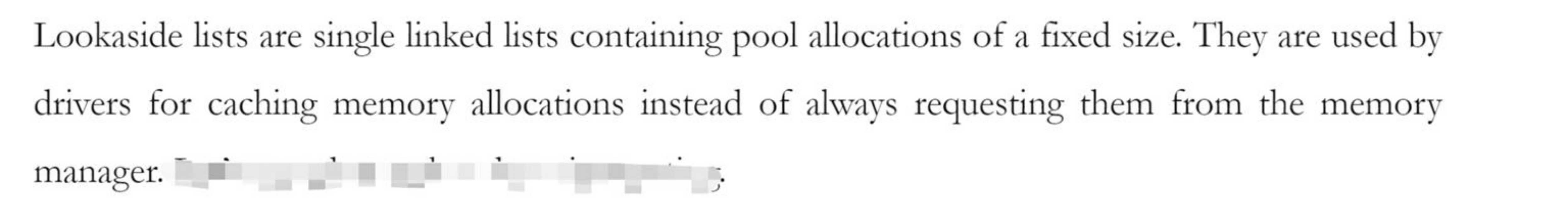
Bad News

Vuln pool is got from AFD Lookaside List but not directly from system

```
LocalBuf = AfdGetBufferFast(AlignedBufSize, …);
```

```
AfdGetBufferFast(
    DWORD BufferDataSize,
    ...
){
    if ( BufferDataSize <= AfdSmallBufferSize ) {
        lookasideList = &AfdLookasideLists->SmallBufferList;  always hit here
    } else if ( BufferDataSize <= AfdMediumBufferSize ) {
        lookasideList = &AfdLookasideLists->MediumBufferList;
    } else {
        lookasideList = &AfdLookasideLists->LargeBufferList;
    }

    buffer = ExAllocateFromNPagedLookasideList( lookasideList );
    return buffer
}
```

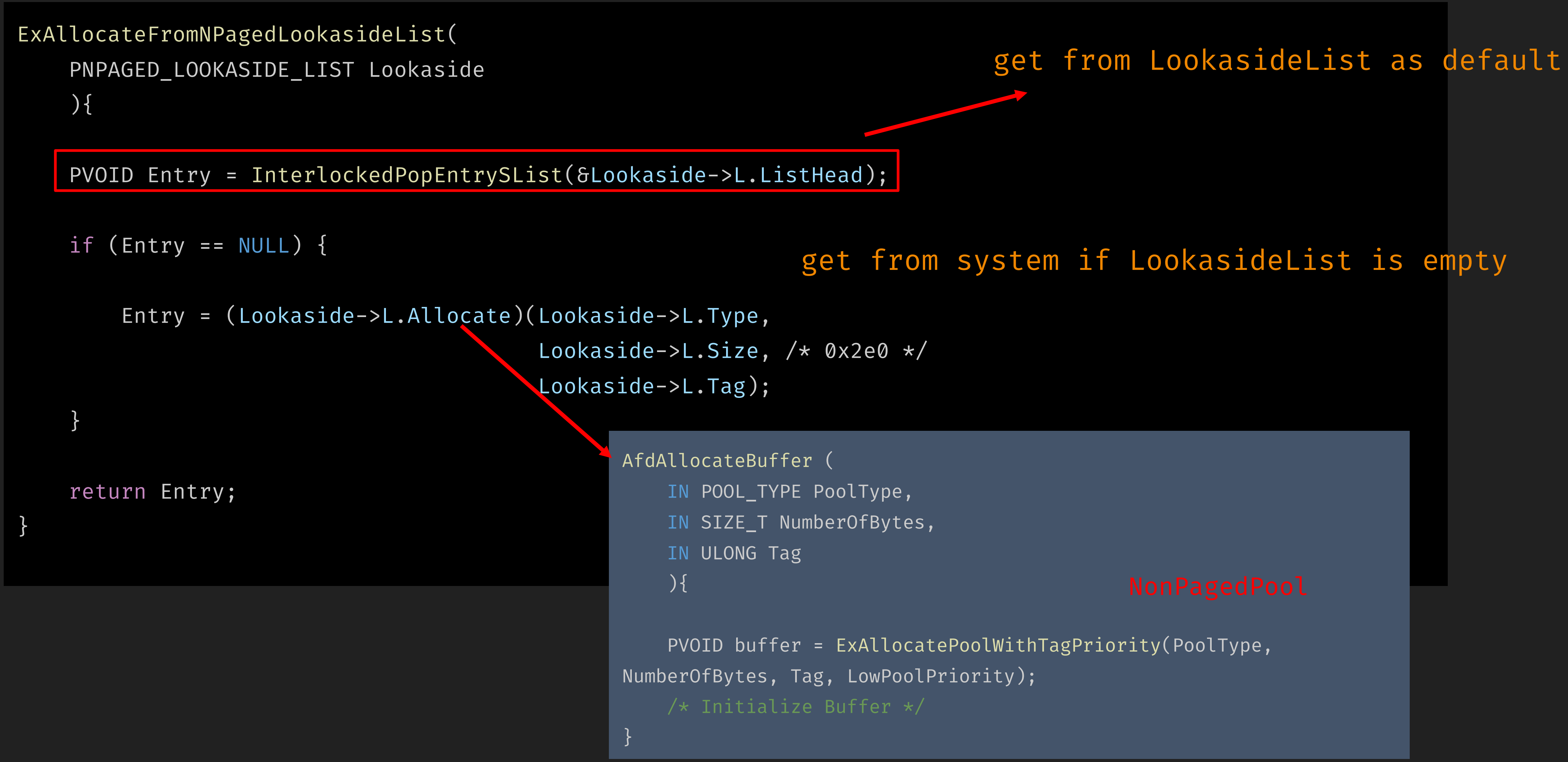
What is Lookaside List?



