Finding low-hanging fruits vulnerabilities in a commercial AV

Sthack – 0x7e8 édition
24-05-2024

Madimodi DIAWARA

Quarkslab

TABLE OF CONTENTS

What is an AV again?

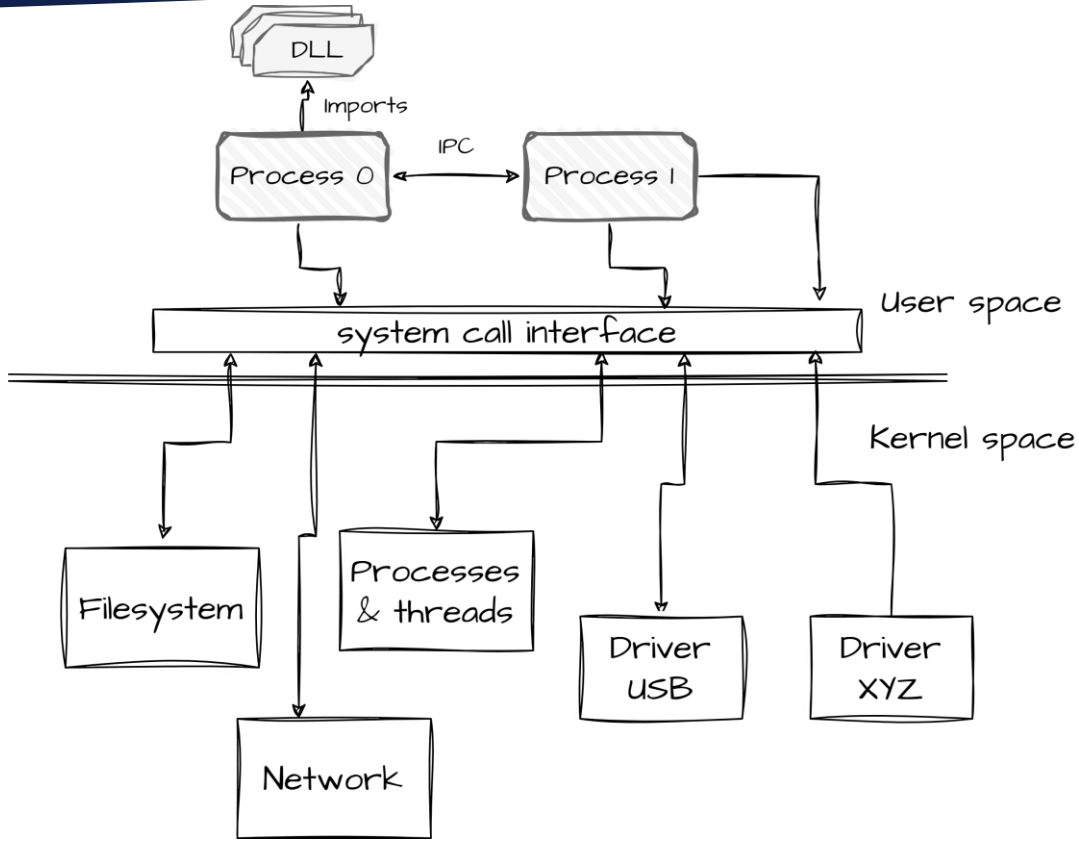
Its purpose, its workings and why it is a target of choice

Quarkslab

WHAT IS AN AV AGAIN?

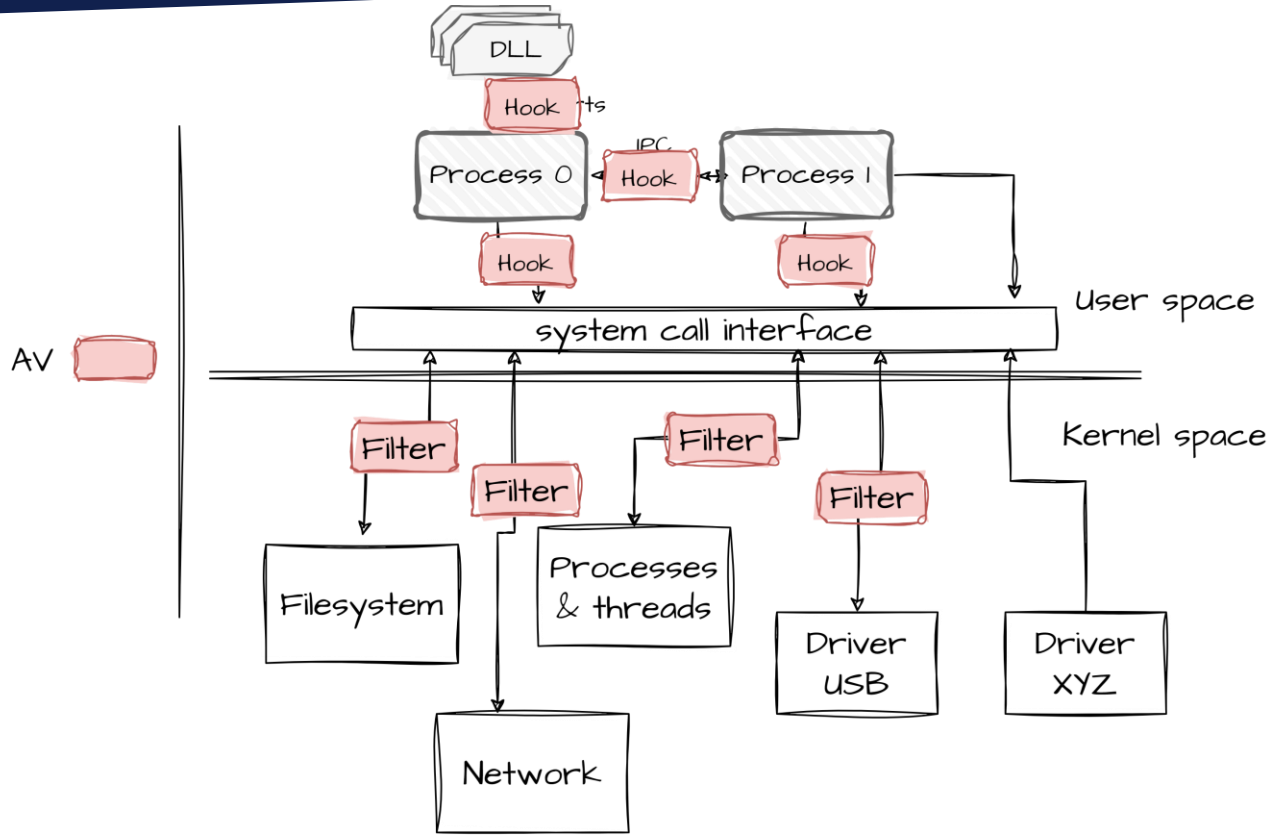
- Software enhancing an operating system (OS) security
- Protects against malware
- Not a software as any other
  - High privileges
  - Kernel components

EMBRACE OS COMPLEXITY



(Very) simplified view of an OS

EMBRACE AV COMPLEXITY



An AV shall fully embrace an OS to be efficient

THE LOGICAL MINUTE: A SYLLOGISM

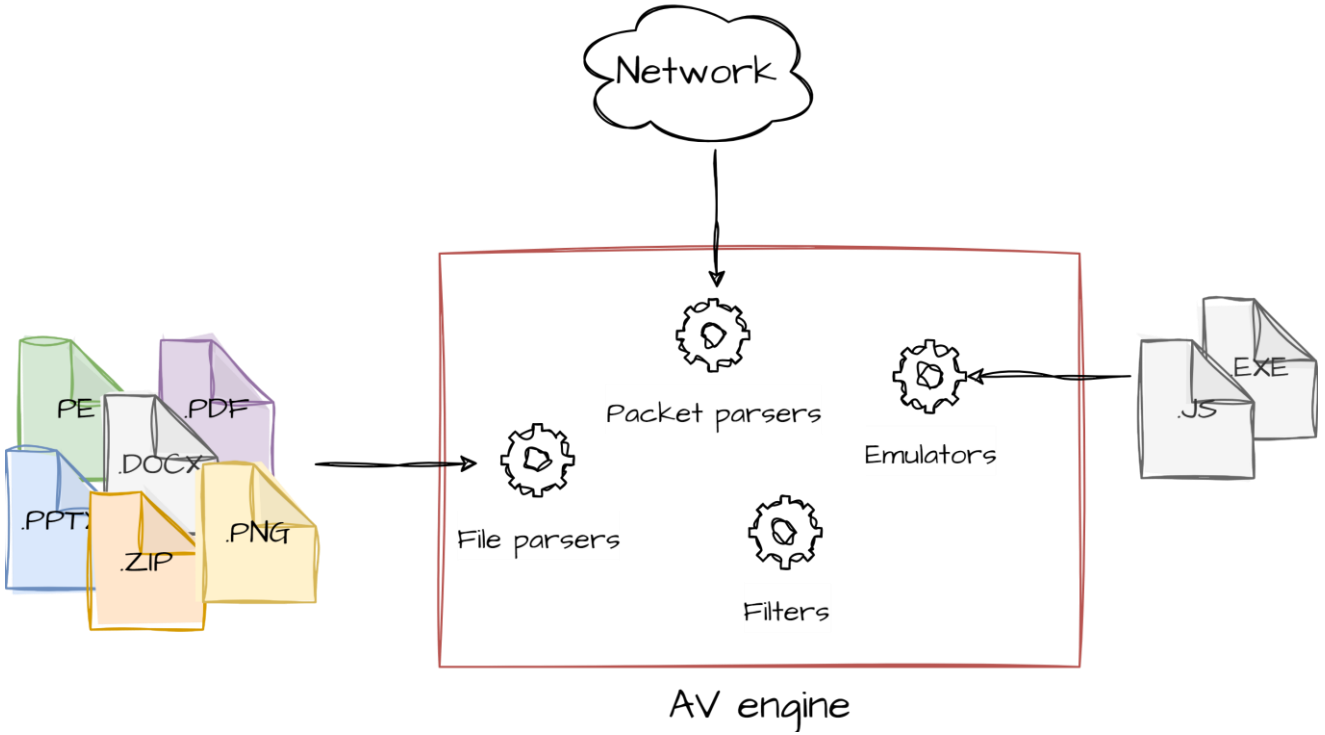
- A running software adds potential attack surface
- An antivirus is a **much more** complex software
- Therefore, an antivirus adds **a much higher** potential attack surface

