



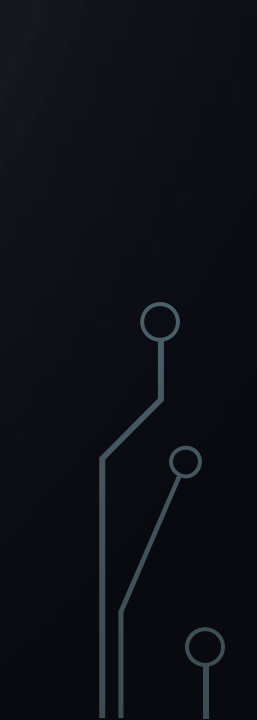
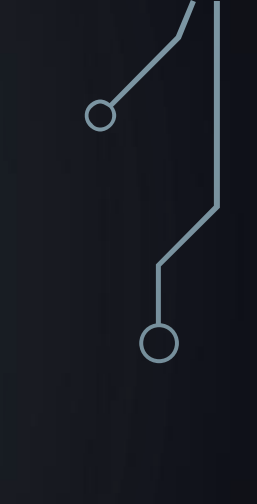

VULNERABILITY IS A LUCKY BUG

BY ARTEM SHISHKIN




DISCLAIMER

I am presenting the contents of this presentation in my personal capacity. The views expressed are solely my own and do not necessarily reflect the views of Intel Corporation or its affiliates.





WHOAMI

- Security researcher at Intel Corporation
 - Intel STORM team member
 - Windows kernel enthusiast
- 



SPOT THE POTENTIAL BUG

```
int CaptureInput(PINPUT_TYPE pInputStruct)
{
    if (pInputStruct->OptionalDataSize > MAX_OPTIONAL_DATA_SIZE)
        return -EINVAL;
    memcpy(pTarget, pInputStruct->OptionalData,
        pInputStruct->OptionalDataSize);

    return 0;
}
```

HERE IT IS

```
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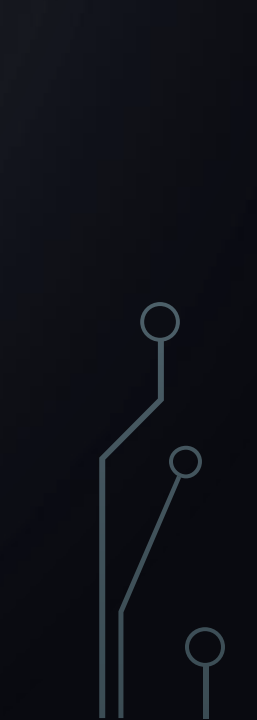
    return 0;
}
```

The image features a dark blue background with white, stylized circuit board traces in the corners. These traces consist of straight lines and small circles, resembling electronic components or connections. The traces are located in the top-left, top-right, bottom-left, and bottom-right corners, framing the central text.

HOW LUCKY THIS BUG IS SUPPOSED TO BE TO
BECOME A SECURITY ISSUE?



SINGLE THREADED ENVIRONMENT

- Not exploitable
 - Well, who is going to attack the value otherwise?
- 
- 

SINGLE THREADED ENVIRONMENT

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```
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MULTITHREADED ENVIRONMENT

- Code is executed within the threads
- Thread is a basic scheduling unit on Windows
- Thread quantum is large (measured in milliseconds)
 - The race window is too small compared to the quantum duration
- Not exploitable in this case
 - Could be in a case with scheduling interruption in the race window

