JD-HITBSECCONF2018

BEIJING

THE FIRST HITB SECURITY CONFERENCE IN CHINA!

JD-HITBSECCONF2018

OFFENSIVE MEMORY FORENSICS

Hugo Teso

@hteso

TESO

VS

TUOMINEN

MAIN MENU

TESO

STORY MODE

TRAINING MODE

VS MODE

GOD MODE

TUOMINEN

MAIN MENU

STORY MODE

TRAINING MODE

VS MODE

GOD MODE

TESO

TUOMINEN

TESO

KO

TUOMINEN

THE STORY

This is no sauna...

y0 T! I need a new... challenge for next year.
Can you think of something to shoot me?

MEMORY FORENSICS! Defeat memory forensics! It’s hard… you won’t manage :P

GAME OVER

THANK YOU FOR PLAYING!

MAIN MENU

TESO

STORY MODE

TRAINING MODE

VS MODE

GOD MODE

TUOMINEN

TRAINING

Know yourself...

Know your enemy...

TRAINING

1P

2P

TESO

KO

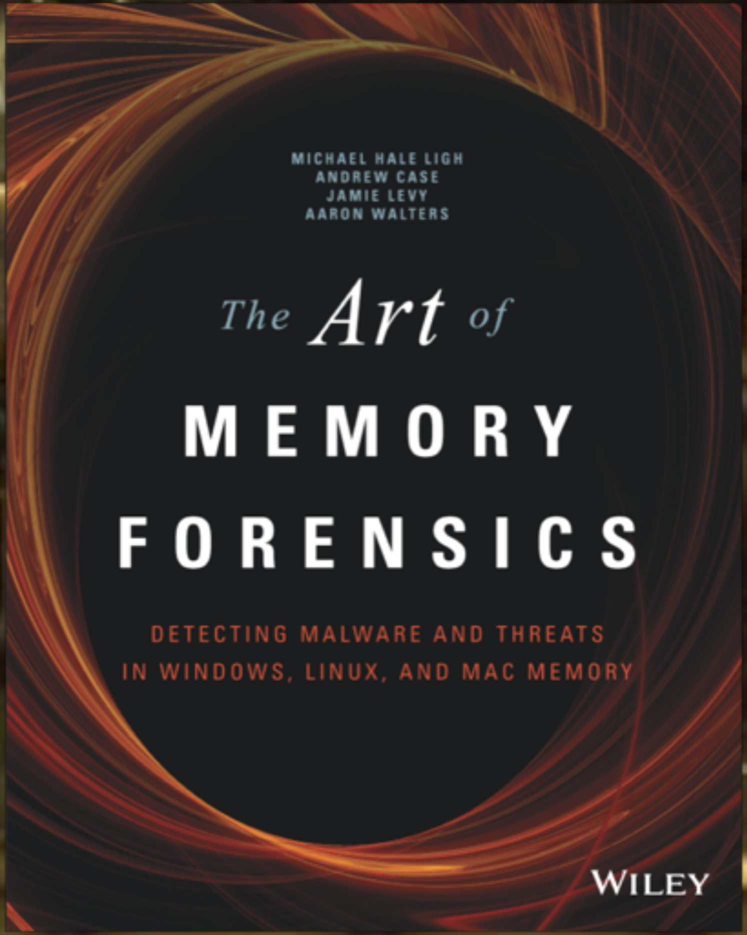
TRAINING

TUOMINEN

No you didn’t

I wrote that book

No I didn’t...



MICHAEL HALE LIGH
ANDREW CASE
JAMIE LEVY
AARON WALTERS

The Art of

MEMORY FORENSICS

DETECTING MALWARE AND THREATS IN WINDOWS, LINUX, AND MAC MEMORY

WILEY

TESO

KO

TRAINING

TUOMINEN

Memory Forensics 101

- Memsics: Memory + Forensics
- One part of DIGITAL FORENSICS
- Analysis of VOLATILE DATA

TESO

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TRAINING

TUOMINEN

MEMORY - FORENSICS

TESO

KO

TRAINING

TUOMINEN

MEMORY - ~~FORENSICS~~

TESO

KO

TRAINING

TUOMINEN

WHICH MEMORY?

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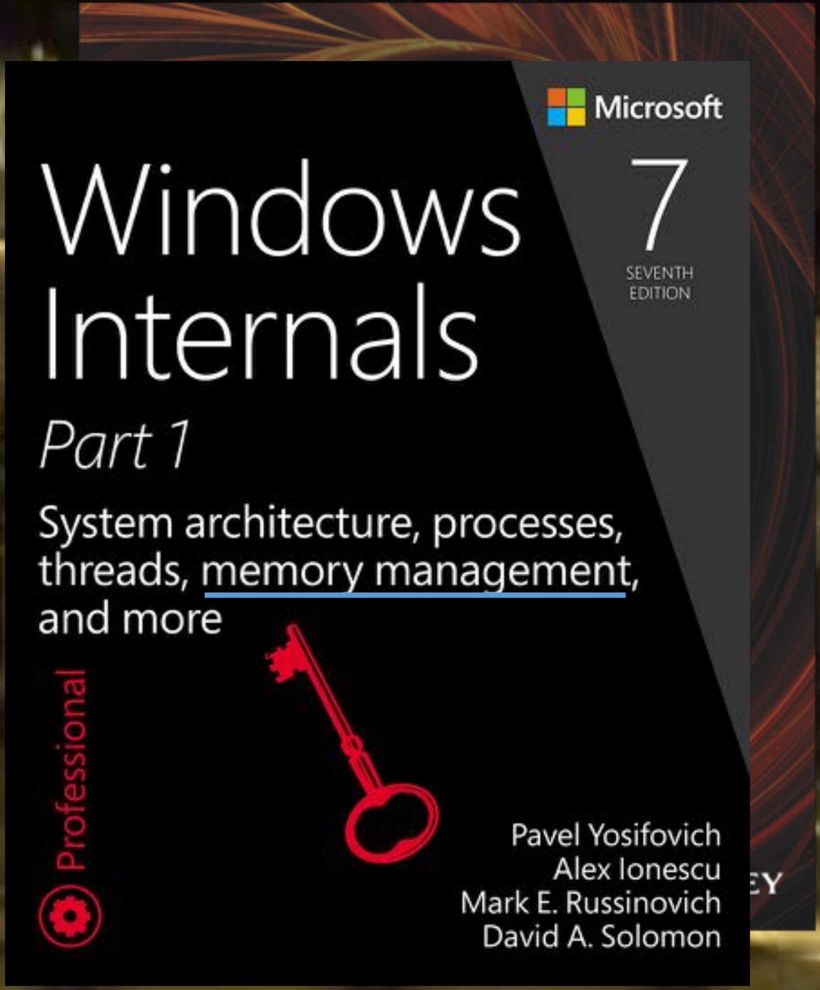
TUOMINEN

Meh...



Microsoft

Windows Internals

Part 1

7

SEVENTH EDITION

System architecture, processes, threads, memory management, and more

Professional

Pavel Yosifovich
Alex Ionescu
Mark E. Russinovich
David A. Solomon

EY

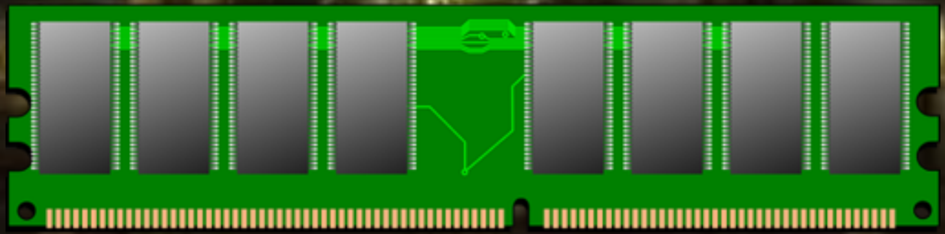
TESO

KO

TRAINING

TUOMINEN

In the beginning was...



RAM

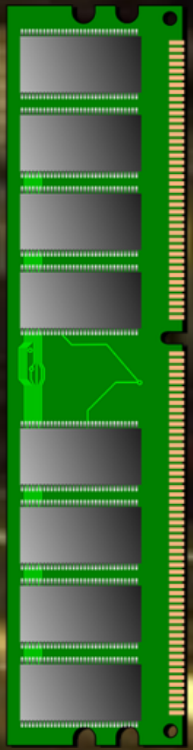
OS (Memsics) doesn't work with "RAM"

VIRTUAL MEMORY

OS (Memsics) doesn't work with "RAM"

VIRTUAL MEMORY

=



RAM

+

...

TESO

KO

TRAINING

TUOMINEN

Wanna know more?

Virtual Memory, in Windows ,is actually a polymorphic term.

- VM = Physical memory + Page file
- VM = the collection of Pages (4KB segments) scattered in memory of a process working set

TESO

KO

TRAINING

TUOMINEN

Virtual Memory, in Windows ,is actually a polymorphic term.

- VM = Physical memory + Page file

TESO

KO

TRAINING

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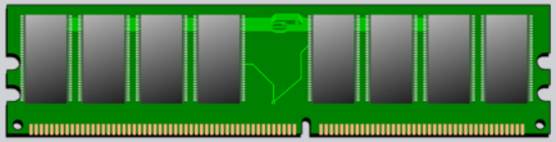
Old fart bad jokes