AV attack surface

Complexity, cartography and analysis efficiency

Quarkslab

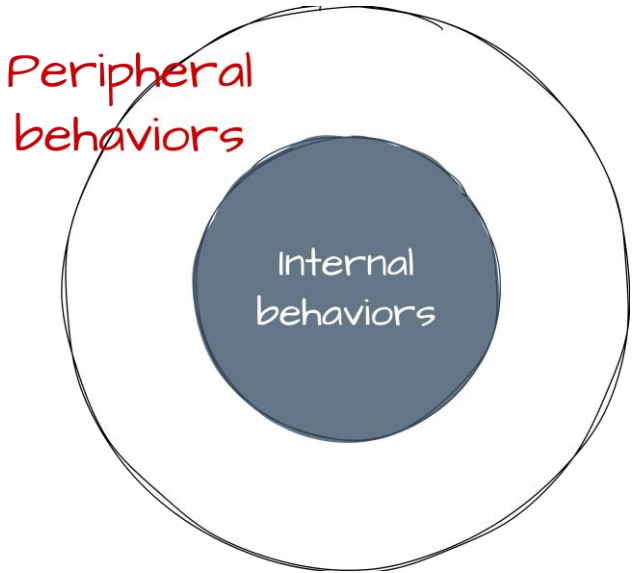
AV ATTACK SURFACE – THE AV ENGINE



A typical AV engine components

INTERNAL VS PERIPHERAL BEHAVIORS

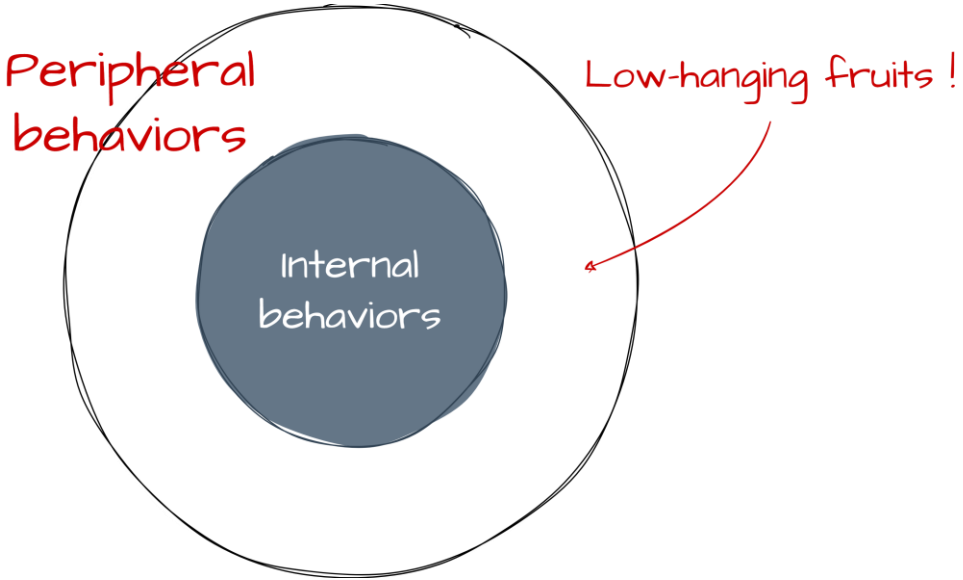
- Analyzing the AV Engine = too time-consuming!
- Let's focus on the ***peripheral behaviors***



Internal vs Peripheral behaviors

INTERNAL VS PERIPHERAL BEHAVIORS

- Analyzing the AV Engine = too time-consuming!
- Let's focus on the ***peripheral behaviors***



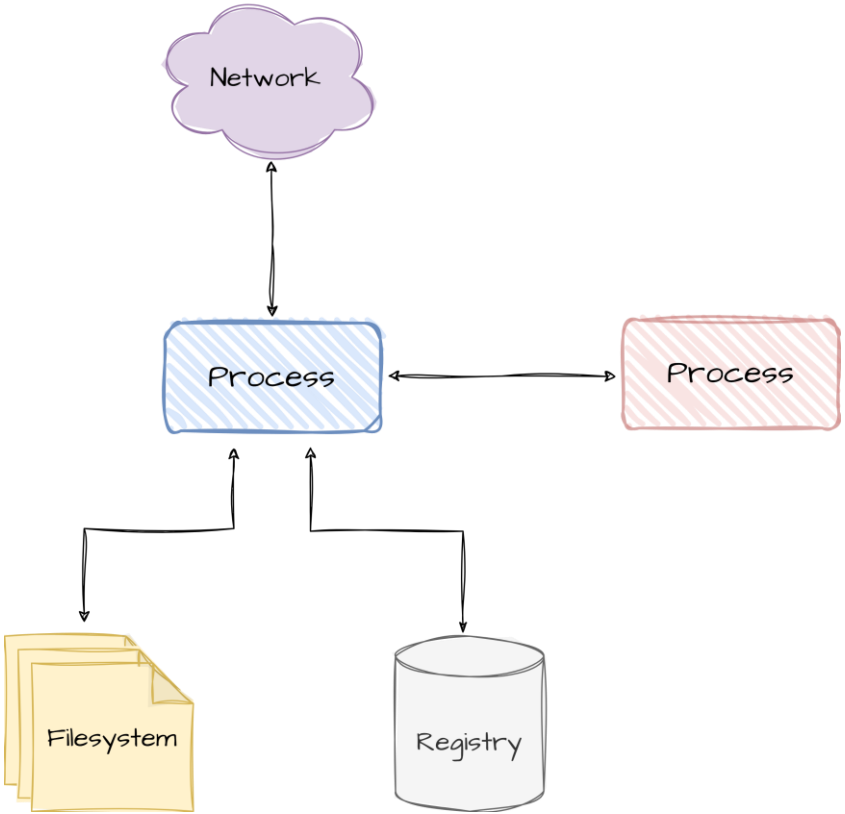
Internal vs Peripheral behaviors

Cartography: Drawing a map

Making a basic cartography

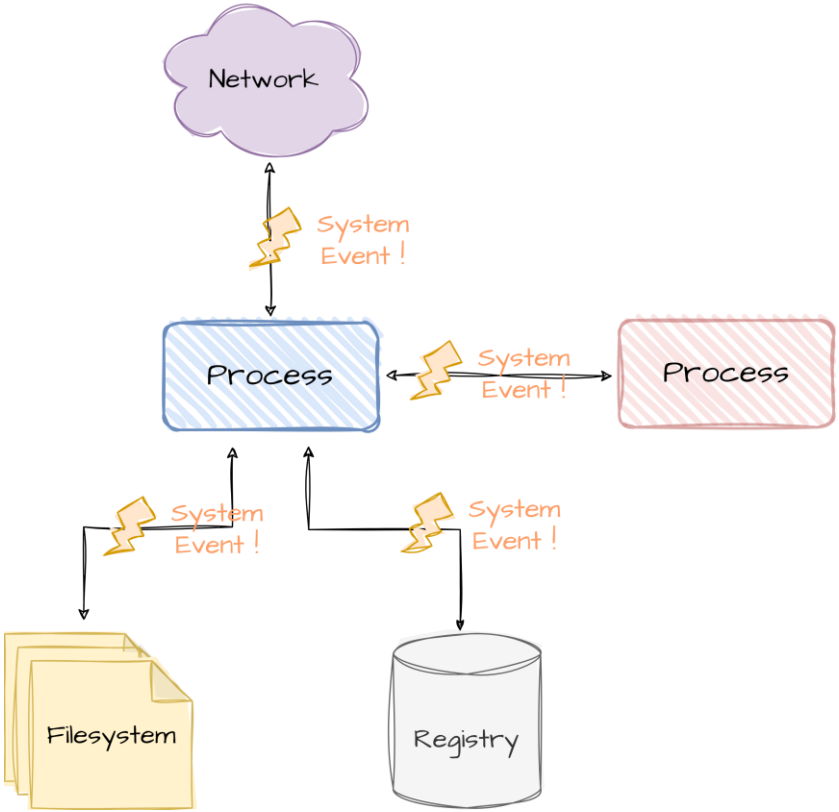
Quarkslab

DRAWING A MAP WITH PERIPHERAL BEHAVIORS



Basic process interactions

DRAWING A MAP WITH PERIPHERAL BEHAVIORS

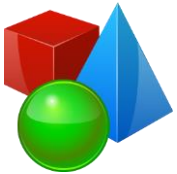


Actions generate events

DRAWING A MAP WITH PERIPHERAL BEHAVIORS

Prepare the artillery !

