PowerHooK:
Enabling Software-Based Power Side Channels Against AMD SEV Technologies via Transient-Execution Replay

SCIENCE
PASSION
TECHNOLOGY

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[1]Graz University of Technology [2]Graz University of Technology Alumni

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About

Transient-replay power side channels against **AMD SEV VMs**

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- Denoising software-based power side channels:
  - Malicious hypervisor uses a transient-replay gadget to amplify and denoise transient power traces
  - Enables single-run power side-channel attacks against VMs protected by AMD SEV technologies

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- Real-world AES-NI key-byte recovery:
  - OpenSSL AES key-byte recovery from a single SEV-ES VM invocation of AES-NI accelerated CBC

Motivation & Threat Model

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Malicious Hypervisor

Confidential VM

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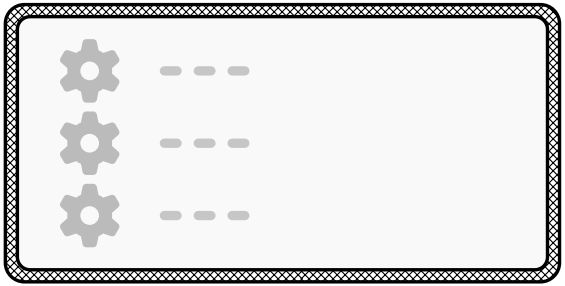
Malicious Hypervisor



Confidential VM

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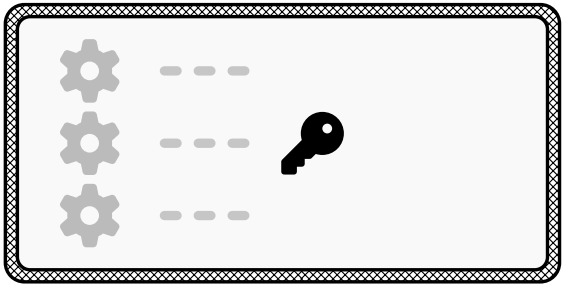

Confidential VM

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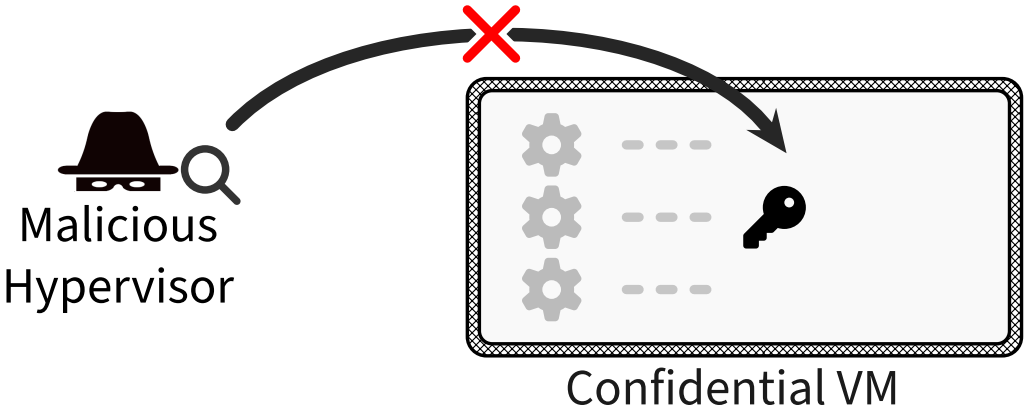

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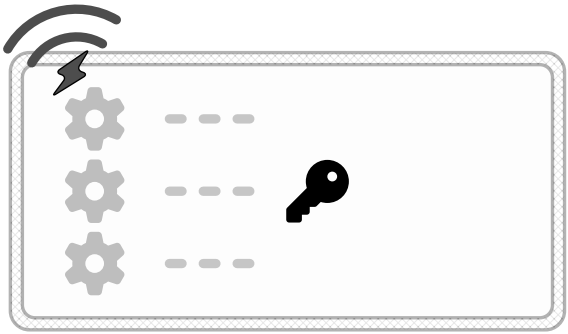

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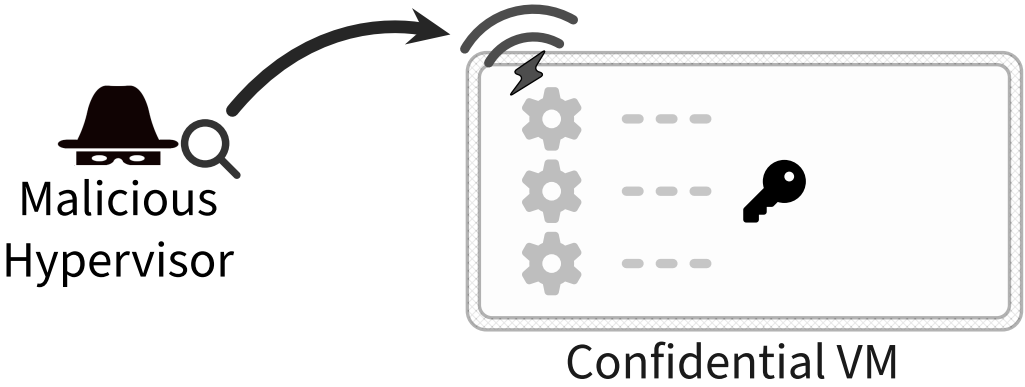
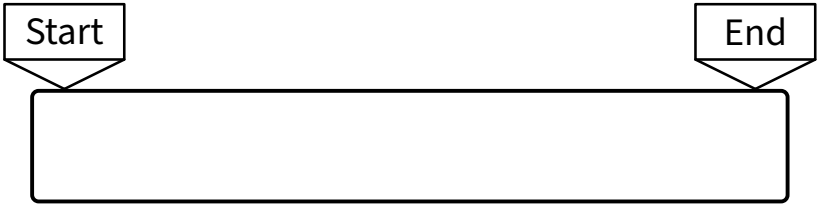


Motivation: Measuring Power in Software



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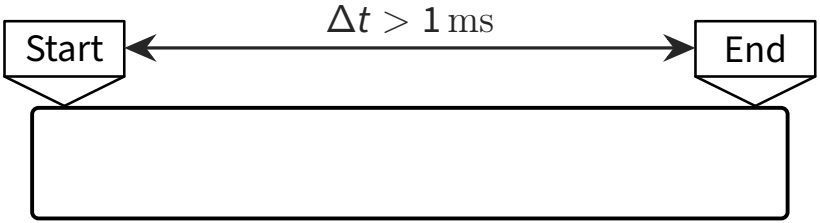

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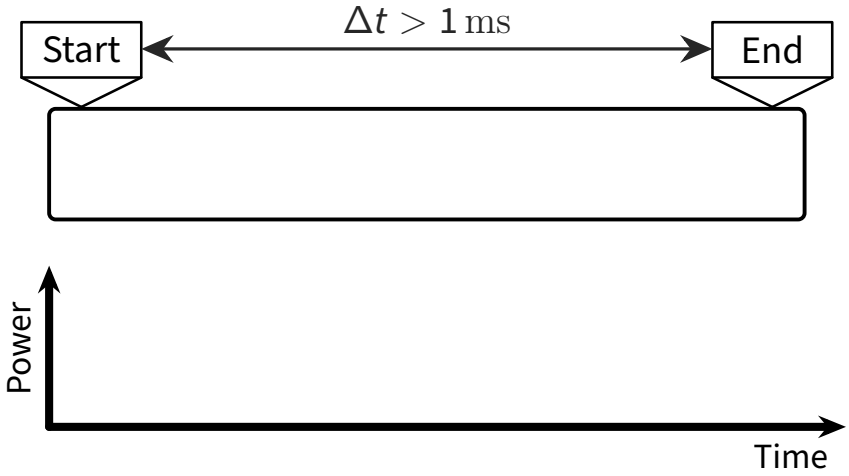

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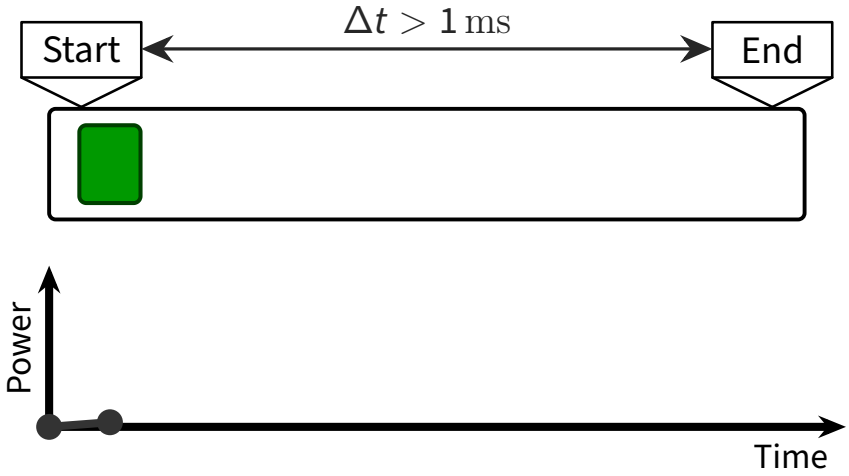

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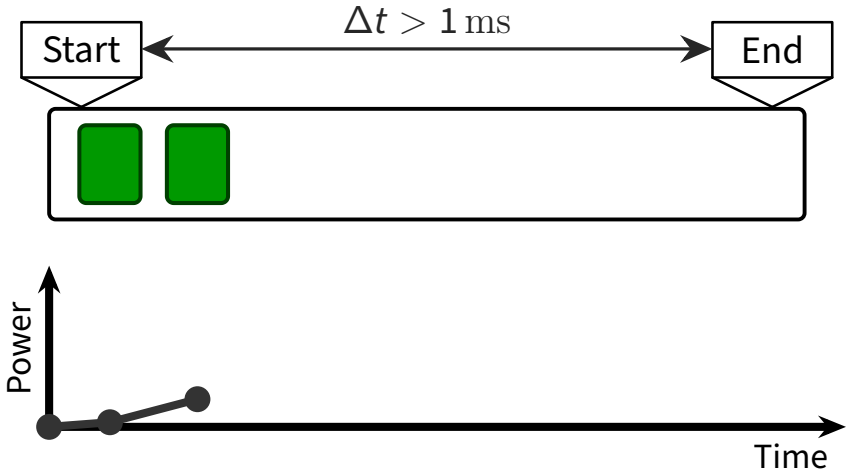