Brings back memories

Virtual Memory

Physical Memory



Page File

TESO

KO

TRAINING

TUOMINEN

Virtual Memory

Physical Memory

TESO

KO

TRAINING

TUOMINEN

Virtual Memory

- Page 1
- Page 2
- Page 3
- Page n

Physical Memory

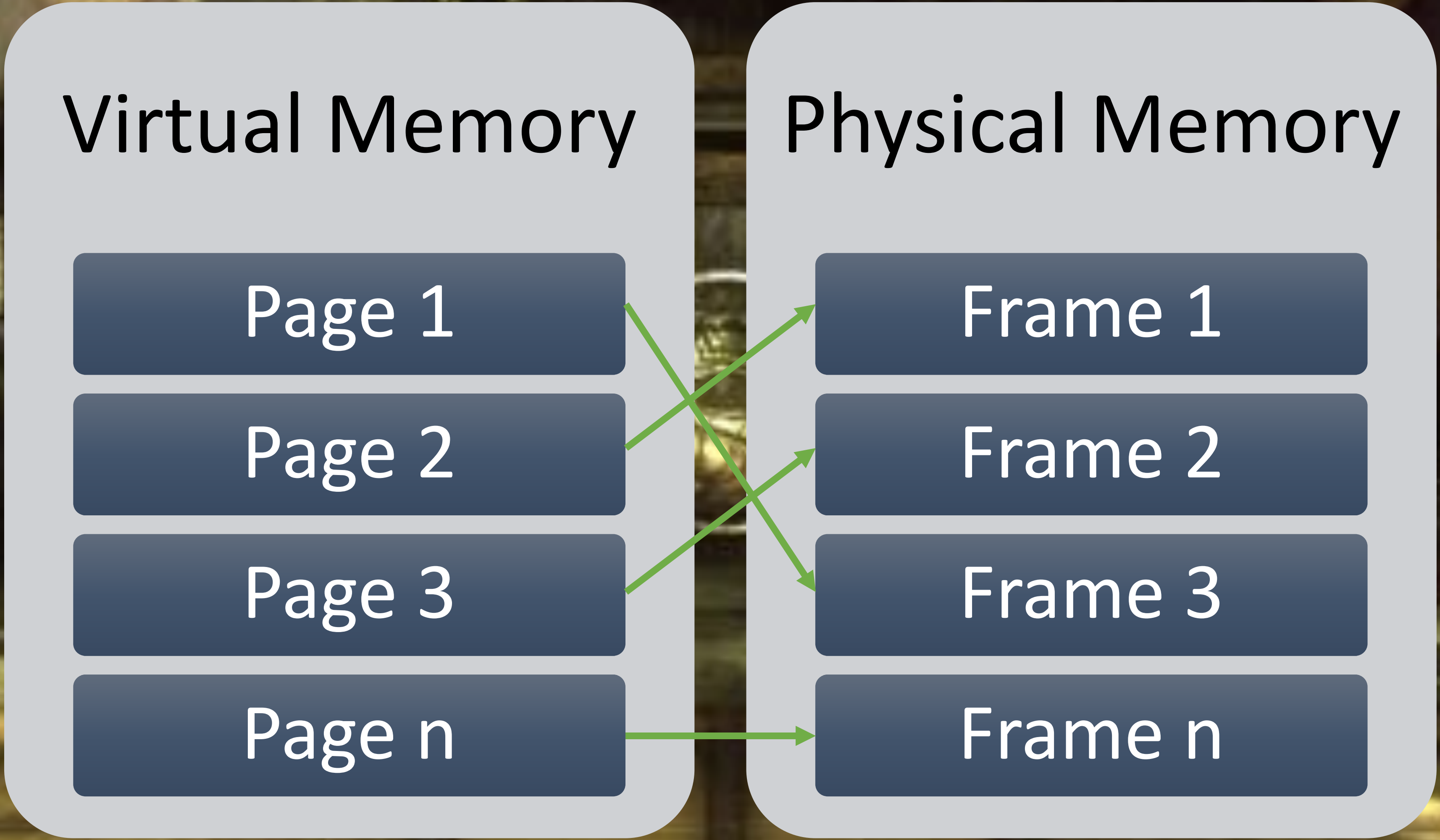
- Frame 1
- Frame 2
- Frame 3
- Frame n

TESO

KO

TRAINING

TUOMINEN



Virtual Memory

Page 1

Page 2

Page 3

Page n

Physical Memory

Frame 1

Frame 2

Frame 3

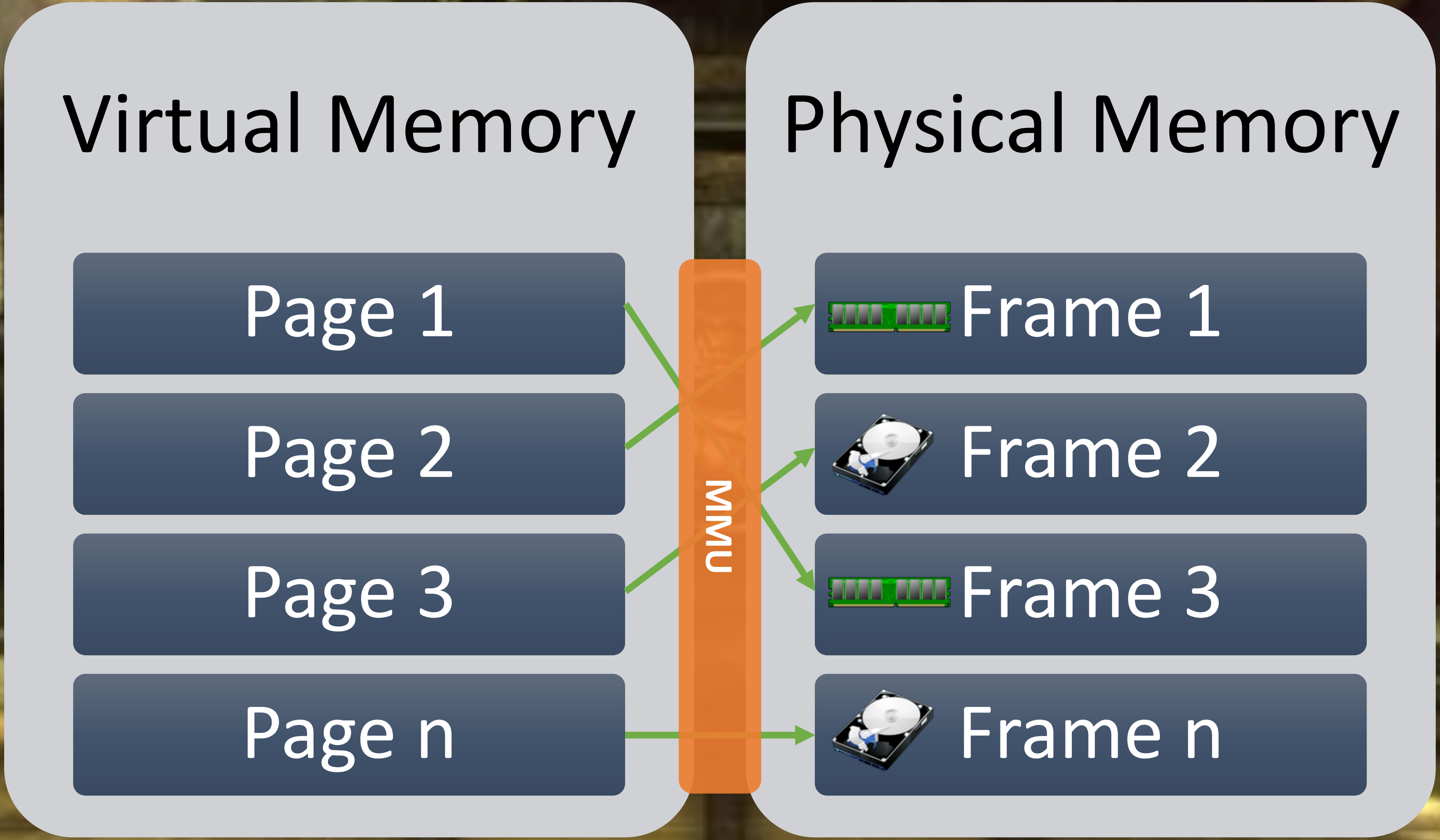
Frame n

TESO

KO

TRAINING

TUOMINEN

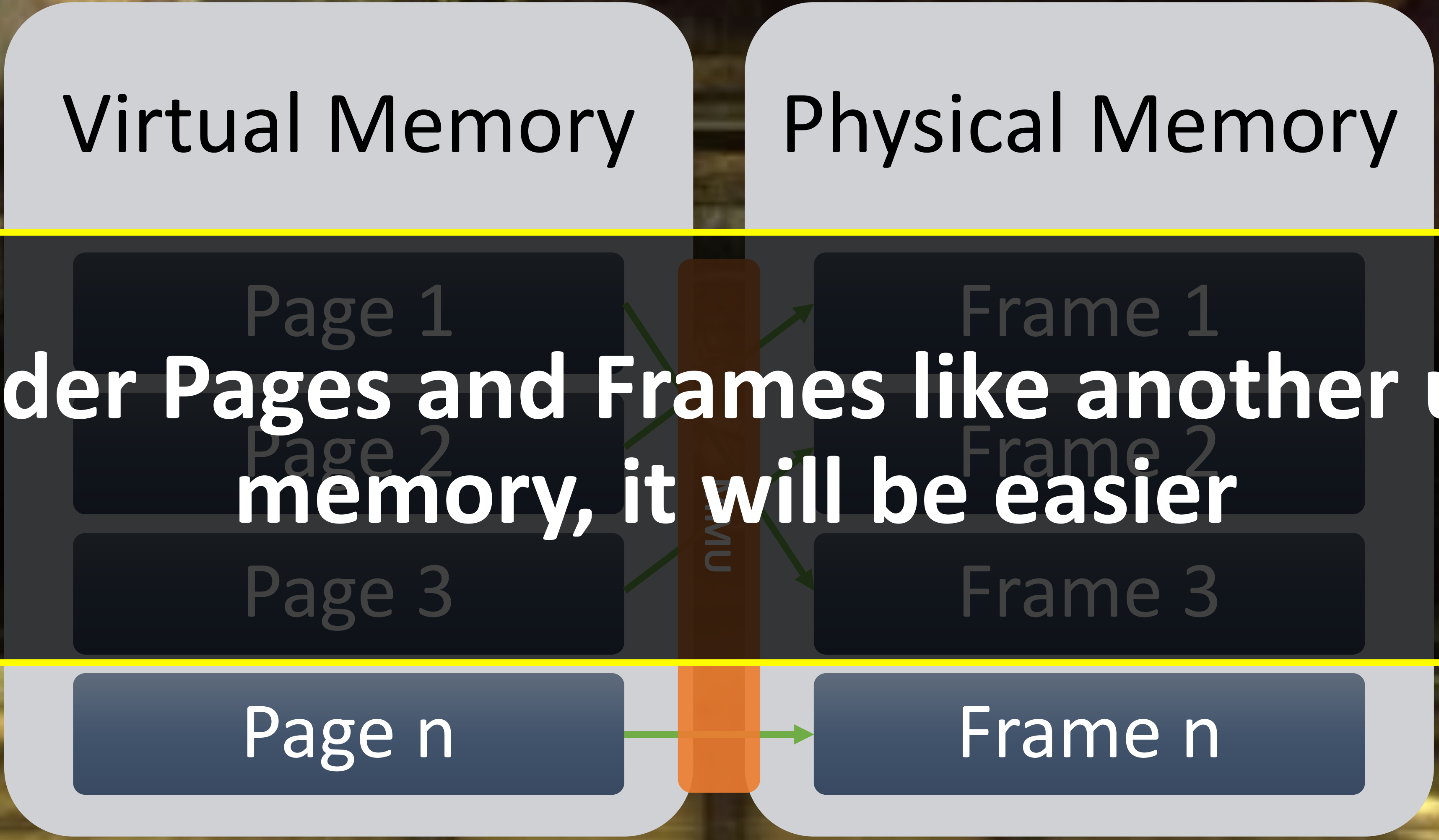


TESO

KO

TRAINING

TUOMINEN

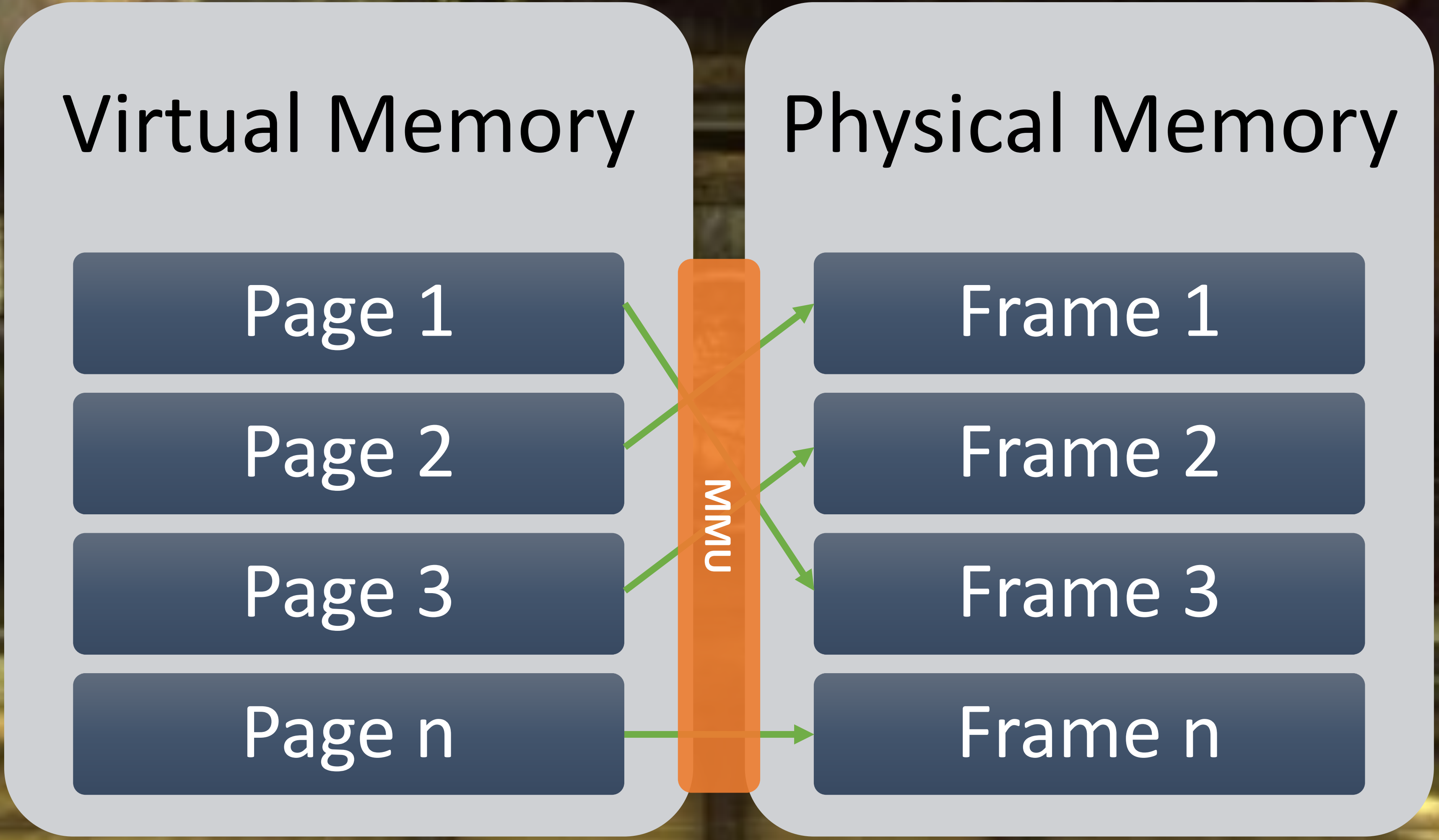


Consider Pages and Frames like another unit of memory, it will be easier

Virtual Memory, in Windows ,is actually a polymorphic term.

- VM = the collection of Pages (4KB segments) scattered in memory of a process working set

TESO
KO
TRAINING
TUOMINEN

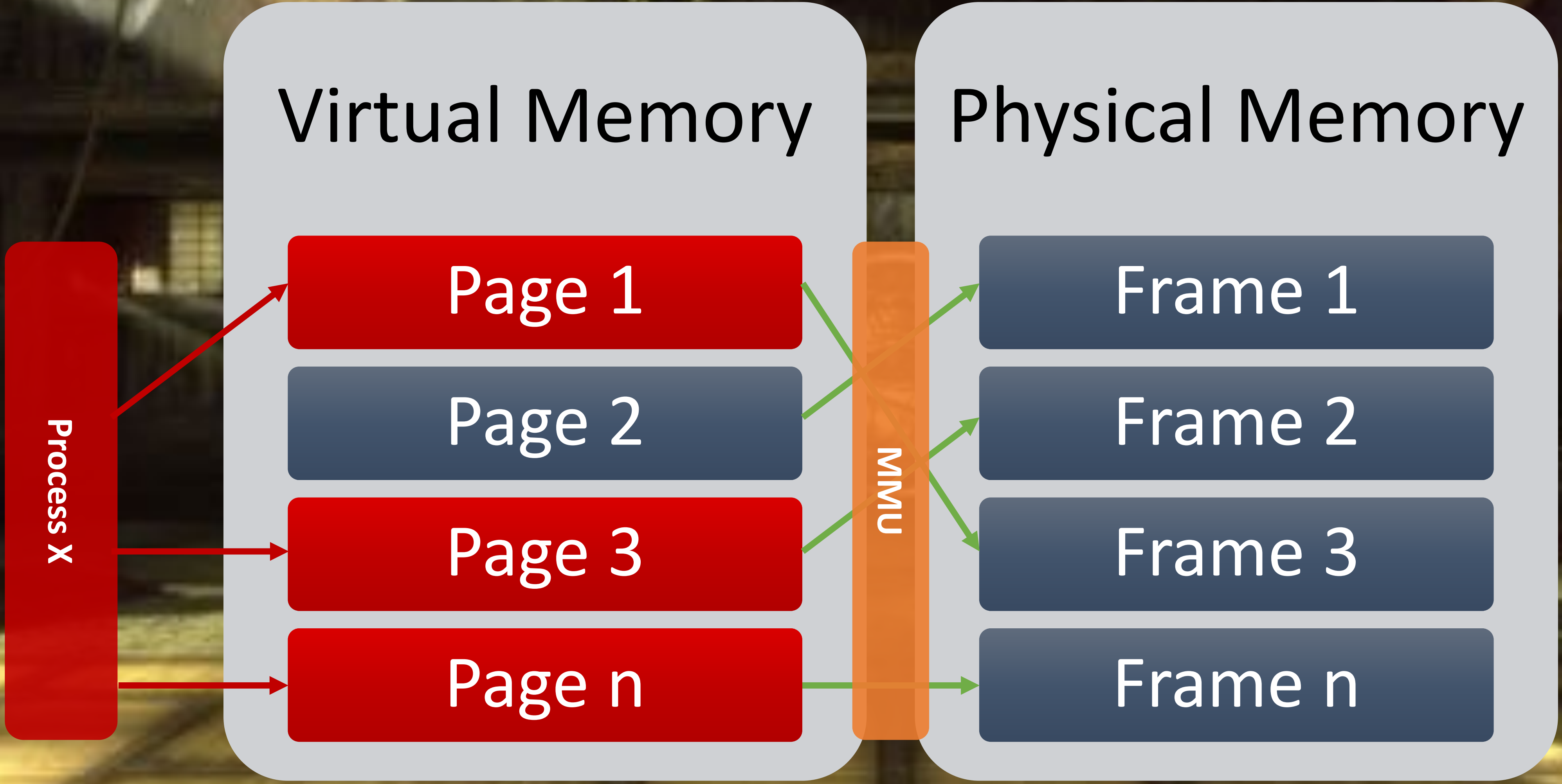

Virtual Memory
Page 1
Page 2
Page 3
Page n
MMU
Physical Memory
Frame 1
Frame 2
Frame 3
Frame n