Procmon

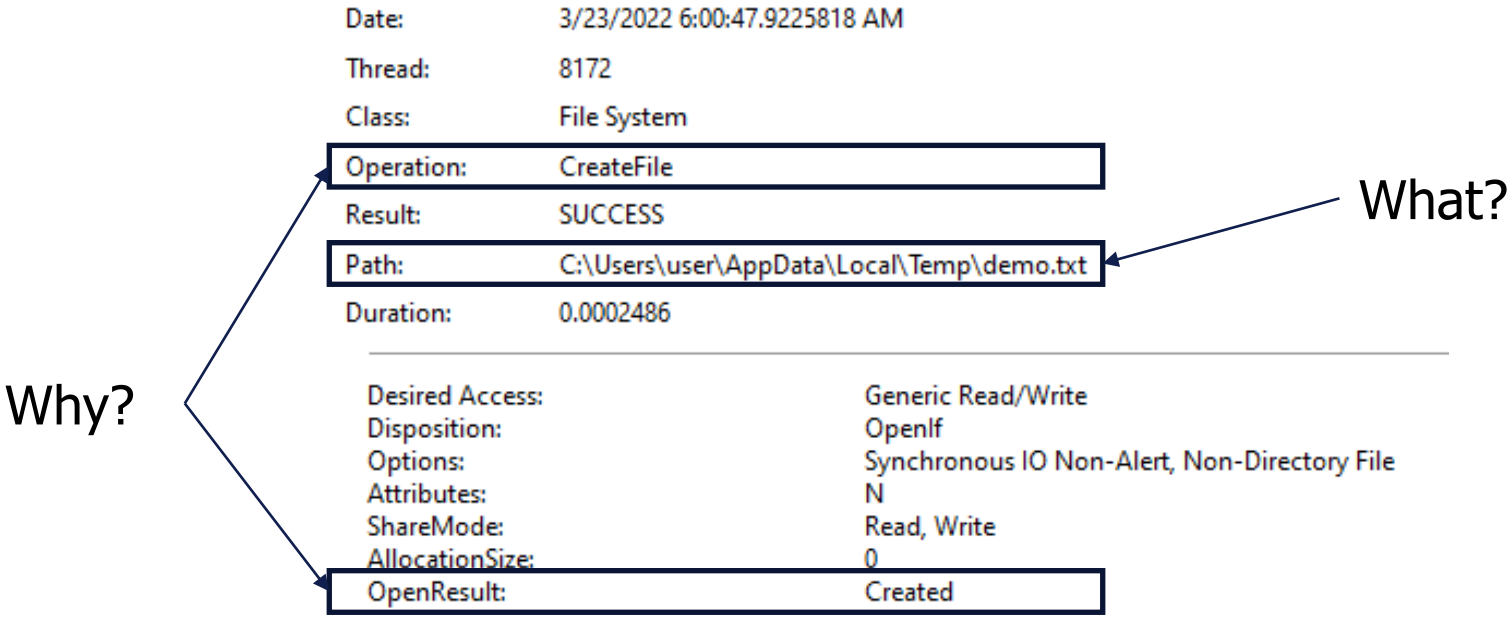


WinObjEx64

DriverView

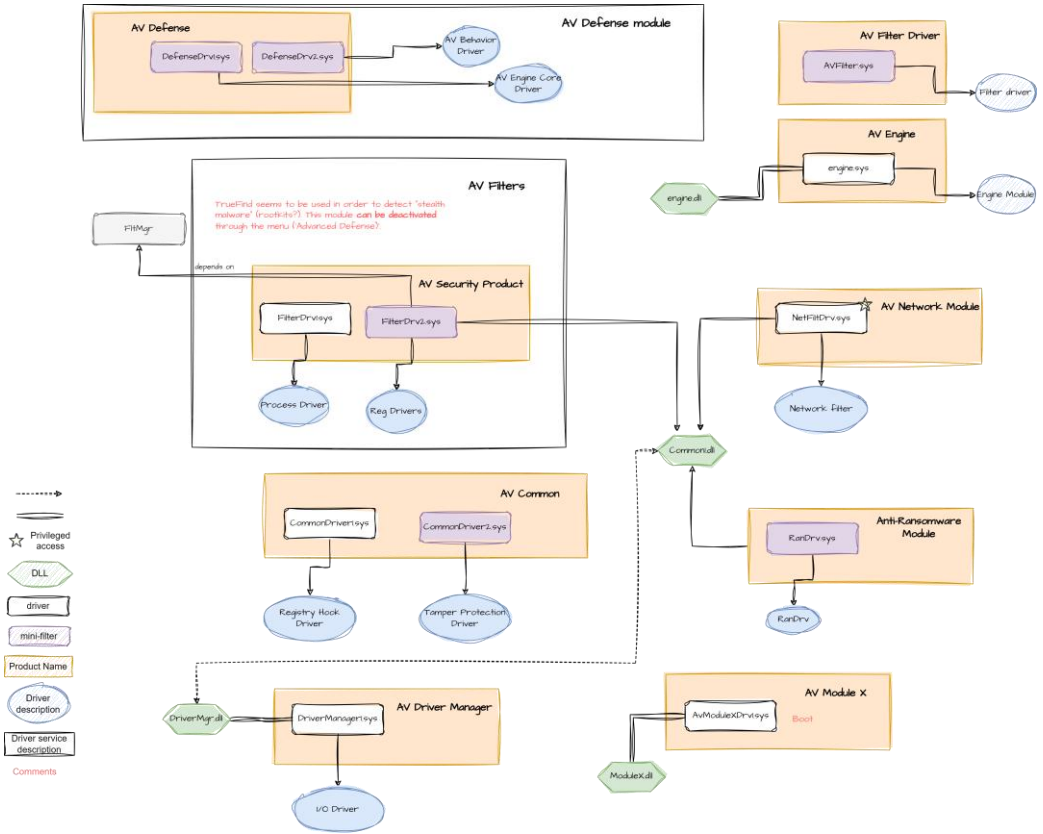
Procexp

DRAWING A MAP WITH PERIPHERAL BEHAVIORS



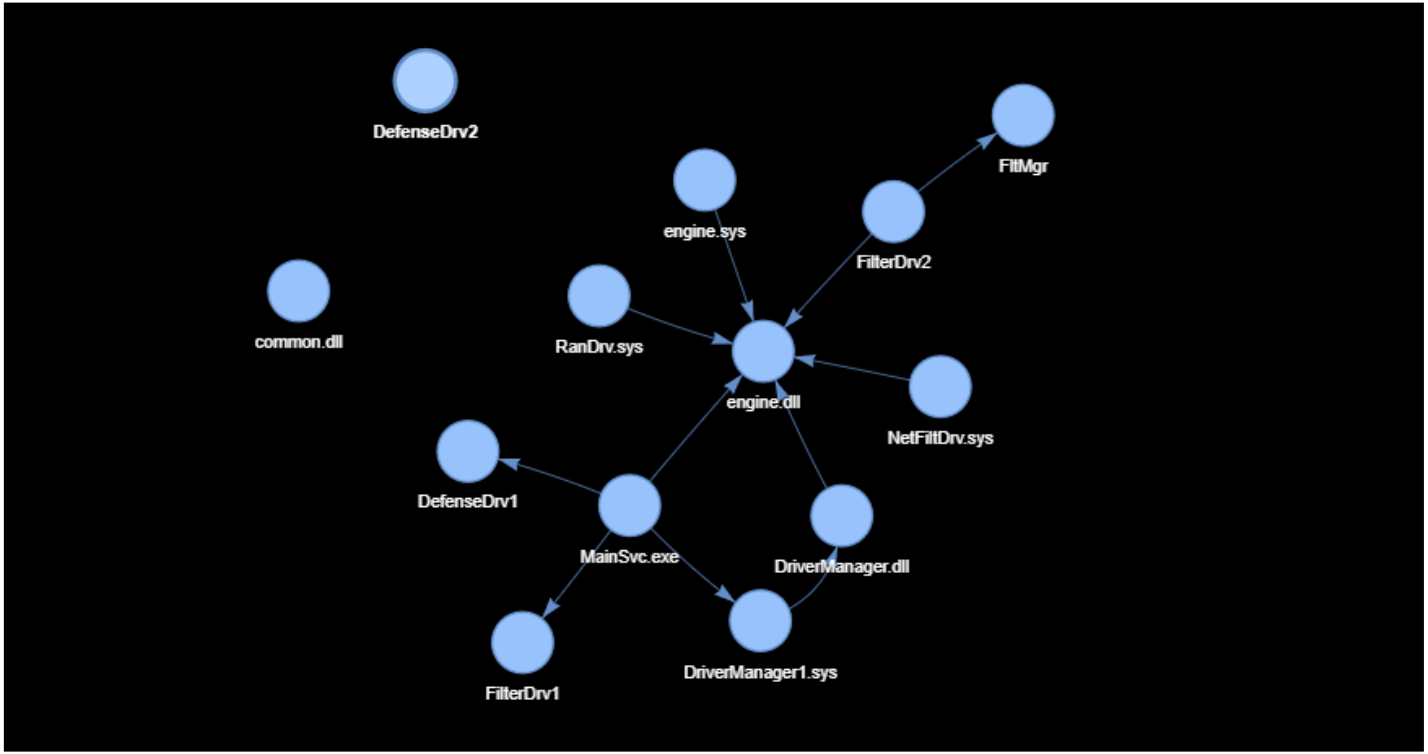
Event from ProcMon representing the creation of demo.txt

DRAWING A MAP WITH PERIPHERAL BEHAVIORS



Result of the cartography phase

DRAWING A MAP WITH PERIPHERAL BEHAVIORS



Files dependencies

Case study

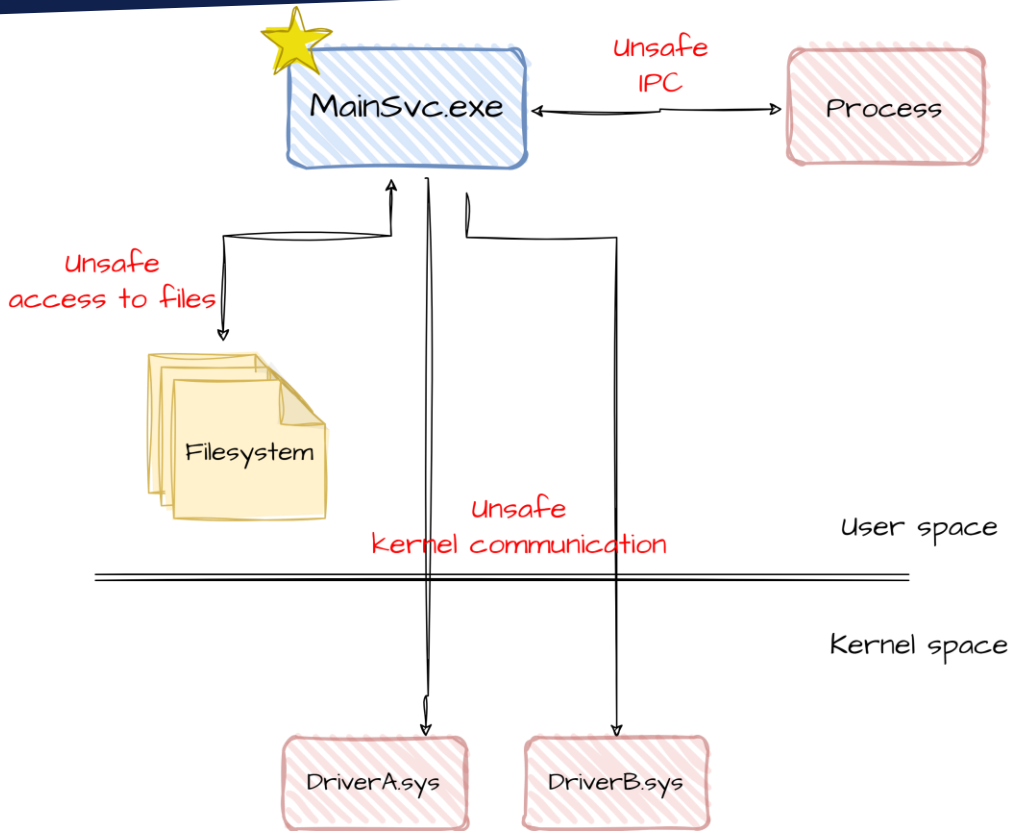
A tour of a commercial product

Quarkslab

USE CASE – UNDISCLOSED COMMERCIAL AV PRODUCT

- Widely used antivirus product (occurs in Tops)
- Reporting process still **on-going** (started in August 2023)

USE CASE – CARTOGRAPHY FINDINGS



Cartography results on the use case

USE CASE – VULNERABILITIES SUMMARY

- 5 vulnerabilities
  - Elevation of privileges (x2)
  - Arbitrary kernel code execution
  - Denial of service (x2)
- And more
  - Bad crypto implementation
  - Service hijacking