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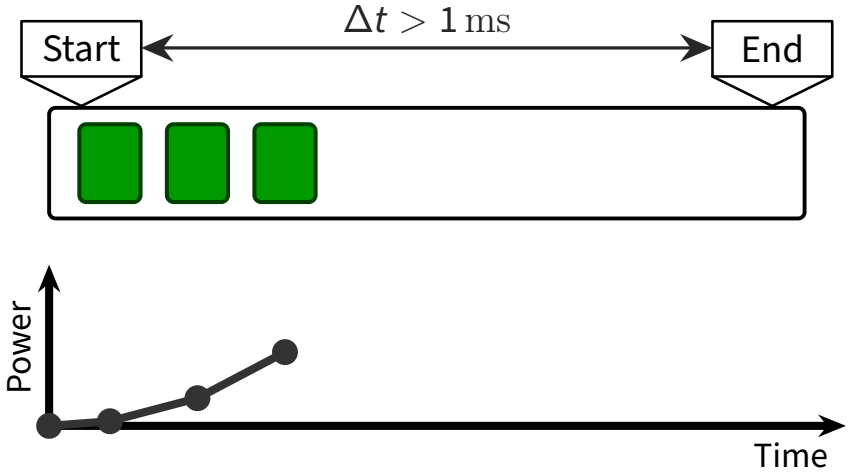

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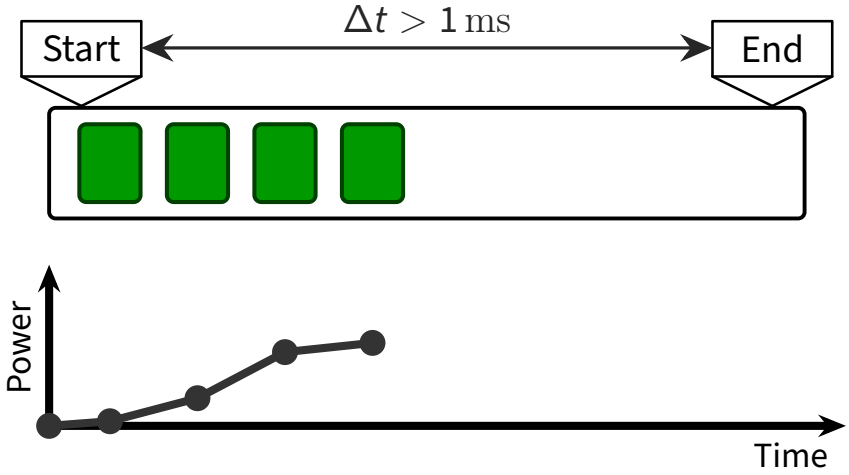

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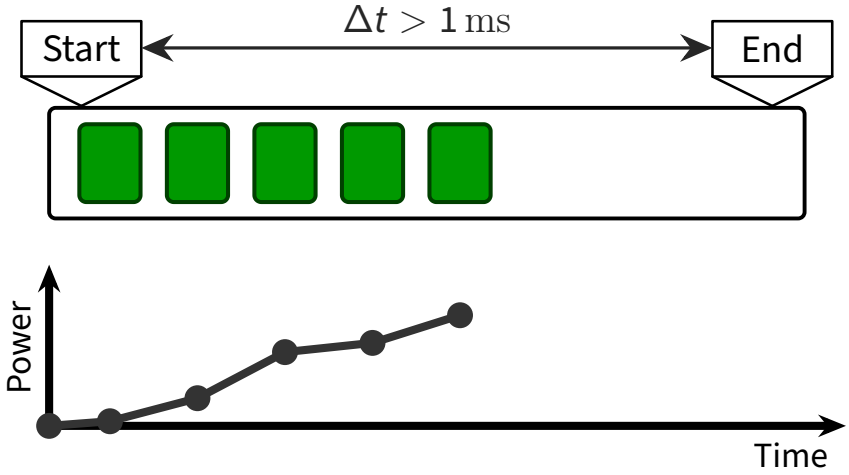

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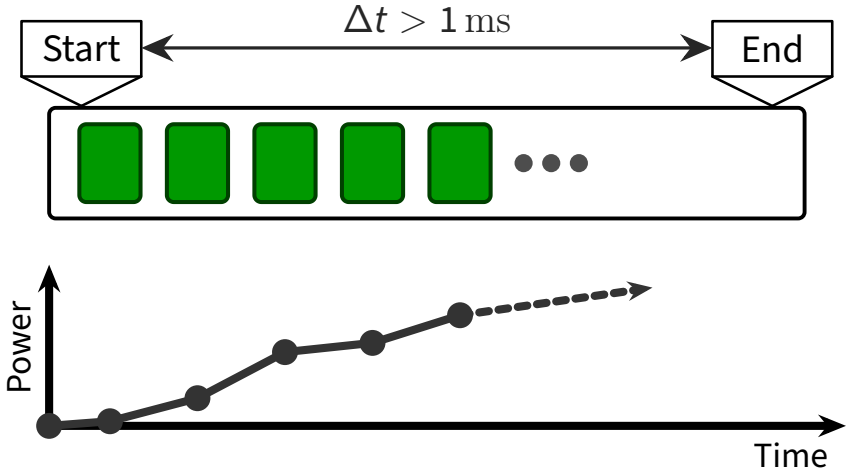

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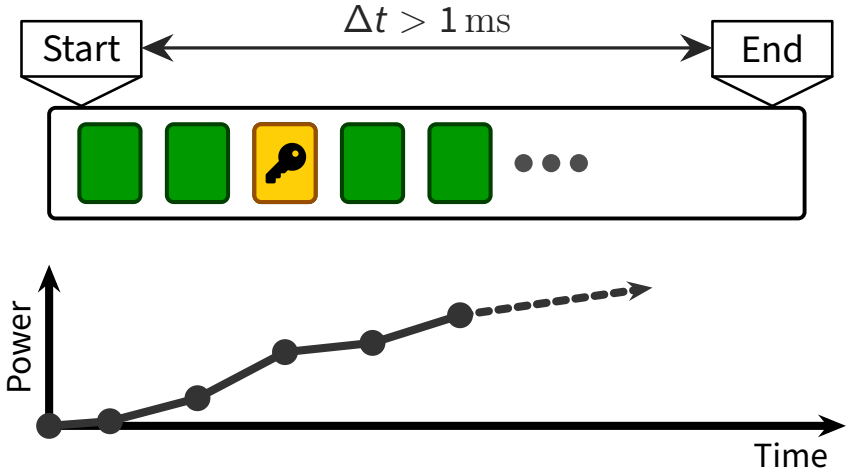

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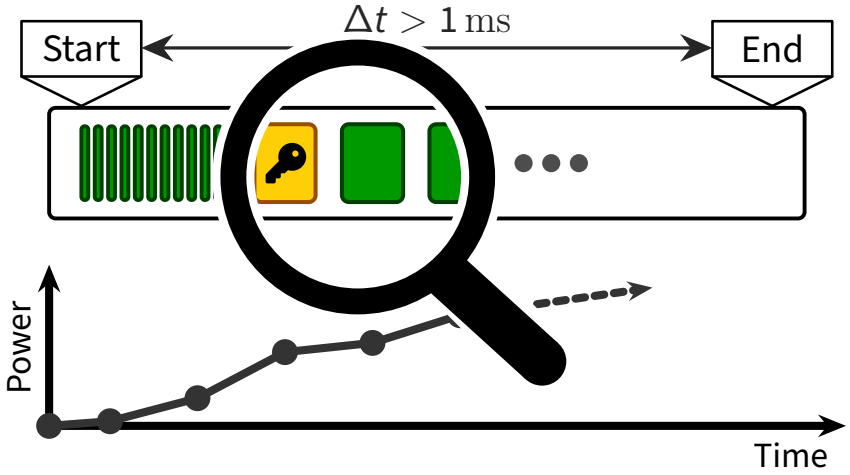

PowerHooK: Overview

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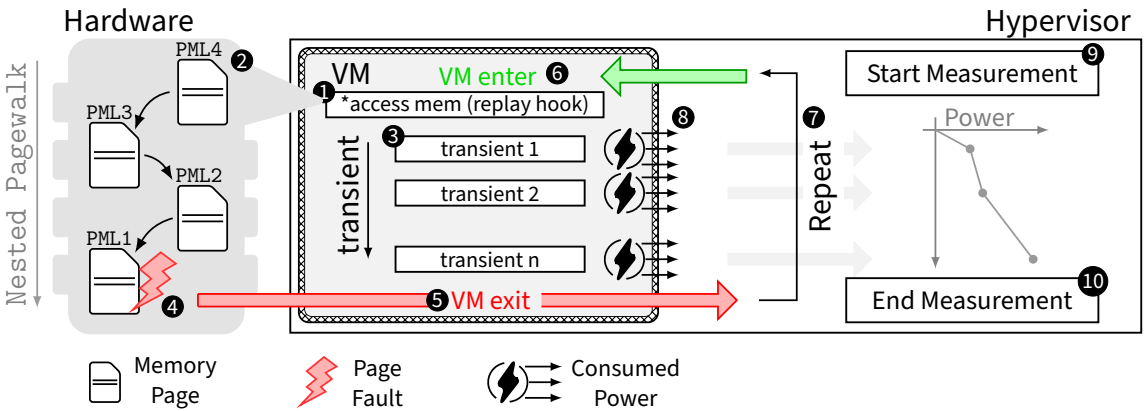
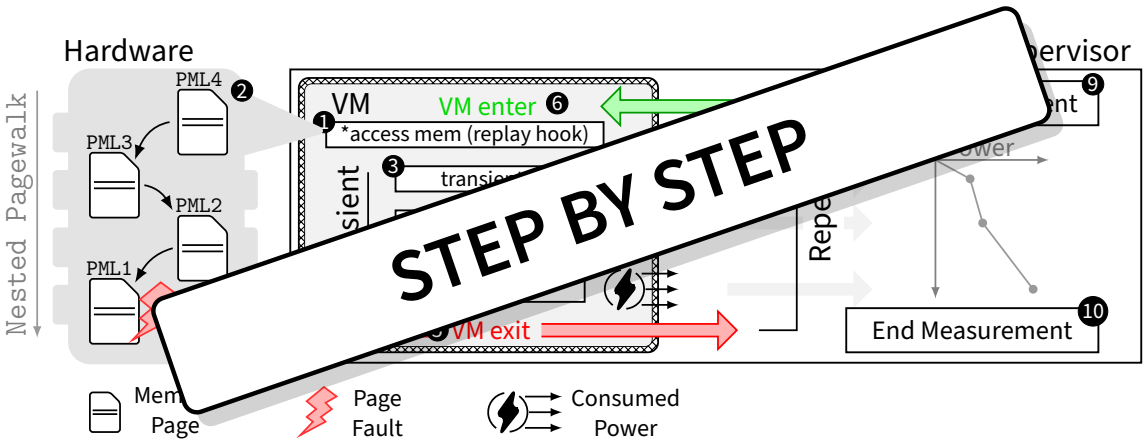
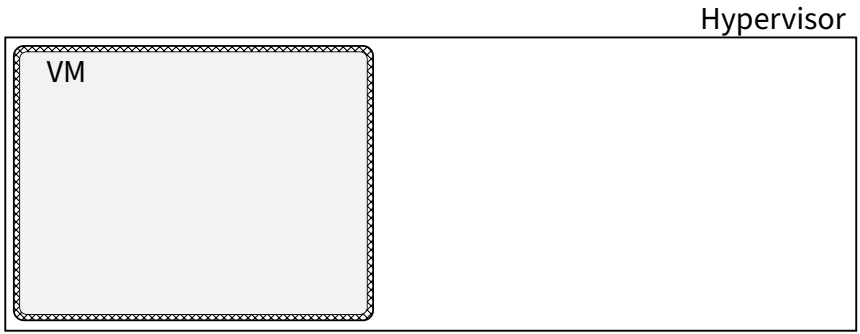



