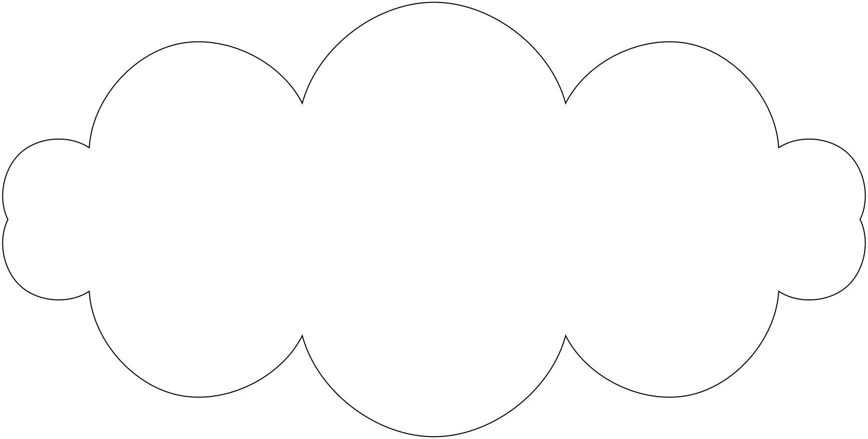
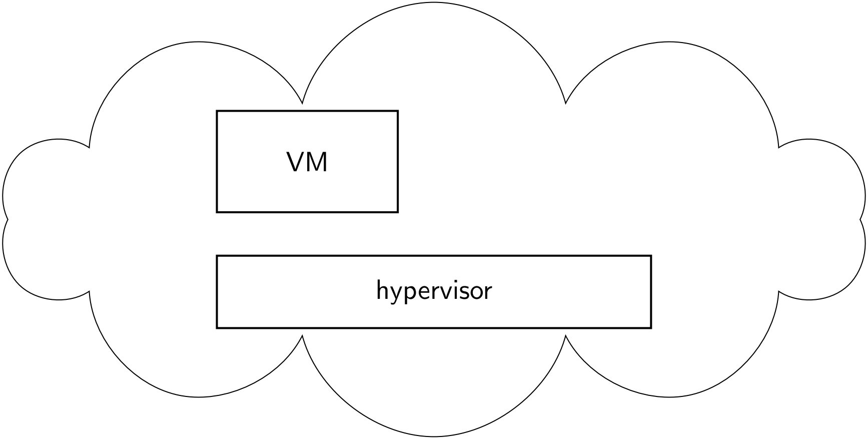
SEVerity: Code Injection Attacks against Encrypted Virtual Machines

Mathias Morbitzer, Sergej Proskurin, Martin Radev, Marko Dorfhuber and Erick Quintanar Salas, 27th May 2021

AMD SEV



AMD SEV



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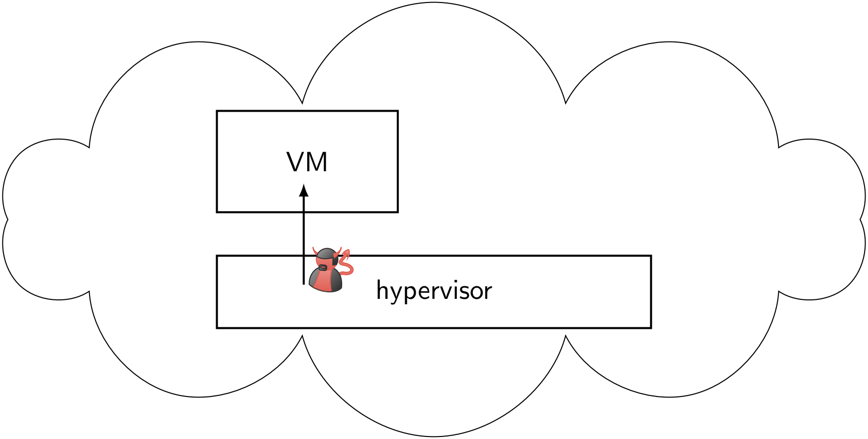

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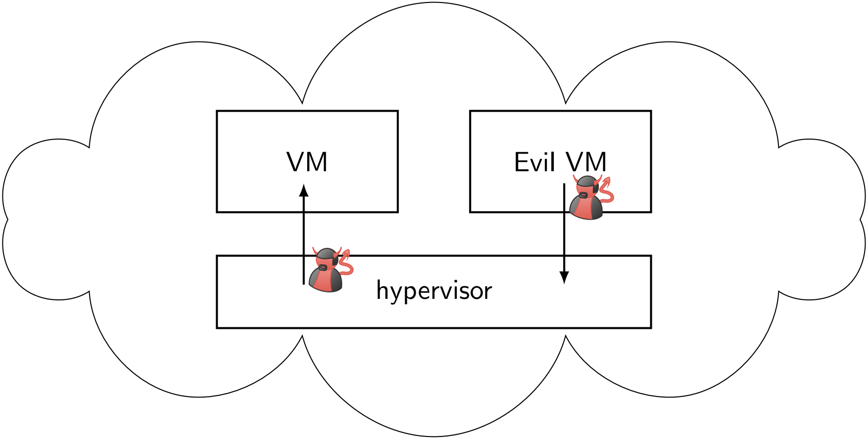

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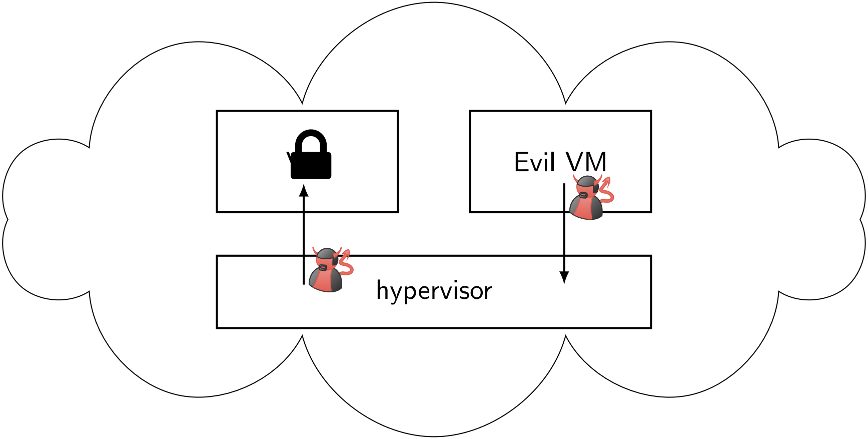

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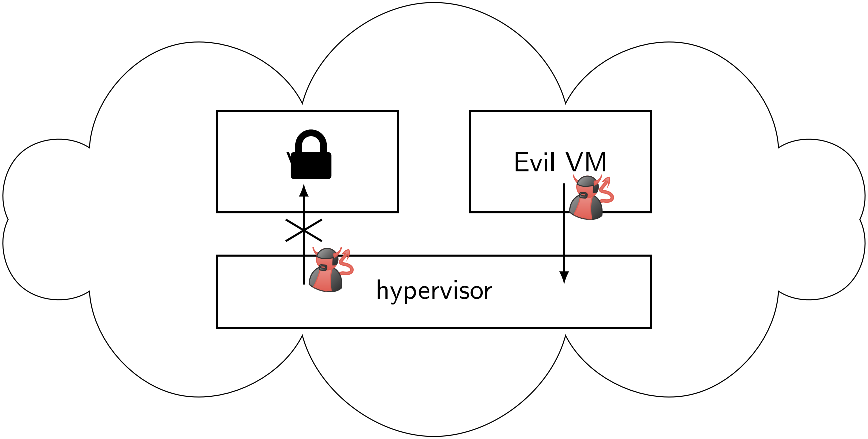