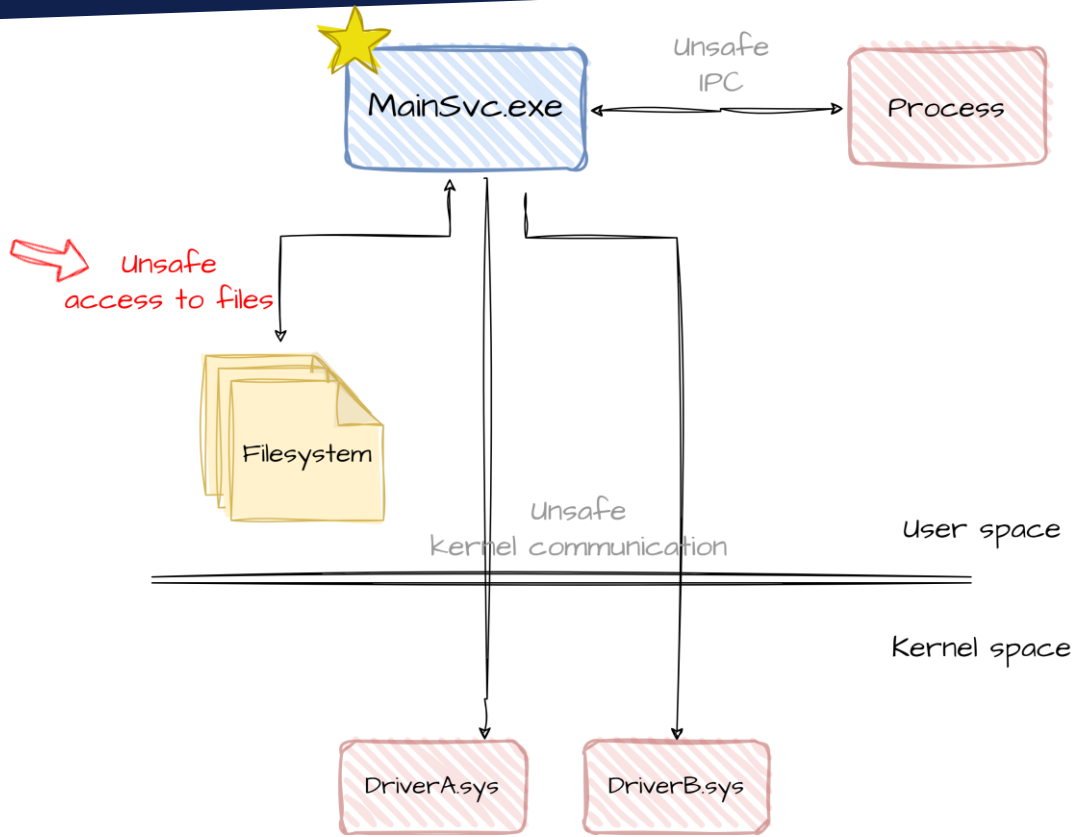
Vulnerability #1

Arbitrary file write

NTFS Junction + Object Manager symbolic link

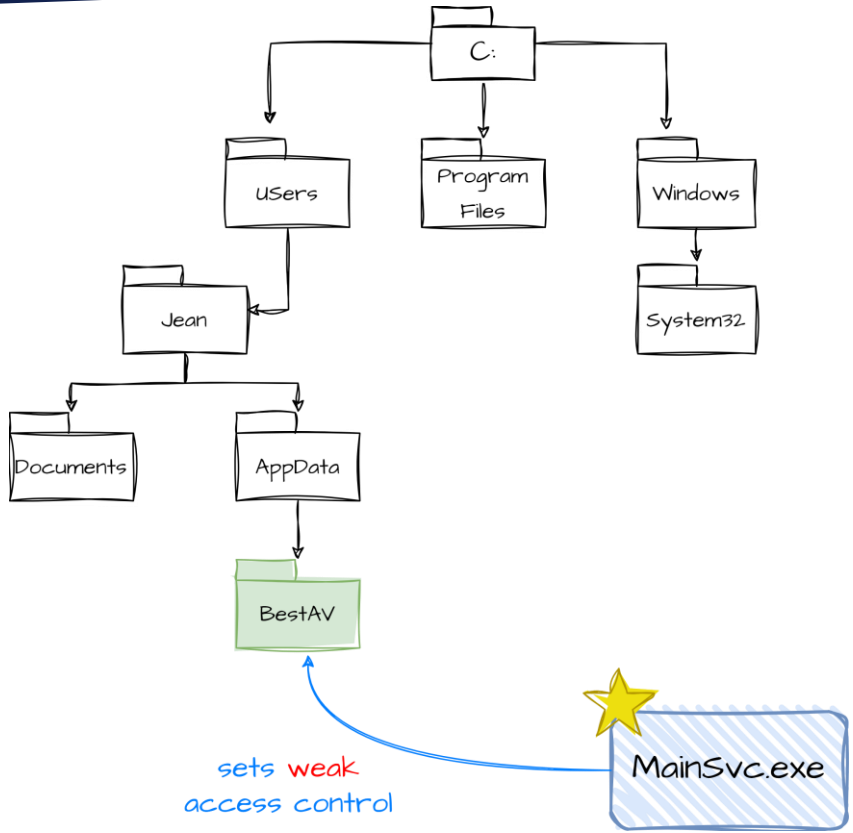
Quarkslab

ARBITRARY FILE WRITE – CARTOGRAPHY FINDING 1



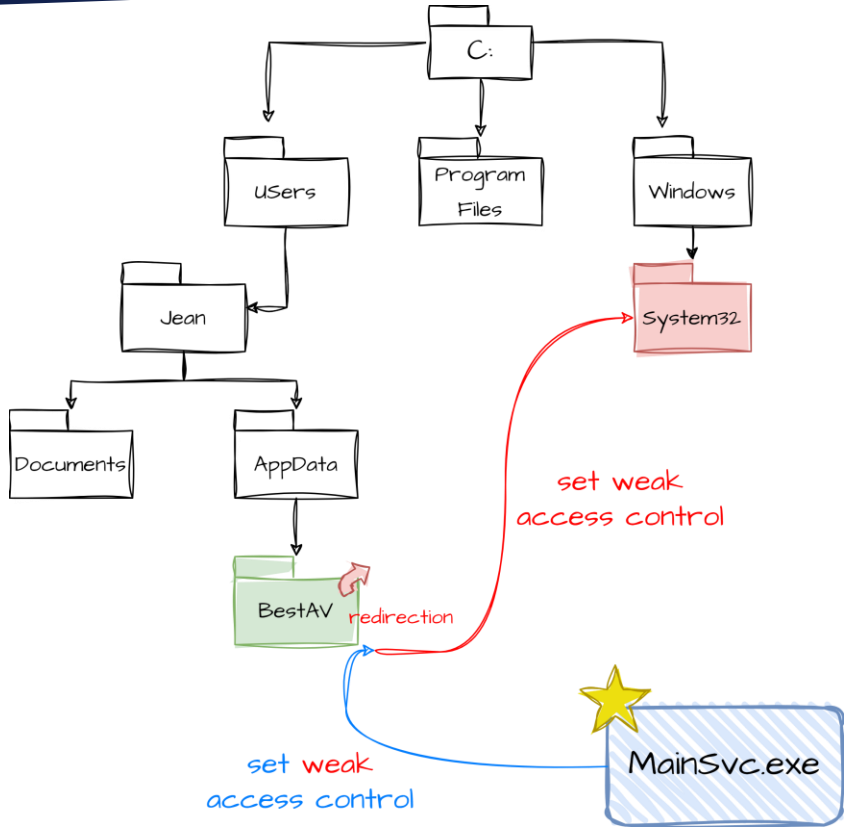
Cartography outlined unsafe access to files