TESO

KO

TRAINING

TUOMINEN



Virtual Memory

Physical Memory

Process X

Page 1

Page 2

Page 3

Page n

MMU

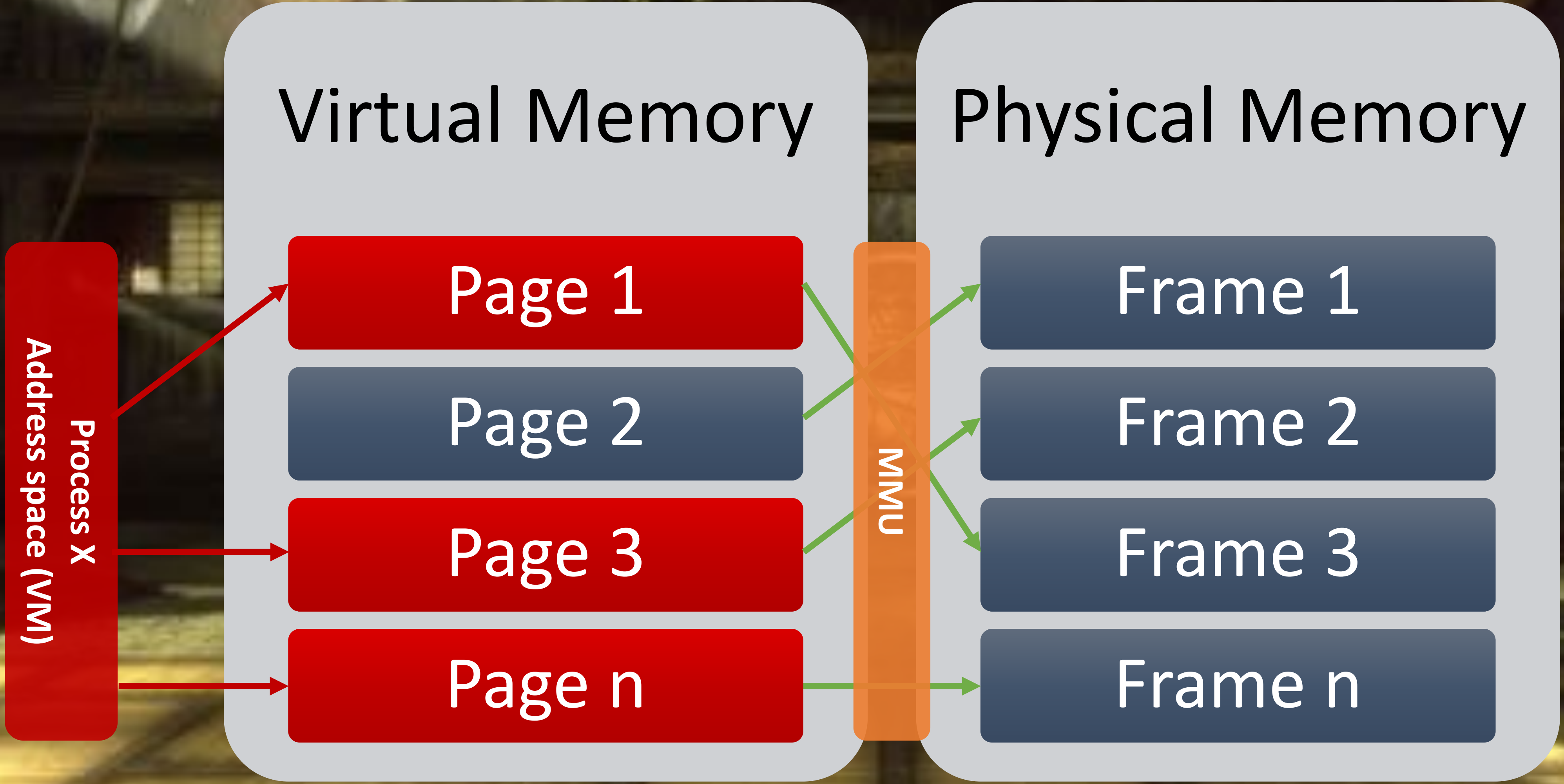
Frame 1

Frame 2

Frame 3

Frame n

KO
TESO
TRAINING
TUOMINEN

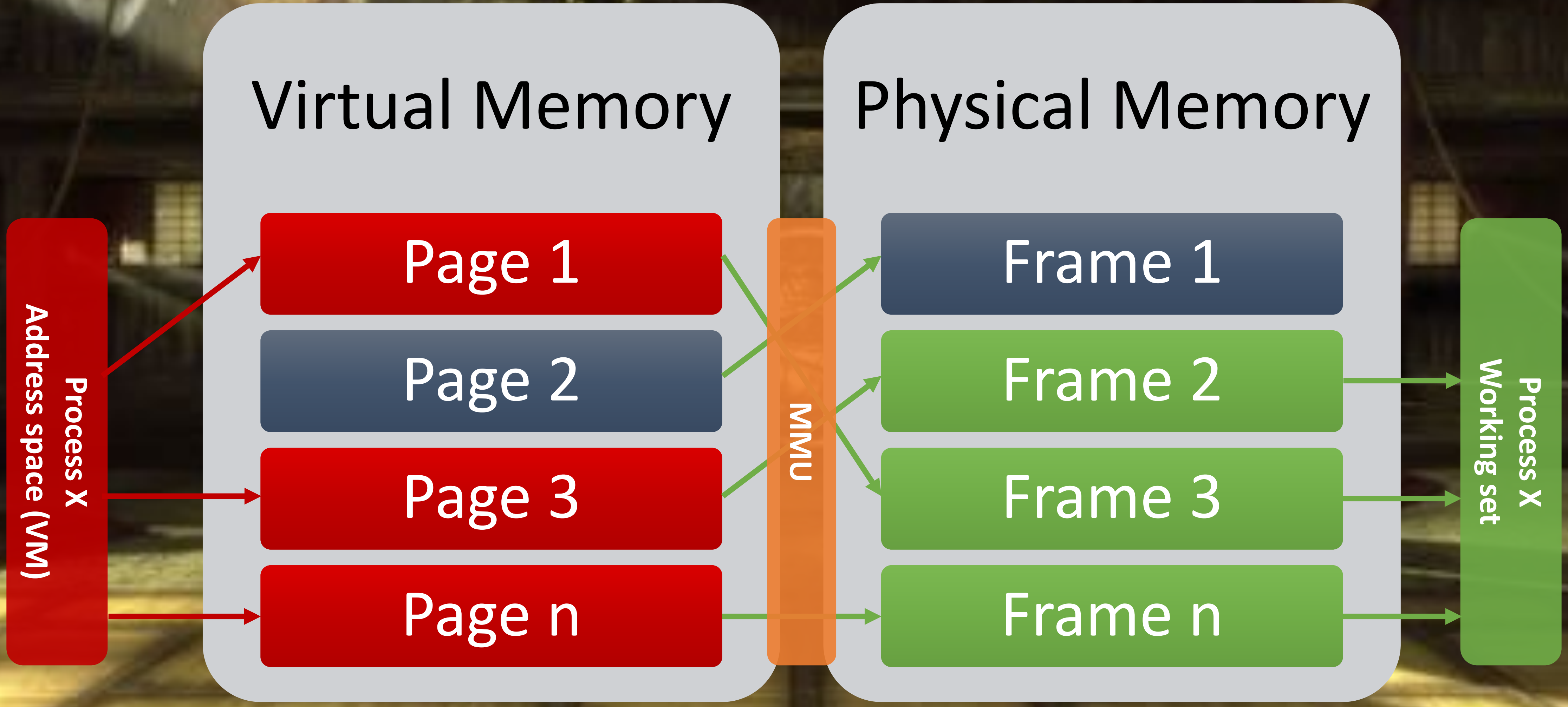

Virtual Memory
Physical Memory
Process X
Address space (VM)
Page 1
Page 2
Page 3
Page n
MMU
Frame 1
Frame 2
Frame 3
Frame n

TESO

KO

TRAINING

TUOMINEN



Virtual Memory

Physical Memory

Process X
Address space (VM)

Page 1

Page 2

Page 3

Page n

MMU

Frame 1

Frame 2

Frame 3

Frame n

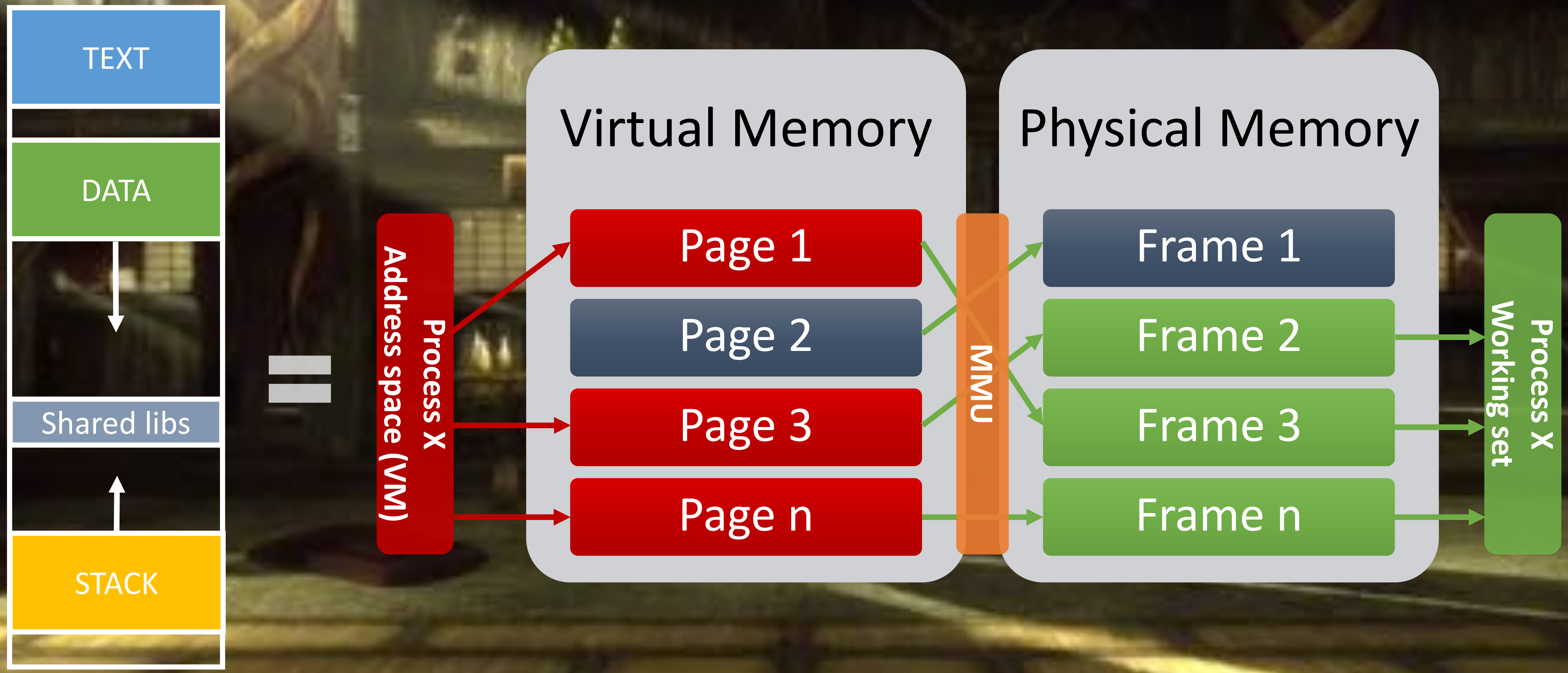
Process X
Working set

TESO

KO

TRAINING

TUOMINEN



TEXT

DATA

Shared libs

STACK

=

Process X
Address space (VM)

Virtual Memory

Page 1

Page 2

Page 3

Page n

MMU

Physical Memory

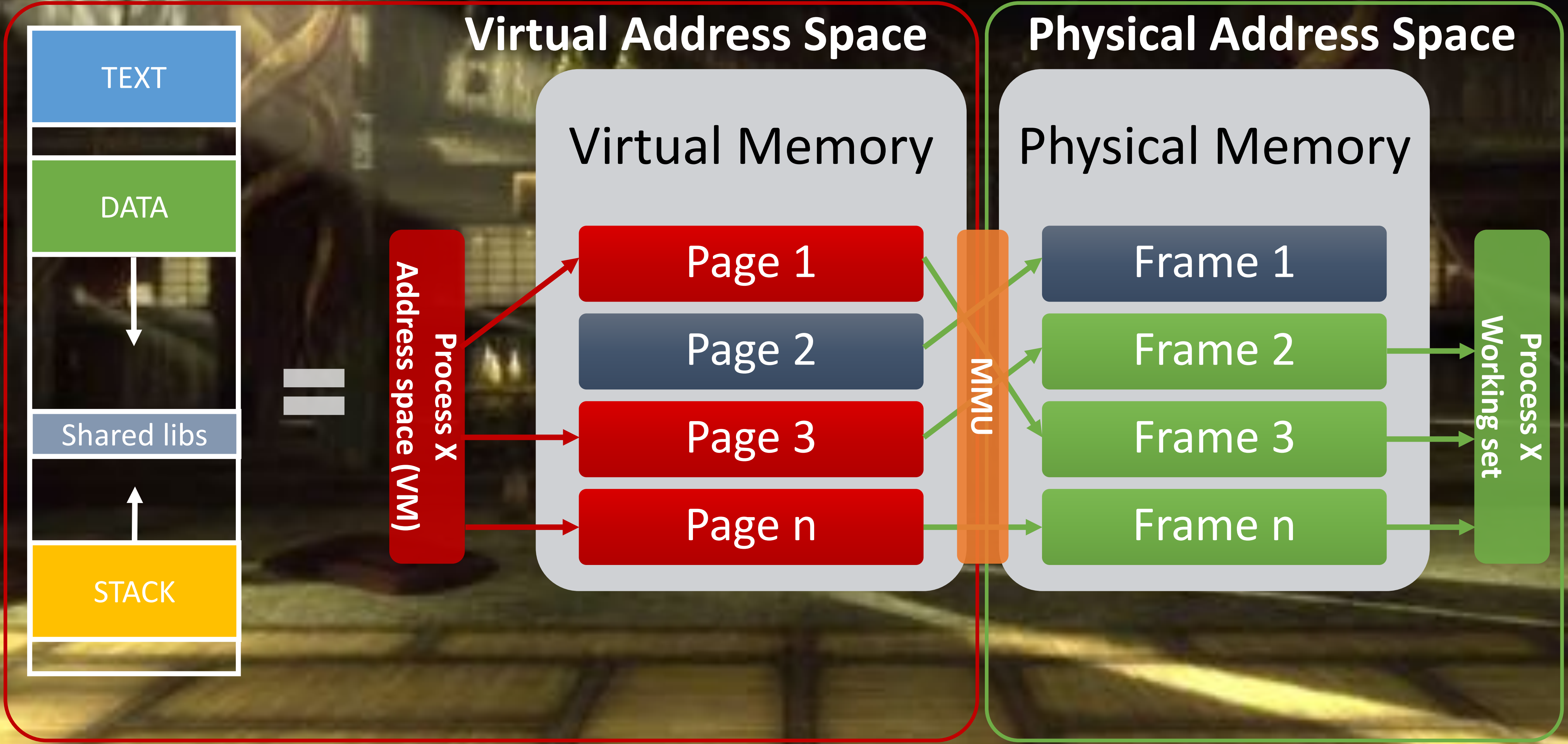
Frame 1

Frame 2

Frame 3

Frame n

Process X
Working set



Virtual Address Space

Physical Address Space

TEXT

DATA

Shared libs

STACK

=

Process X Address space (VM)