MULTITHREADED ENVIRONMENT

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```
int CaptureInput(PINPUT_TYPE pInputStruct)
{
    if (pInputStruct->OptionalDataSize > MAX_OPTIONAL_DATA_SIZE)
        return -EINVAL;
    sleep(3000);
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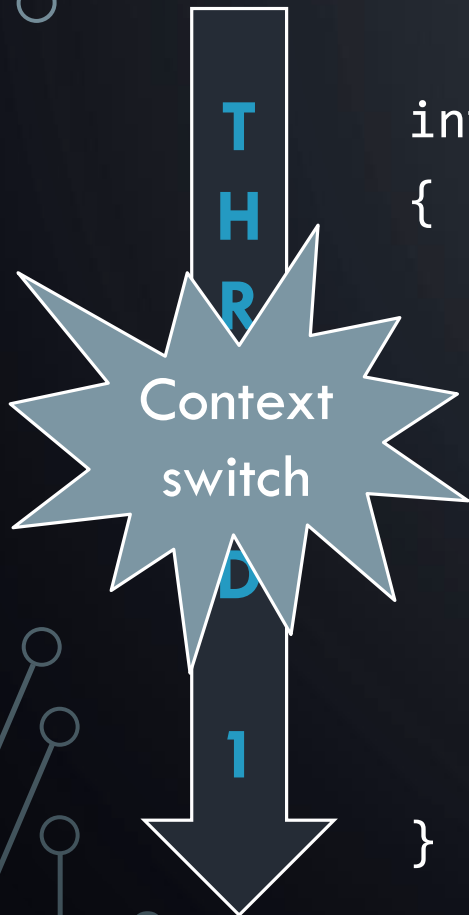
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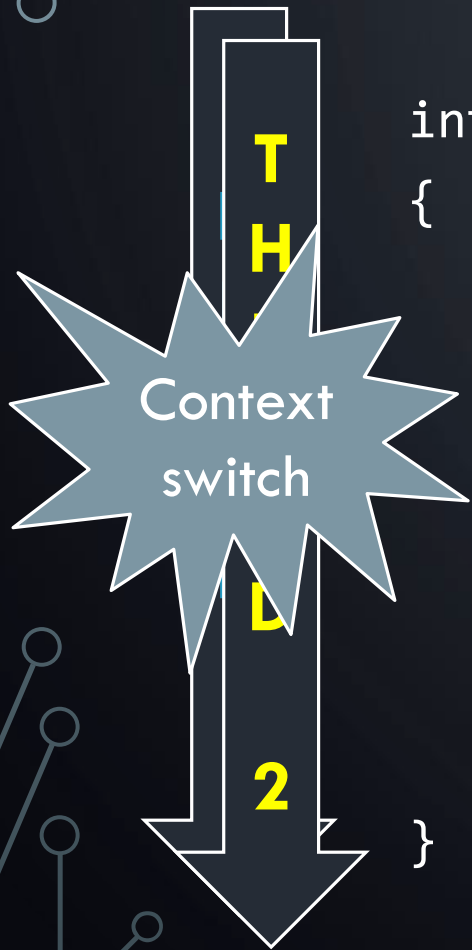

MULTITHREADED ENVIRONMENT

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MULTITHREADED ENVIRONMENT



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MULTITHREADED MULTICORE ENVIRONMENT

- CPU cores execute code simultaneously
- So we can schedule thread execution on different CPU cores
- So, exploitable?

MULTITHREADED MULTICORE ENVIRONMENT

**E
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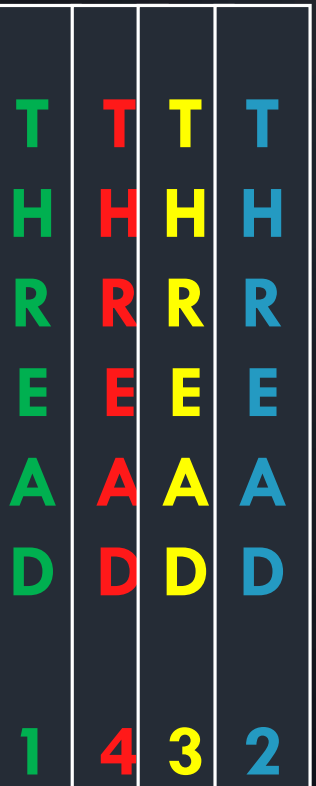
MULTITHREADED MULTICORE ENVIRONMENT