ARBITRARY FILE WRITE



Too permissive access control

ARBITRARY FILE WRITE



Redirection of access control rule

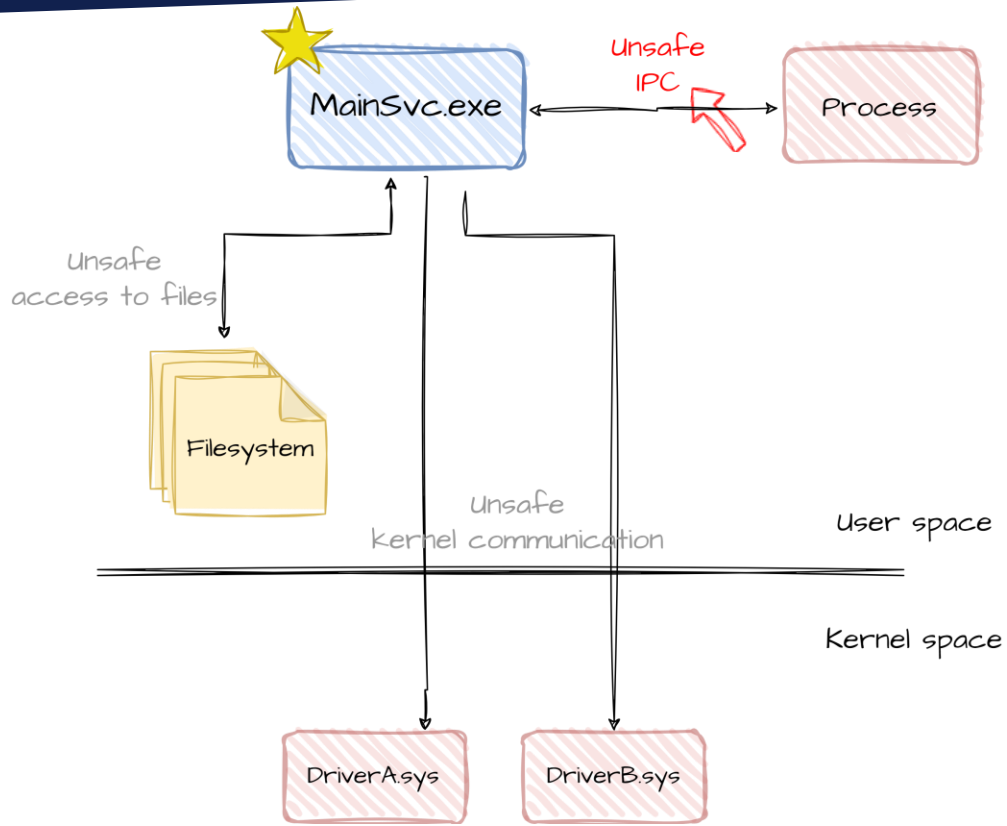
Vulnerability #2

DLL hijacking

Bypassing AV kernel protections

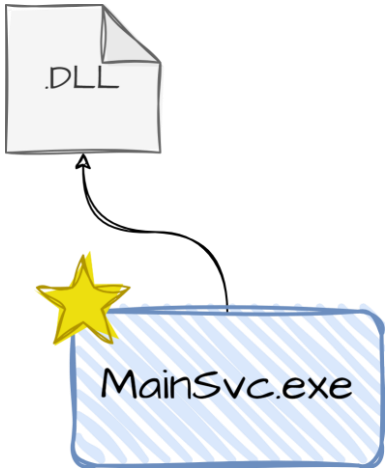
Quarkslab

DLL HIJACKING – CARTOGRAPHY FINDING 2



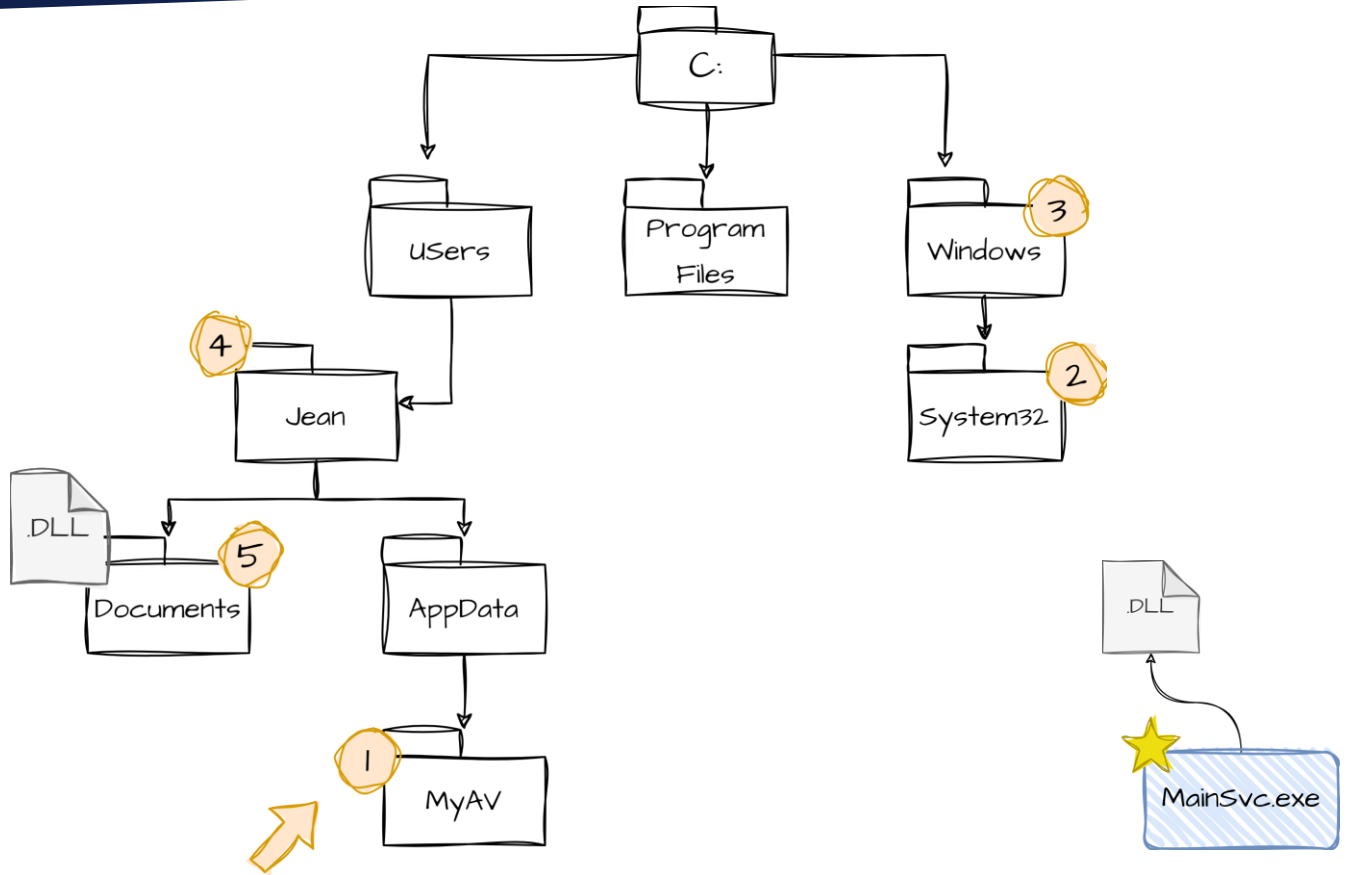
Cartography outlined unsafe IPC

DLL HIJACKING – DLL LOADING

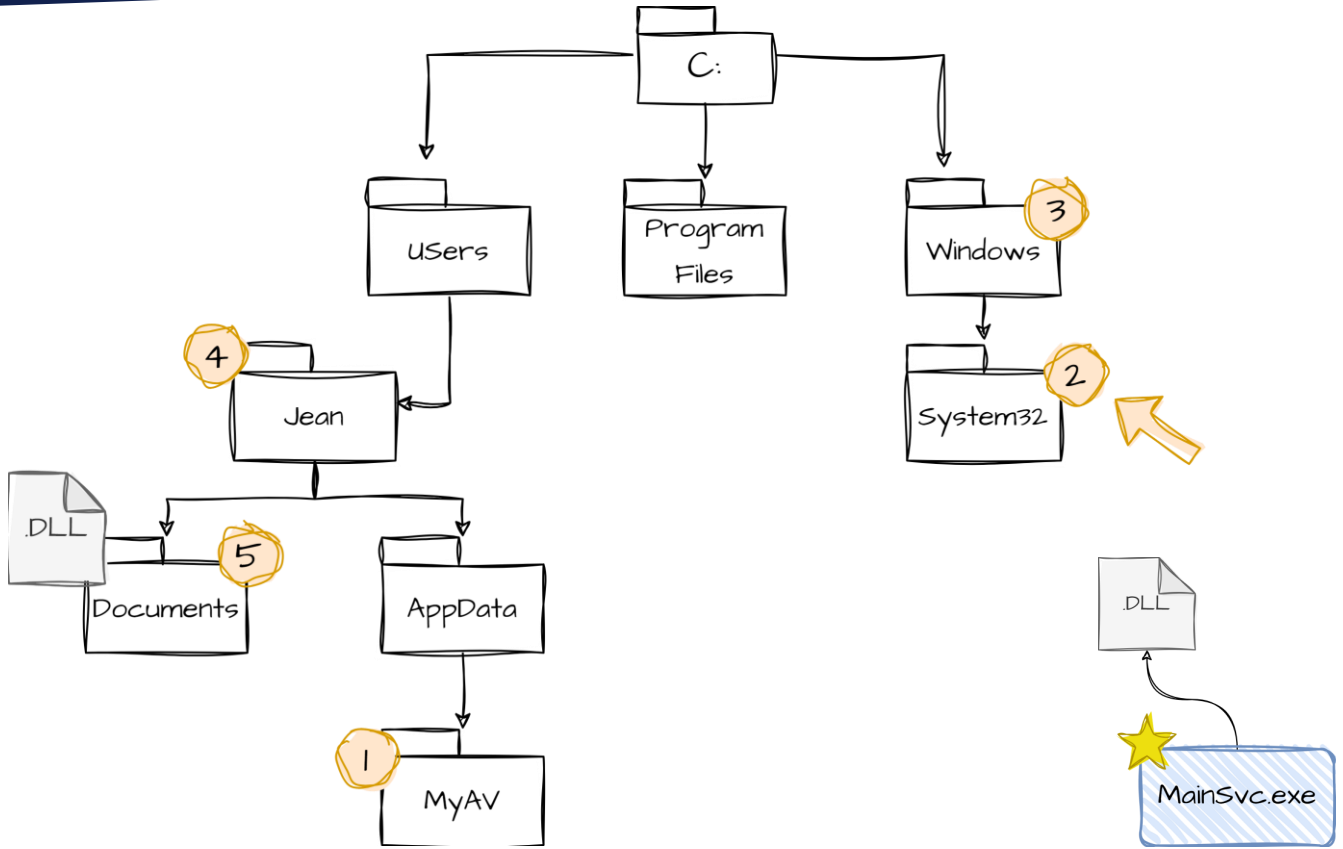


A process loading a DLL

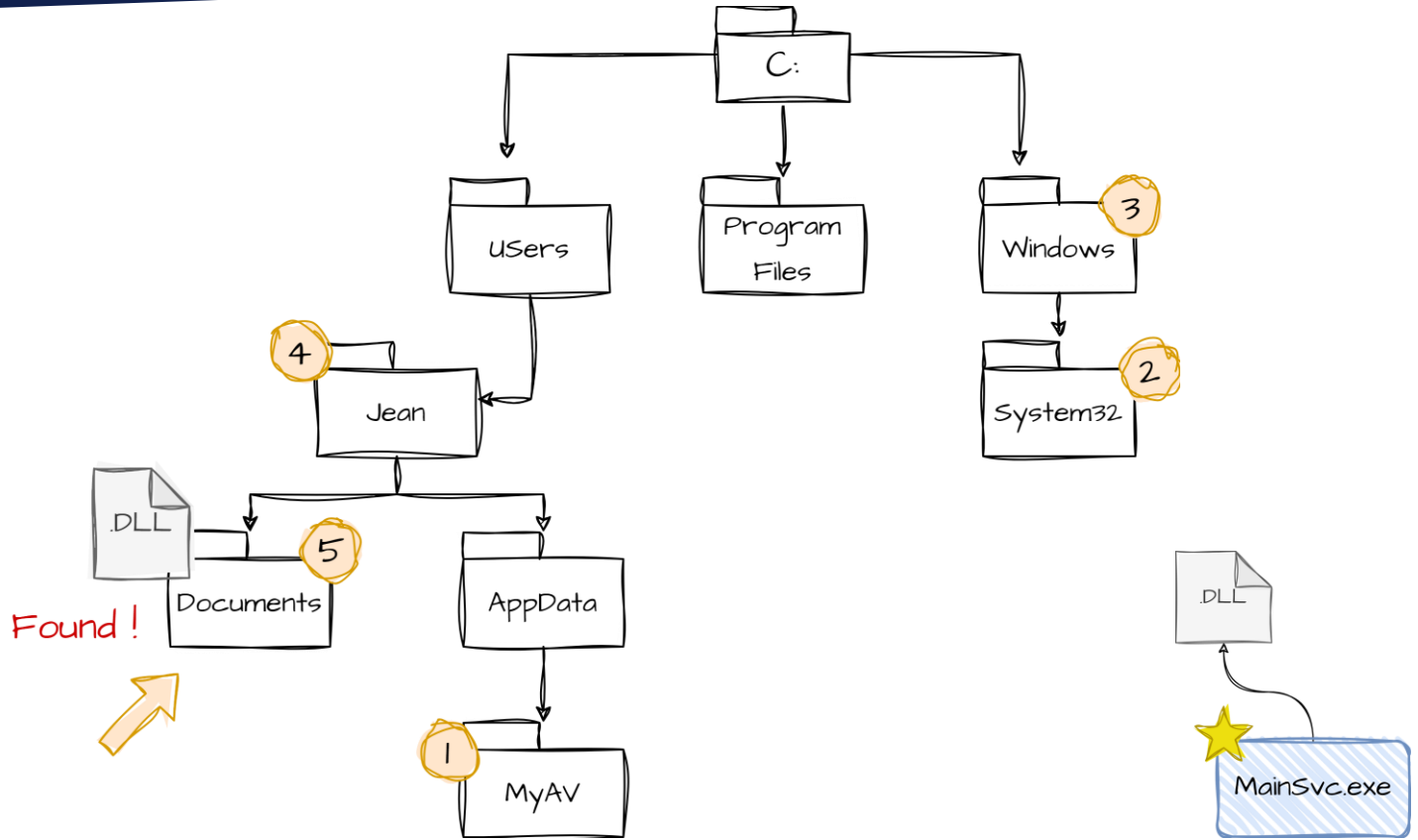
DLL HIJACKING – SEARCH ORDER



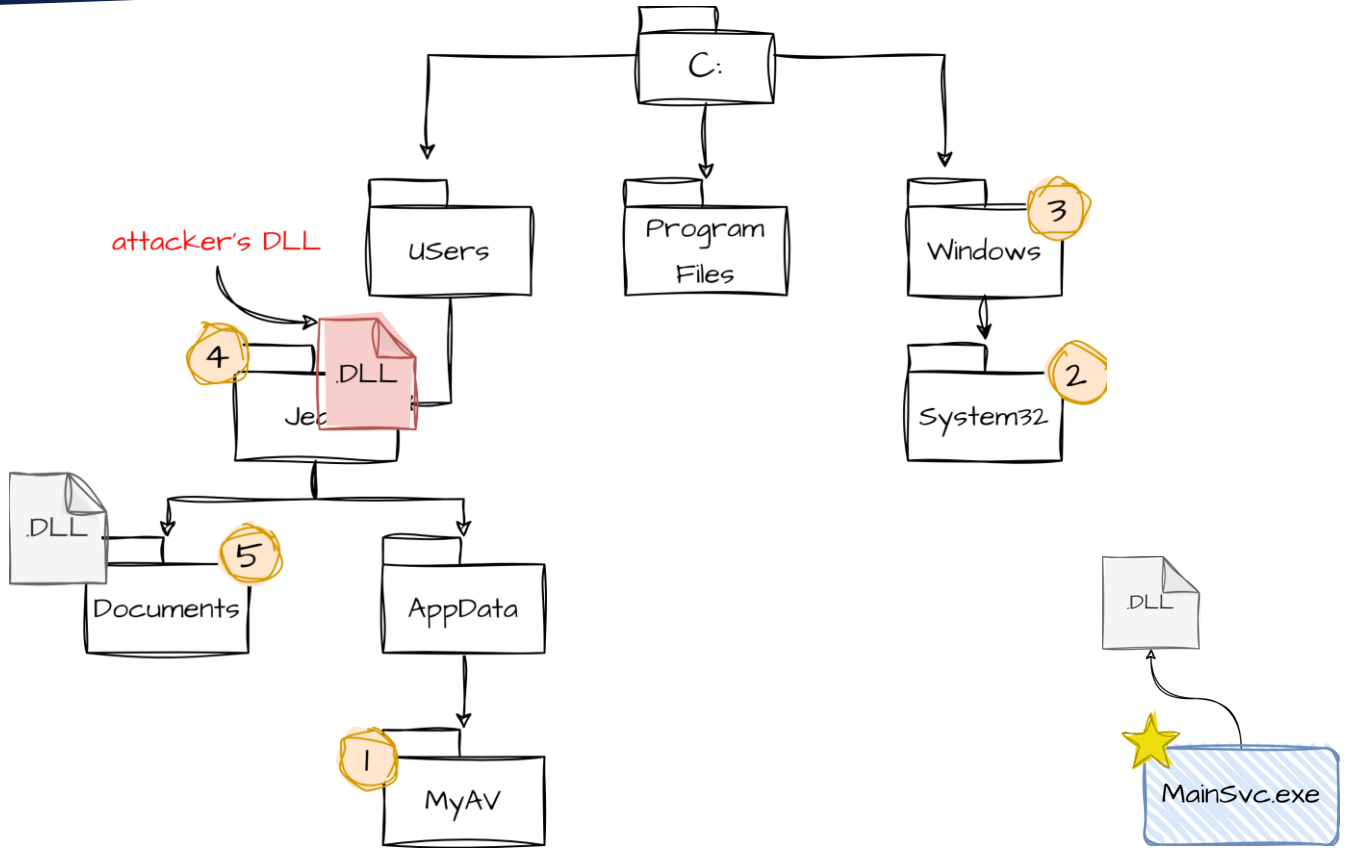
DLL HIJACKING – SEARCH ORDER



DLL HIJACKING – SEARCH ORDER



DLL HIJACKING – LOADING MALICIOUS FILE



DLL HIJACKING

- Well known technique
- We also loaded drivers
  - **Foreign signed** drivers
- Bypass of driver protection
  - Mini-filter based