Virtual Memory

Page 1

Page 2

Page 3

Page n

MMU

Physical Memory

Frame 1

Frame 2

Frame 3

Frame n

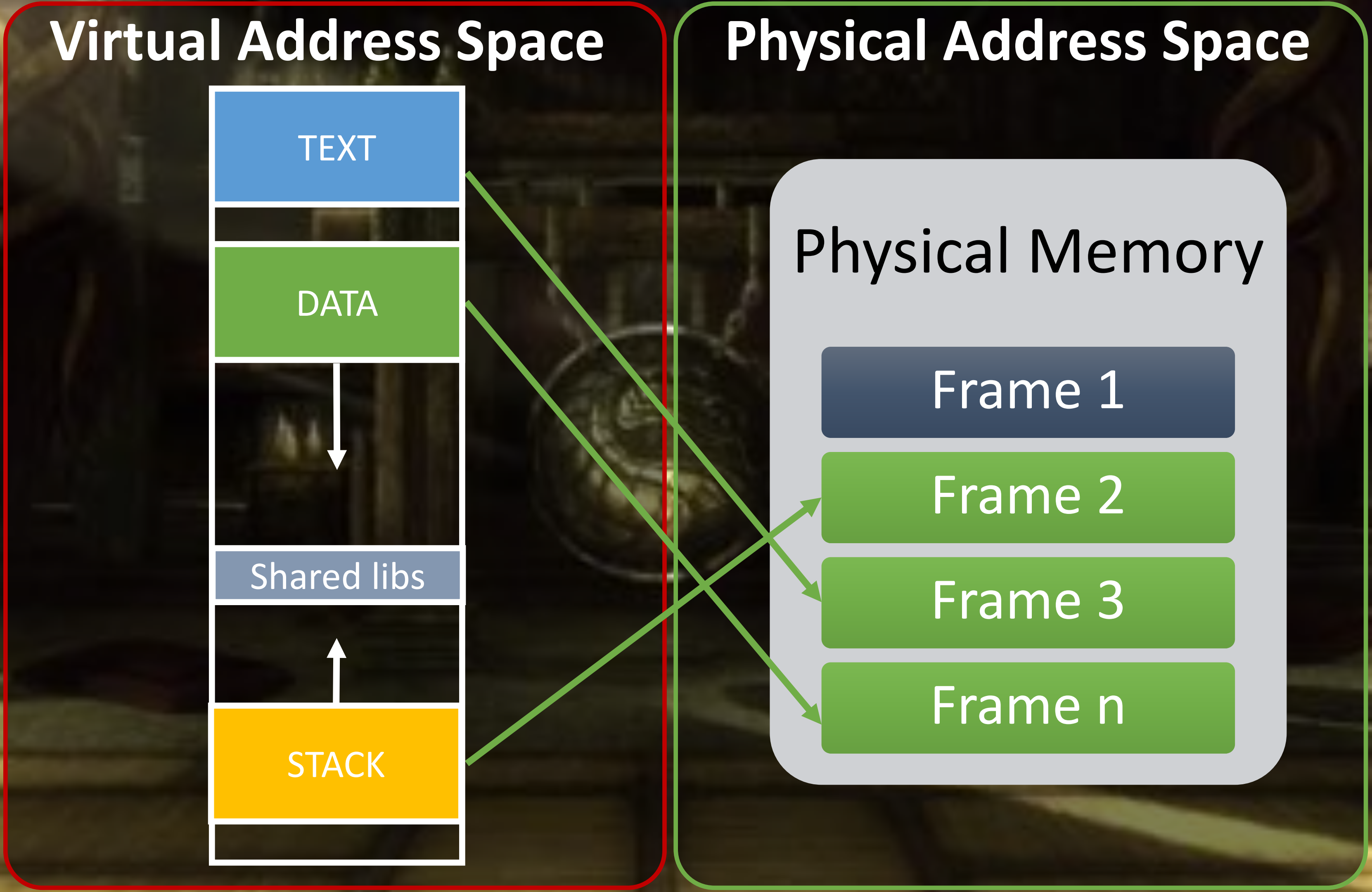
Process X Working set

TESO

KO

TRAINING

TUOMINEN



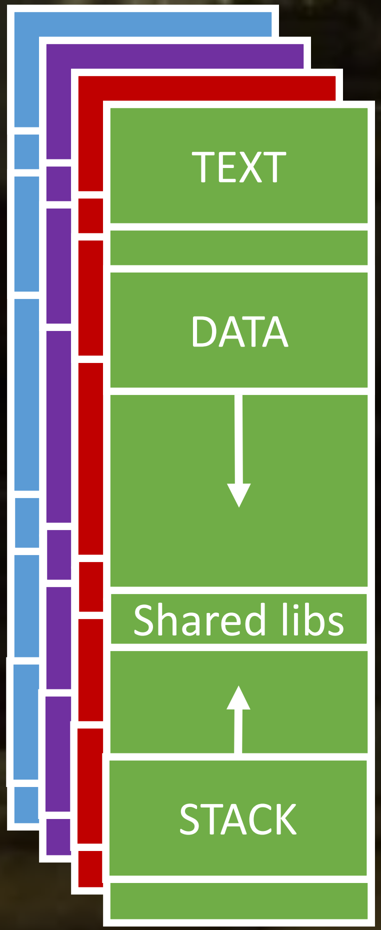
TESO

KO

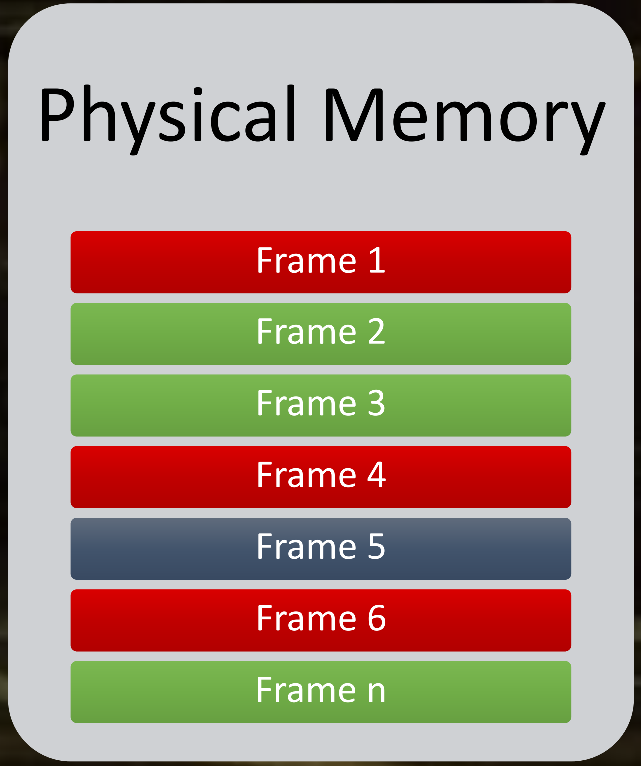
TRAINING

TUOMINEN

Virtual Address Space



Physical Address Space

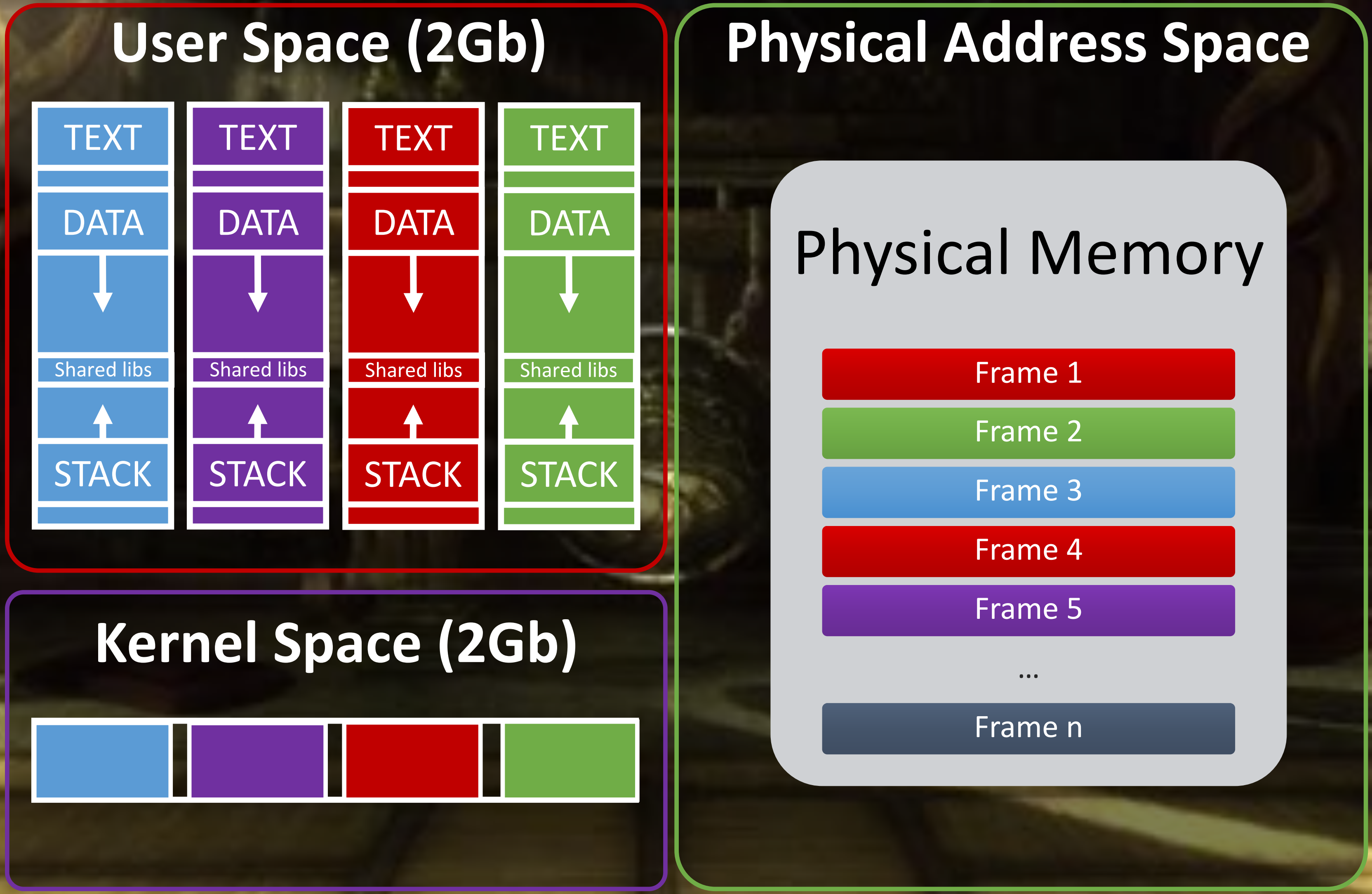


TESO

KO

TRAINING

TUOMINEN



User Space (2Gb)

TEXT
DATA
Shared libs
STACK

TEXT
DATA
Shared libs
STACK

TEXT
DATA
Shared libs
STACK

TEXT
DATA
Shared libs
STACK

Kernel Space (2Gb)

Physical Address Space

Physical Memory

Frame 1
Frame 2
Frame 3
Frame 4
Frame 5
…
Frame n

TESO

KO

TRAINING

TUOMINEN

WAIT! Where are my files? And registry? And network? And...?

TESO

KO

TRAINING

TUOMINEN

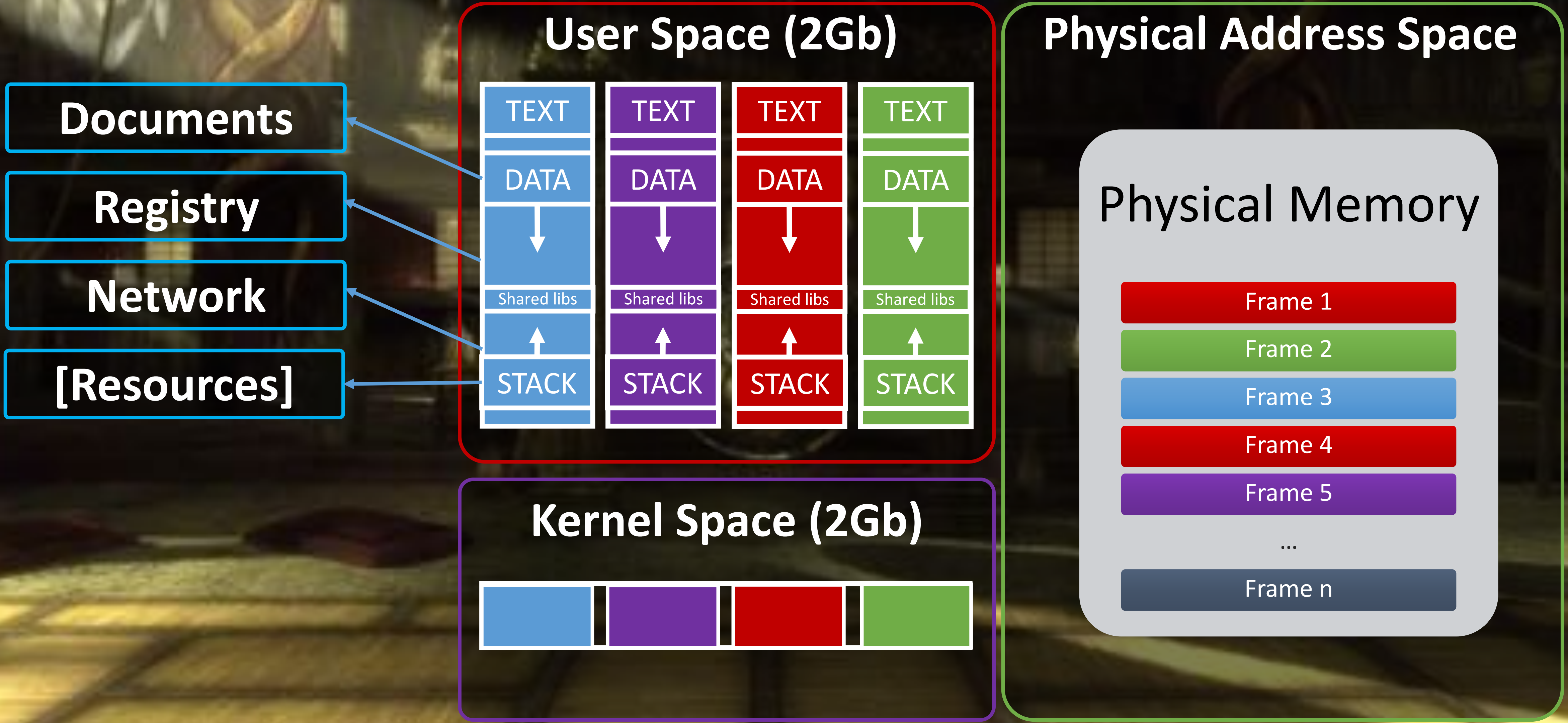
Of course, where you put them…
In the Hard Drive!

TESO

KO

TRAINING

TUOMINEN



Documents

Registry

Network

[Resources]

User Space (2Gb)

TEXT	TEXT	TEXT	TEXT
DATA	DATA	DATA	DATA
Shared libs	Shared libs	Shared libs	Shared libs
STACK	STACK	STACK	STACK

Kernel Space (2Gb)

Physical Address Space

Physical Memory

Frame 1

Frame 2

Frame 3

Frame 4

Frame 5

…

Frame n

TESO

KO

TRAINING

TUOMINEN

~~MEMORY~~ - FORENSICS

KO

TESO

TRAINING

TUOMINEN

TESO

KO

TRAINING

TUOMINEN

TESO

KO

TRAINING

TUOMINEN

GAME OVER

THANK YOU FOR PLAYING!