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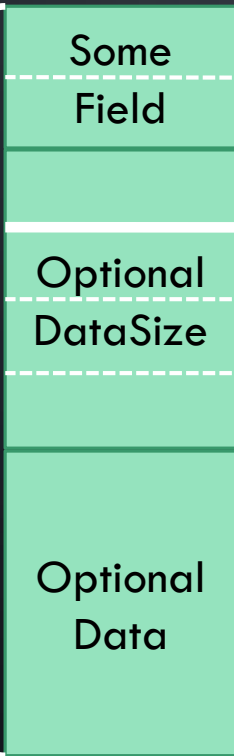
    return 0;
}
```


RACE COMPETITION

- Thread 1 executes the vulnerable code
- Thread 2 is trying to modify the controlled data in the structure
- Slow down the first thread
 - Place the data on a page boundary for the first thread
 - Keep flipping the attacked value in the second thread
 - Flip only the part that is spread on a single page

PAGE BOUNDARY

Input
Struct



ADDRESS
0xXXXXXFFE
0xXXXXXFFF
0xXXXXY000
0xXXXXY001
0xXXXXY002

PAGE BOUNDARY

MEMORY LAYOUT

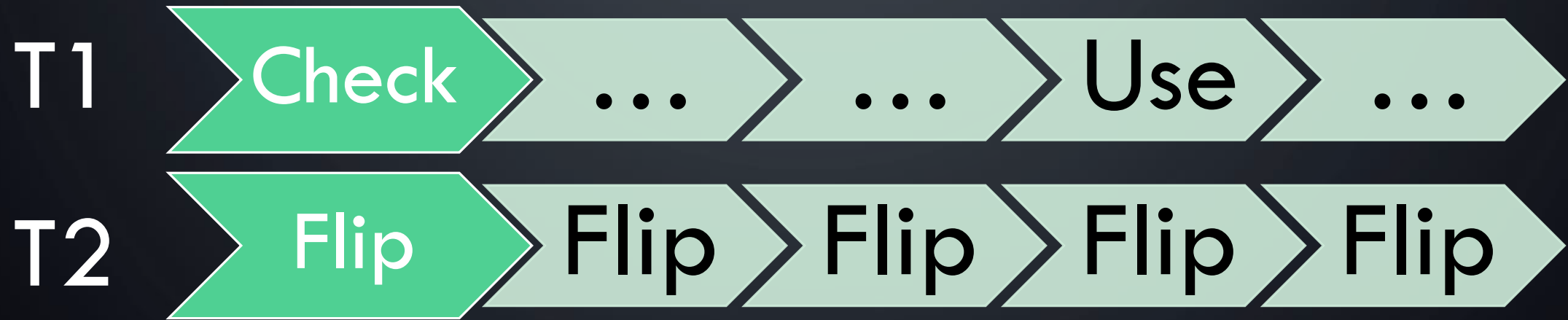
```
0: kd> dt someapp!_INPUT_TYPE 0x00000207`f0590ffb
```

```
+0x000 SomeField      : 2  
+0x004 OptionalDataSize : 4  
+0x008 OptionalData   : [1] "A"
```