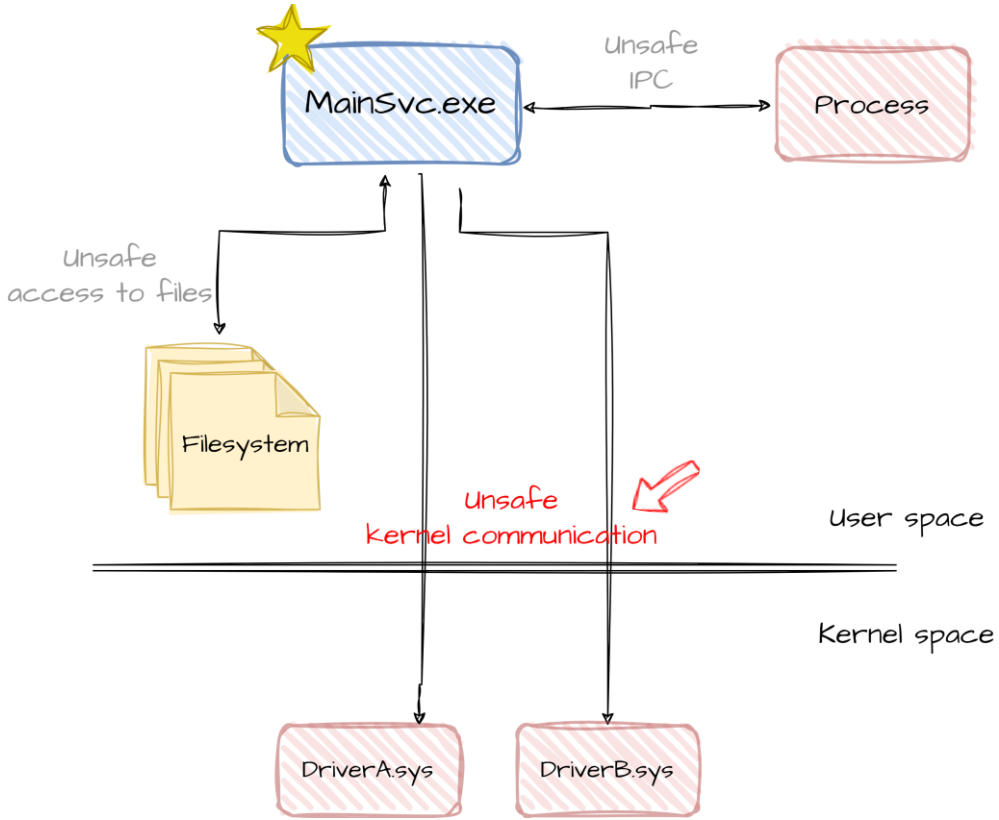
Vulnerability #3

Type confusion

Denial of service

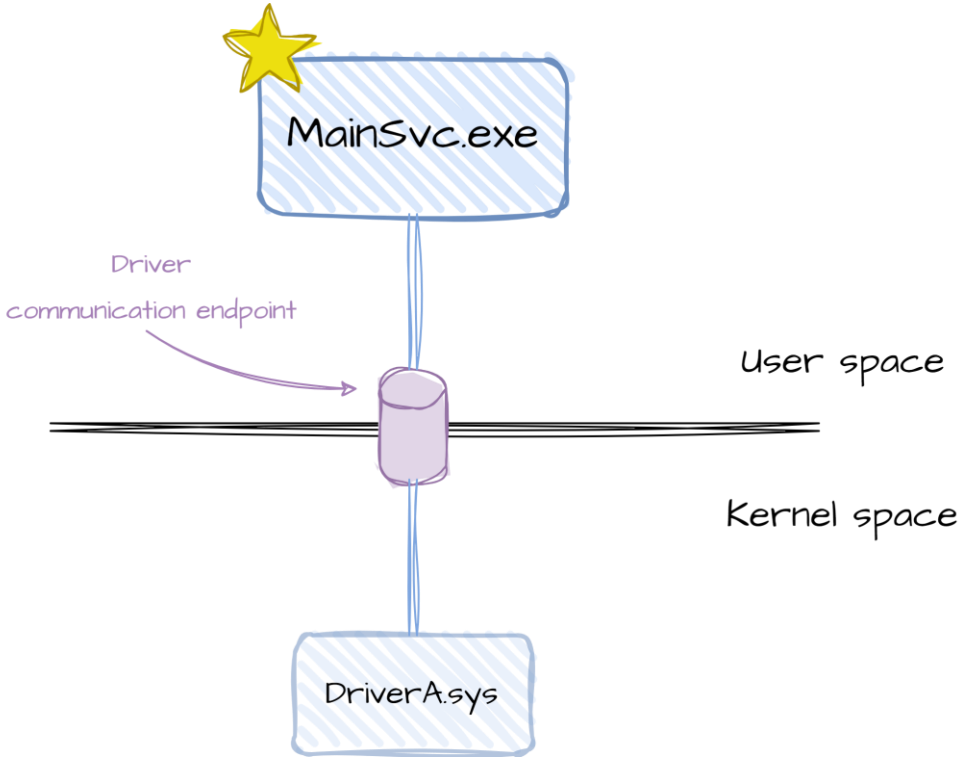
Quarkslab

TYPE CONFUSION - CARTOGRAPHY FINDING 3

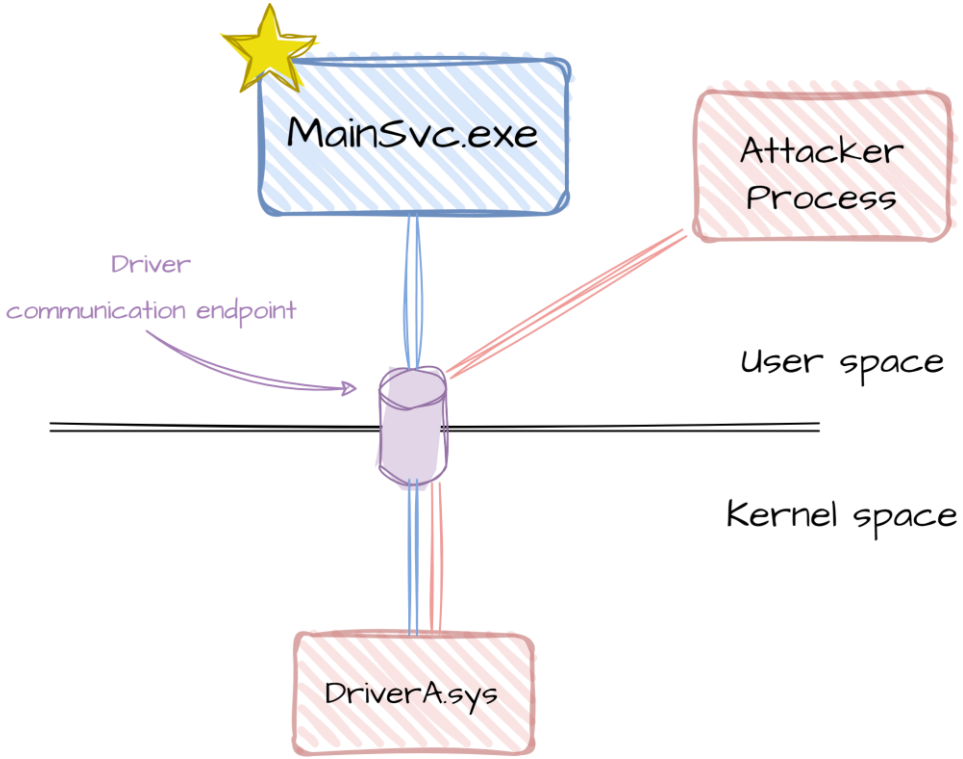


Cartography outlined unsafe kernel communication

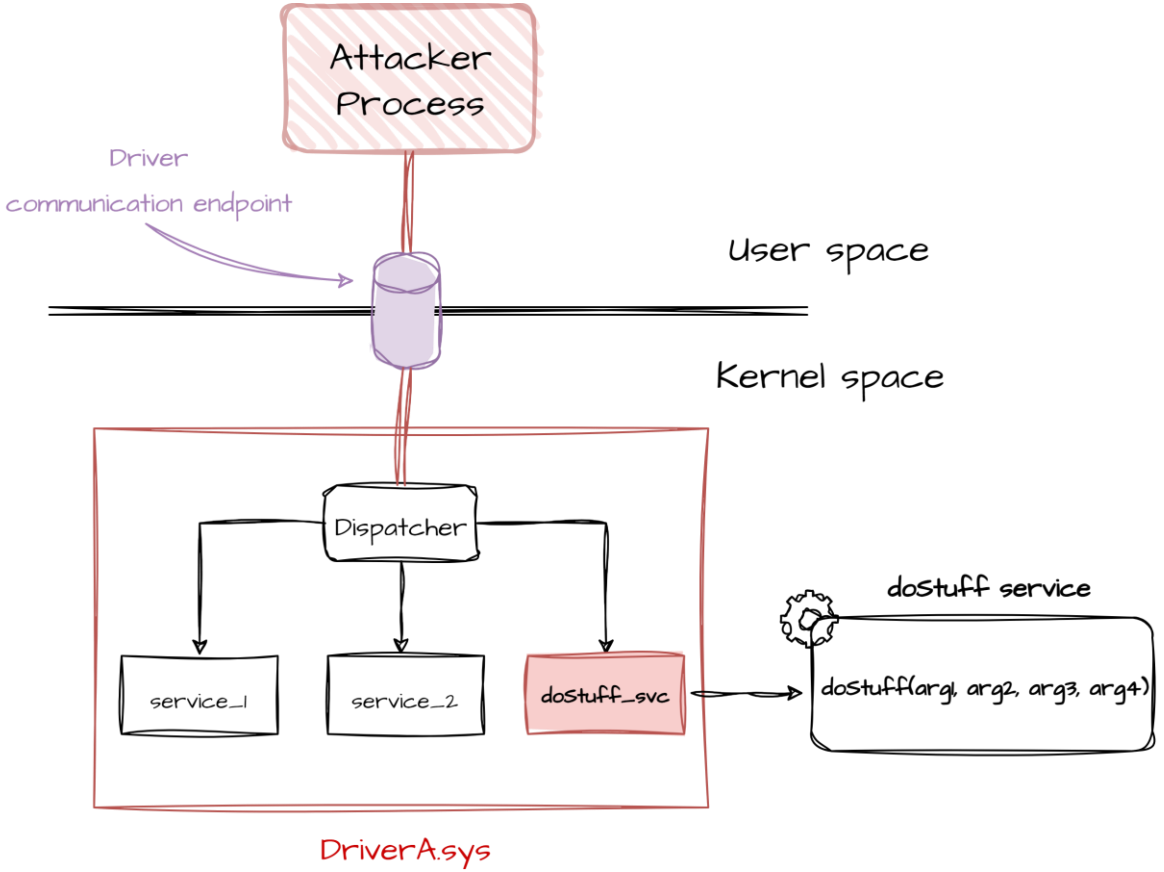
BRIEF ASIDE – DRIVER COMMUNICATION



BRIEF ASIDE – DRIVER COMMUNICATION



BRIEF ASIDE – DRIVER COMMUNICATION



TYPE CONFUSION - CARTOGRAPHY FINDING 3

- Found a IOCTL with those characteristics :

```
struct PACKET_1 {
    HANDLE handle;
    PVOID ptr;
    DWORD size;
    DWORD unknown0;
    ULONGLONG unknown1;
};
```

TYPE CONFUSION - CARTOGRAPHY FINDING 3

- Found a IOCTL with those characteristics :
  - **`ptr`** is probed ✖

```
struct PACKET_1 {
    HANDLE handle;
    PVOID ptr;
    DWORD size;
    DWORD unknown0;
    ULONGLONG unknown1;
};
```

TYPE CONFUSION - CARTOGRAPHY FINDING 3

- Found a IOCTL with those characteristics :
  - **`ptr`** is probed ✖
  - **`size`** is checked ✖

```
struct PACKET_1 {
    HANDLE handle;
    PVOID ptr;
    DWORD size;
    DWORD unknown0;
    ULONGLONG unknown1;
};
```

TYPE CONFUSION - CARTOGRAPHY FINDING 3

- Found a IOCTL with those characteristics :
  - **`ptr`** is probed ✖
  - **`size`** is checked ✖
  - **`handle`** is not ! 

```
struct PACKET_1 {
    HANDLE handle;
    PVOID ptr;
    DWORD size;
    DWORD unknown0;
    ULONGLONG unknown1;
};
```

TYPE CONFUSION - CARTOGRAPHY FINDING 3

- Handle is used directly with **`ObReferenceObjectByHandle`**

```
if ((packet != 0 && out_val != 0))
{
    void* pObject;
    NTSTATUS status = ObReferenceObjectByHandle(packet->handle, 0, NULL, 1, &pObject, NULL);
}
```

- And ?