An (incomplete) timeline on AMD SEV

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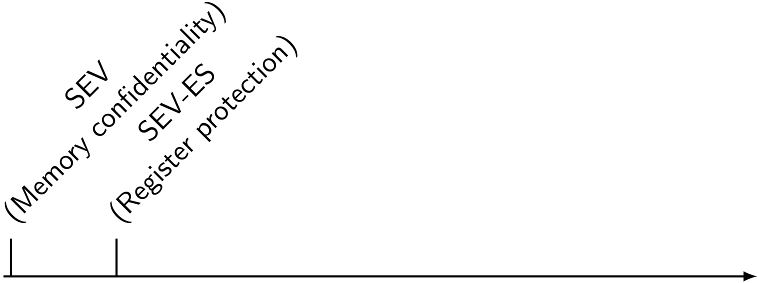

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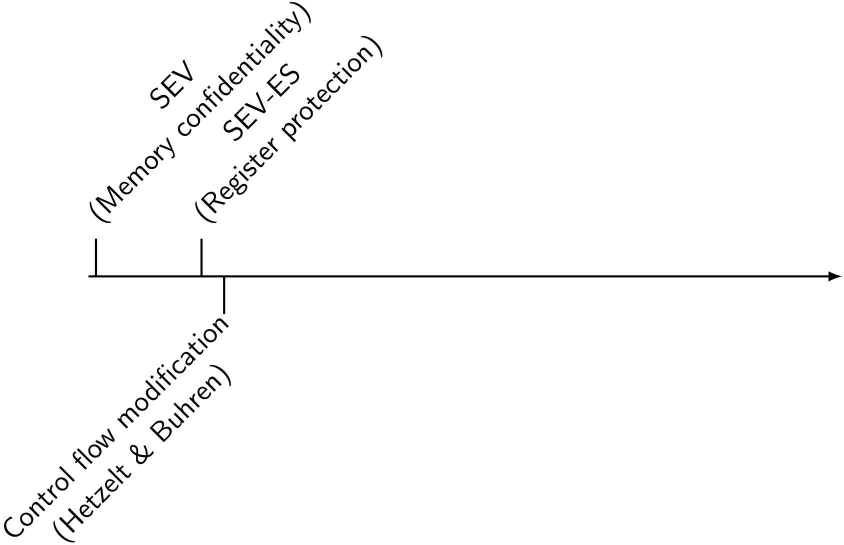

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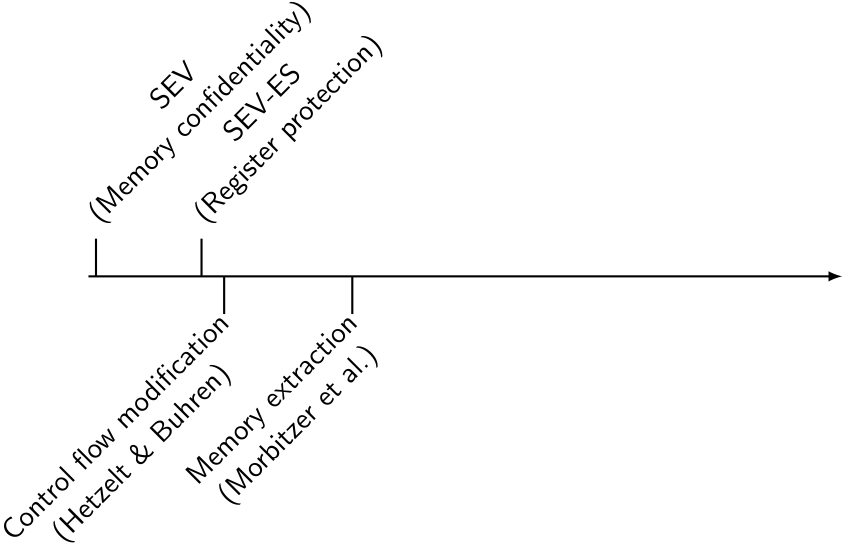

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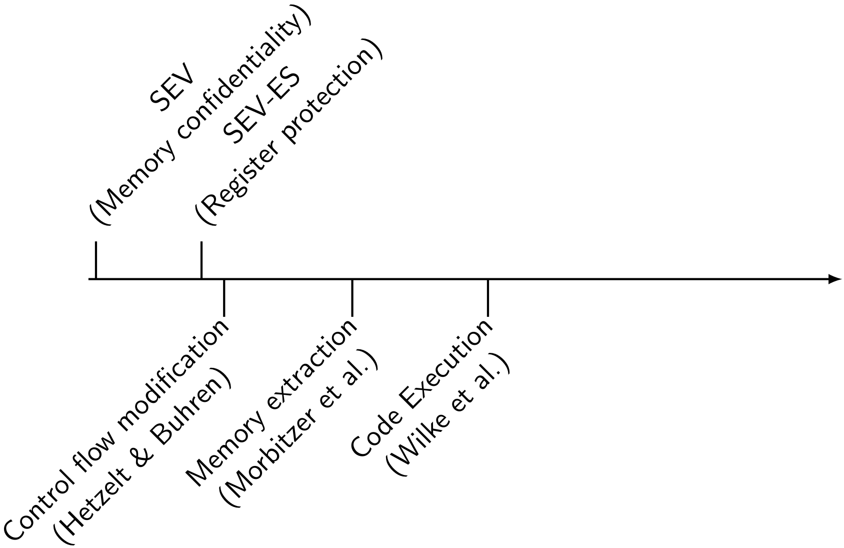

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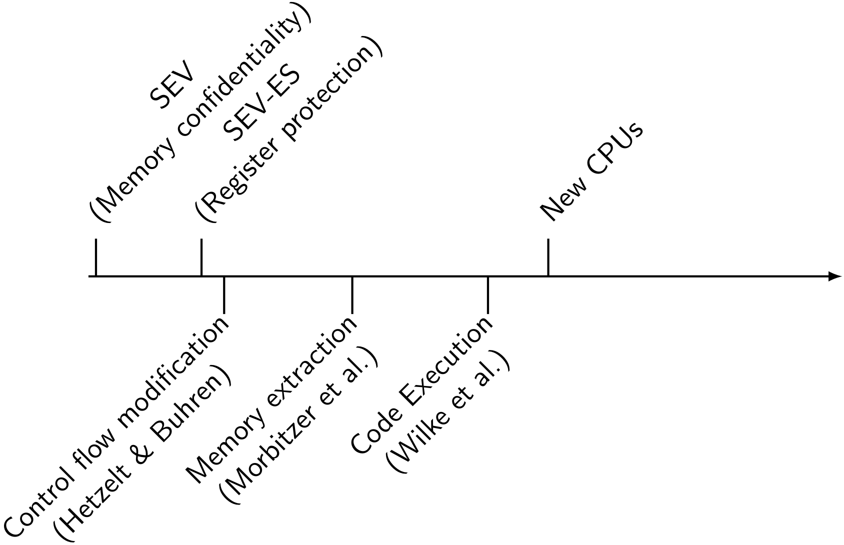