```
0: kd> db 0x00000207`f0590ff0
```

```
00000207`f0590ff0  00 00 00 00 00 00 00 00-00 00 00 02 00 00 00 04 .....  
00000207`f0591000  00 00 00 41 41 41 41 41-41 41 41 41 41 41 41 ...AAAAAAAAAAAAA  
00000207`f0591010  41 41 41 41 41 41 41 41-41 41 41 41 41 41 41 AAAAAAAAAAAAAAAAA  
00000207`f0591020  41 41 41 41 41 41 41 41-41 41 41 41 41 41 41 AAAAAAAAAAAAAAAAA
```

RACE COMPETITION

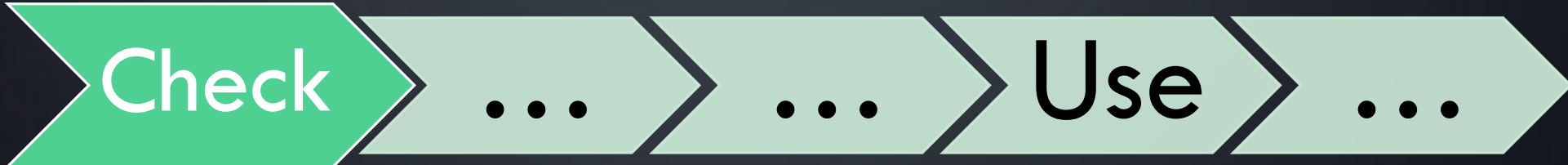


RACE COMPETITION

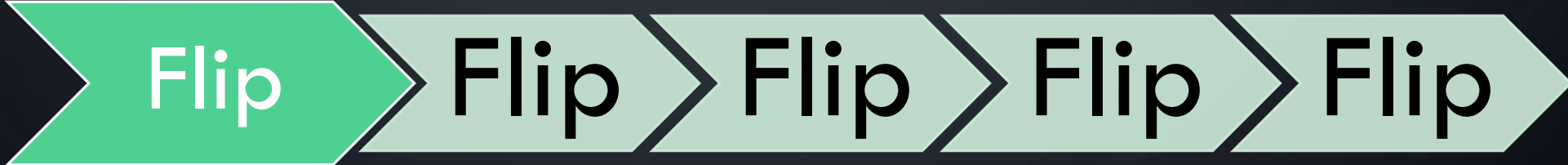
SIZE > 200?



T1

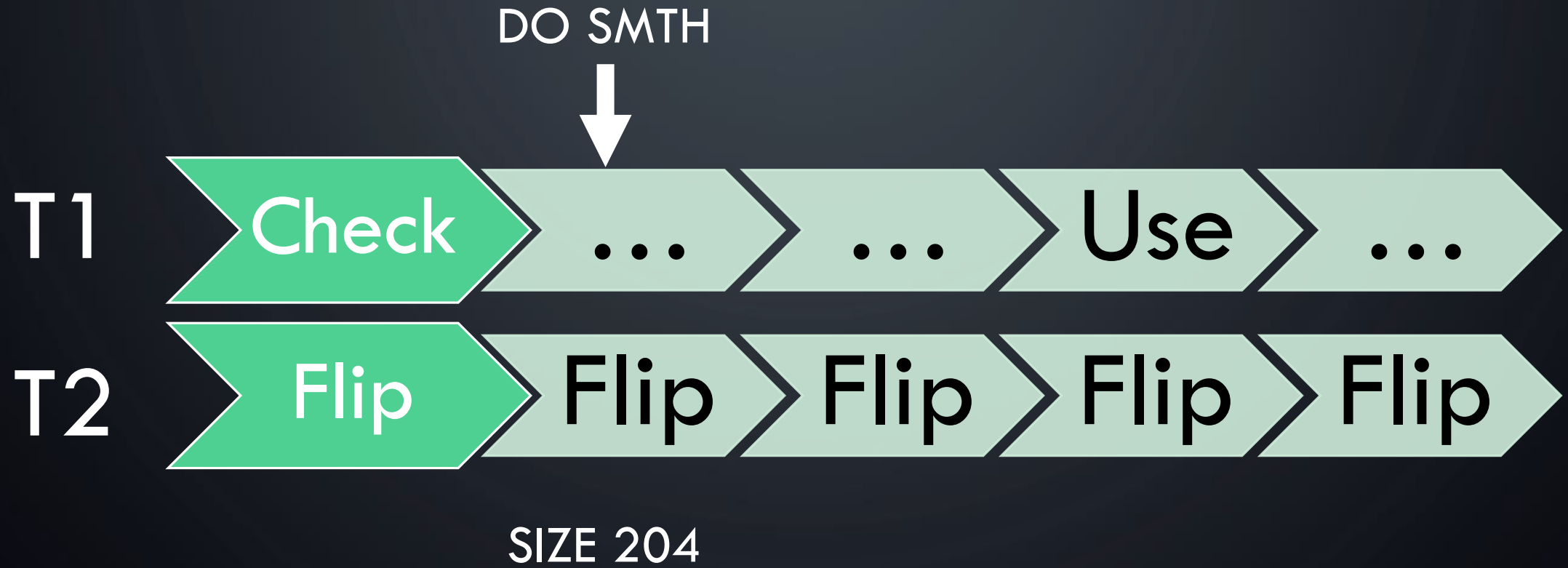


T2



SIZE 4

RACE COMPETITION

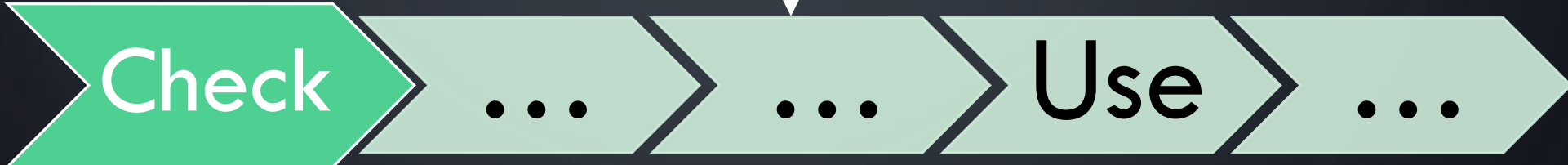


RACE COMPETITION

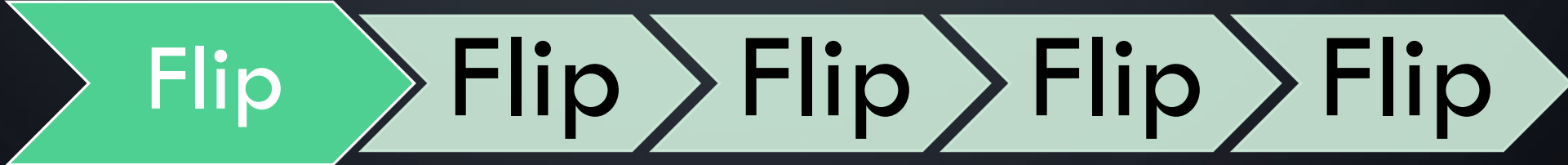
DO SMTH



T1



T2



SIZE 4

RACE COMPETITION