Hardware
Nested Pagewalk
PML4
PML3
PML2
PML1
VM
*access mem (replay hook)
VM enter
VM exit
End Measurement
Page Fault
Consumed Power
STEP BY STEP

PowerHooK Overview



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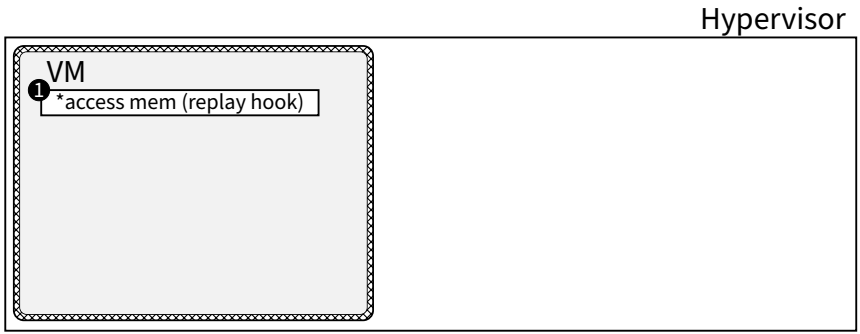

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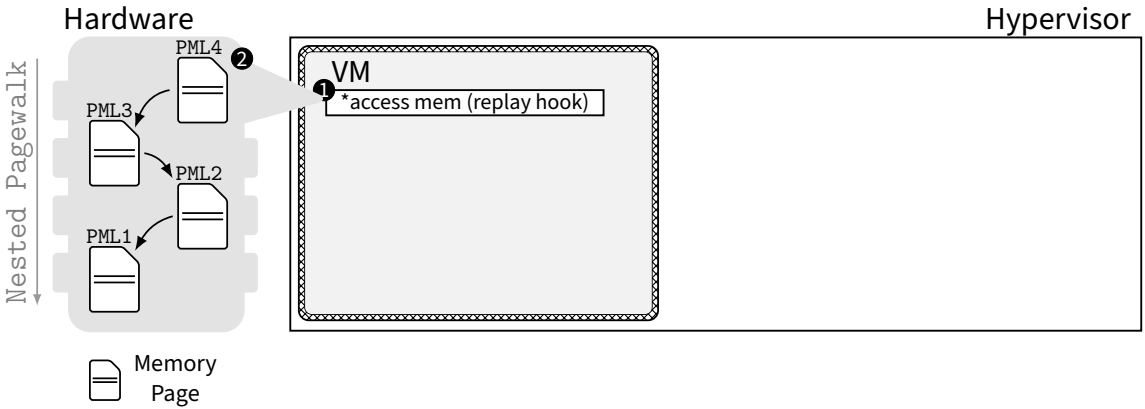

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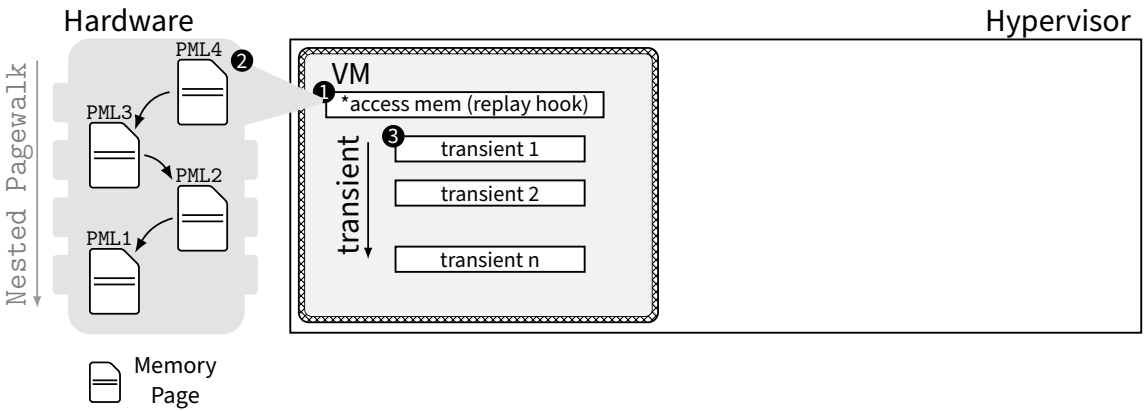

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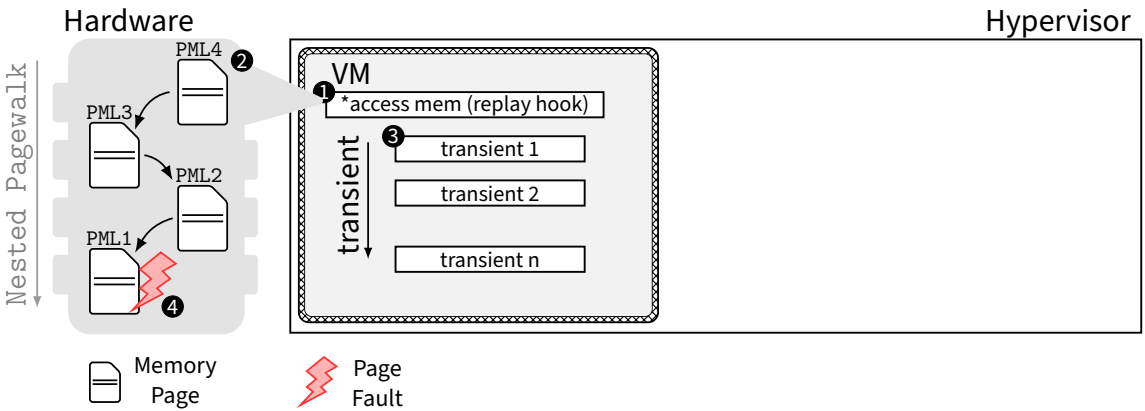

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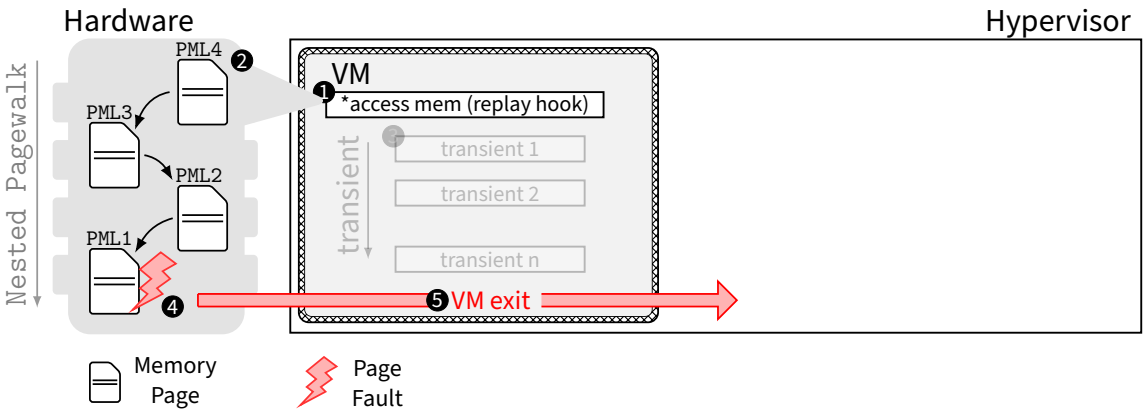

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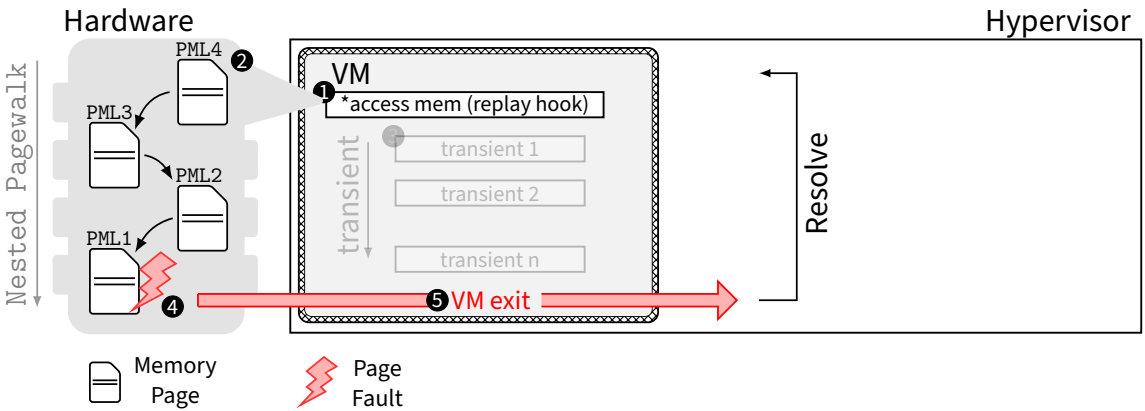