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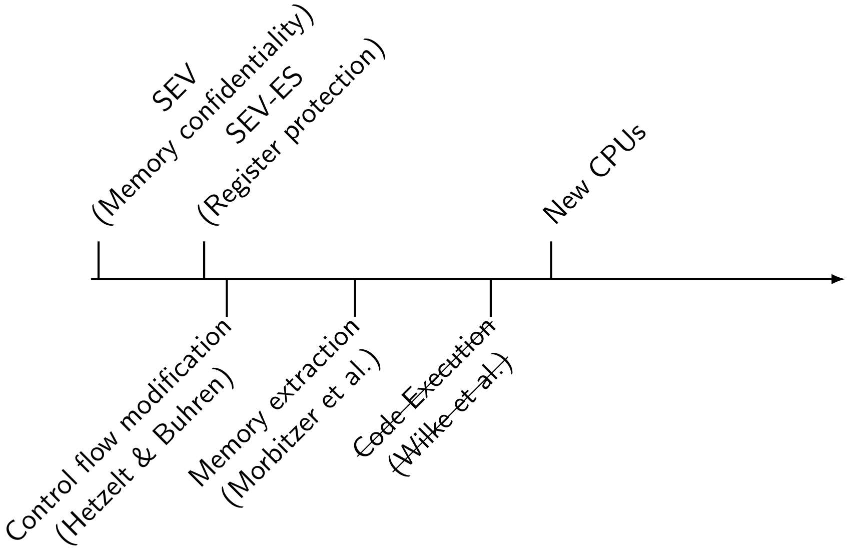

SEV
(Memory confidentiality)

SEV-ES
(Register protection)

New CPUs

Control flow modification
(Hetzelt & Buhren)

Memory extraction
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~~Code Execution~~
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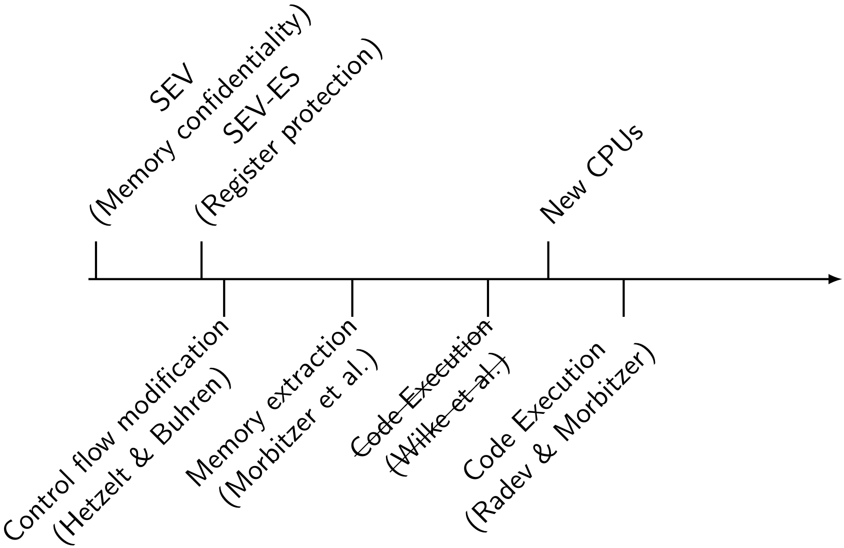

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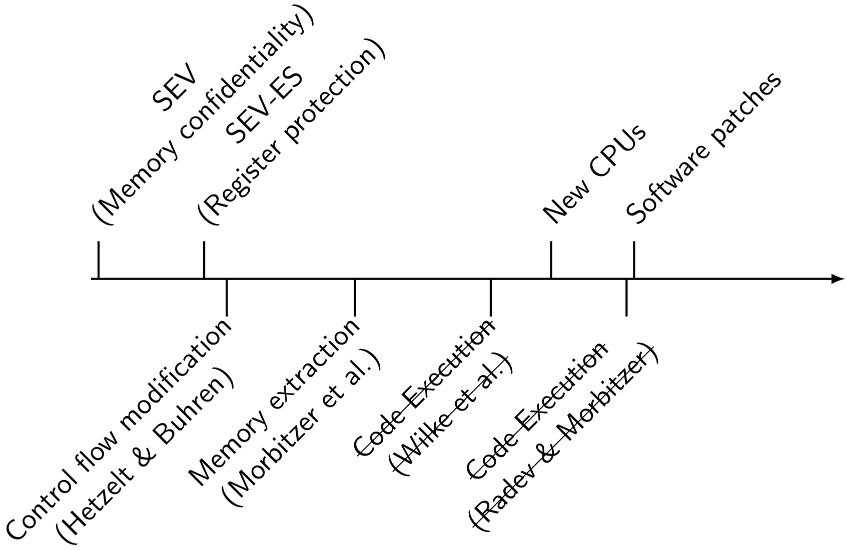

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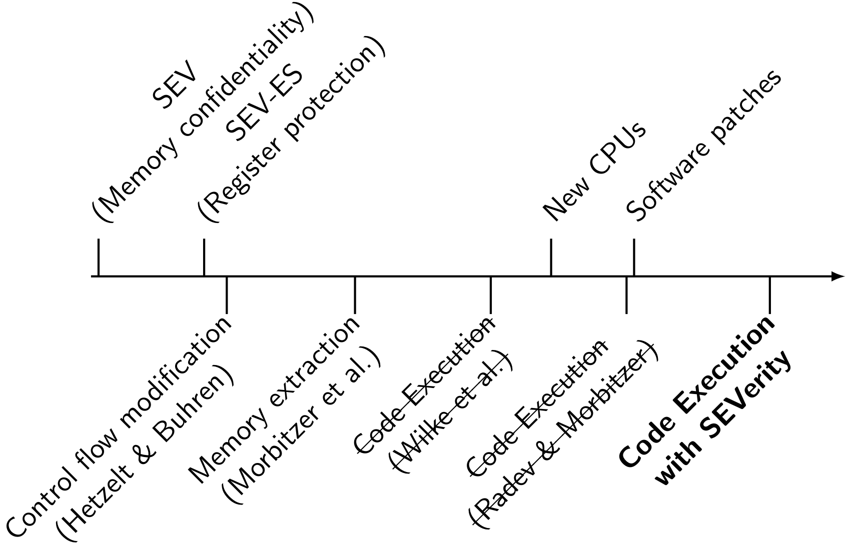

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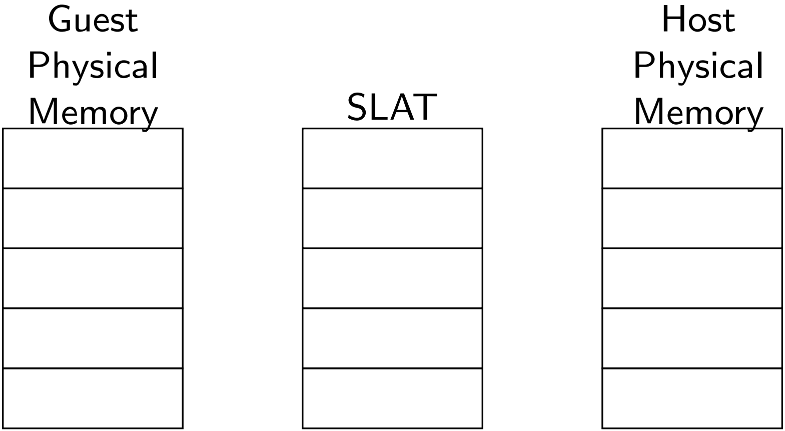
Code Execution with SEVerity