Lookaside lists are single linked lists containing pool allocations of a fixed size. They are used by drivers for caching memory allocations instead of always requesting them from the memory manager. [redacted]

https://windows-internals.com/lookaside-list-forensics/

Allow drivers to manage the ‘freed’ pool, Speed up the process of pool allocation



```
ExAllocateFromNPagedLookasideList(
    PNPAGED_LOOKASIDE_LIST Lookaside
    ){

    PVOID Entry = InterlockedPopEntrySList(&Lookaside->L.ListHead);

    if (Entry == NULL) {

        Entry = (Lookaside->L.Allocate)(Lookaside->L.Type,
                                        Lookaside->L.Size, /* 0x2e0 */
                                        Lookaside->L.Tag);

    }

    return Entry;
}
```

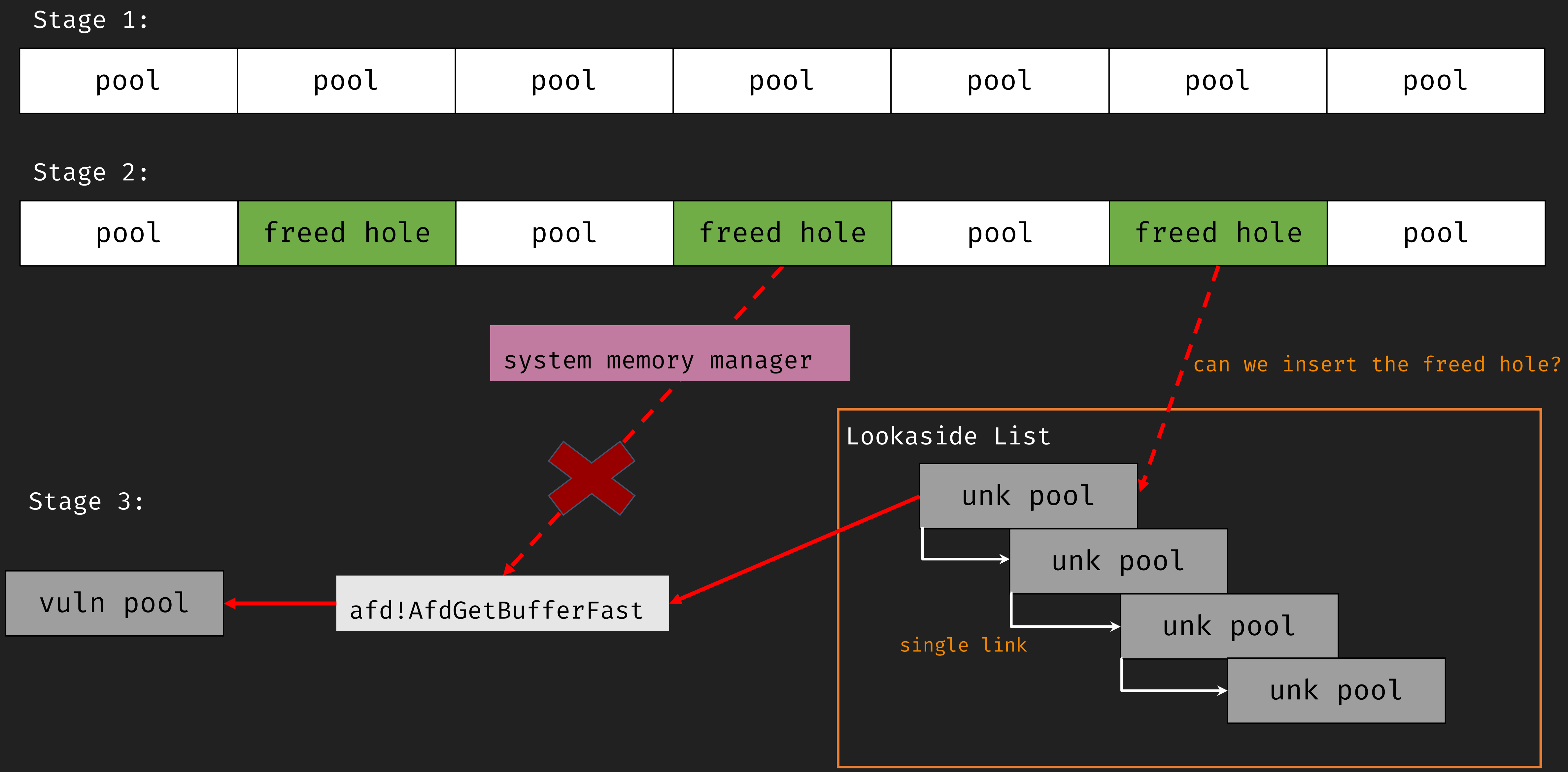
get from LookasideList as default

get from system if LookasideList is empty

```
AfdAllocateBuffer (
    IN POOL_TYPE PoolType,
    IN SIZE_T NumberOfBytes,
    IN ULONG Tag
    ){

    PVOID buffer = ExAllocatePoolWithTagPriority(PoolType,
NumberOfBytes, Tag, LowPoolPriority);
    /* Initialize Buffer */
}
```