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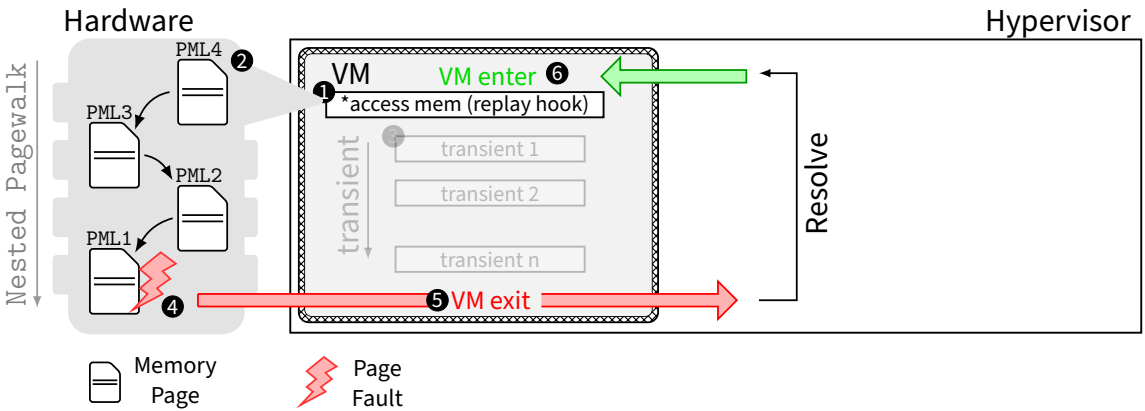

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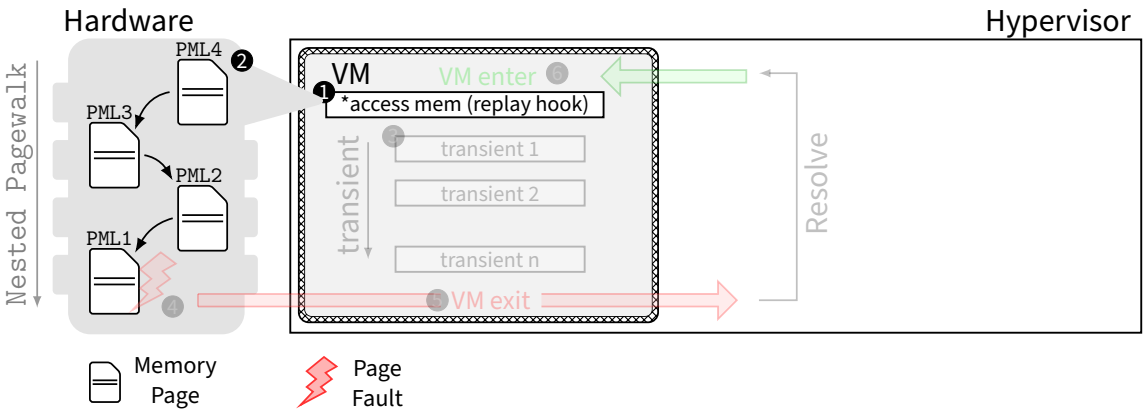

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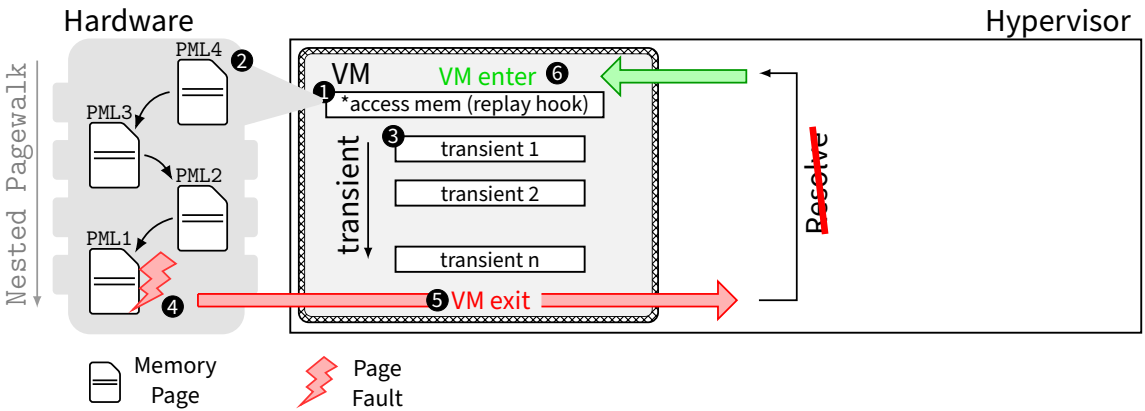

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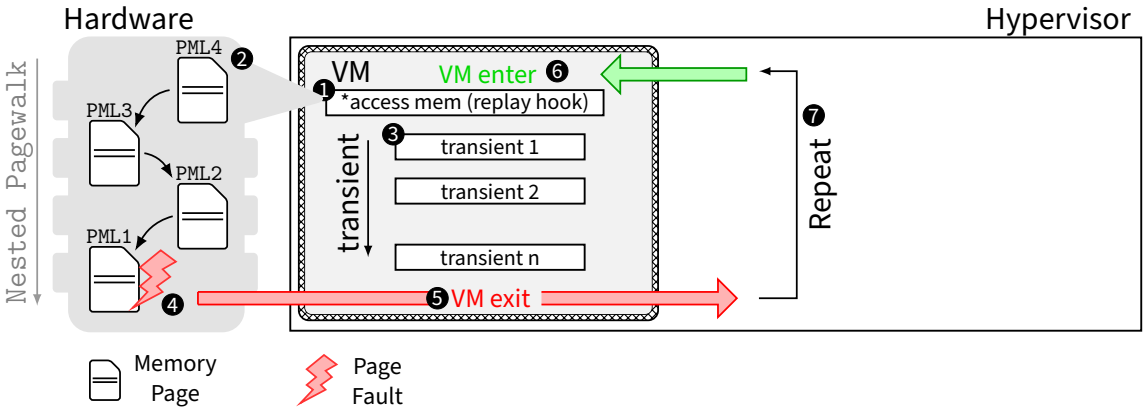

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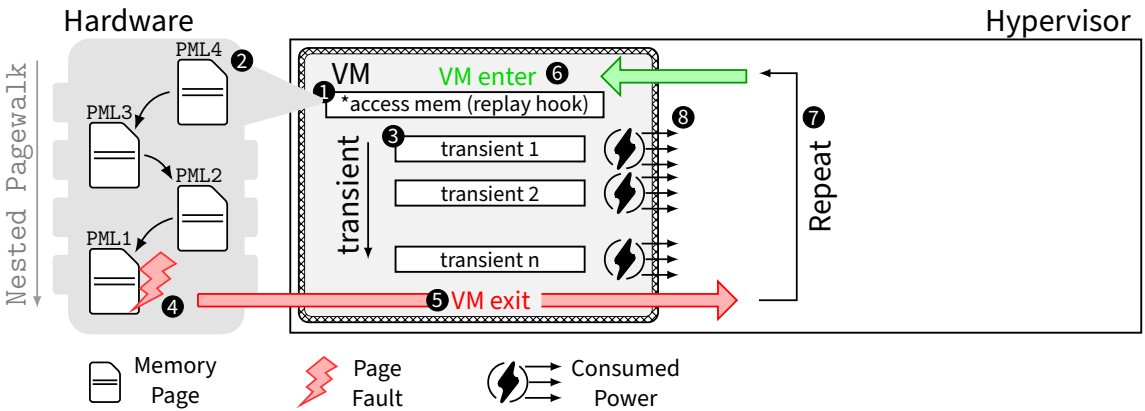

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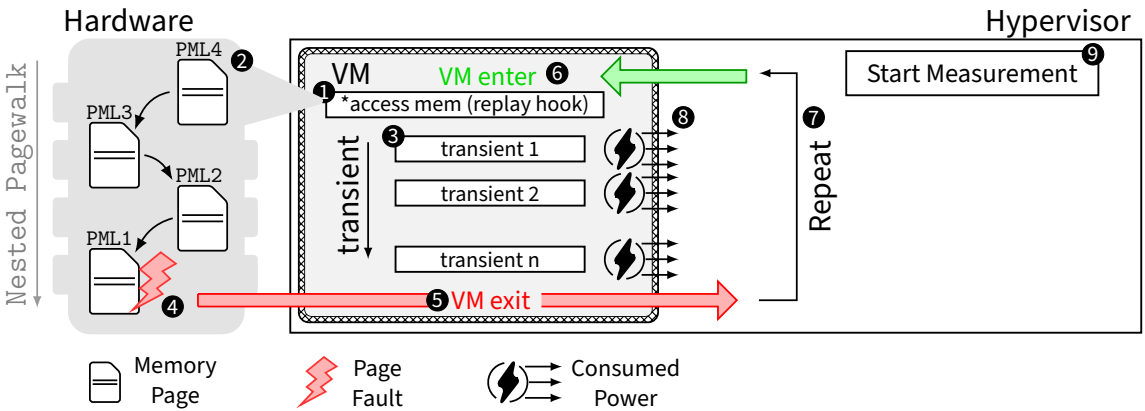

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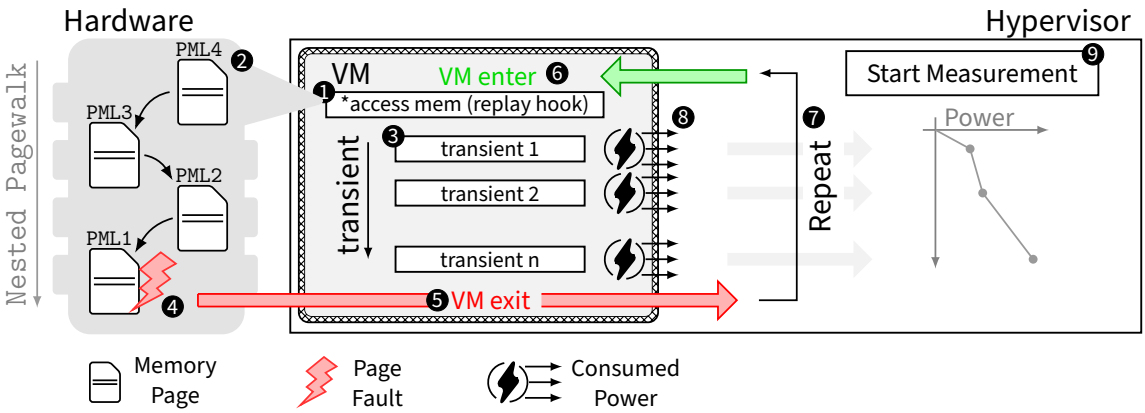