Attack Overview



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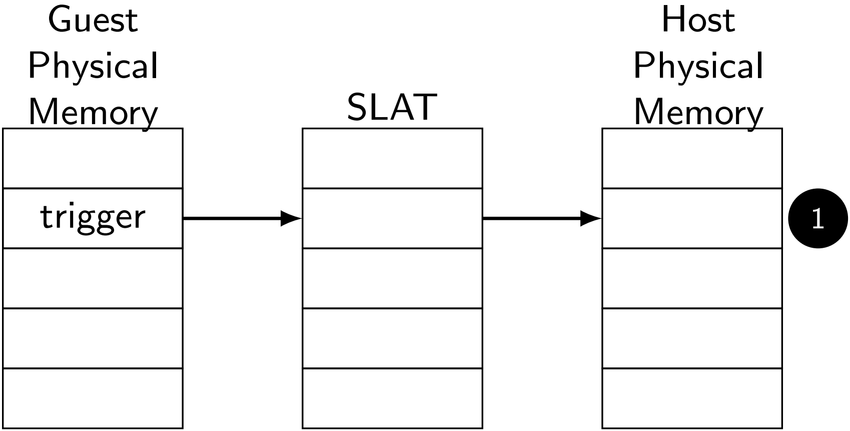

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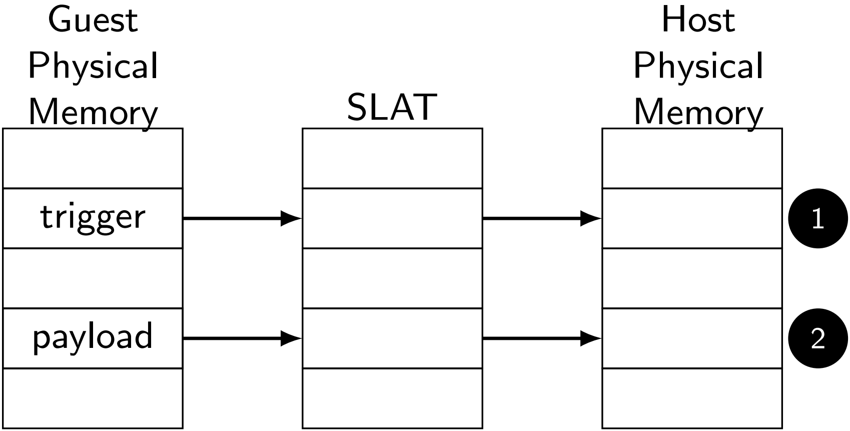

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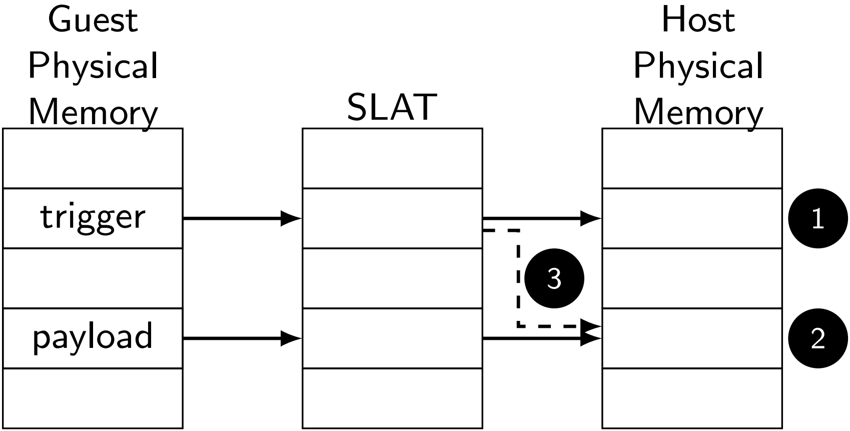

❶ Identifying the trigger

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- VM executes NMI handler immediately
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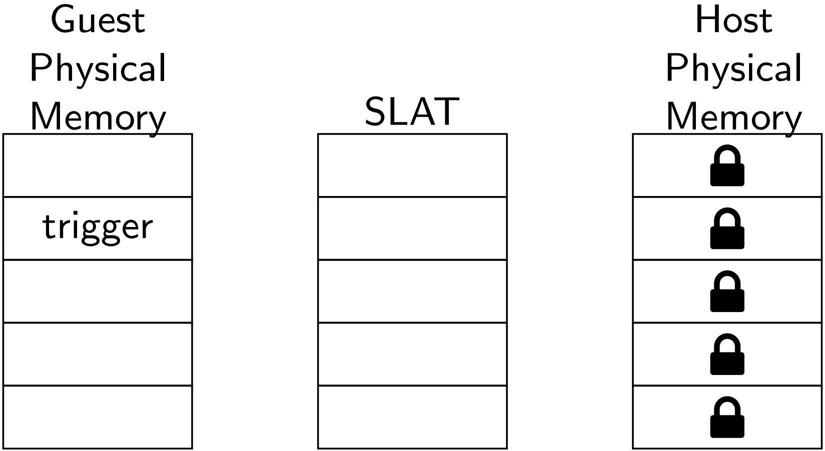
- Analyze kernel binary to determine location of NMI handler
- KASLR randomizes the kernel's offset in the VM's virtual and physical memory
- Three methods to determine KASLR offset

❶ Identifying the trigger: probing NMI handler



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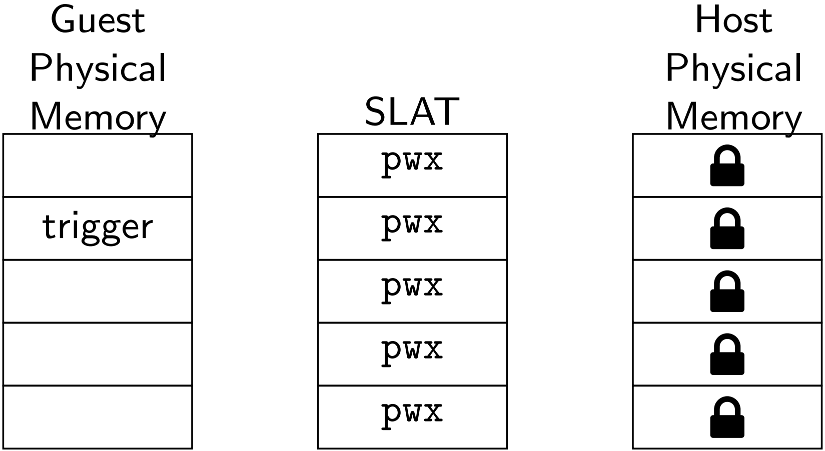

Guest Physical Memory	SLAT	Host Physical Memory
	`pwx`	🔒
trigger	`pwx`	🔒
	`pwx`	🔒
	`pwx`	🔒
	`pwx`	🔒

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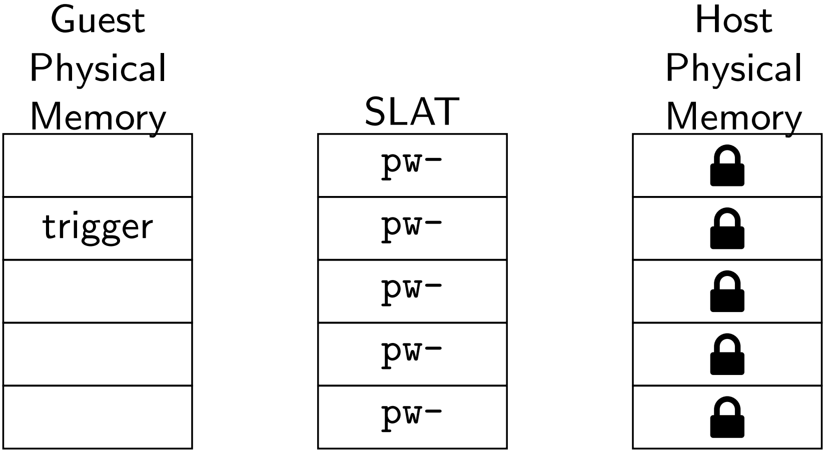