TYPE CONFUSION - CARTOGRAPHY FINDING 3

```
NTSTATUS ObReferenceObjectByHandle(
 HANDLE                     Handle,
 ACCESS_MASK                DesiredAccess,
 POBJECT_TYPE               ObjectType,
 KPROCESSOR_MODE            AccessMode,
 PVOID                      *Object,
 POBJECT_HANDLE_INFORMATION HandleInformation
);
```

- *"If ObjectType is not NULL, the operating system verifies that the supplied object type matches the object type of the object that Handle specifies."*

- And if not ? **Arbitrary handle => Pointer to unexpected object**

TYPE CONFUSION - CARTOGRAPHY FINDING 3

Expects to receive a **_FILE_OBJECT**...

```
struct _FILE_OBJECT
{

    SHORT Type;
    SHORT Size;
    struct _DEVICE_OBJECT* DeviceObject;

    ...
}
```

```
int32_t _status = doStuff(arg1: a_int, PDEVICE_OBJECT: Object->_DEVICE_OBJECT, ...);
```

TYPE CONFUSION - CARTOGRAPHY FINDING 3

Expects to receive a **_FILE_OBJECT**... so we give it a **_TOKEN** !

```
struct _FILE_OBJECT
{

    SHORT Type;
    SHORT Size;
    struct _DEVICE_OBJECT* DeviceObject;

    ...
}
```

```
struct _TOKEN
{
    struct {

        CHAR SourceName[8];              // 0x0
        struct _LUID SourceIdentifier;   // 0x8
    } _TOKEN_SOURCE ;
    ...
}
```

```
int32_t _status = doStuff(arg1: a_int, PDEVICE_OBJECT: Object->SourceIdentifier, ...);
```

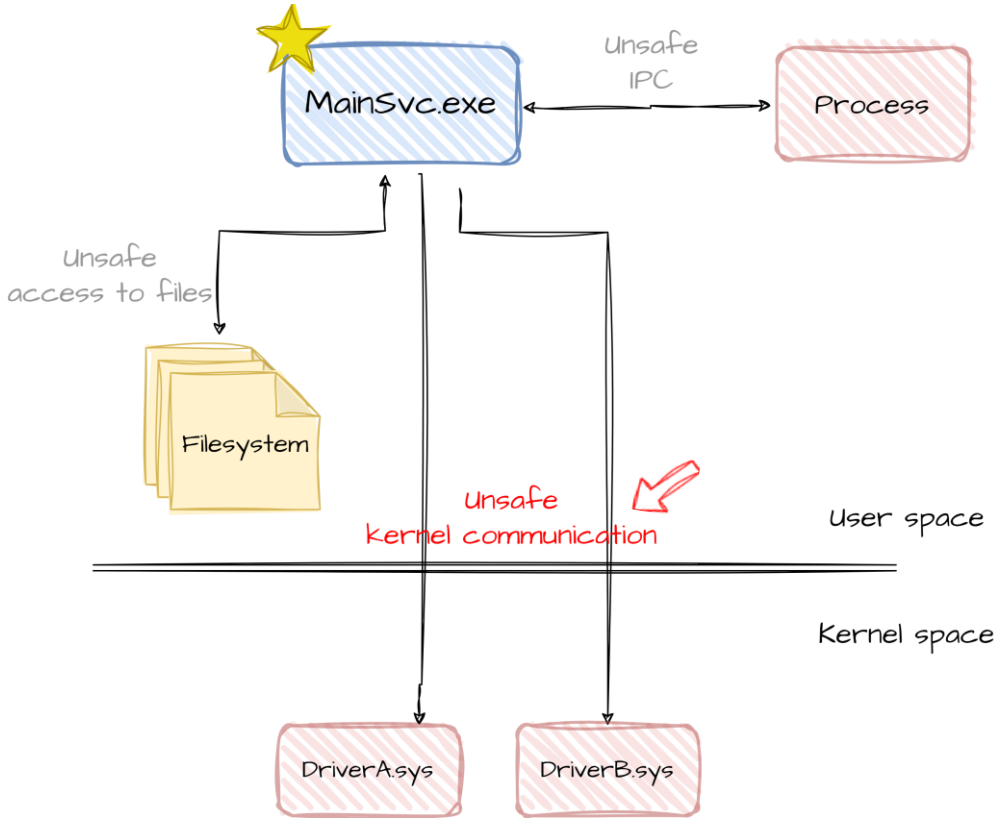
Vulnerabilities #4

Kernel code execution

Write-What-Where

Quarkslab

KERNEL CODE EXECUTION – CARTOGRAPHY FINDING 4



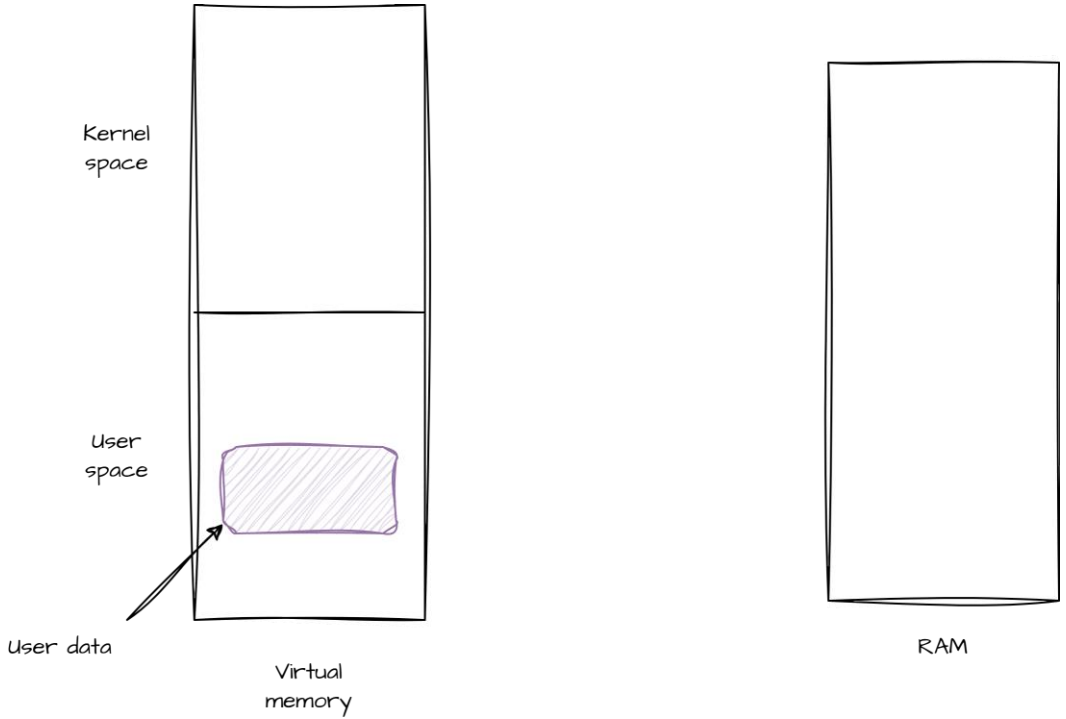
Cartography outlined unsafe kernel communication

KERNEL CODE EXECUTION – CARTOGRAPHY FINDING 4

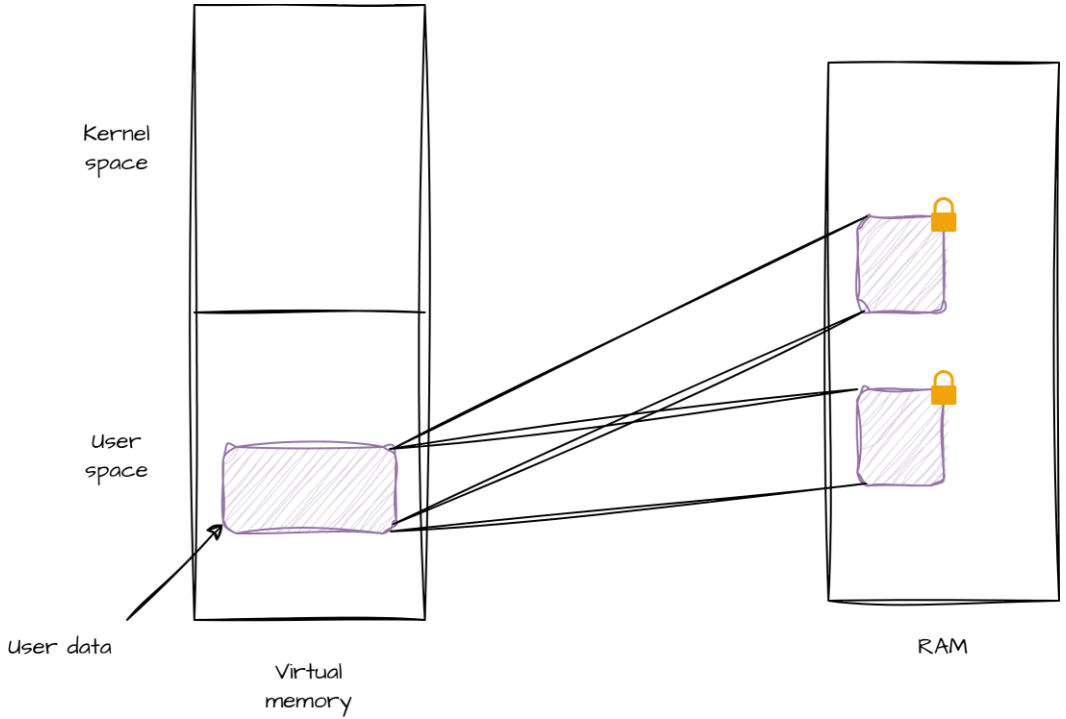
```
struct PACKET2
{
    void* va_address_destination;
    void* va_address_source;
    unsigned int size;
}
```