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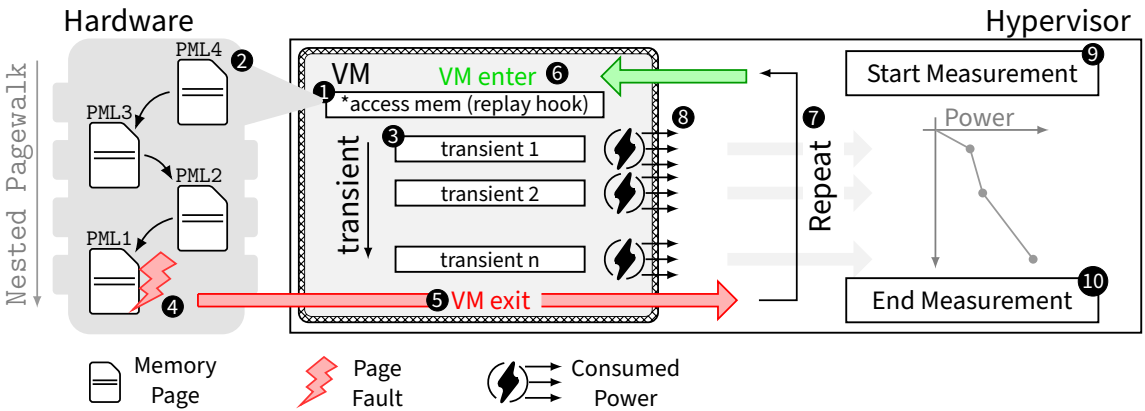

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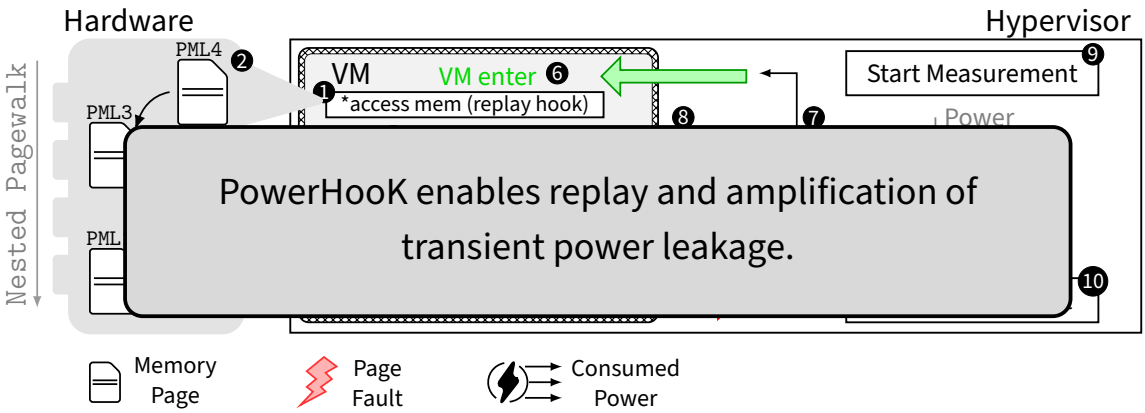

Systematic Analysis

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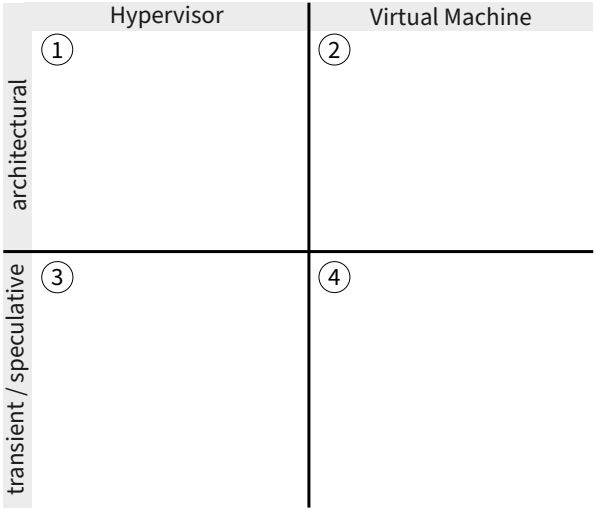

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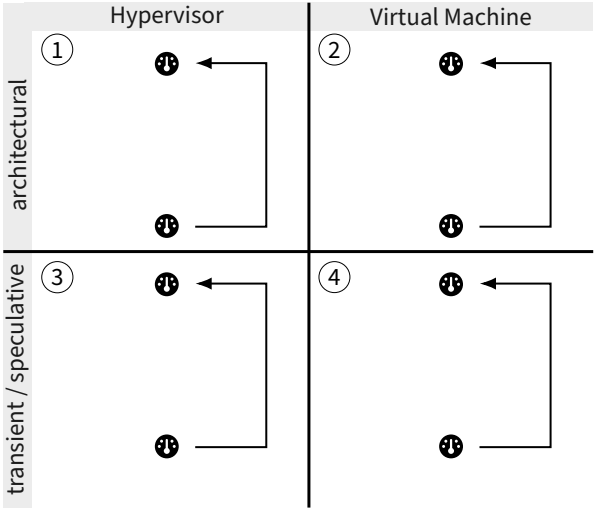

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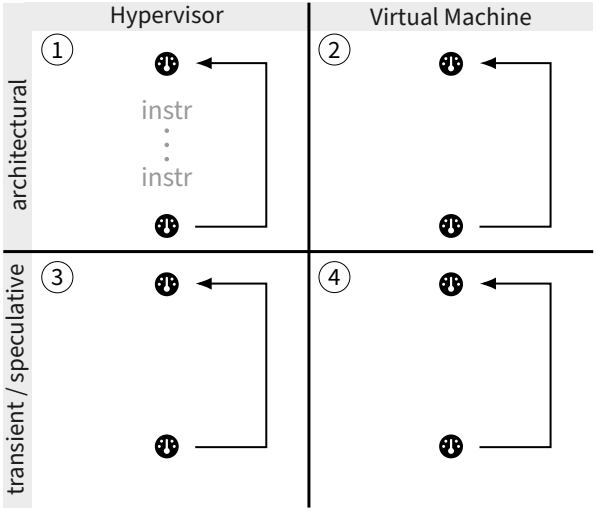

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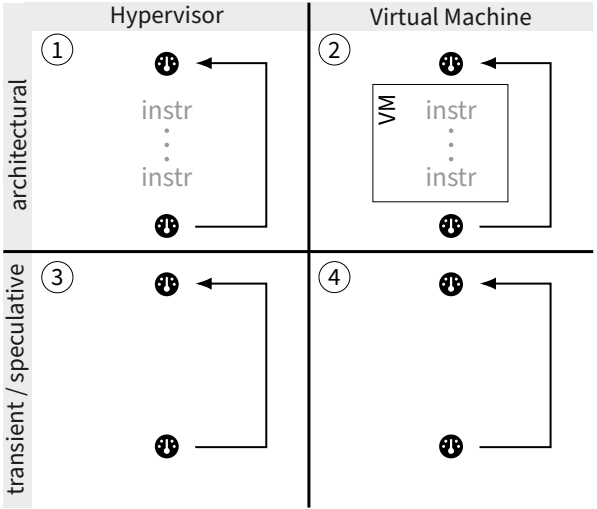

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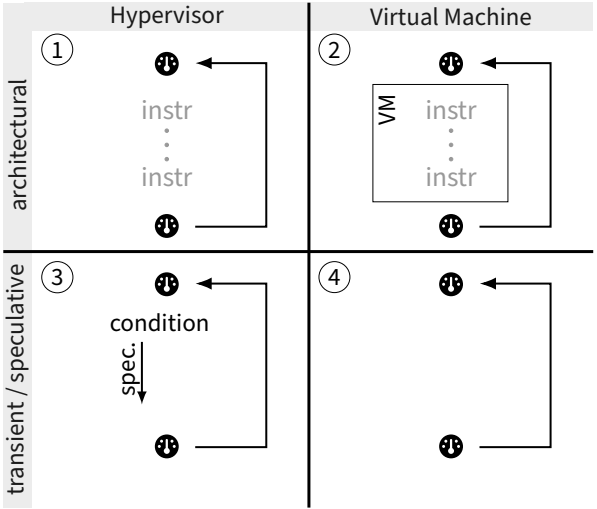

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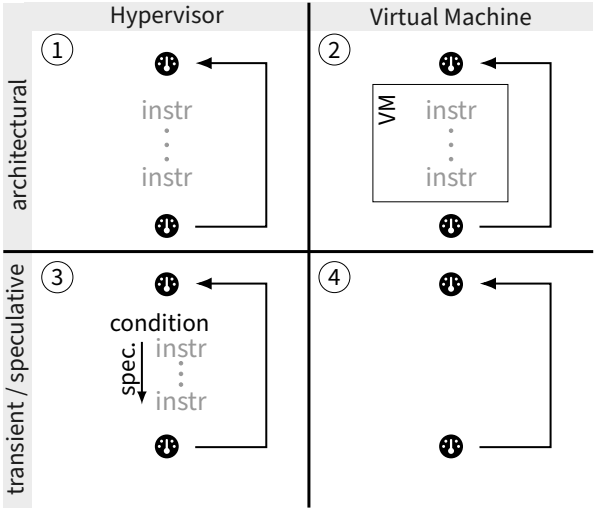

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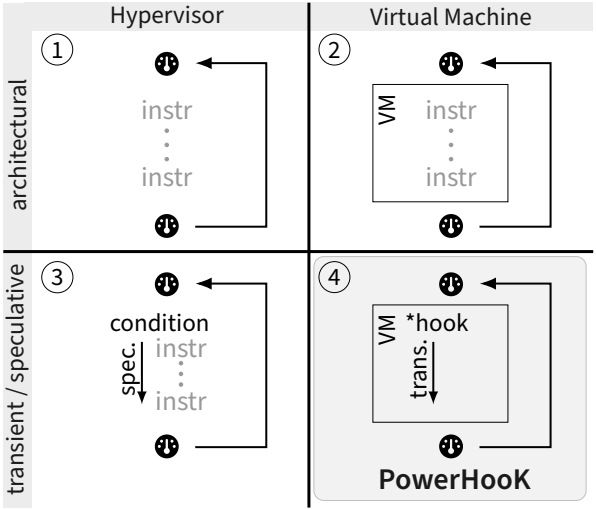