Guest Physical Memory	SLAT	Host Physical Memory
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	`pw-`	🔒
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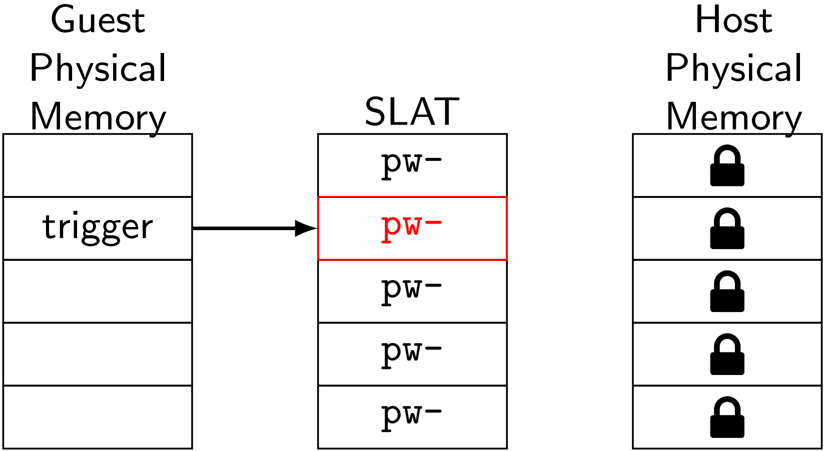

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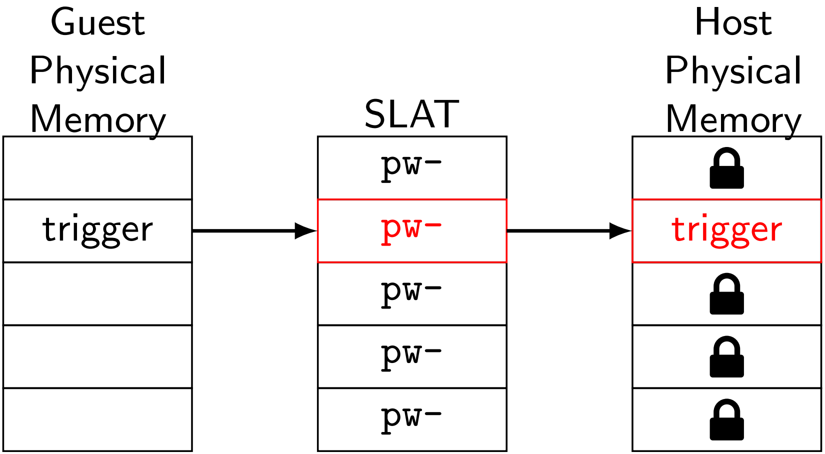

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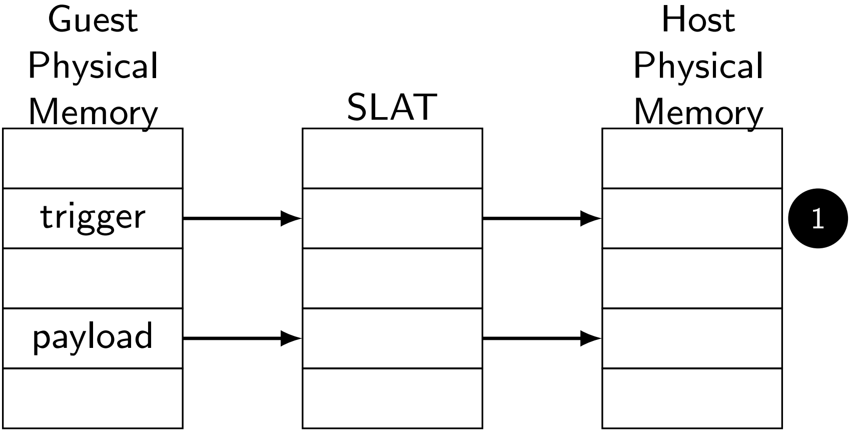


Guest Physical Memory

SLAT

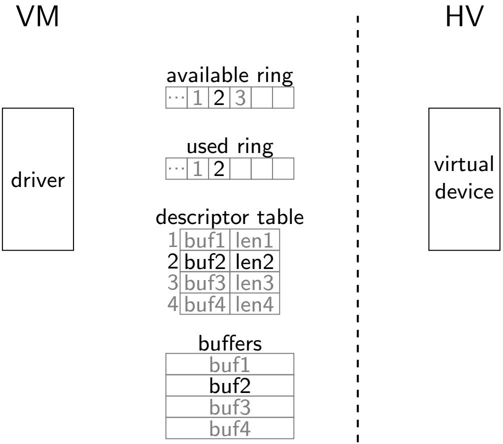
Host Physical Memory

trigger

payload

1

❷ Identifying the payload: virtio without SEV



VM

HV

driver

virtual device

available ring

⋯ | 1 | 2 | 3 | |

used ring

⋯ | 1 | 2 | | |

descriptor table

1	buf1	len1
2	buf2	len2
3	buf3	len3
4	buf4	len4

buffers

buf1

buf2

buf3

buf4

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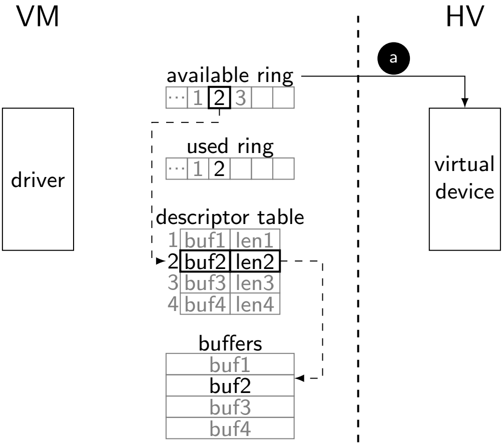

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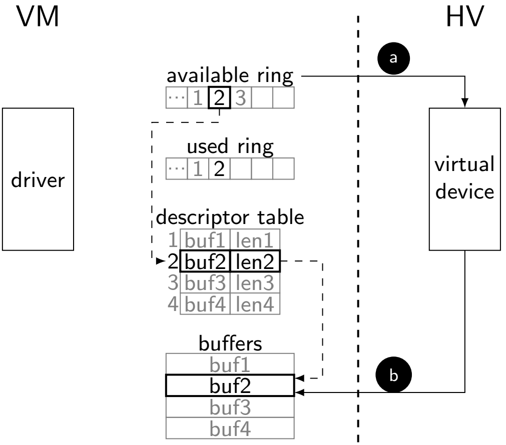

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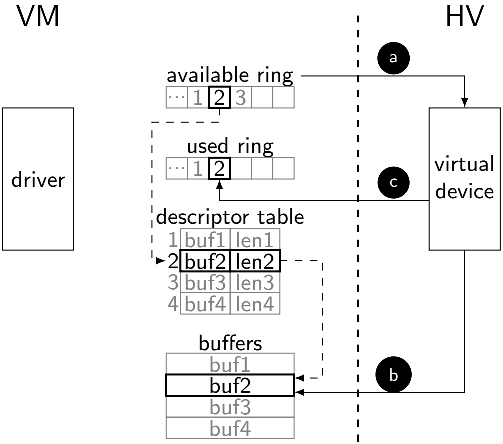