MAIN MENU

TESO

STORY MODE

TRAINING MODE

VS MODE

GOD MODE

TUOMINEN

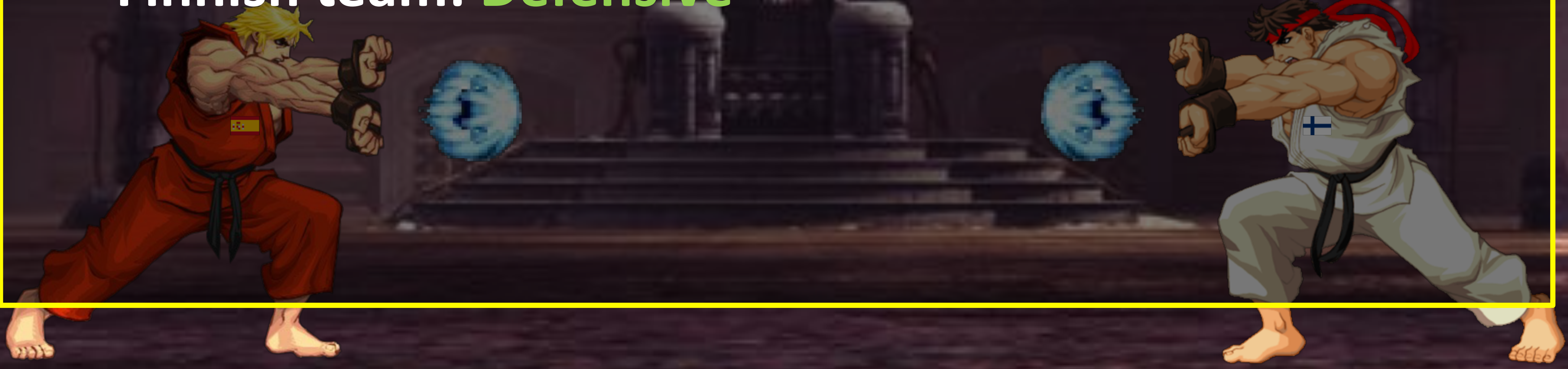
TESO

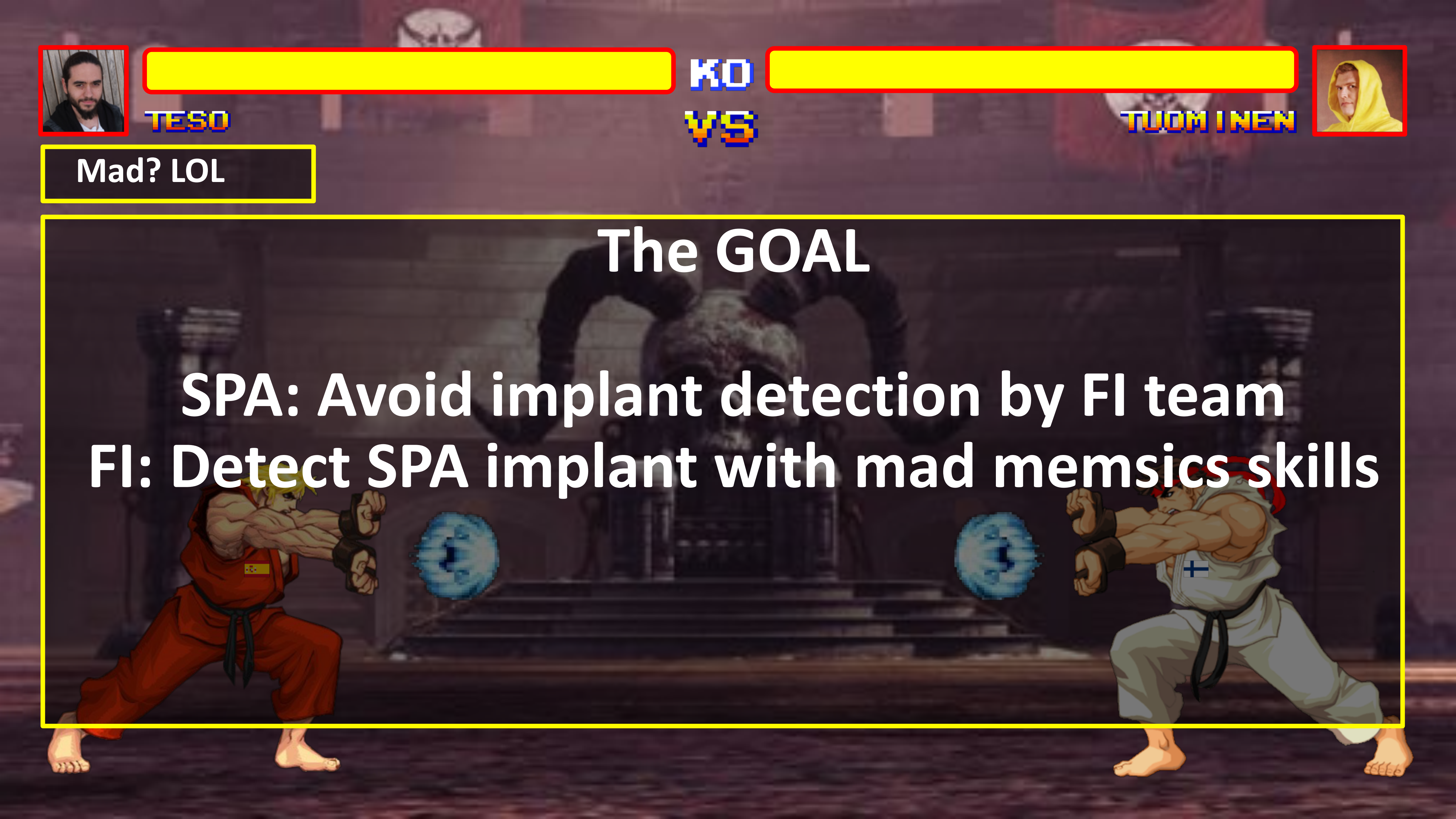
VS

TUOMINEN

The Contenders

- 2 representatives:
  - Spanish team: Offensive
  - Finnish team: Defensive





Mad? LOL

The GOAL

SPA: Avoid implant detection by FI team

FI: Detect SPA implant with mad memsics skills

TESO

KO

VS

TUOMINEN

The TARGET

The TARGET

The REFEREE

“You're absolutely one brilliant lunatic :D”

TESO

KO

VS

TUOMINEN

The RULES

None...

KO

TESO

VS

TUOMINEN

YOU MUST DEFEAT MY DRAGON PUNCH TO STAND A CHANCE!

TESO

KO

VS

TUOMINEN

ATTACK ME IF YOU DARE,
I WILL CRUSH YOU.

MAIN MENU

TESO

STORY MODE

TRAINING MODE

VS MODE

GOD MODE

TUOMINEN

TESO
KO
TUOMINEN
GOD MODE

The Requirements

- No deep “OS XYZ” memory skills
- No deep memsics skills
- Multiplatform – 1 solution to rule them all

The approach

- Avoid presence detection…?
- Avoid acquisition…?
- Avoid analysis detection…?

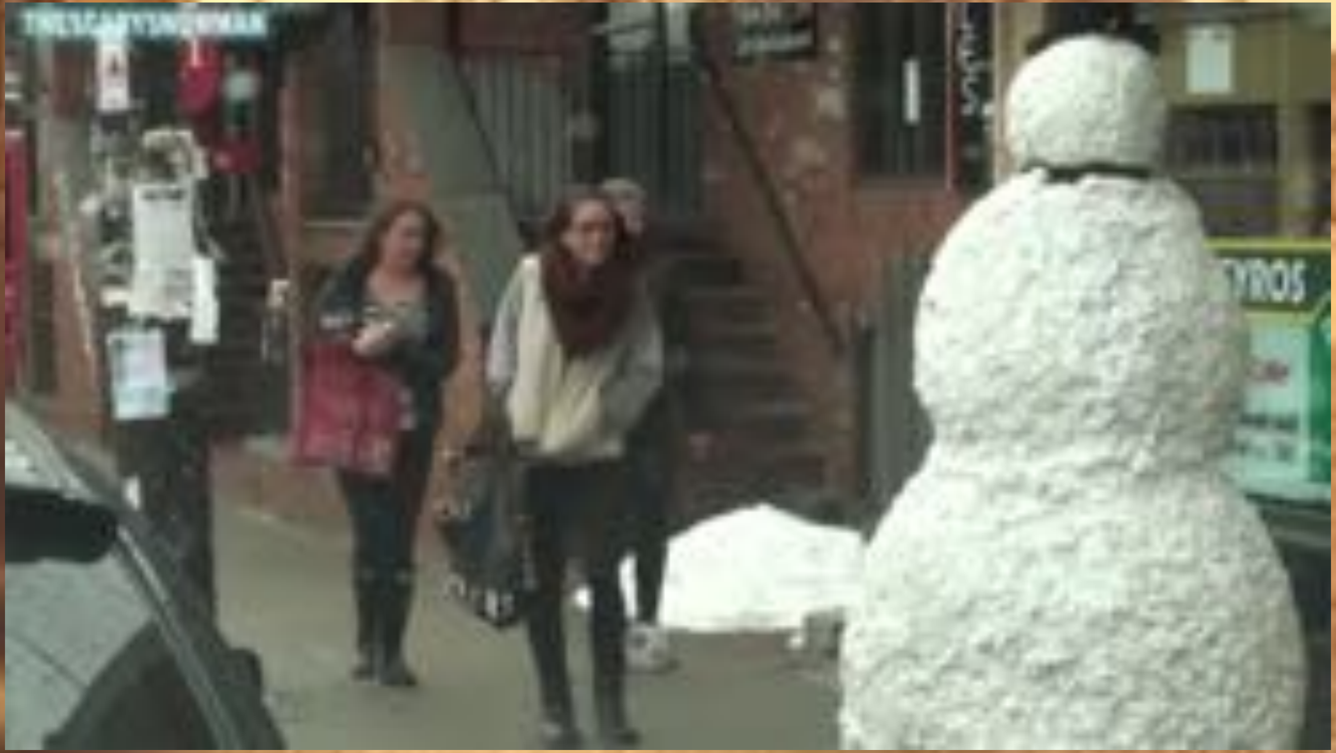
TESO

KO

GOD MODE

TUOMINEN

Option 1



TESO

KO

GOD MODE

TUOMINEN

Option 2

TESO

KO

GOD MODE

TUOMINEN

Option 3

TESO

KO

GOD MODE

TUOMINEN

F**k yeah, that's the offensive way!

Option 4

TESO

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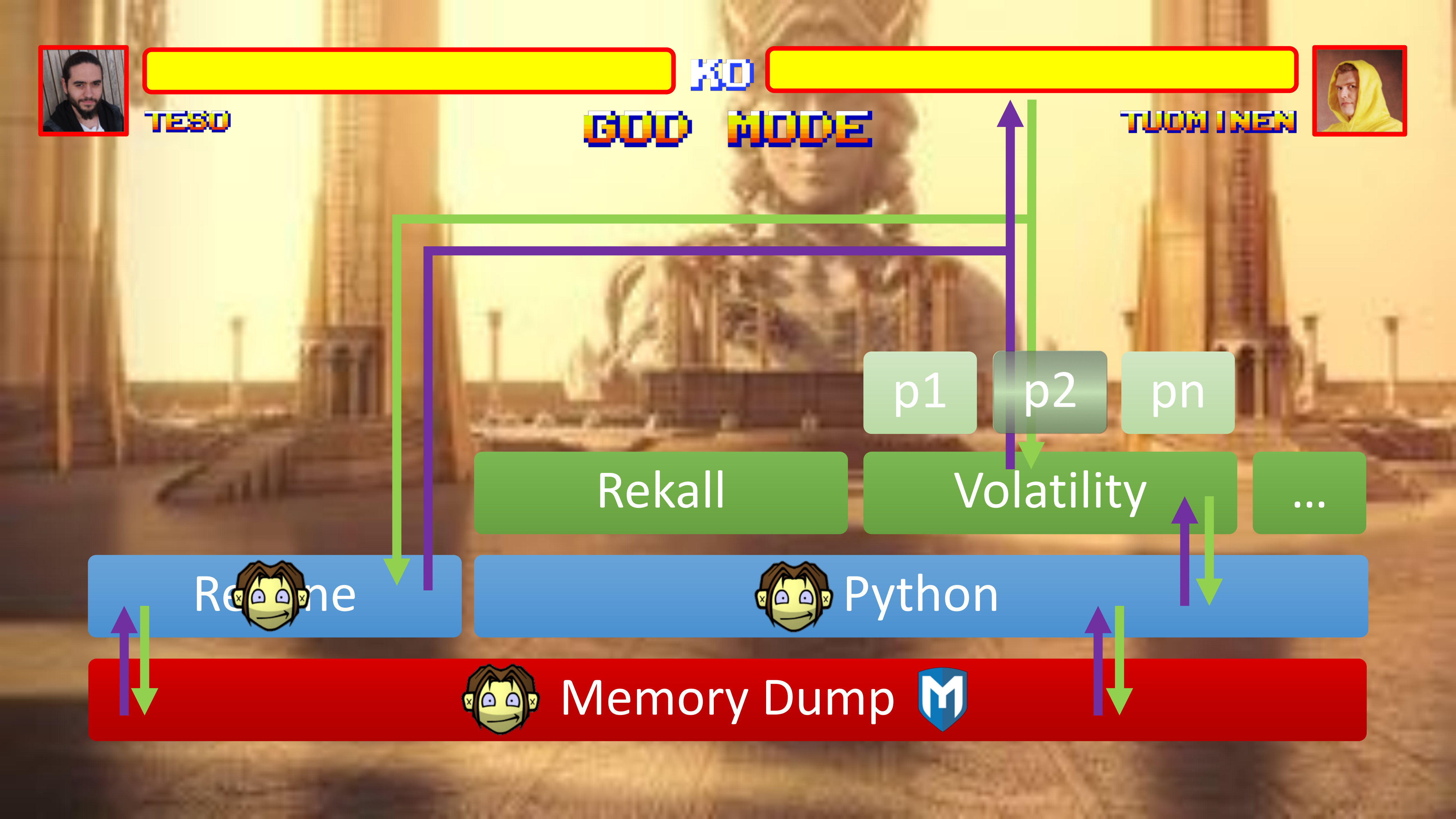
GOD MODE

TUOMINEN

The offensive approach :D

FIGHT BACK

GOD MODE



p1

p2

pn

Rekall

Volatility

...