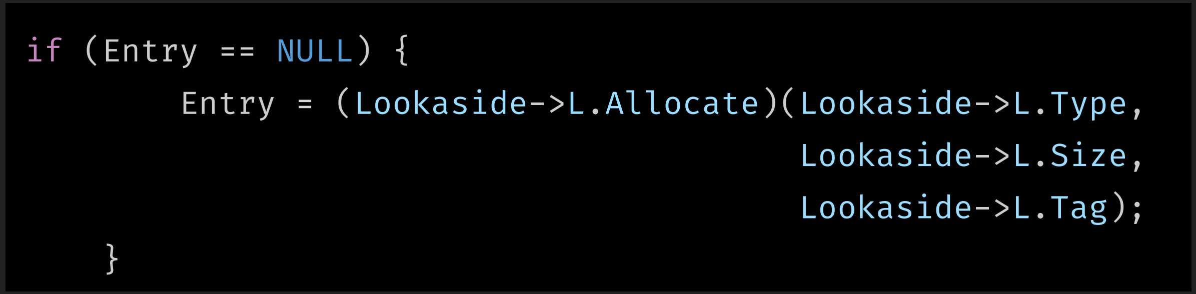
NonPagedPool

Pool Fengshui

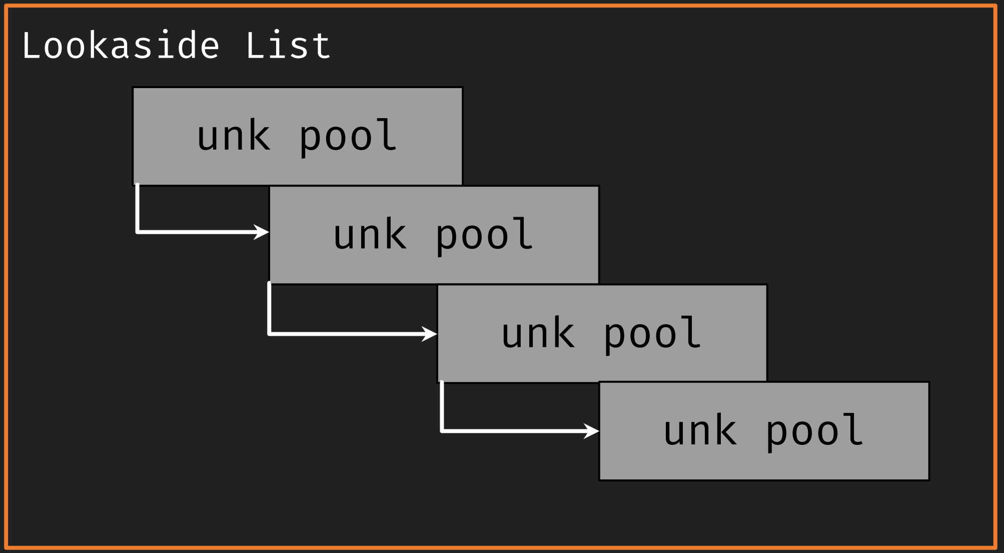


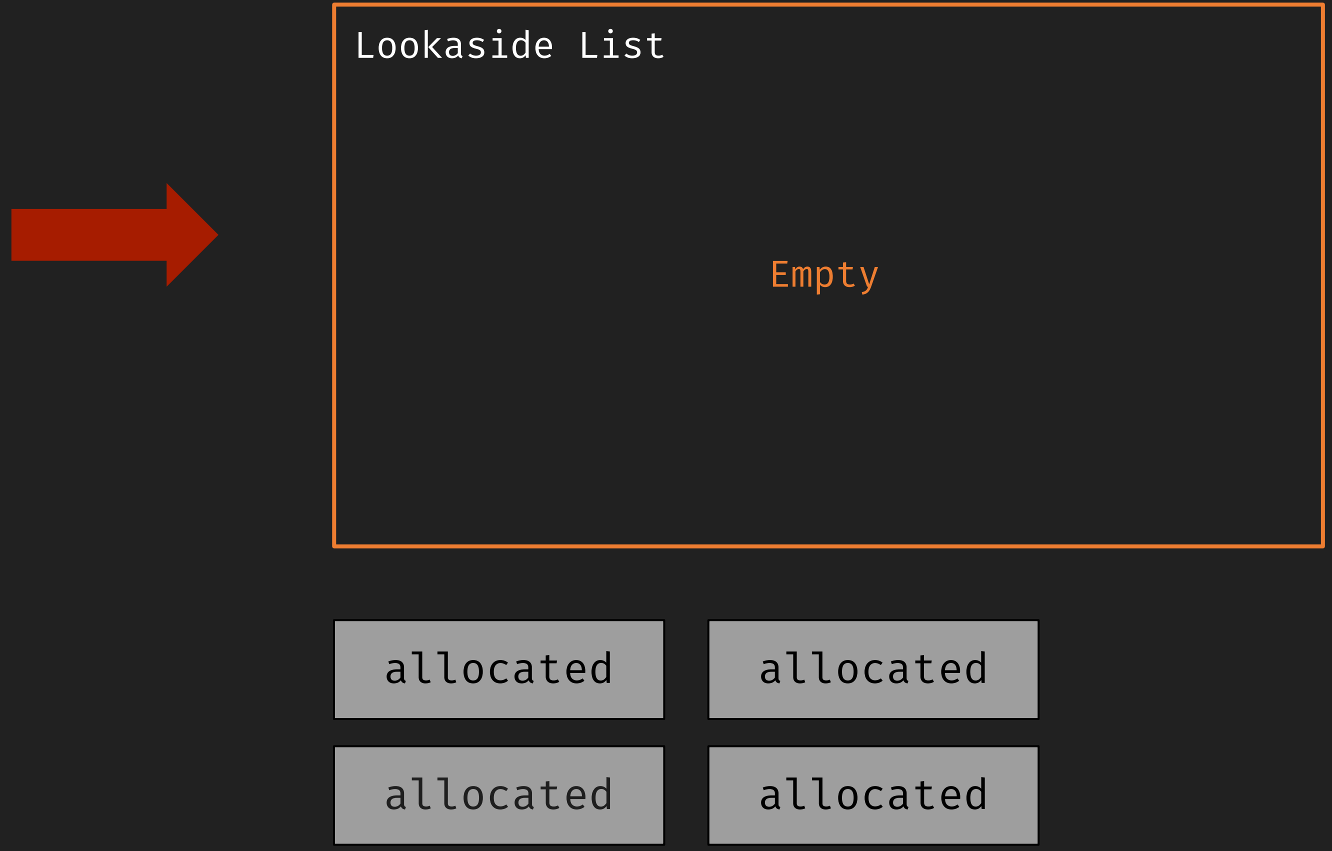
Exhausting Cached Pool in Lookaside List

A new pool is created only when the Lookaside List is empty!