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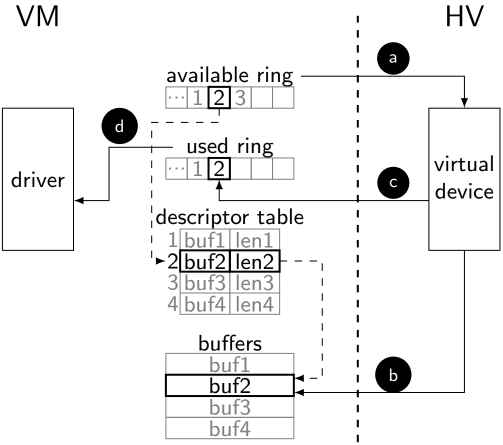

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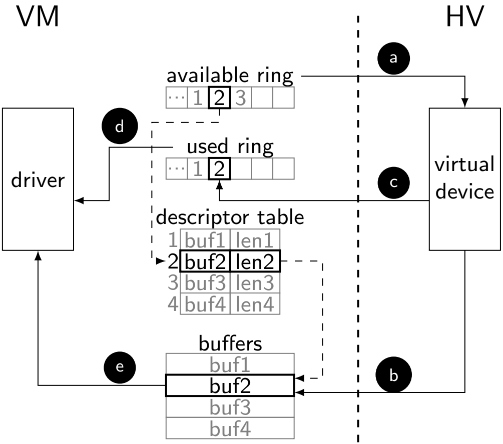

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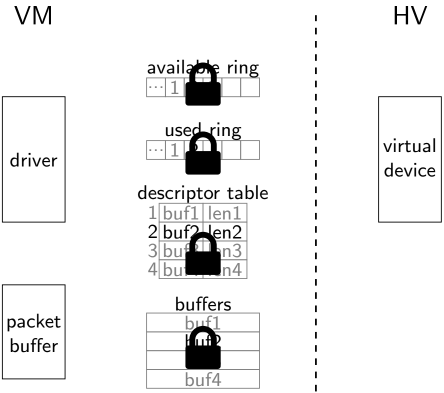

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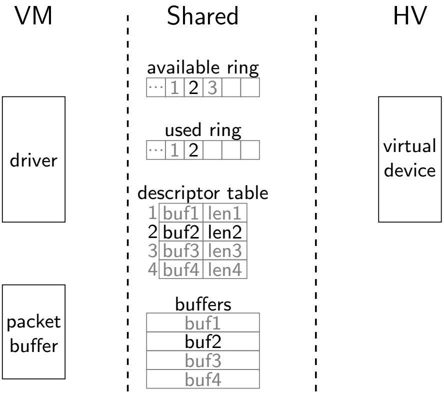

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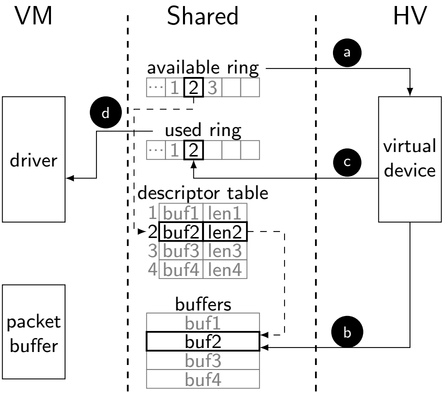

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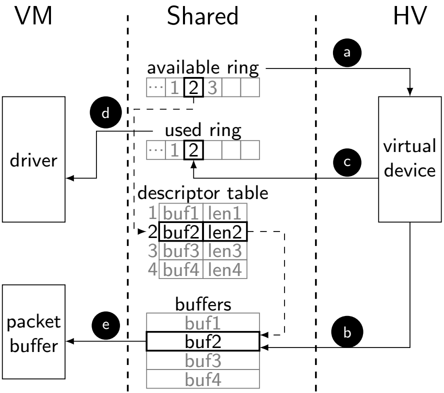

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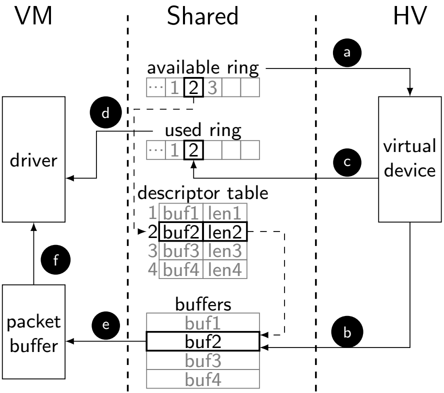

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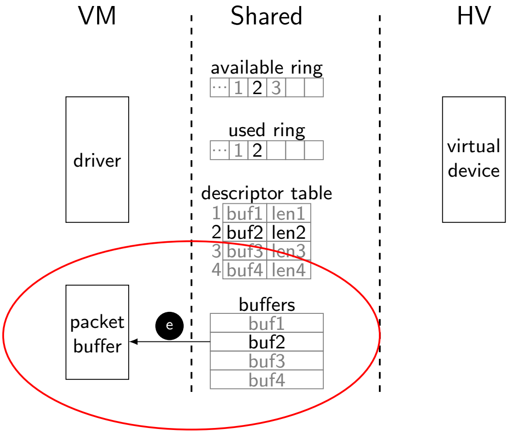

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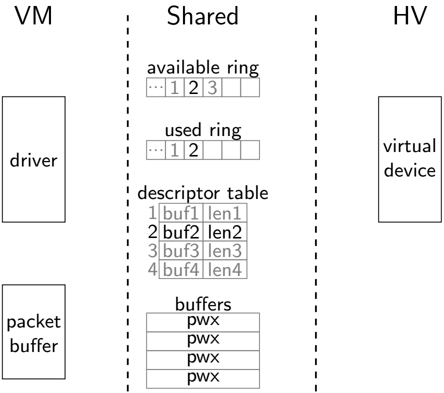

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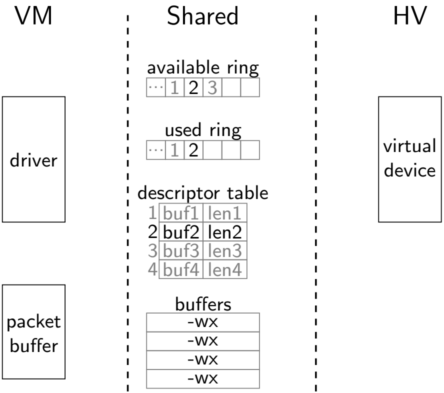

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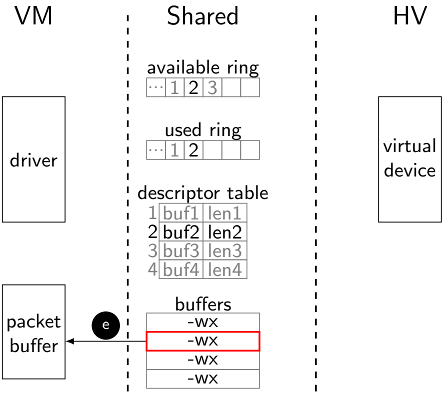