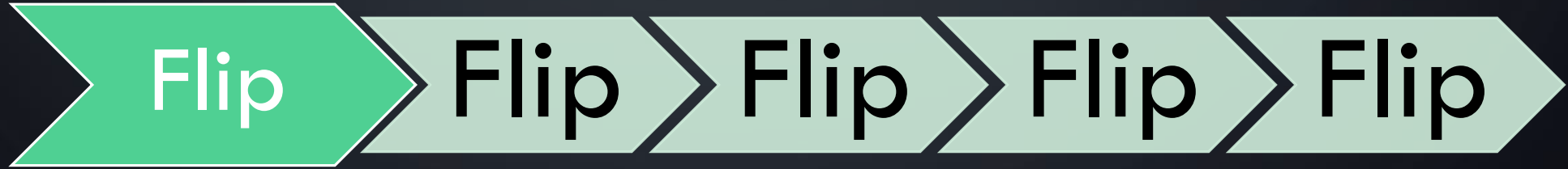
MEMCOPY



T1



T2



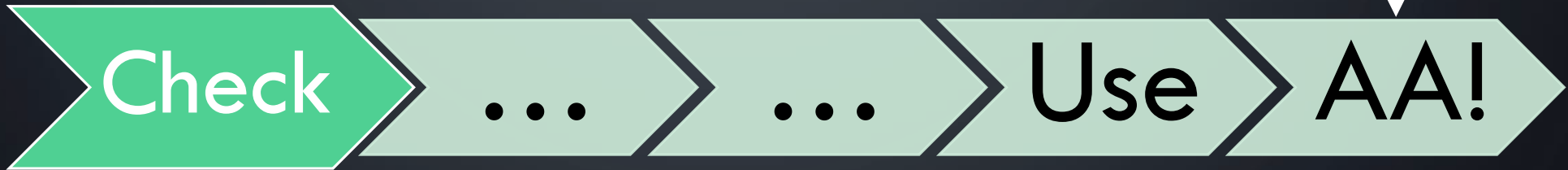
SIZE 204

RACE COMPETITION

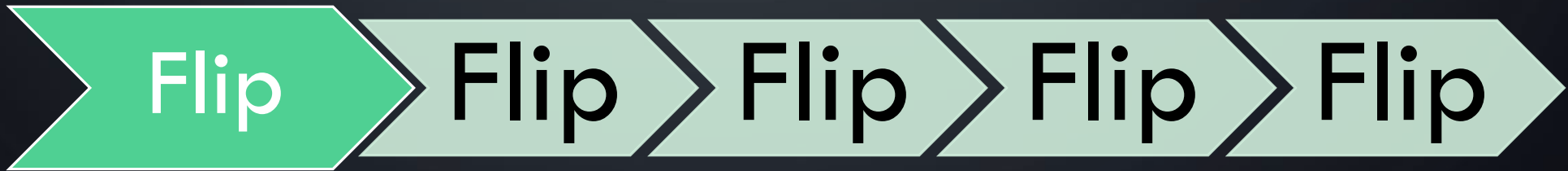
PWNED



T1

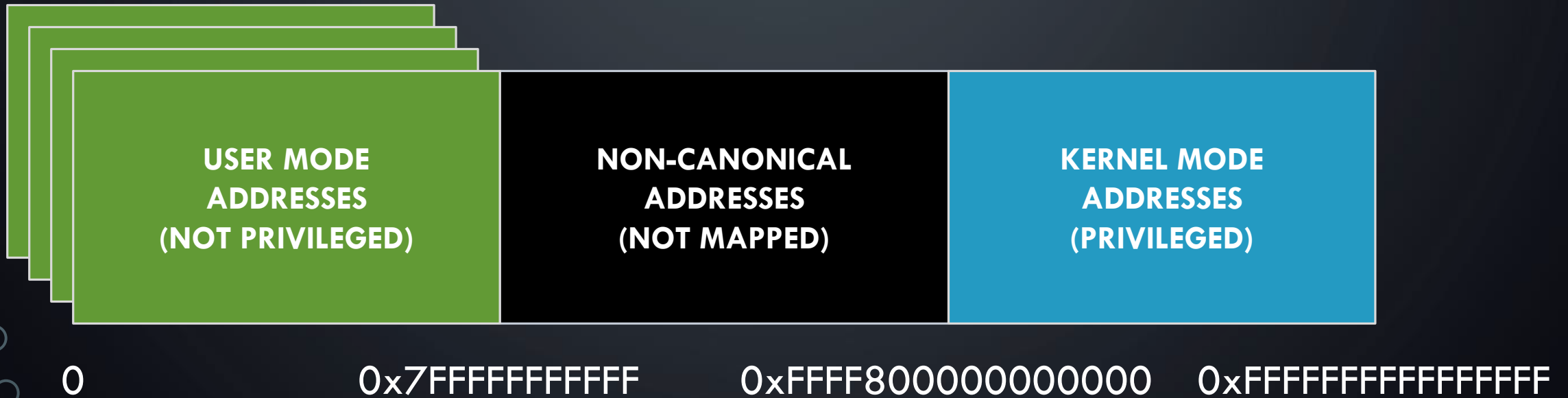


T2



SIZE 4

WINDOWS VIRTUAL ADDRESS SPACE LAYOUT (X64)





DEMO

LET'S WINDBG THIS



WINNER WINNER CHICKEN DINNER

- This doesn't lead to the code execution anyway
- Chaining with some other bug needed
- Every exploitation path is unique
 - Depends on the environment
 - Depends on input limitation
 - Depends on reachability

CODE EXEC GAINED

- What's the impact?
 - Privilege escalation
 - Remote code execution
 - Guest to admin
 - User to kernel
 - Trust boundary violation
 - Sensitive data leak