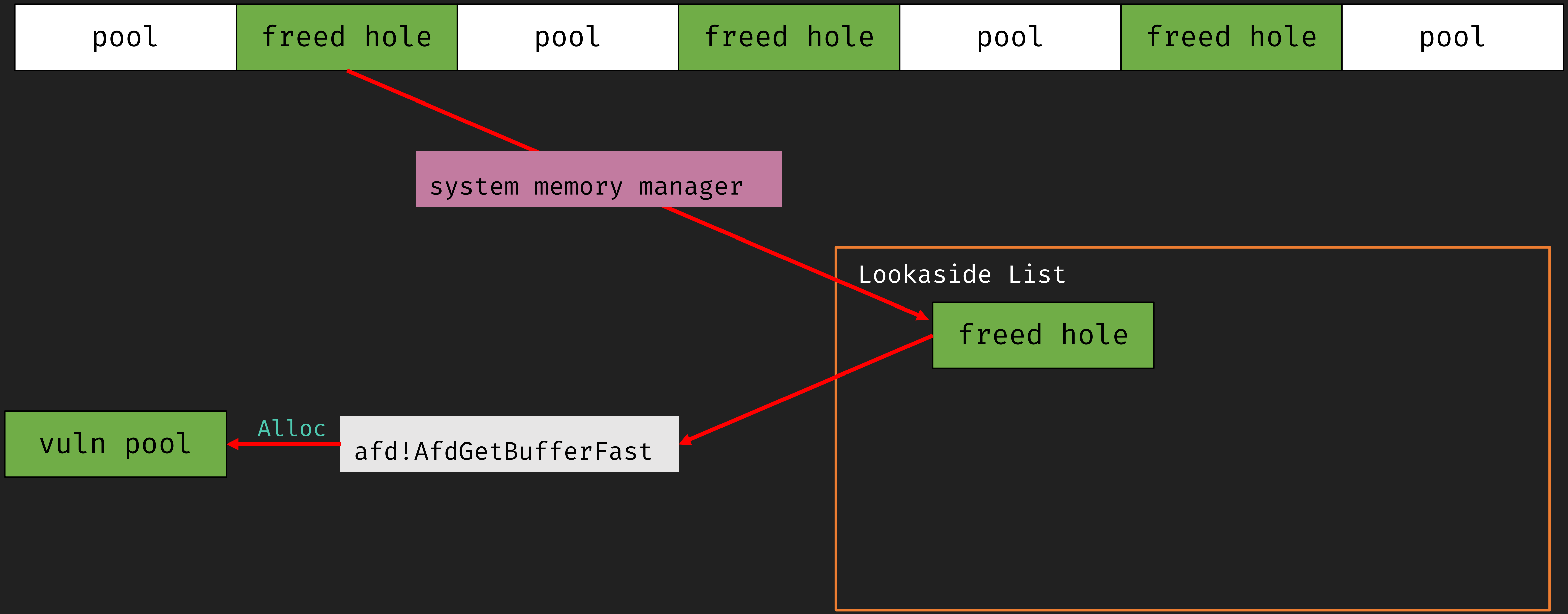
```
if (Entry == NULL) {
            Entry = (Lookaside->L.Allocate)(Lookaside->L.Type,
                                                Lookaside->L.Size,
                                                Lookaside->L.Tag);
      }
```





Several AFD function can help us to do that since lookaside list is used everywhere

Fill Lookaside List with Freed Hole



What We Have Now:

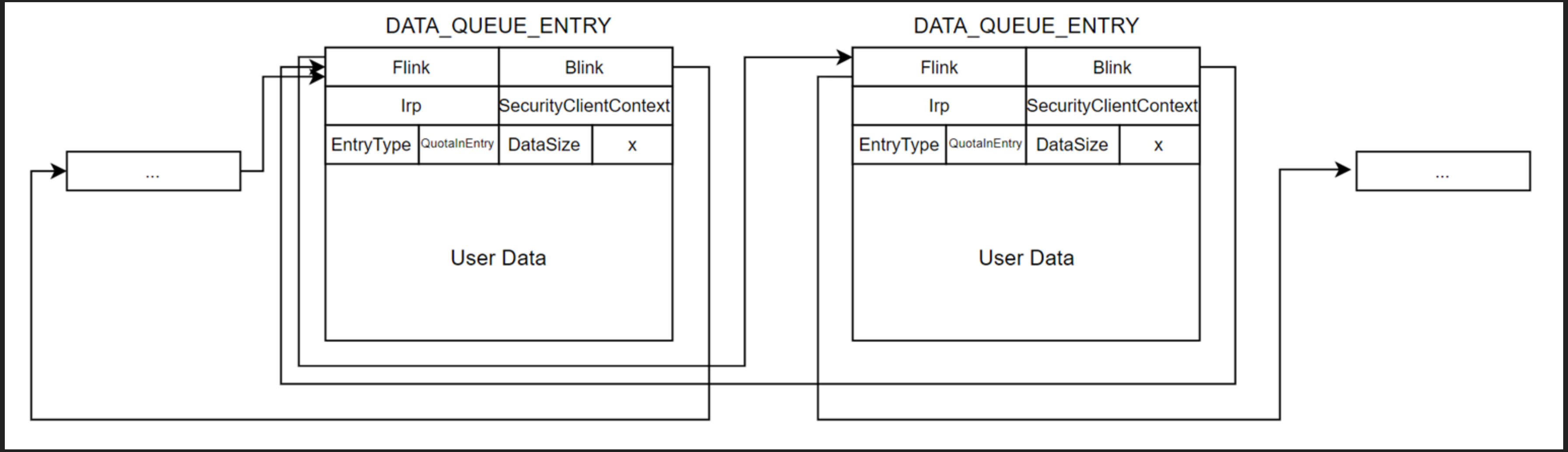
- vuln pool is got from system memory manager
- vuln pool size is 0x2e0
- vuln pool type is nonpaged pool
- Out-of-Bound Writes arbitrary size

Why Do Pool Fengshui with Named Pipe?