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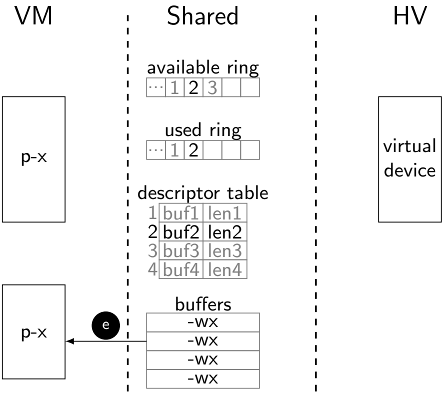

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HV

available ring

···	1	2	3		

used ring

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buffers

-wx
-wx
-wx
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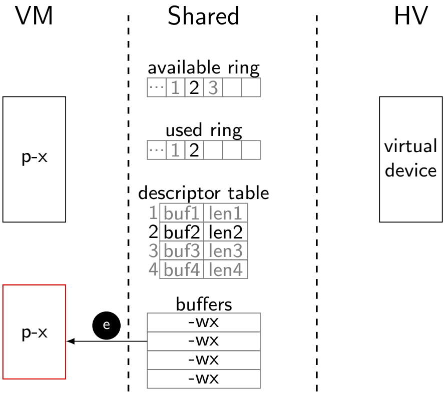

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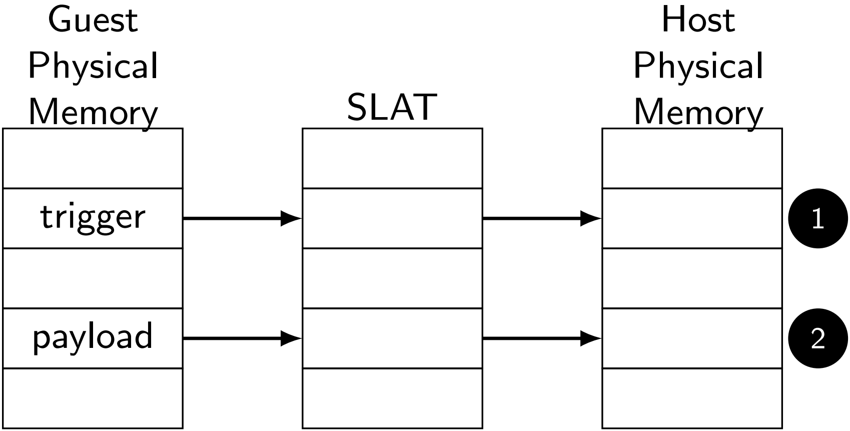

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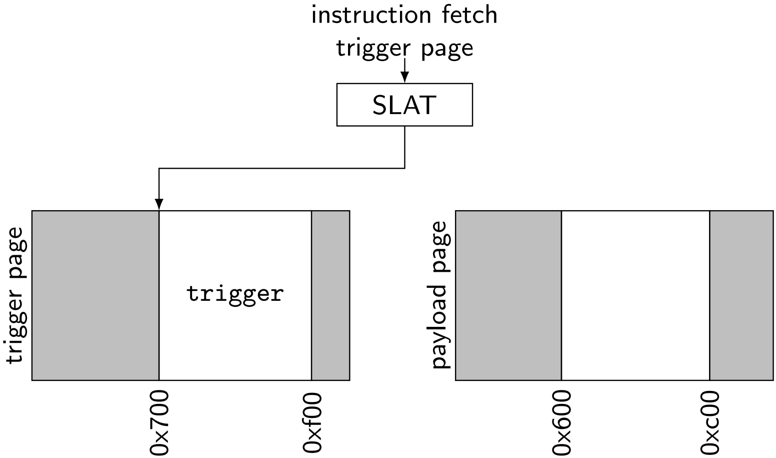
instruction fetch
trigger page
SLAT
trigger page
trigger
0x700
0xf00
payload page
0x600
0xc00

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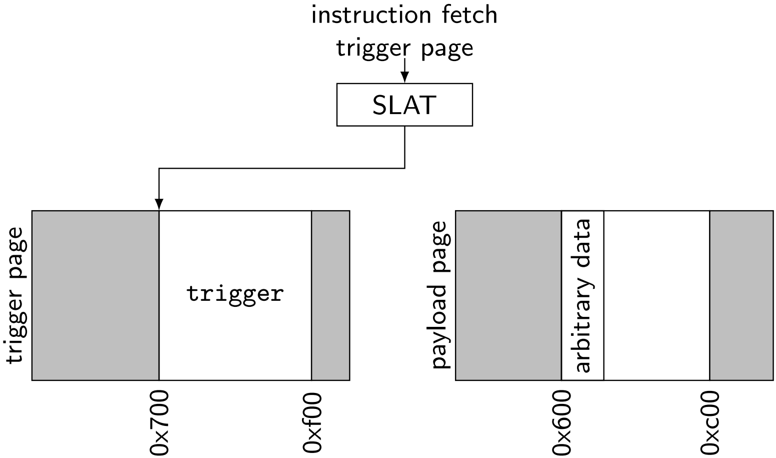
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trigger page
SLAT
trigger page
trigger
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0xf00
payload page
arbitrary data
0x600
0xc00

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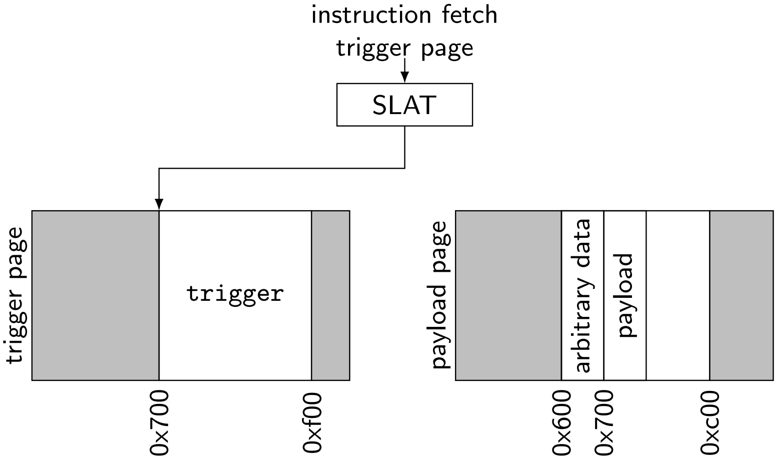
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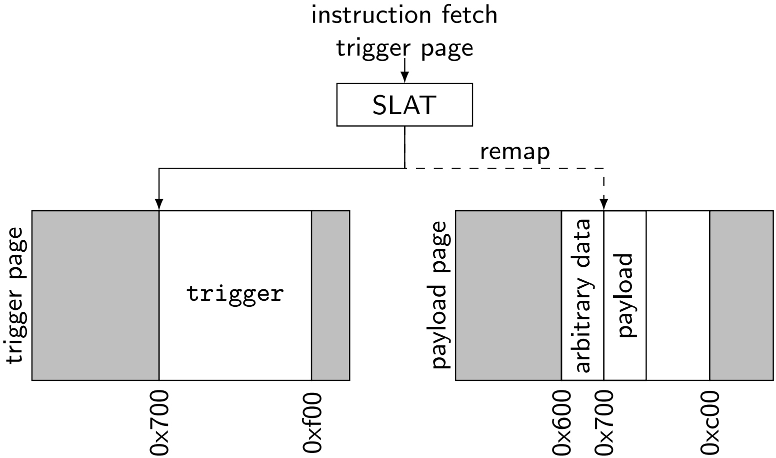
instruction fetch
trigger page
SLAT
remap
trigger page
trigger
0x700
0xf00
payload page
arbitrary data
payload
0x600
0x700
0xc00