Re ne

Python

Memory Dump

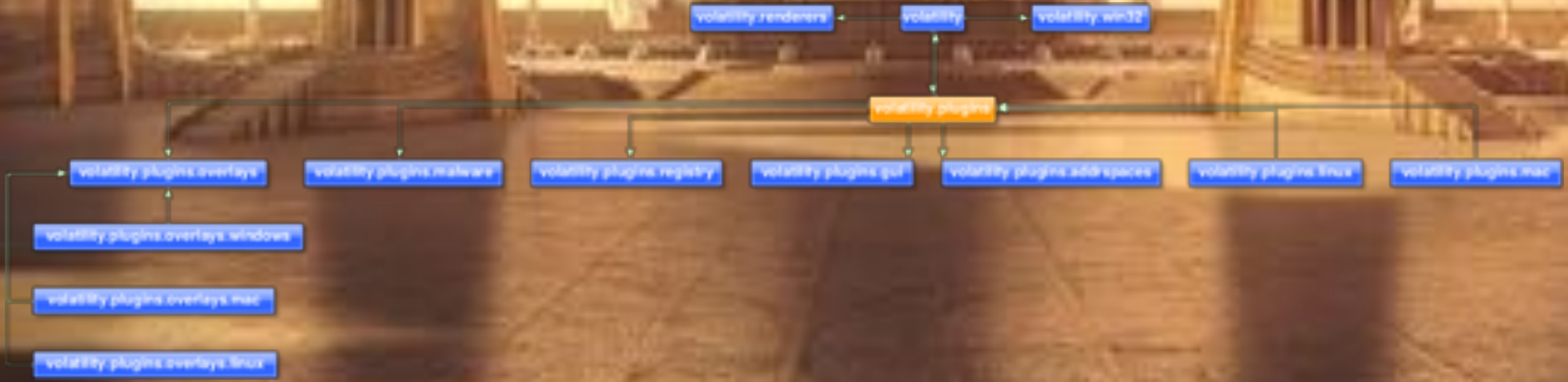
TESO

KO

GOD MODE

TUOMINEN

Volatility



volatility.renderers

volatility

volatility.win32

volatility.plugins

volatility.plugins.overlays

volatility.plugins.malware

volatility.plugins.registry

volatility.plugins.gui

volatility.plugins.addrspaces

volatility.plugins.linux

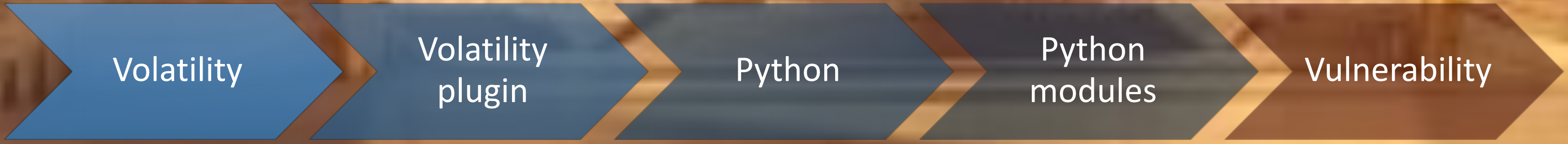
volatility.plugins.mac

volatility.plugins.overlays.windows

volatility.plugins.overlays.mac

volatility.plugins.overlays.linux

Vulnerabilities



Volatility

Volatility plugin

Python

Python modules

Vulnerability

The vulnerabilities. Fuzzing?

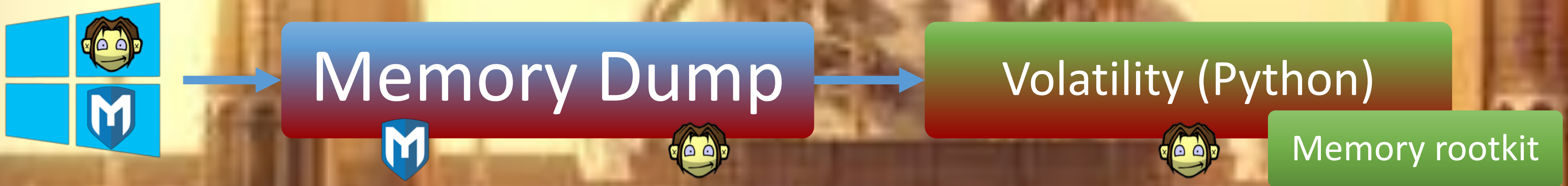
Human Fuzzing

TESO

KO

GOD MODE

TUOMINEN



Weaponized memory dump

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GOD MODE

TUOMINEN

DLL

TESO

KO

GOD MODE

TUOMINEN

Trigger

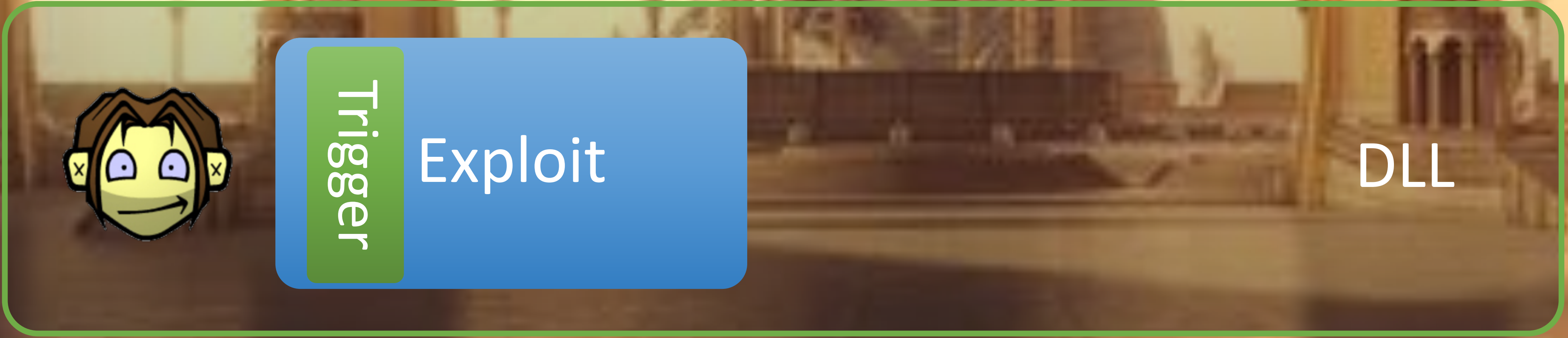
DLL

TESO

KO

GOD MODE

TUOMINEN



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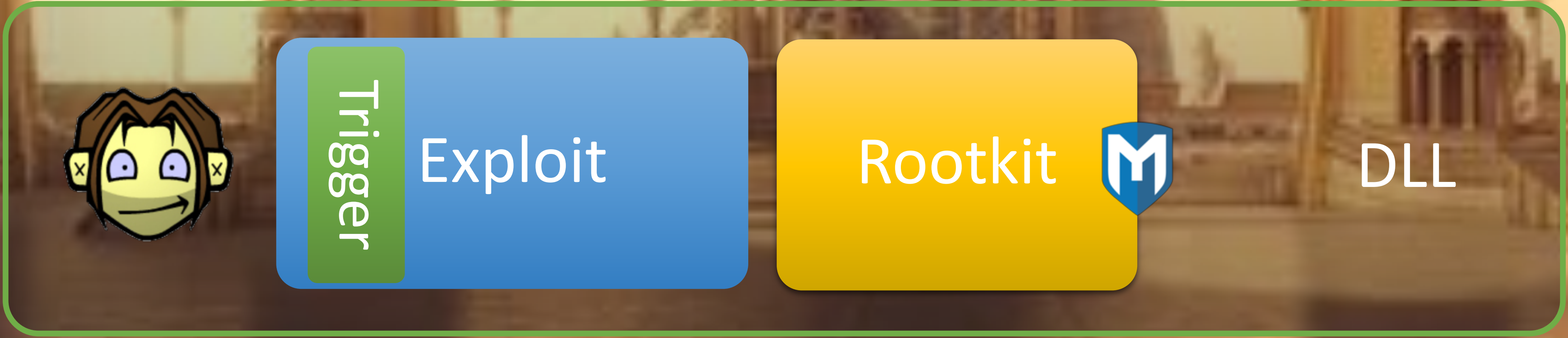
GOD MODE