- ➢ Can be accessed from both Adobe sandboxed process/Chrome GPU sandbox
- ➢ Vuln pool is nonpaged pool
- ➢ Well-known technology and documented in github

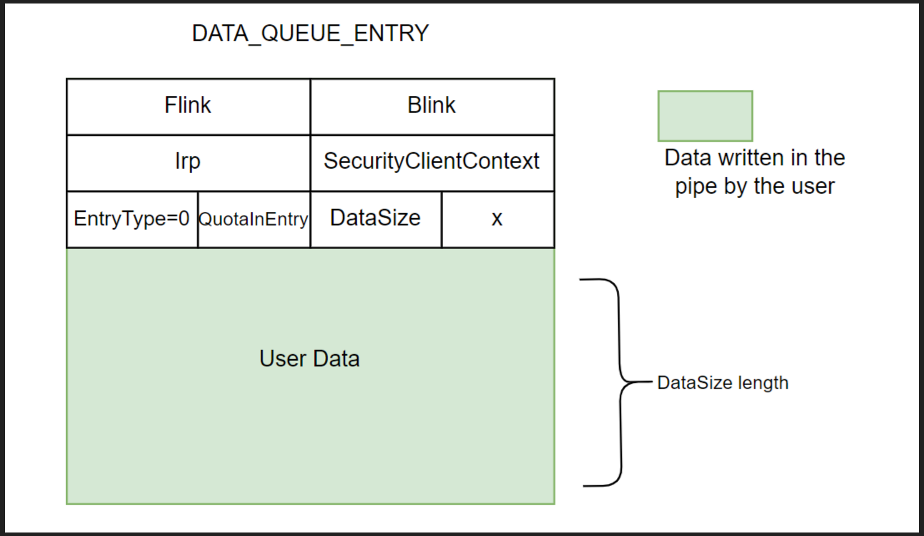
Spray Named Pipe

```
struct DATA_QUEUE_ENTRY {
    LIST_ENTRY NextEntry;
    _IRP* Irp;
    _SECURITY_CLIENT_CONTEXT* SecurityContext;
    uint32_t EntryType;
    uint32_t QuotaInEntry;
    uint32_t DataSize;
    uint32_t x;
    char Data[];
}
```



Spray Named Pipe

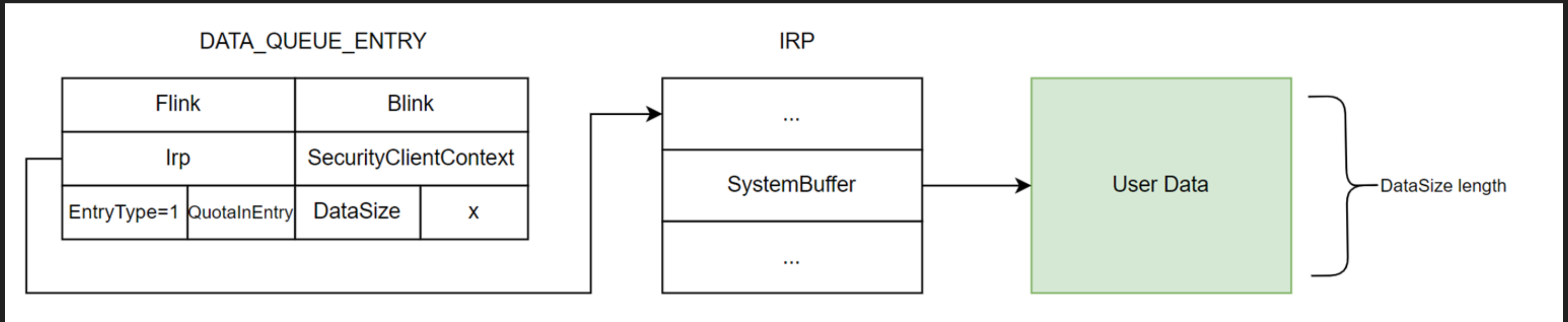
EntryType = 0 (Buffered Entries)



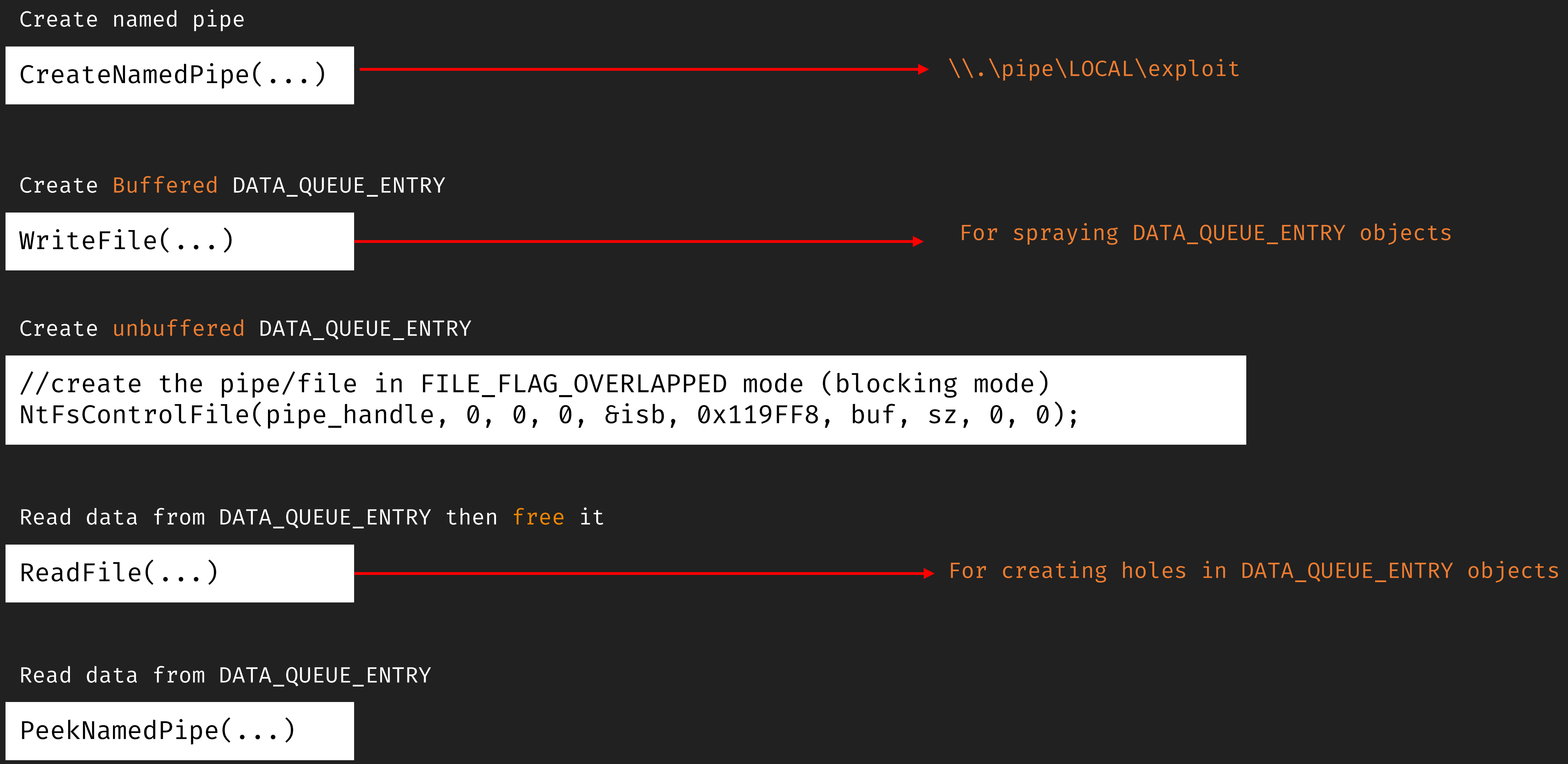
Variable-sized objects are suitable for pool spraying.