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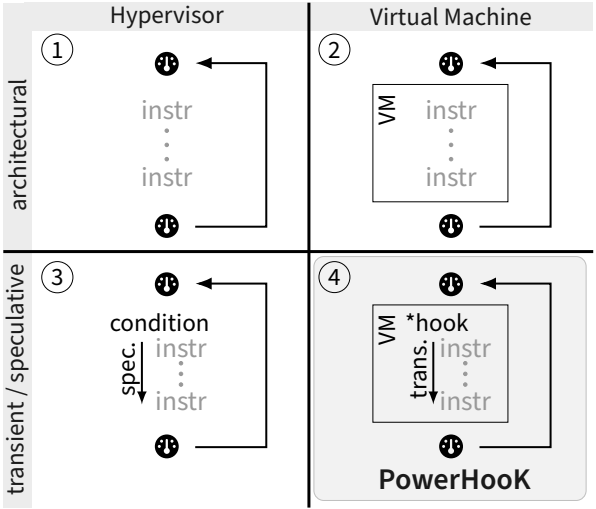

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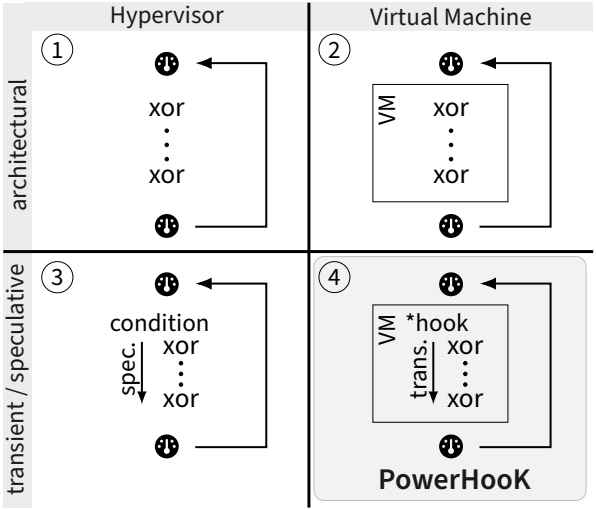
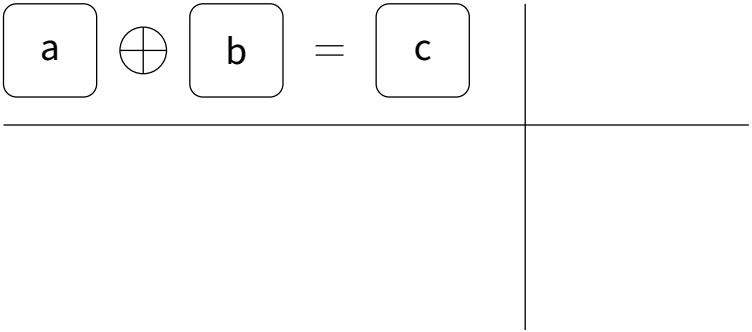


Systematic Analysis: Executed Workload



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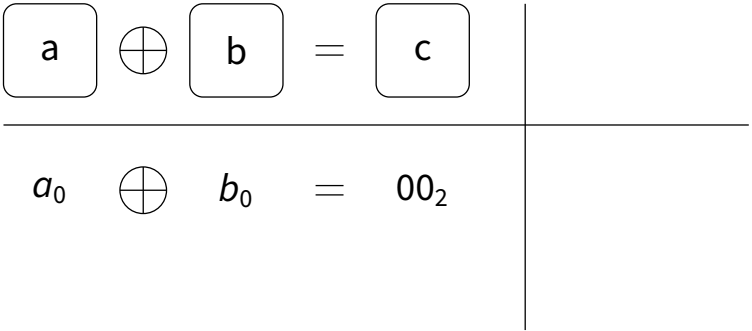

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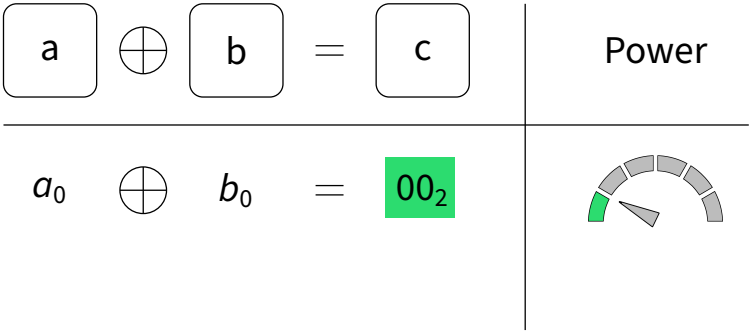
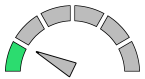
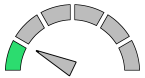
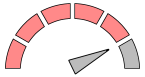


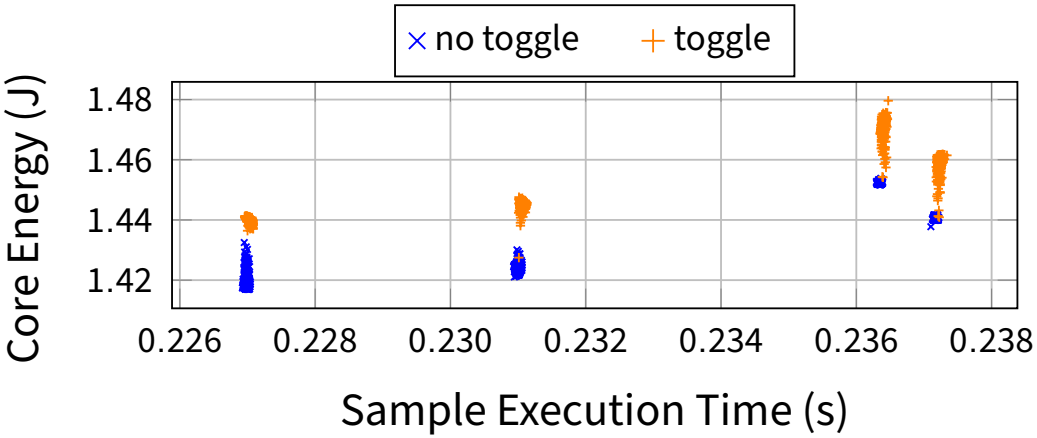
Systematic Analysis: Executed Workload

a ⊕ b = c	Power
$a_0 \oplus b_0 = 00_2$	
$a_1 \oplus b_1 = 11_2$	

Systematic Analysis: Executed Workload

a	⊕	b	=	c	Power
a_0	⊕	b_0	=	00_2	
a_1	⊕	b_1	=	11_2	

Systematic Analysis: Generic Filtering



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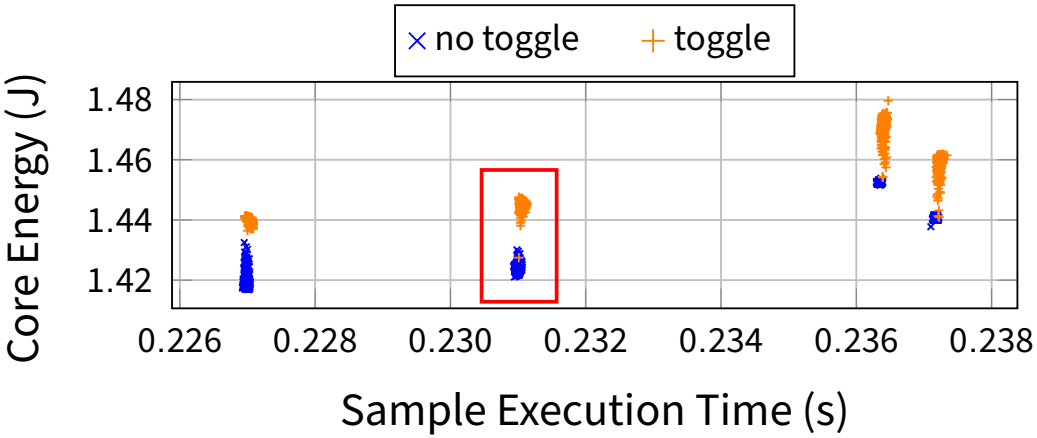
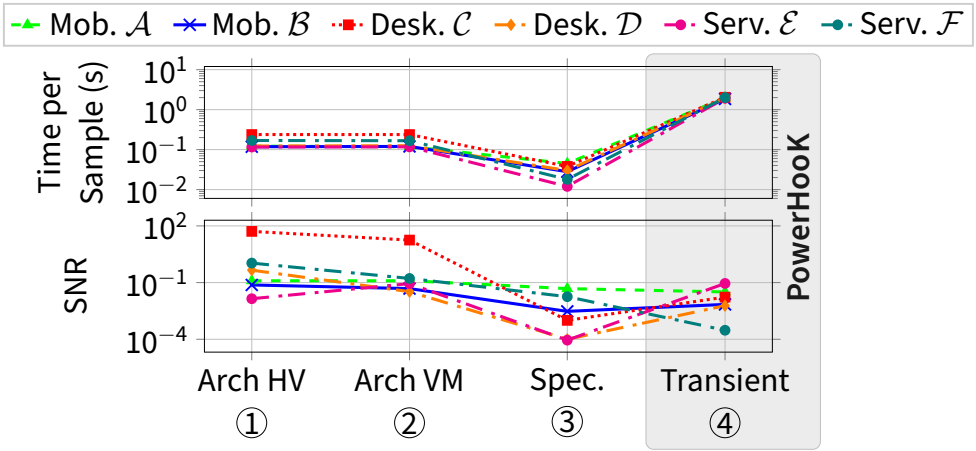


Systematic Analysis: Evaluation



PowerHooK Execution Time Across SEV Technologies

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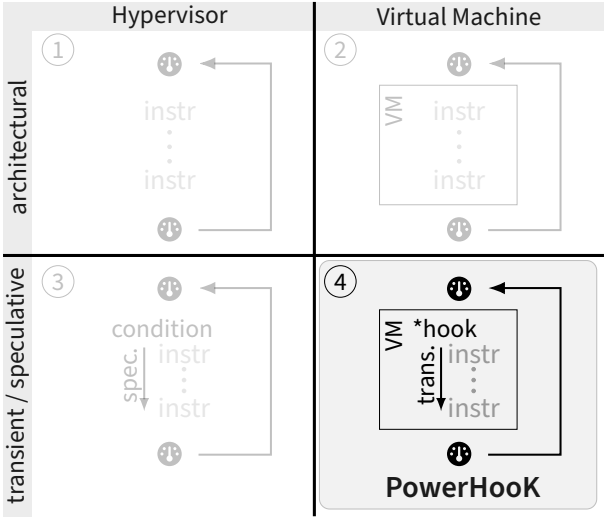
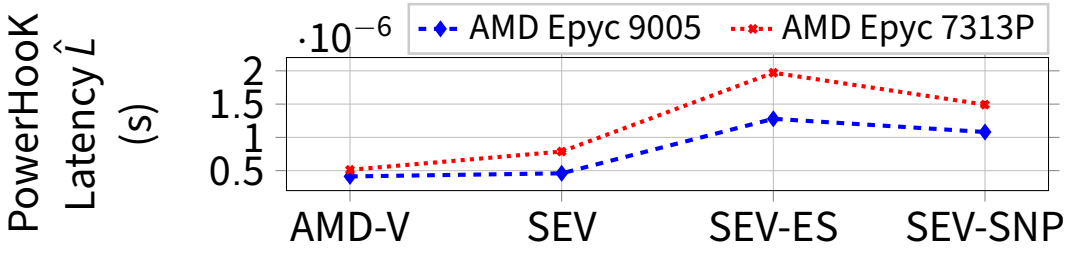