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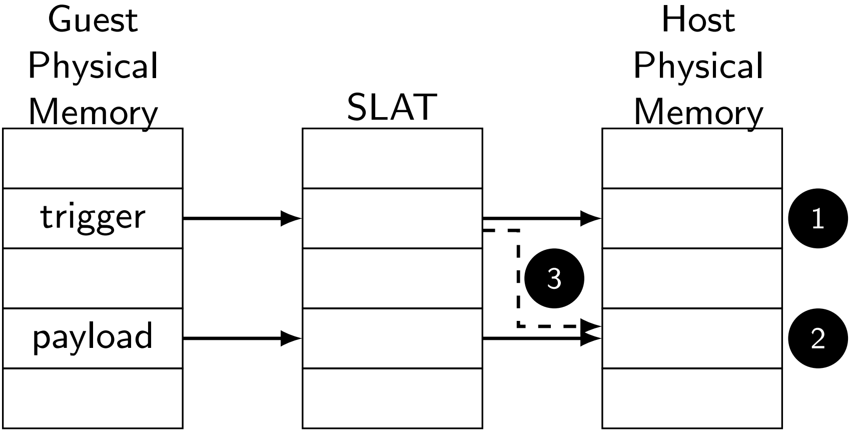

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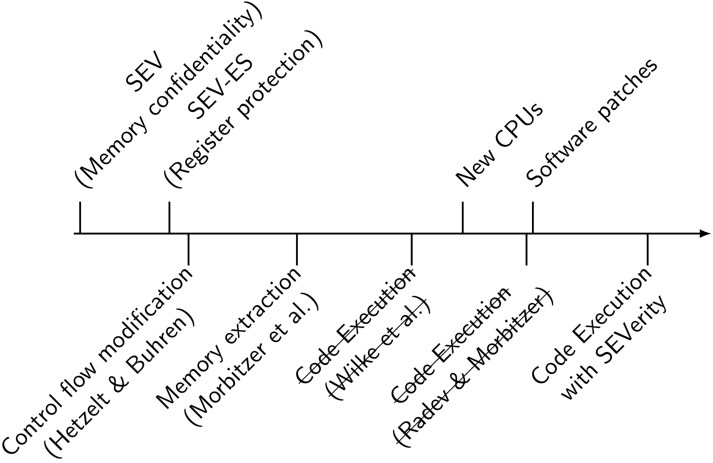

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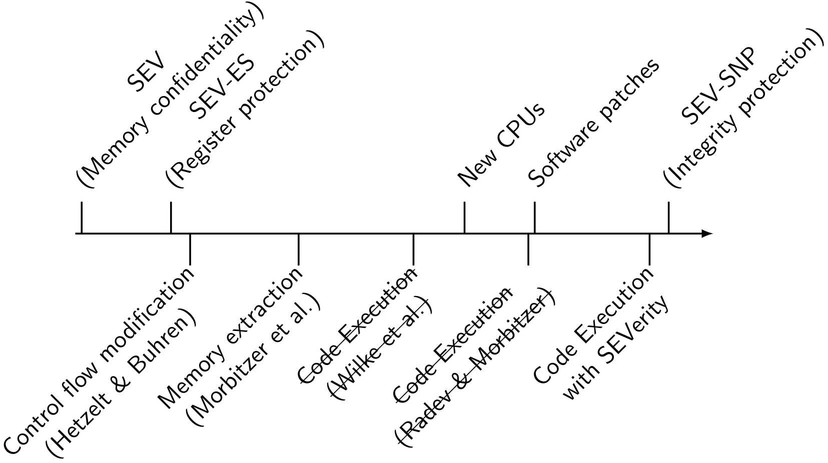

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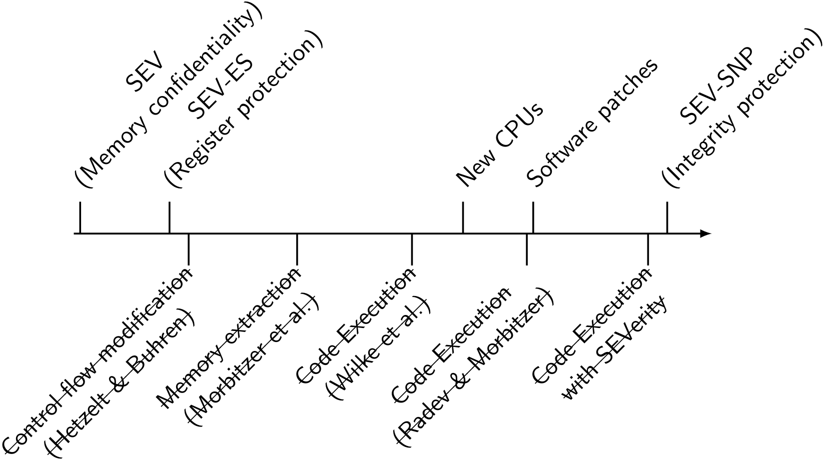

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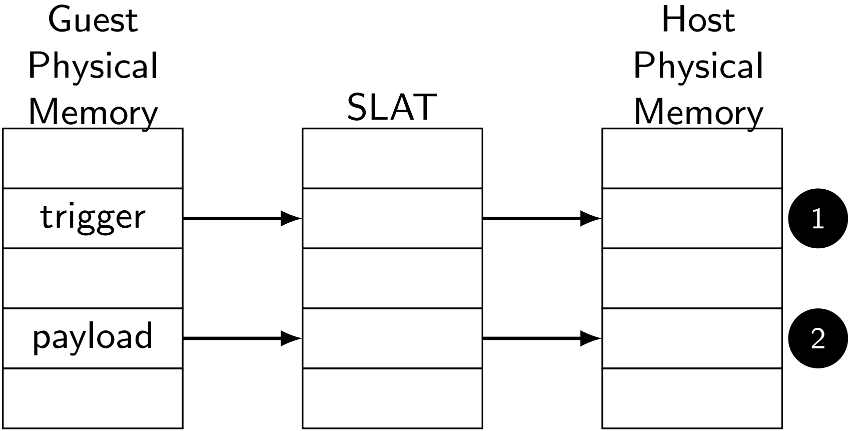
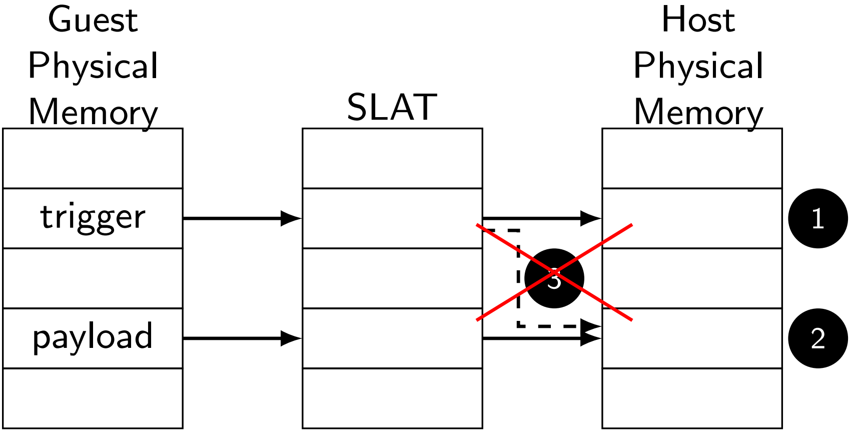
SEV-SNP (Integrity protection)

Attack overview with SEV-SNP



Attack overview with SEV-SNP



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  - First software patches also available

Questions?

Photo by Nicole Lawton from FreeImages