IRP always be NULL

EntryType = 1 (Unbuffered Entries)



Spray Named Pipe



Create named pipe

```
CreateNamedPipe(...)
```

\\.\pipe\LOCAL\exploit

Create Buffered DATA_QUEUE_ENTRY

```
WriteFile(...)
```

For spraying DATA_QUEUE_ENTRY objects

Create unbuffered DATA_QUEUE_ENTRY

```
//create the pipe/file in FILE_FLAG_OVERLAPPED mode (blocking mode)
NtFsControlFile(pipe_handle, 0, 0, 0, &isb, 0x119FF8, buf, sz, 0, 0);
```

Read data from DATA_QUEUE_ENTRY then free it

```
ReadFile(...)
```

For creating holes in DATA_QUEUE_ENTRY objects

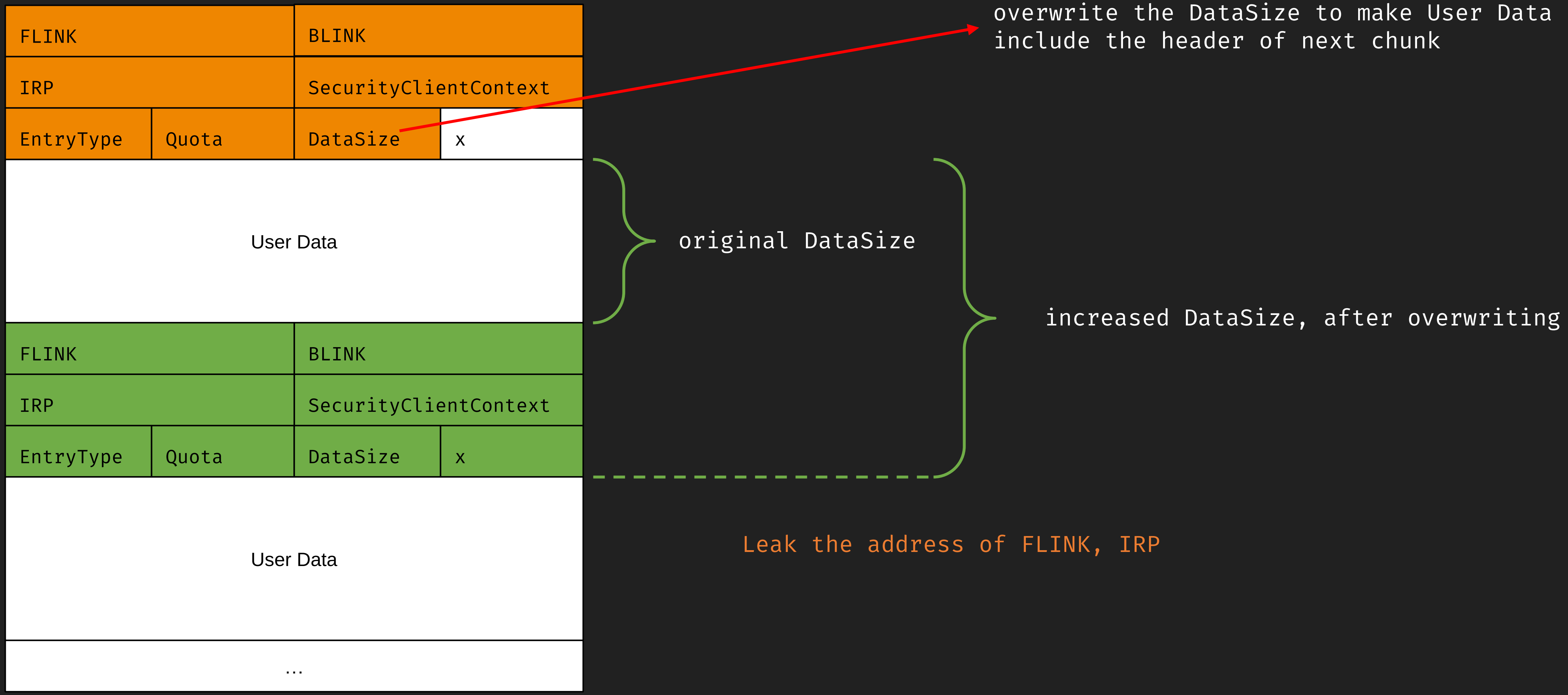
Read data from DATA_QUEUE_ENTRY

```
PeekNamedPipe(...)
```

From OOBW to OOBR (Info Leak)