 - Media impact

The image features a dark blue background with white, stylized circuit board traces in the corners. These traces consist of straight lines of varying lengths and angles, ending in small white circles that represent components or connection points. The traces are located in the top-left, top-right, bottom-left, and bottom-right corners, framing the central text.

BUT IT HAS TO BE FOUND FIRST

DETECTION PRINCIPLES

- Detect consecutive memory accesses
- Static
 - Lack of runtime info
- Dynamic
 - Coverage issues

DYNAMIC DETECTION APPROACH

- This is an example for Windows kernel vulnerabilities
- Using the full system emulation
 - Bochs (bochspwn)
 - Simics
- Using the live system
 - SMAP_wn

BOCHSPWN

- By Mateusz "j00ru" Jurczyk and Gynvael Coldwind
 - <https://research.google.com/pubs/archive/42189.pdf>
- Slow but reliable
- Open source
 - <https://github.com/googleprojectzero/bochspwn>
- Can also try info leaks



SIMICS BASED TRACKER

- BSDaemon and NadavCh did that using Simics
 - https://github.com/rrbranco/poc_gtfo/blob/master/pocorgtfo15.pdf
- Simics is not a public tool



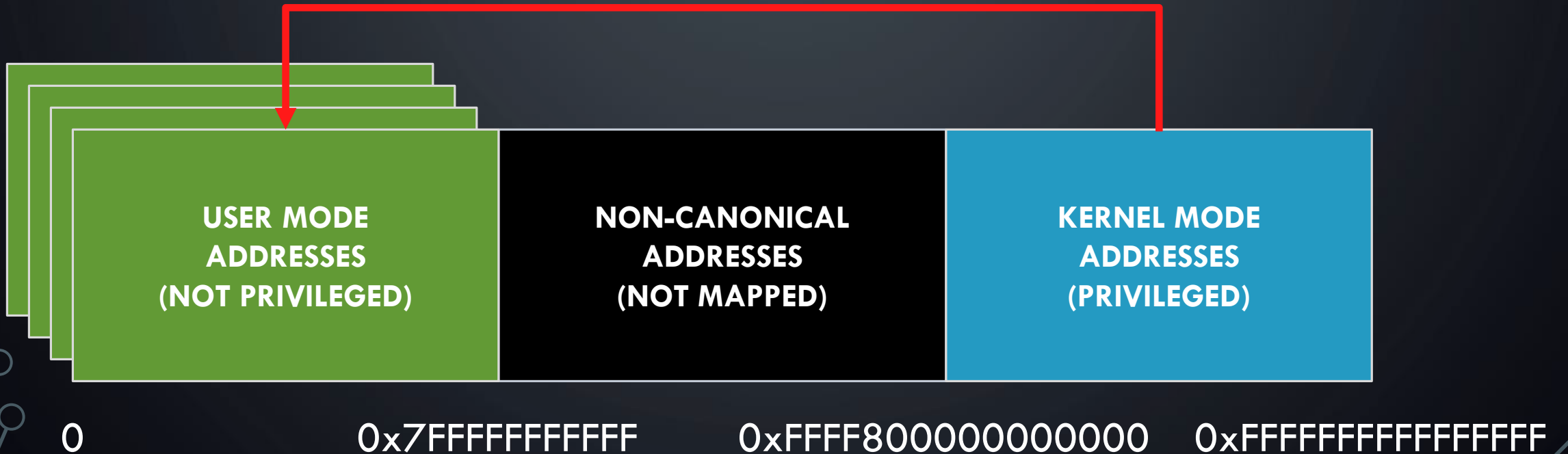
SMAPWN WINDBG PLUGIN

- By me
- Thoroughly described at H2HC 2018
 - <https://github.com/h2hconference/2018>
- The plugin is still not released
 - But can be easily reproduced



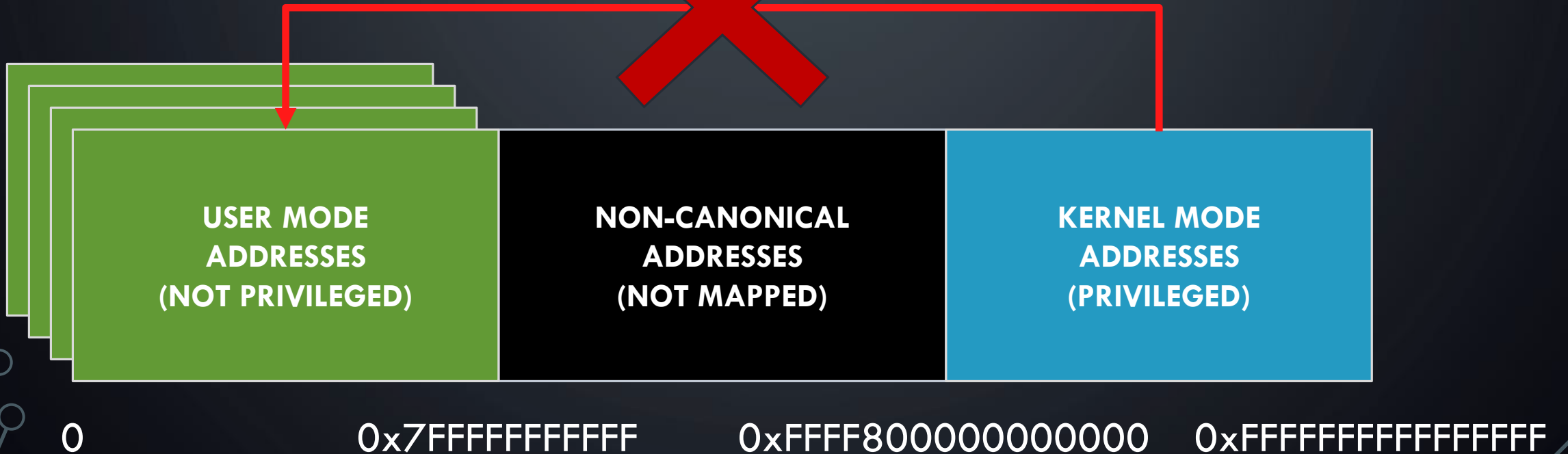
SUPERVISOR MODE ACCESS PREVENTION OFF

MEMORY ACCESS