PowerHooK: Replay Execution Time



Synthetic AES-NI CPA Attack across AMD SEV

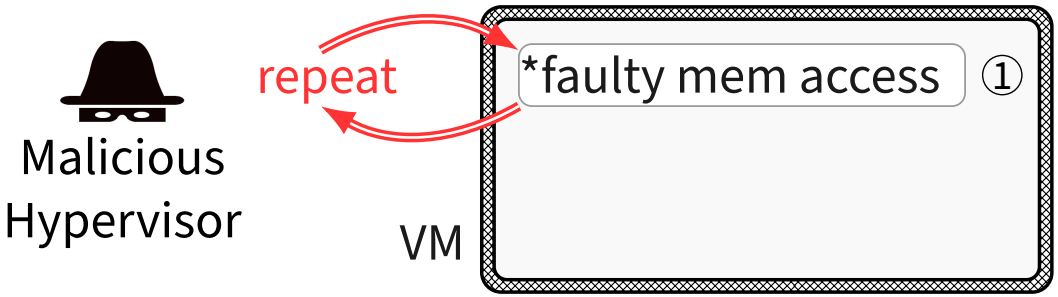
Malicious Hypervisor

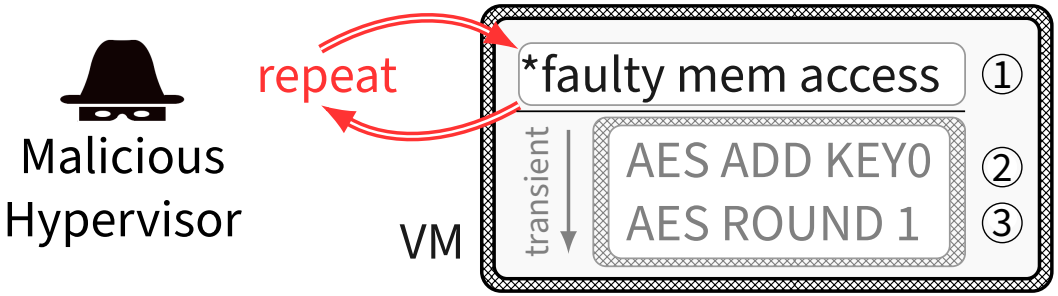
VM

Malicious Hypervisor

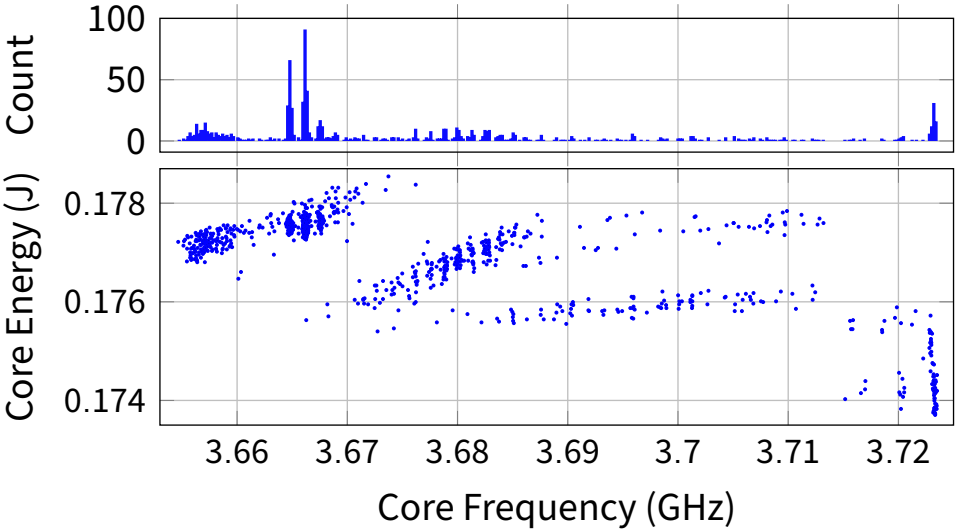
VM

*faulty mem access ①

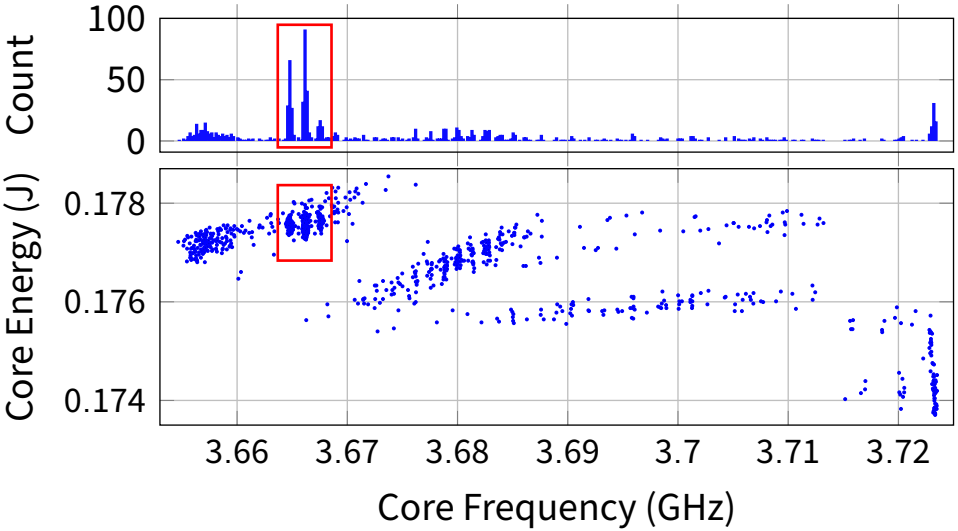

repeat
*faulty mem access
①
Malicious
Hypervisor
VM


repeat
*faulty mem access
①
transient
AES ADD KEY0
②
AES ROUND 1
③
VM
Malicious
Hypervisor

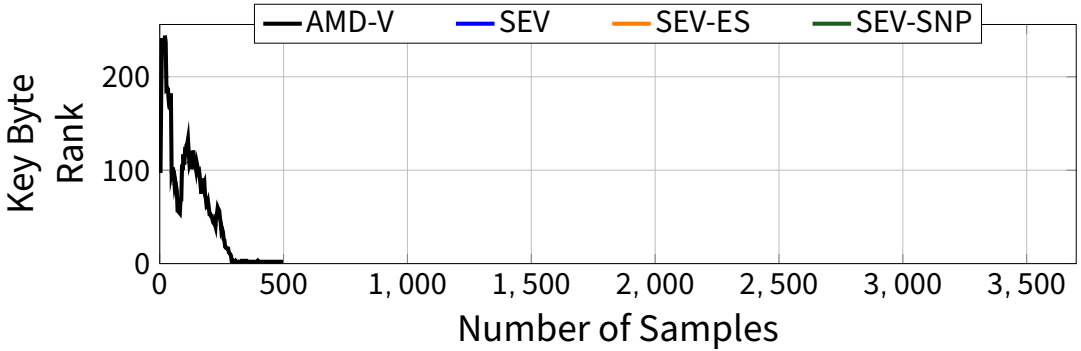
AES-NI Leakage Characterization: Filtering



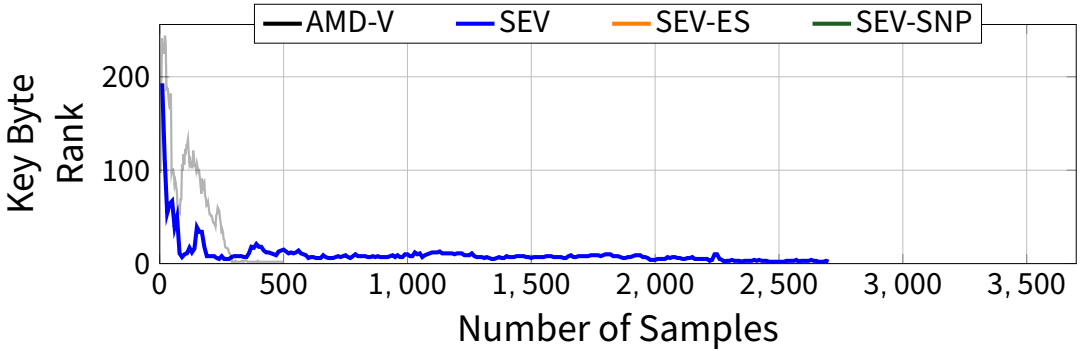
AES-NI Leakage Characterization: Filtering



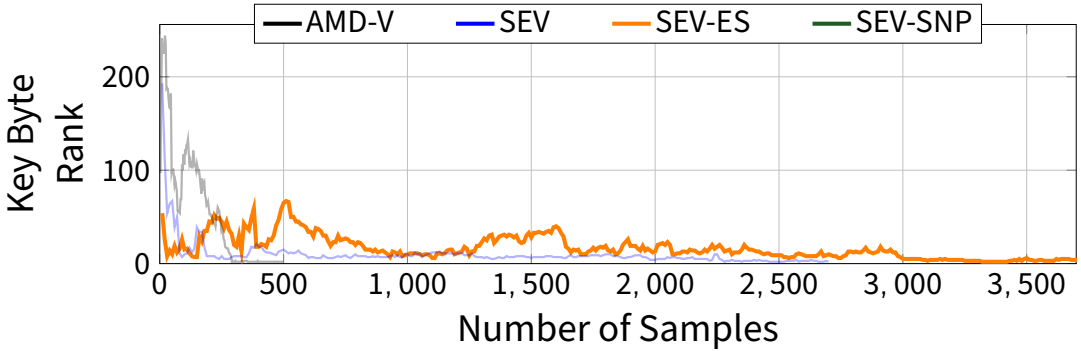
AES-NI Leakage Characterization: Evaluation