🟧 OOBW part

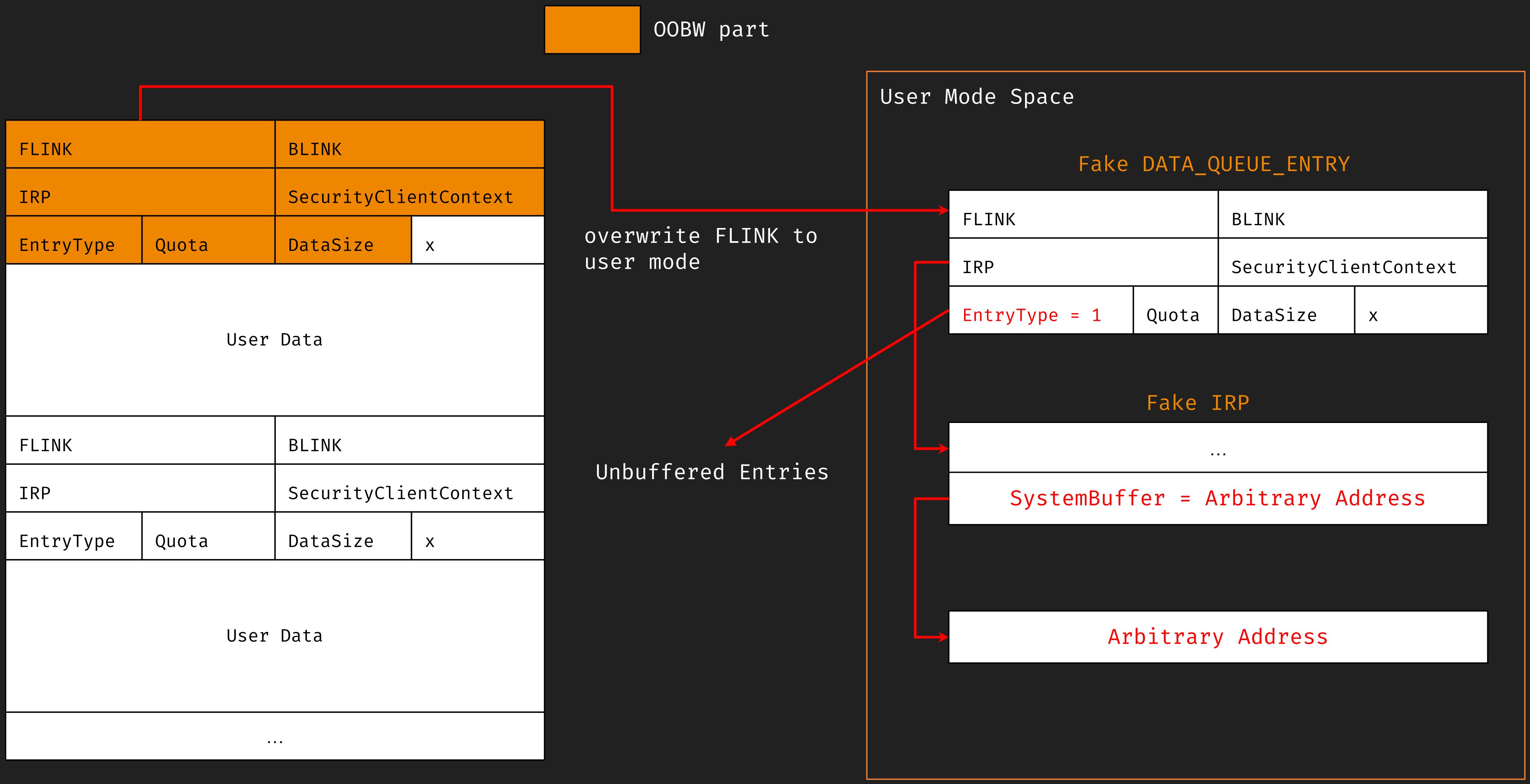
🟩 OOBR part



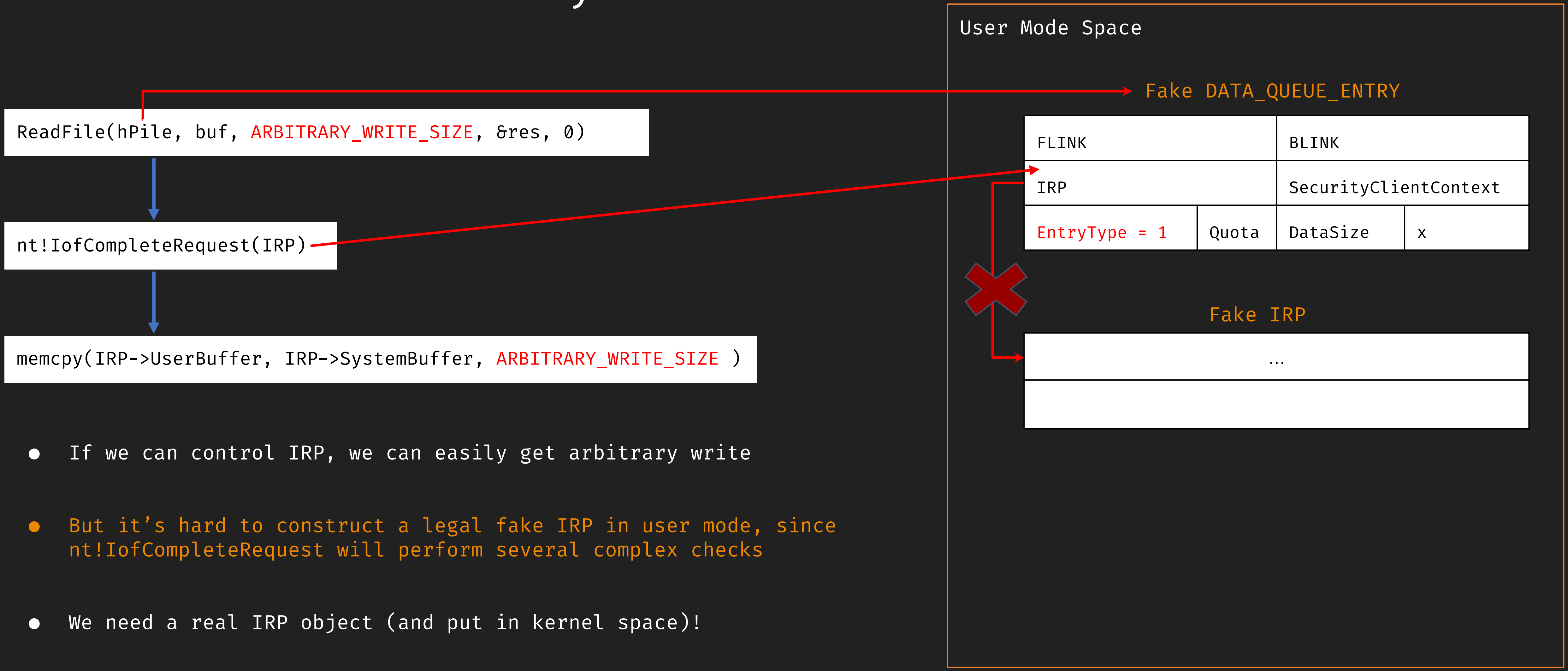
overwrite the DataSize to make User Data include the header of next chunk