TUOMINEN

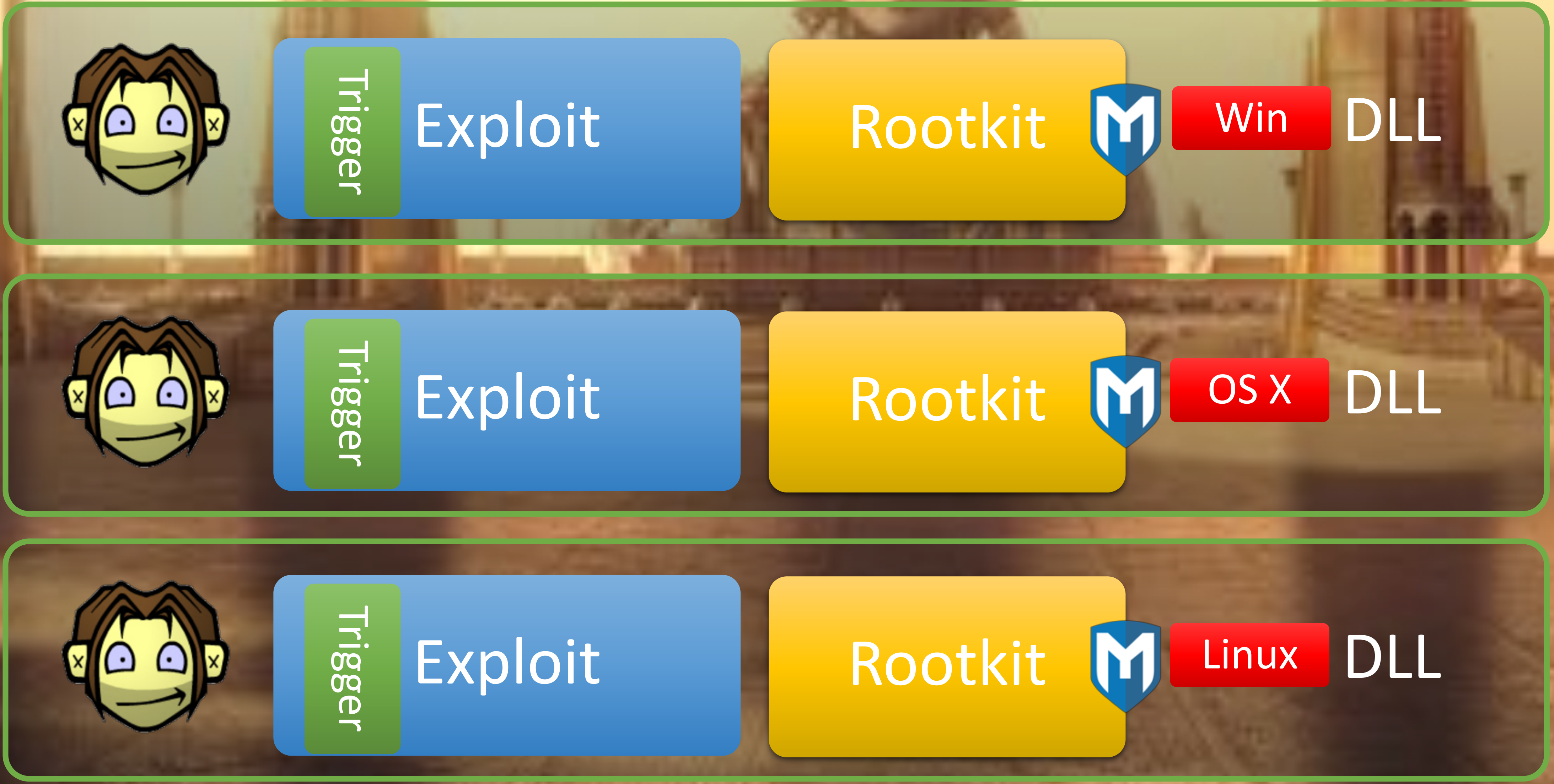


TESO

KO

GOD MODE

TUOMINEN



Trigger Exploit Rootkit Win DLL

Trigger Exploit Rootkit OS X DLL

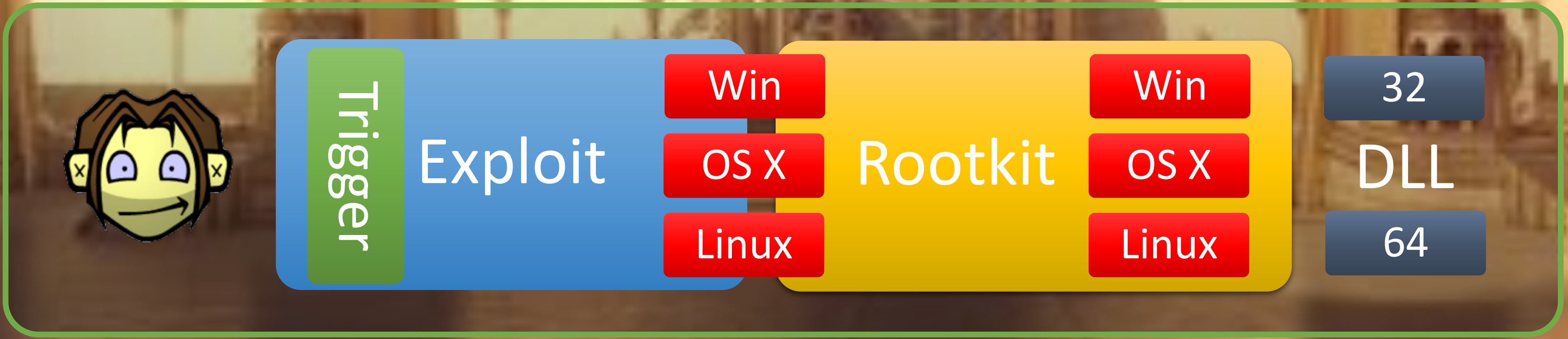
Trigger Exploit Rootkit Linux DLL

TESO

KO

GOD MODE

TUOMINEN



Trigger

Exploit

Win

OS X

Linux

Rootkit

Win

OS X

Linux

32

DLL

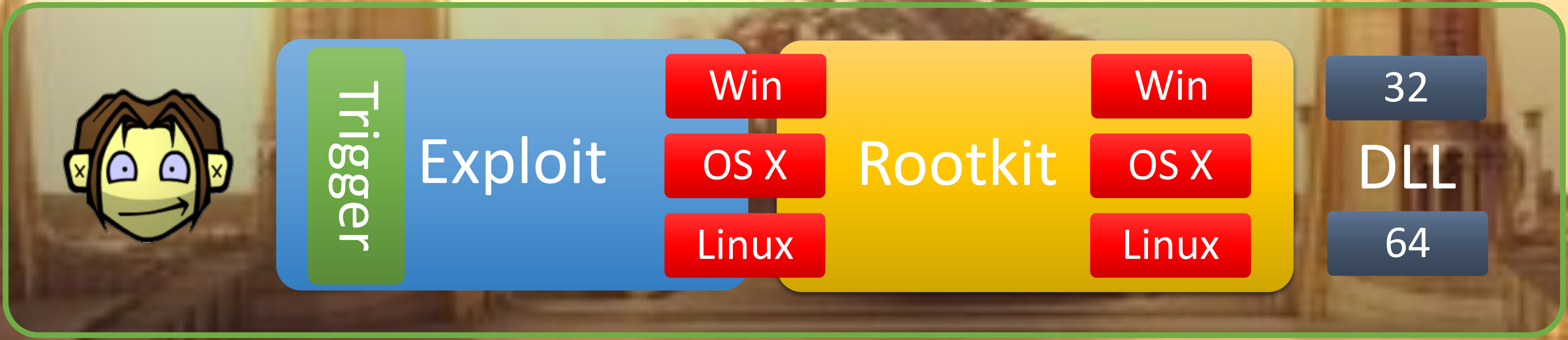
64

TESO

KO

GOD MODE

TUOMINEN



Volatility

Rekall

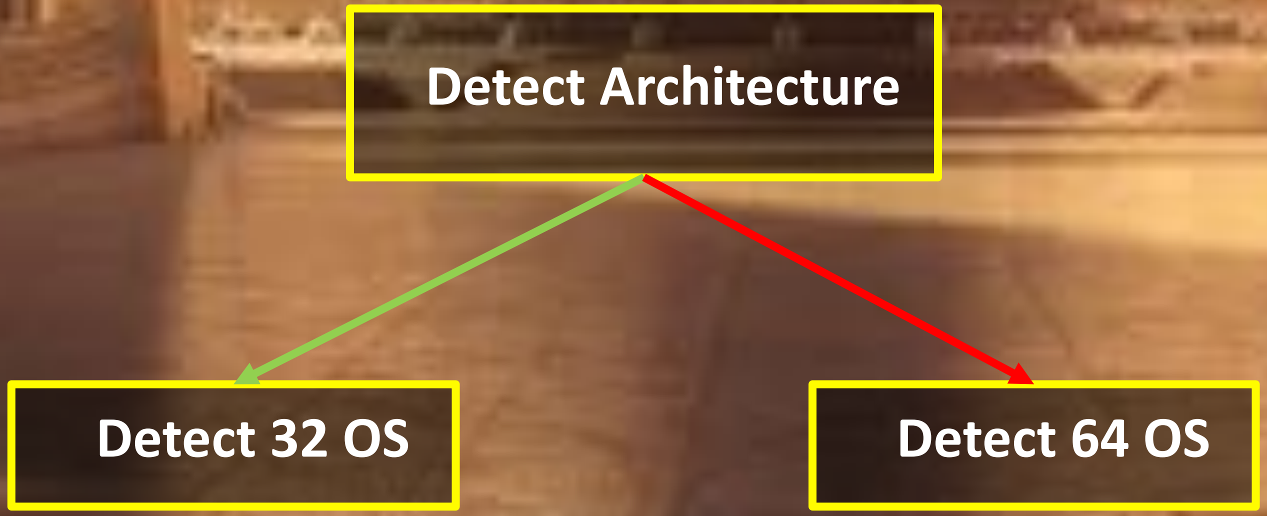
Redline

Radare2

EnCase

…

Approach



Detect Architecture

Detect 32 OS

Detect 64 OS

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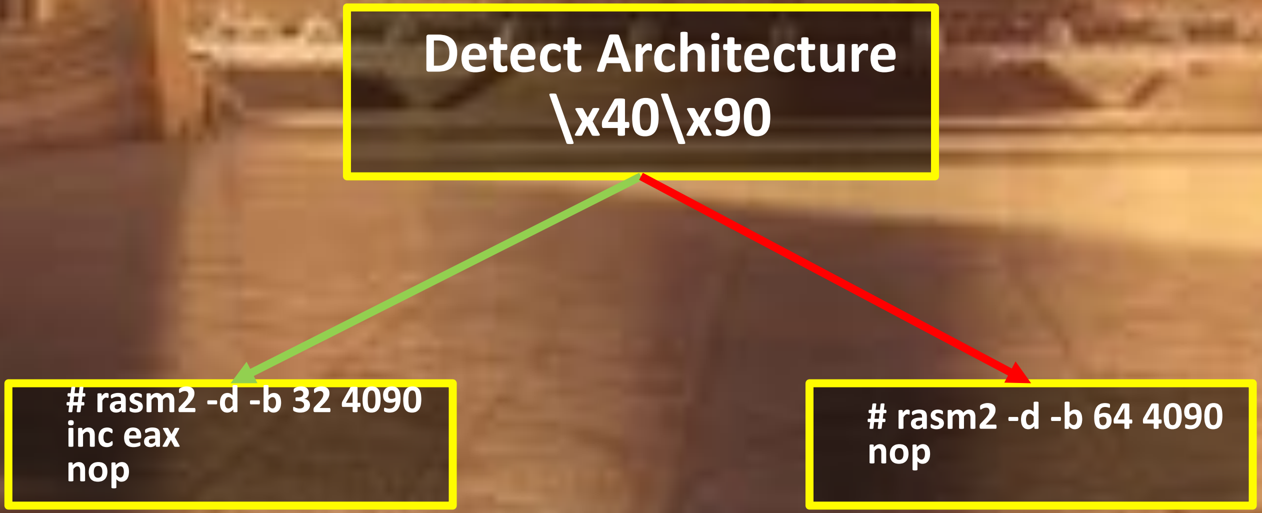
KO

GOD MODE

TUOMINEN

Determine architecture

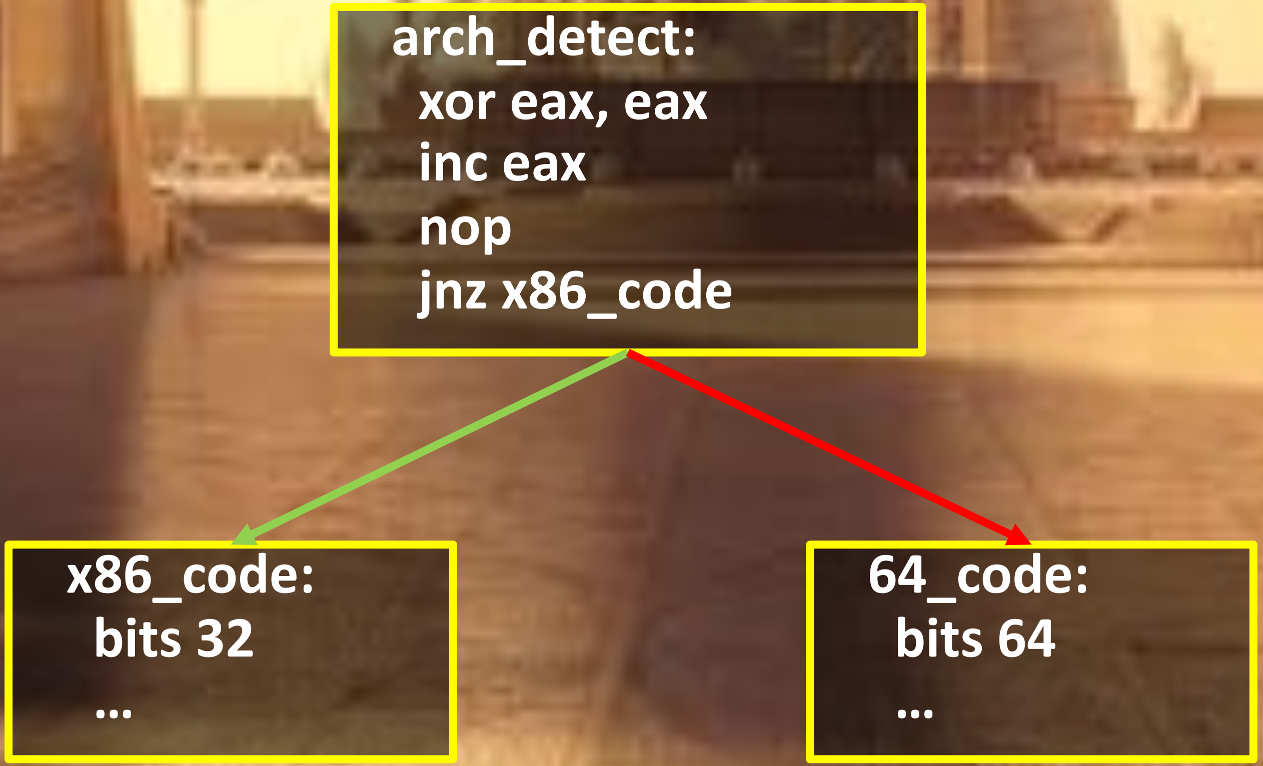


Detect Architecture
\x40\x90

```
# rasm2 -d -b 32 4090
inc eax
nop
```

```
# rasm2 -d -b 64 4090
nop
```

Determine Architecture



```
arch_detect:
  xor eax, eax
  inc eax
  nop
  jnz x86_code
```

```
x86_code:
  bits 32
  …
```

```
64_code:
  bits 64
  …
```

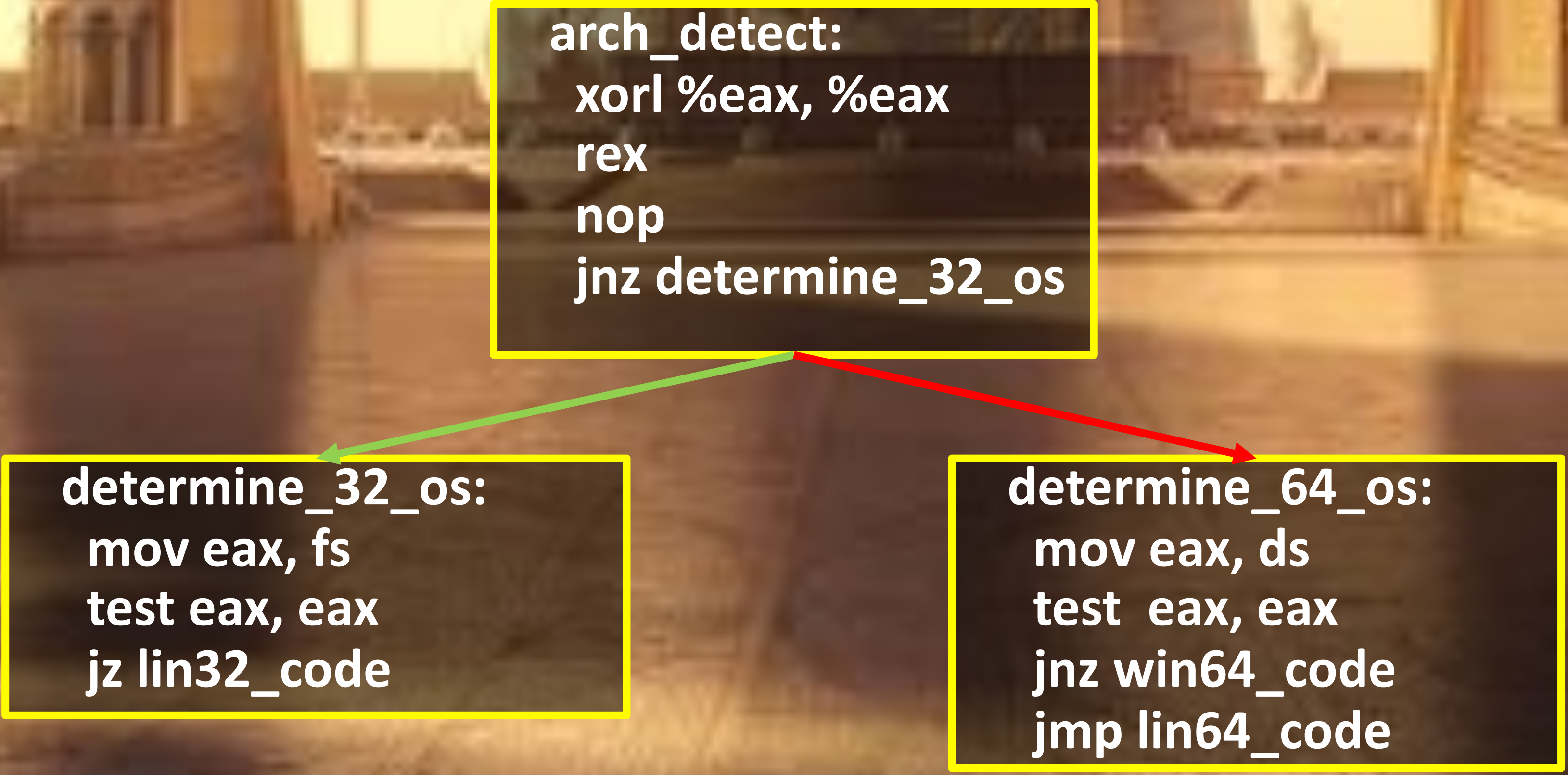
TESO

KO

GOD MODE

TUOMINEN

Determine OS



```
arch_detect:
  xorl %eax, %eax
  rex
  nop
  jnz determine_32_os
```

```
determine_32_os:
  mov eax, fs
  test eax, eax
  jz lin32_code
```

```
determine_64_os:
  mov eax, ds
  test  eax, eax
  jnz win64_code
  jmp lin64_code
```