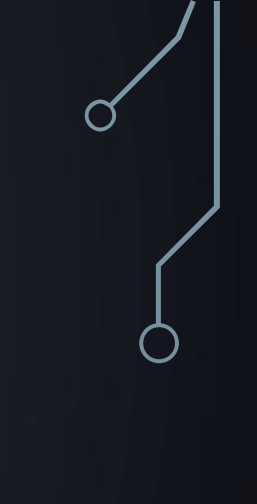
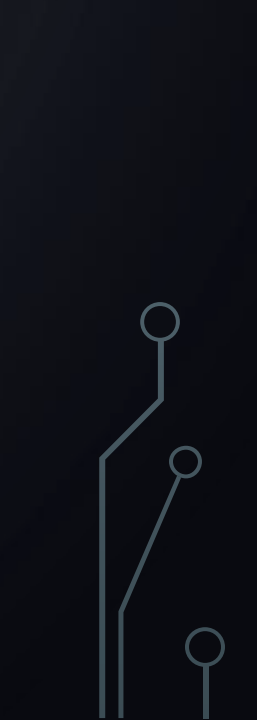
SUPERVISOR MODE ACCESS PREVENTION ON

MEMORY ACCESS





SUMMARY

- The bug has to be found
 - The bug has to be reachable
 - The bug has to be controlled
 - The environment has to be aligned
 - Security premise must be broken
 - Someone must care about it
- 
- 
- 

THE FIX

```
int CaptureInput(PINPUT_TYPE pInputStruct)
{
    int OptionalSize = pInputStruct->OptionalDataSize;
    if (OptionalSize > MAX_OPTIONAL_DATA_SIZE)
        return -EINVAL;
    memcpy(pTarget, pInputStruct->OptionalData, OptionalSize);

    return 0;
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```

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THANKS AND HAPPY FISHING!