Leak the address of FLINK, IRP

From OOBW to Arbitrary Read



From OOBW to Arbitrary Write



```
ReadFile(hPile, buf, ARBITRARY_WRITE_SIZE, &res, 0)
```

```
nt!IofCompleteRequest(IRP)
```

```
memcpy(IRP->UserBuffer, IRP->SystemBuffer, ARBITRARY_WRITE_SIZE )
```

- If we can control IRP, we can easily get arbitrary write
- But it’s hard to construct a legal fake IRP in user mode, since nt!IofCompleteRequest will perform several complex checks
- We need a real IRP object (and put in kernel space)!

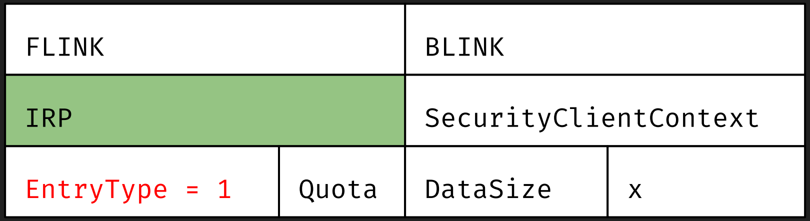
Construct Fake IRP object

Abusing our Info Leak and Arbitrary Read primitive:

- Create a real unbuffered DATA_QUEUE_ENTRY
- Leak the content of IRP

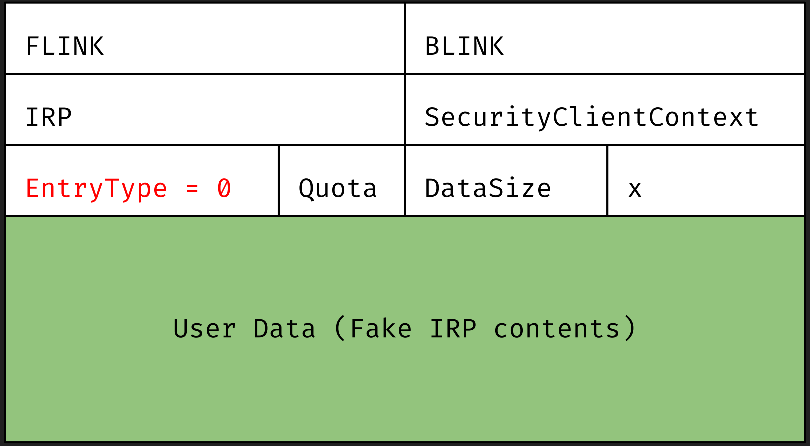
- Modify the UserBuffer and SystemBuffer field fake IRP to prepare for Arbitrary Write
- Create a real buffered DATA_QUEUE_ENTRY
- Put Fake IRP in the user data field of the entry (kernel space)
- Trigger IofCompleteRequest to get Arbitrary Write

Real DATA_QUEUE_ENTRY (Unbuffered Entries)



FLINK		BLINK	
IRP		SecurityClientContext	
EntryType = 1	Quota	DataSize	x

Real DATA_QUEUE_ENTRY (Buffered Entries)



FLINK		BLINK	
IRP		SecurityClientContext	
EntryType = 0	Quota	DataSize	x
User Data (Fake IRP contents)			

Replace Our Token with SYSTEM Token

Abusing our Arbitrary Read/Write primitive:

- Parsing Leaked IRP:
    - Get sandbox process token kernel address
    - Get system process token kernel address

- replace sandbox process token with system token

- Inject shellcode into winlogon.exe to spawn a new process
  (Directly spawn new process in sandbox is not allowed, because of the job limitation)

Wrapped Up

- Spray several named pipe objects
- Free some objects to create holes
- Exhaust the AFD lookaside List
- Put UserBuf in the proper position to make the OOBW size controllable
- Trigger the vul to overwrite the DATA_QUEUE_ENTRY
- Abuse the Modified DATA_QUEUE_ENTRY object to get Arbitrary Read/Write
- Replace sandboxed process token with SYSTEM token
- Inject winlogon.exe to spawn a new process.

Demo for Chrome

Demo for Adobe PDF Reader

Summary

Review

- Sandbox Internal
- Sandbox Escape Methodology
- Attack Surface Comparison
  - Chrome Renderer
  - Chrome GPU Process
  - Adobe Sandboxed Process
- Build Fullchain 1-Day Exploit
  - Chrome Renderer
  - Adobe Sandboxed Process

Takeaway

- Chrome Renderer SBX is Hard but Doable
  - GPU process is a good stairway: both in Android and Windows
- SBX for Chrome GPU and Adobe Sandboxed Process is Relatively Easier
  - More restricts need
- Exploitation Tricks
  - Chrome and Windows Kernel

THANK YOU

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