TESO

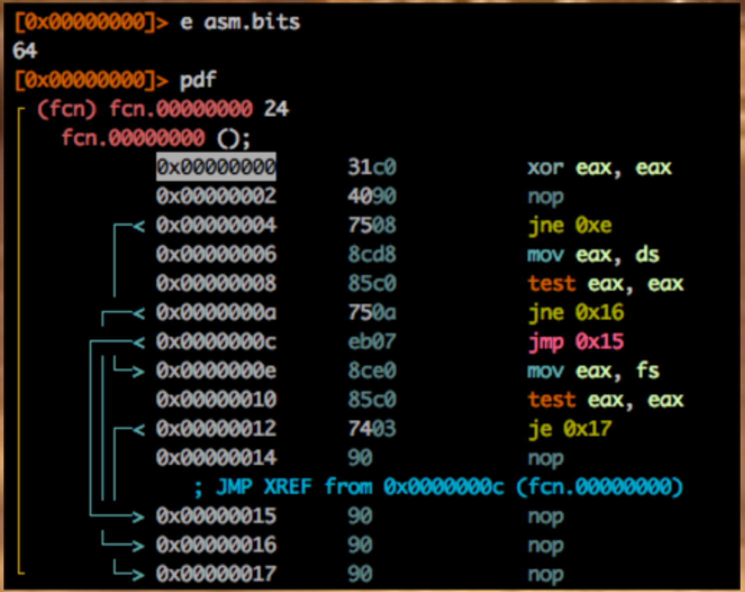
KO

GOD MODE

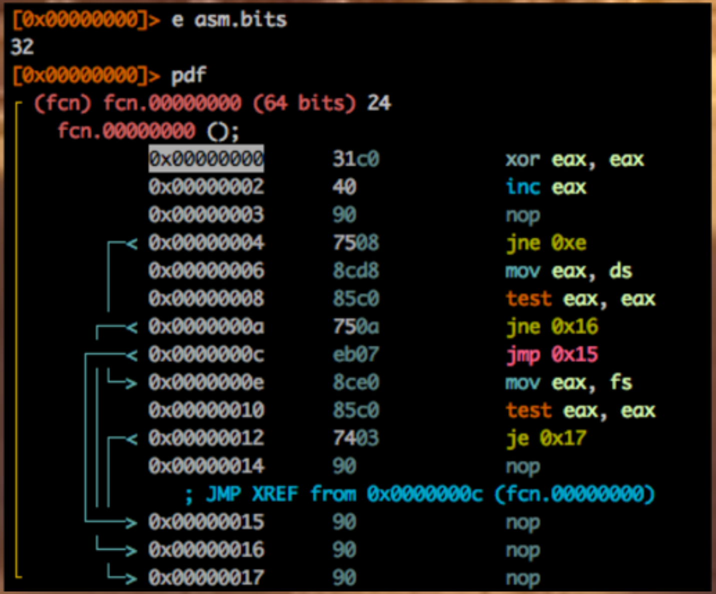
TUOMINEN

Disassembly

\x31\xc0\x40\x90\x75\x08\x8c\xd8\x85\xc0\x75\x0a\xeb\x07\x8c\xe0\x85\xc0\x74\x03\x90\x90\x90\x90



```
[0x00000000]> e asm.bits
64
[0x00000000]> pdf
  (fcn) fcn.00000000 24
    fcn.00000000 ();
          0x00000000      31c0        xor eax, eax
          0x00000002      4090        nop
        < 0x00000004      7508        jne 0xe
          0x00000006      8cd8        mov eax, ds
          0x00000008      85c0        test eax, eax
        < 0x0000000a      750a        jne 0x16
        < 0x0000000c      eb07        jmp 0x15
        > 0x0000000e      8ce0        mov eax, fs
          0x00000010      85c0        test eax, eax
        < 0x00000012      7403        je 0x17
          0x00000014      90          nop
          ; JMP XREF from 0x0000000c (fcn.00000000)
        > 0x00000015      90          nop
        > 0x00000016      90          nop
        > 0x00000017      90          nop
```



```
[0x00000000]> e asm.bits
32
[0x00000000]> pdf
  (fcn) fcn.00000000 (64 bits) 24
    fcn.00000000 ();
          0x00000000      31c0        xor eax, eax
          0x00000002      40          inc eax
          0x00000003      90          nop
        < 0x00000004      7508        jne 0xe
          0x00000006      8cd8        mov eax, ds
          0x00000008      85c0        test eax, eax
        < 0x0000000a      750a        jne 0x16
        < 0x0000000c      eb07        jmp 0x15
        > 0x0000000e      8ce0        mov eax, fs
          0x00000010      85c0        test eax, eax
        < 0x00000012      7403        je 0x17
          0x00000014      90          nop
          ; JMP XREF from 0x0000000c (fcn.00000000)
        > 0x00000015      90          nop
        > 0x00000016      90          nop
        > 0x00000017      90          nop
```

TESO

KO

GOD MODE

TUOMINEN

But in real world…

ASLR/PIE

…

TESO

KO

GOD MODE

TUOMINEN

But in real world…
ROP gadgets!

TESO

KO

GOD MODE

TUOMINEN

So, for real world…

I need help!

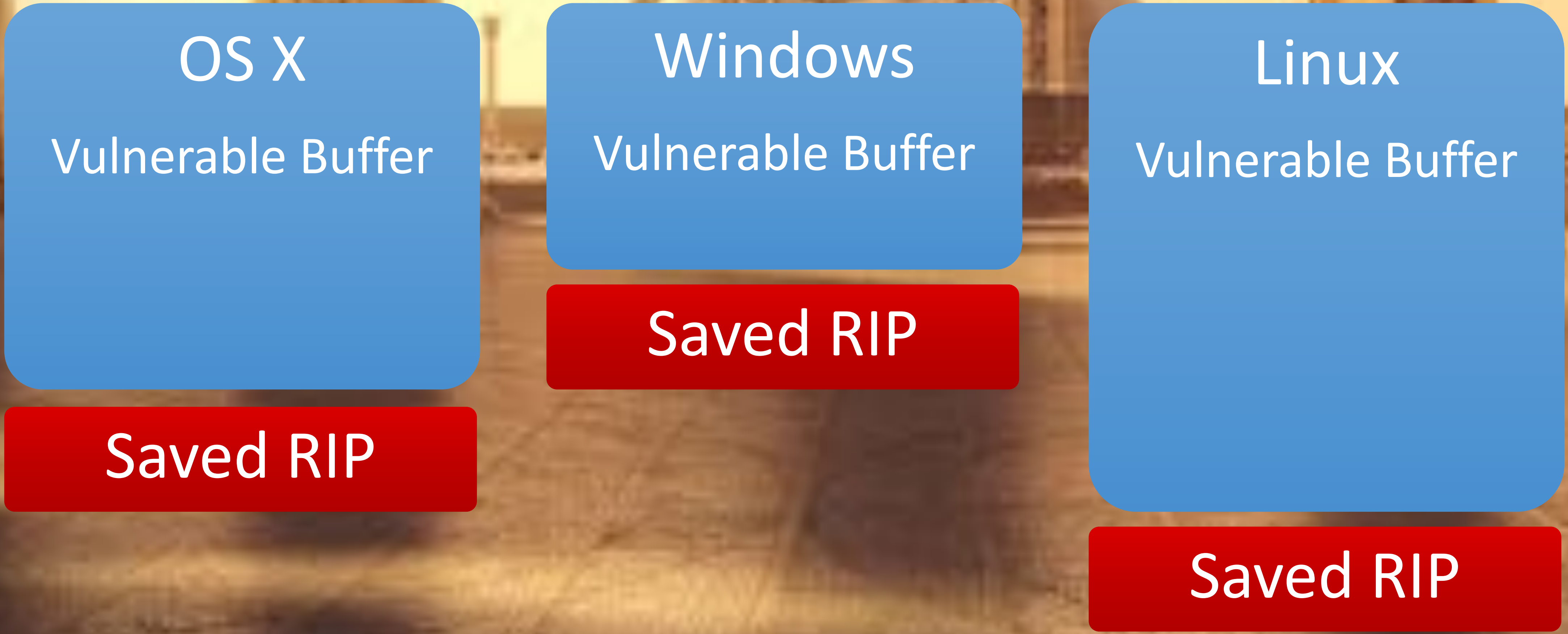
TESO

KO

GOD MODE

TUOMINEN

Assuming...



OS X

Vulnerable Buffer

Saved RIP

Windows

Vulnerable Buffer

Saved RIP

Linux

Vulnerable Buffer

Saved RIP

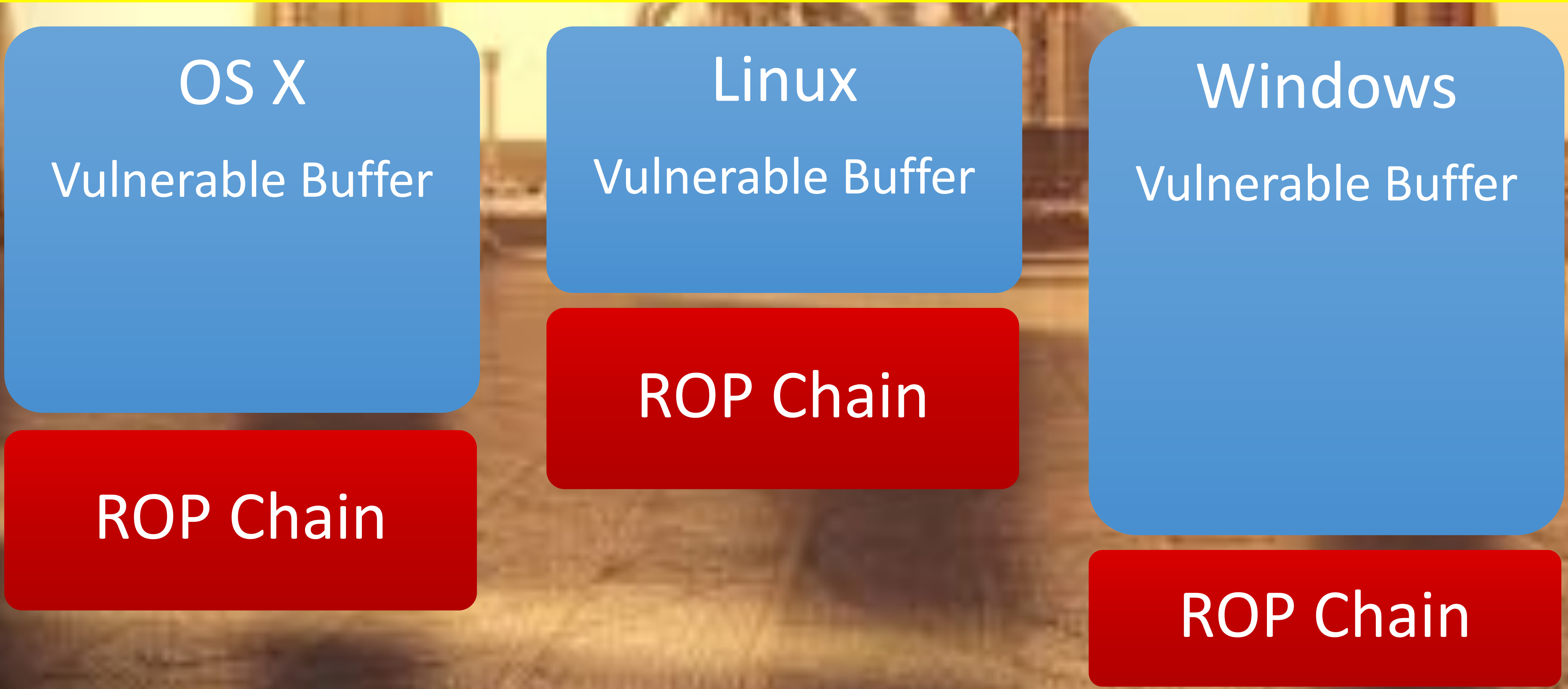
TESO

KO

GOD MODE

TUOMINEN

Then...



OS X

Vulnerable Buffer

ROP Chain

Linux

Vulnerable Buffer

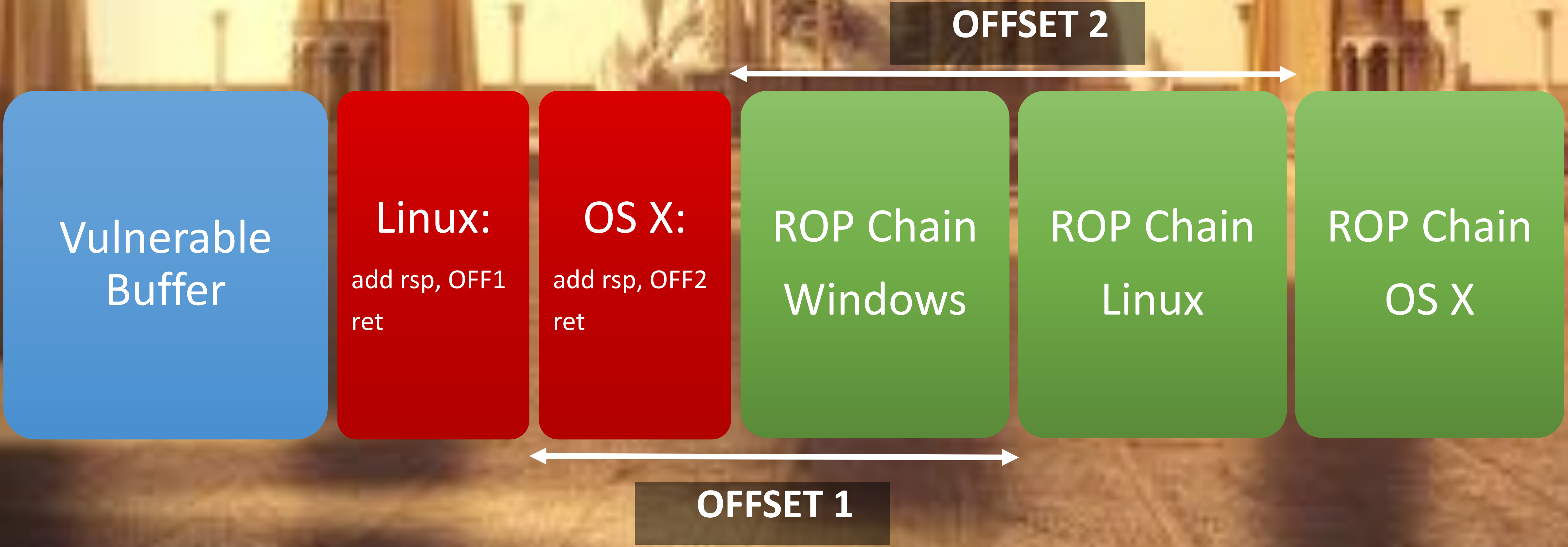
ROP Chain

Windows

Vulnerable Buffer

ROP Chain

Finally...



OFFSET 2

Vulnerable Buffer

Linux:

add rsp, OFF1

ret

OS X:

add rsp, OFF2

ret

ROP Chain Windows

ROP Chain Linux

ROP Chain OS X

OFFSET 1

TESO

KO

GOD MODE

TUOMINEN

And what now?
Post-exploitation time!

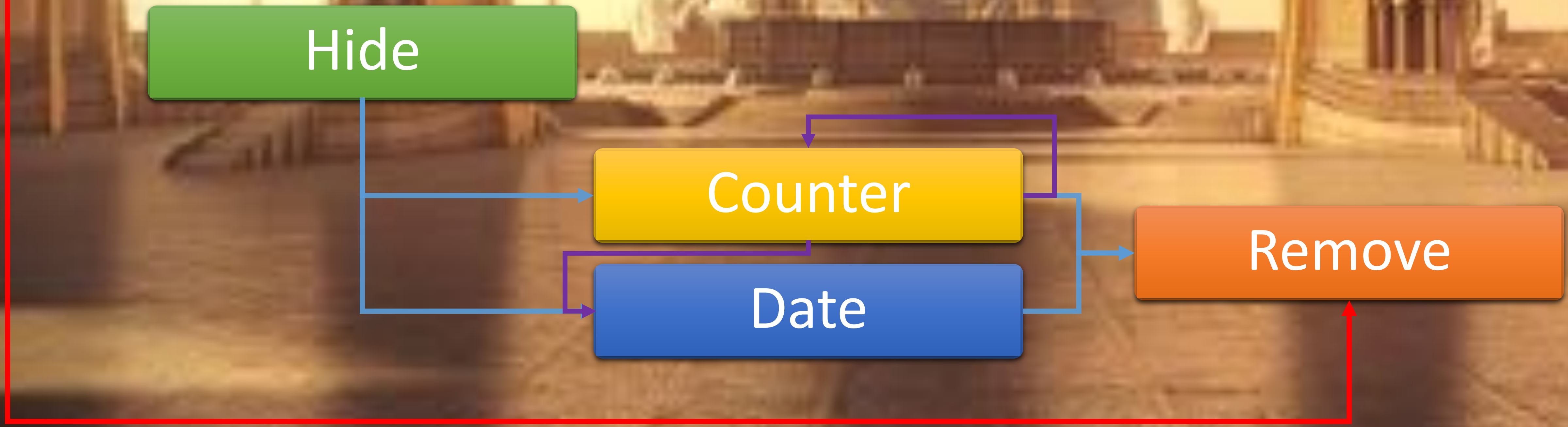
TESO

KO

GOD MODE

TUOMINEN

Post-exploitation time!



Hide

Counter

Date

Remove

So Long, and Thanks for All the Fish

Hugo Teso