- Parameters are used to create an **MDL**

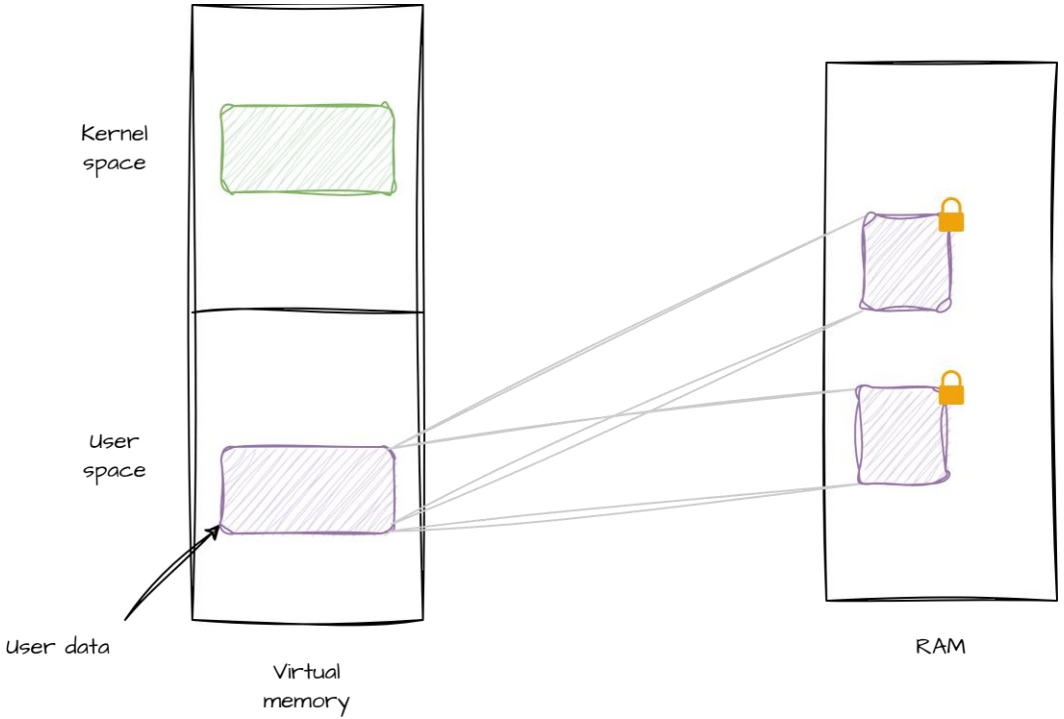
APARTÉ – AN MDL IN A GLANCE



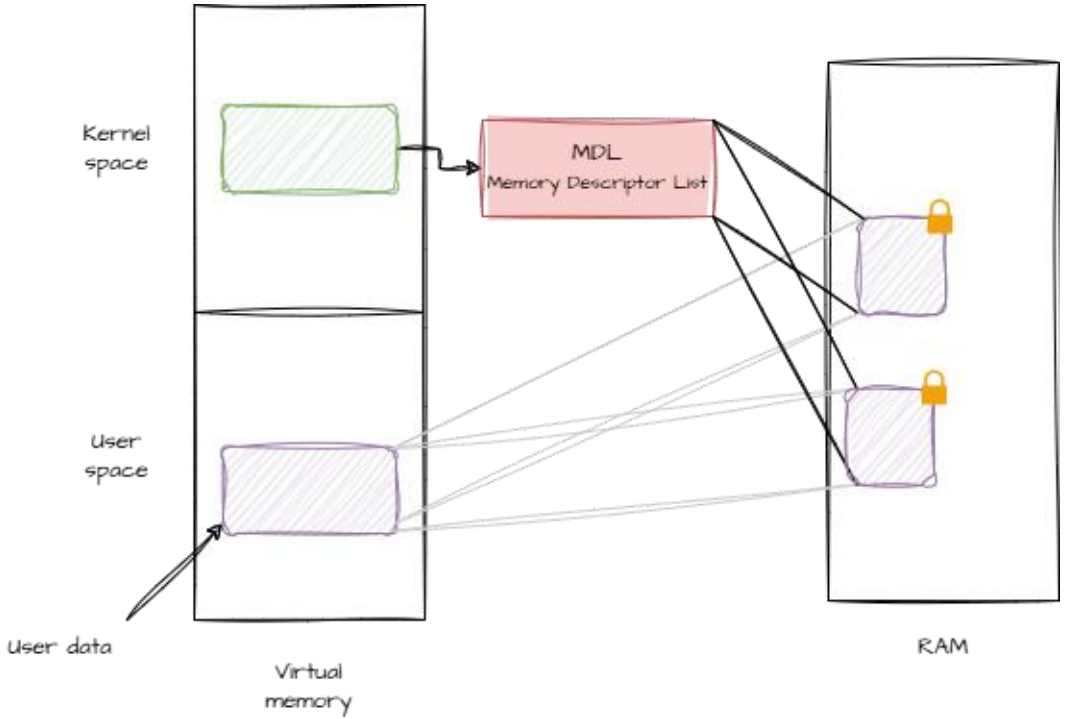
APARTÉ – AN MDL IN A GLANCE



APARTÉ – AN MDL IN A GLANCE



APARTÉ – AN MDL IN A GLANCE

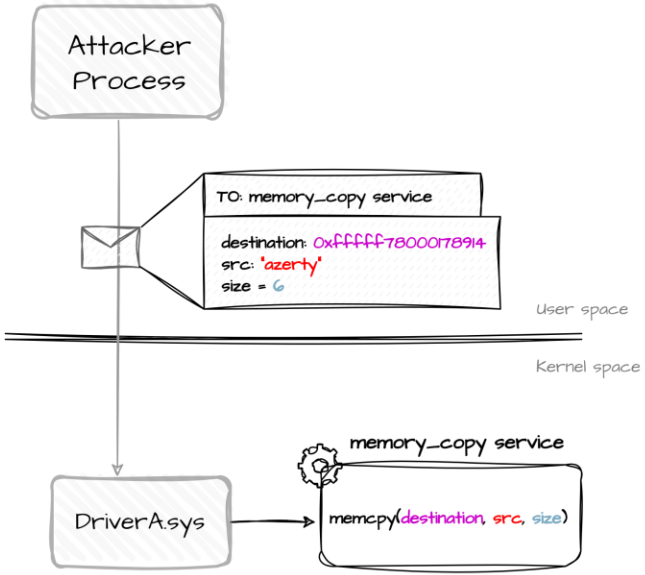


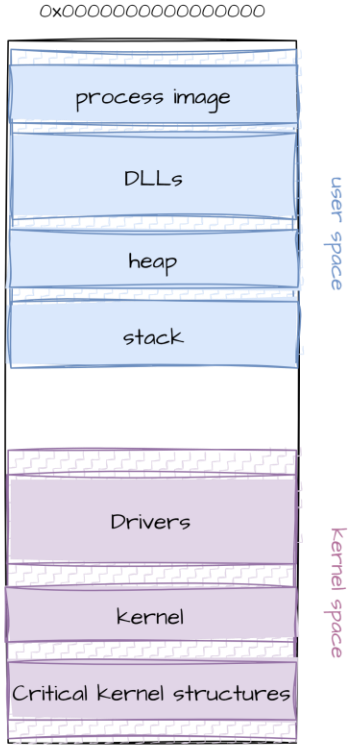
KERNEL CODE EXECUTION – CARTOGRAPHY FINDING 4

```
mdl_address_source = IoAllocateMdl(packet->va_address_source, packet->size, 0, AccessMode_UserMode, 0);
MmProbeAndLockPages(mdl_address_source, AccessMode_UserMode, 0);
void* va_system_address_source = MmMapLockedPagesSpecifyCache(mdl_address_source, ...);


int64_t phy_address_destination = MmGetPhysicalAddress(packet->va_address_destination);
if (/* some conditions*/)
{
    int64_t va_system_address_destination = MmMapIoSpace(phy_address_destination, packet->size, 0);
    __builtin_memcpy(va_system_address_destination, va_system_address_source, packet->size);
}
```

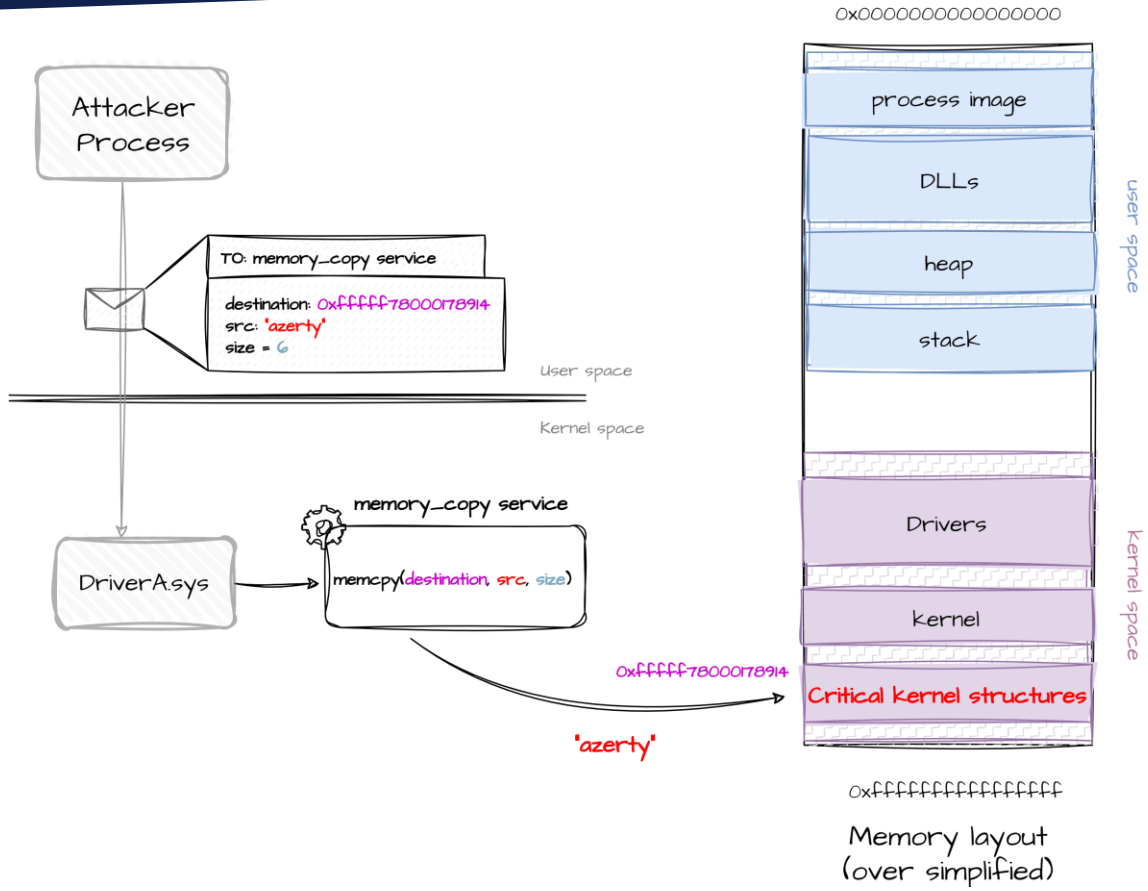
KERNEL CODE EXECUTION – CARTOGRAPHY FINDING 4





Memory layout (over simplified)

KERNEL CODE EXECUTION – CARTOGRAPHY FINDING 4



KERNEL CODE EXECUTION – CARTOGRAPHY FINDING 4

- **Veeery** powerful primitive

- Privilege escalation : easy

- Code execution : not that hard but
  - `MmMapIoSpace()` can't map page tables
    → Can't get rid of DEP nor SMEP
  - One solution: get a **new write primitive** from the first one

Conclusion

Quarkslab

CONCLUSION

- AVs are huge and complex by nature

  ➡ **Attack surface is really important**
  (can even lower overall security)

- Loads of stuff to check

  ➡ **Audits can be tedious and time-consuming**

CONCLUSION

- Find the entry points and prioritize them

  ➡ **Perform a thorough cartography**

- Not necessarily over-complicated!

  ➡ **Being smart brings results**

Thank you

Contact information:

Email: contact@quarkslab.com

Phone: +33 1 58 30 81 51

Website: quarkslab.com

@quarkslab

Quarkslab