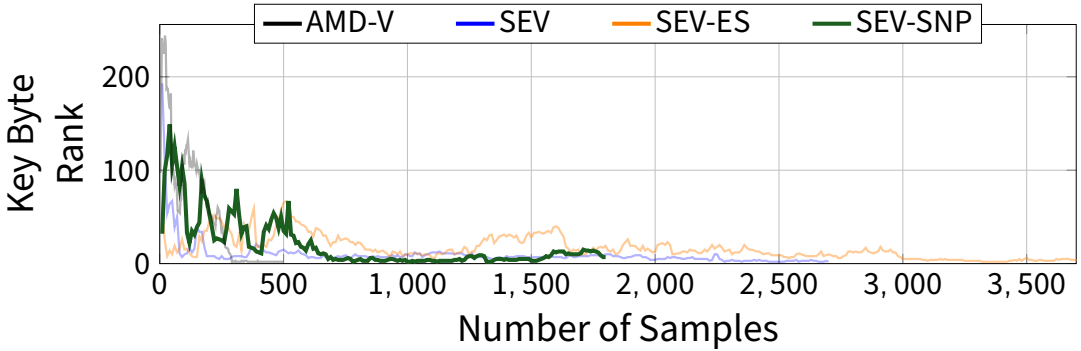
AES-NI Leakage Characterization: Evaluation



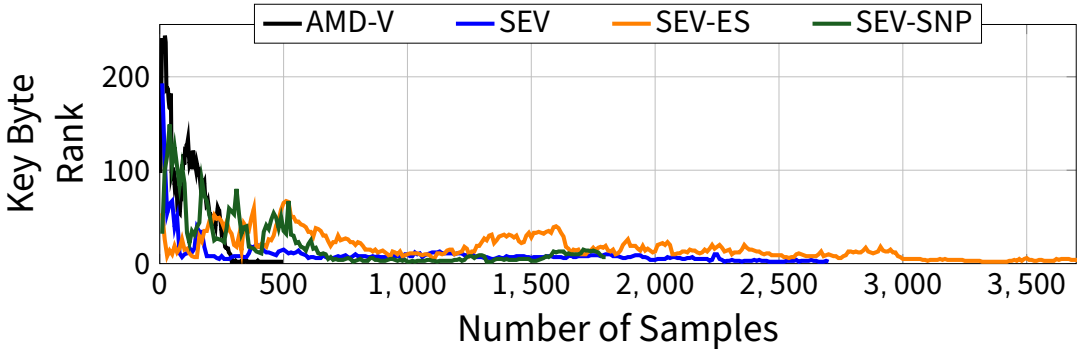
AES-NI Leakage Characterization: Evaluation



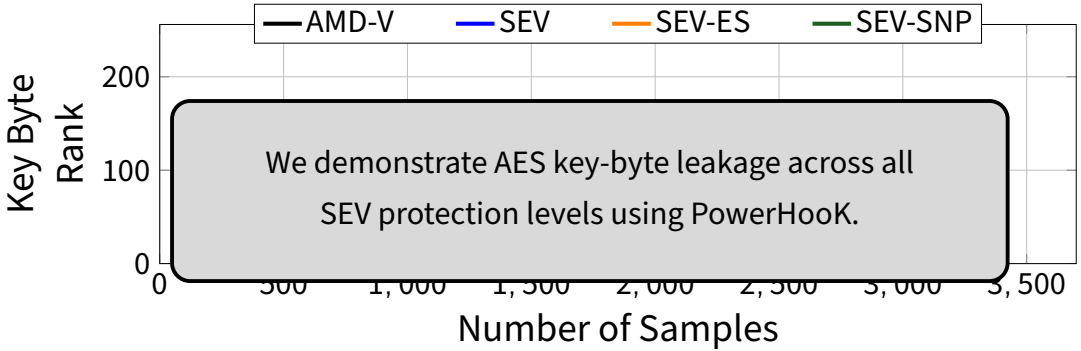
AES-NI Leakage Characterization: Evaluation



AES-NI Leakage Characterization: Evaluation

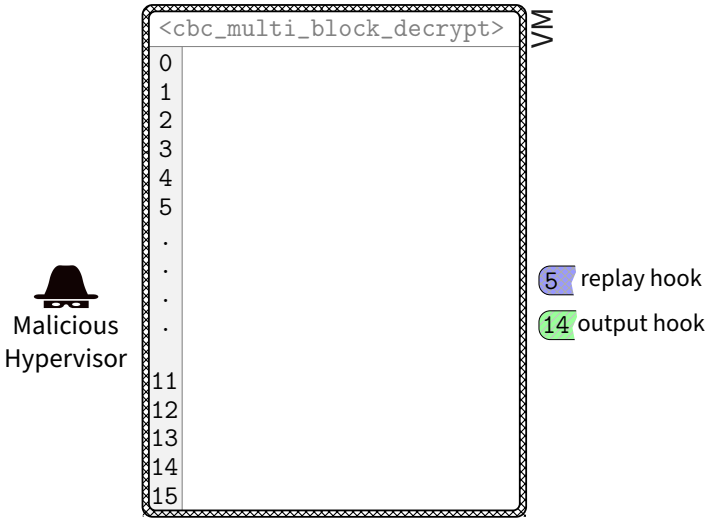


AES-NI Leakage Characterization: Evaluation

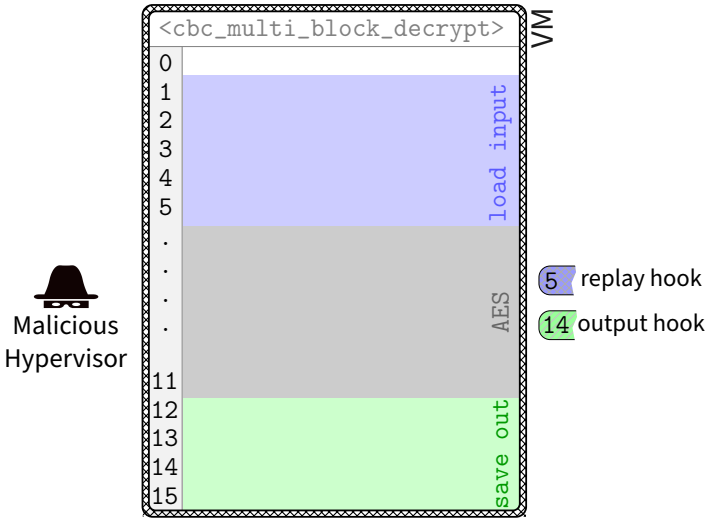


Real-World Attack Case Study: AES-CBC Multi-Block Decryption

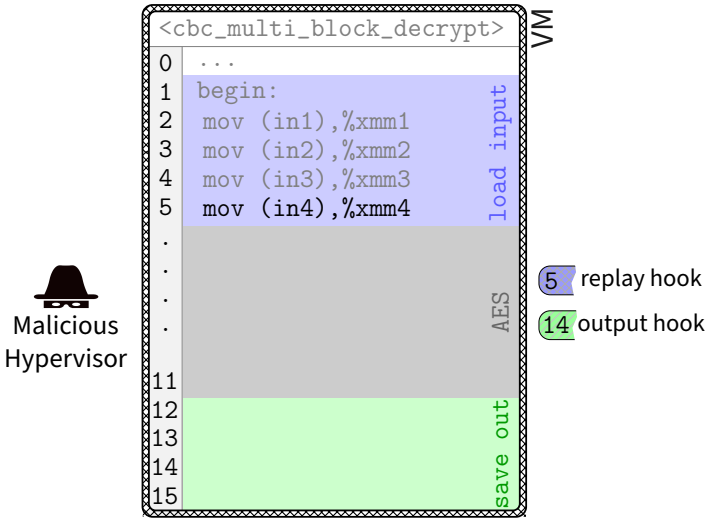
Real-World Attack Case Study



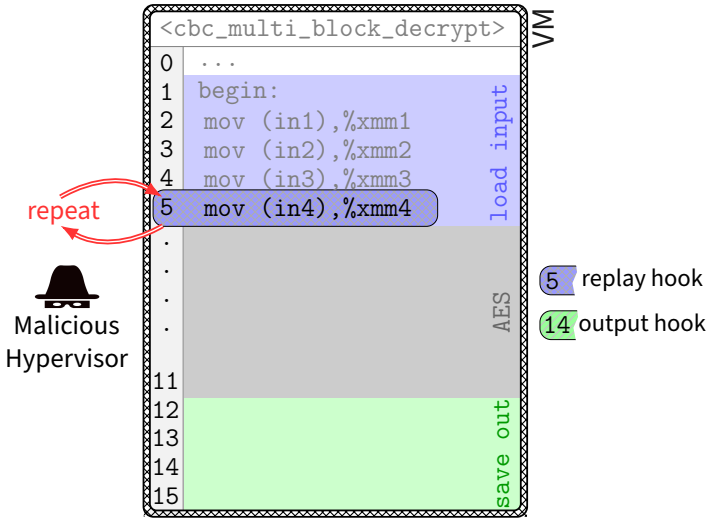
Real-World Attack Case Study



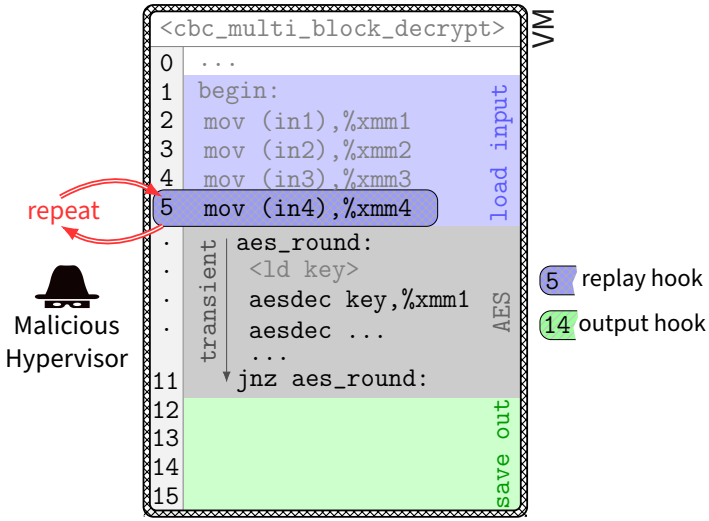
Real-World Attack Case Study



Real-World Attack Case Study



Real-World Attack Case Study



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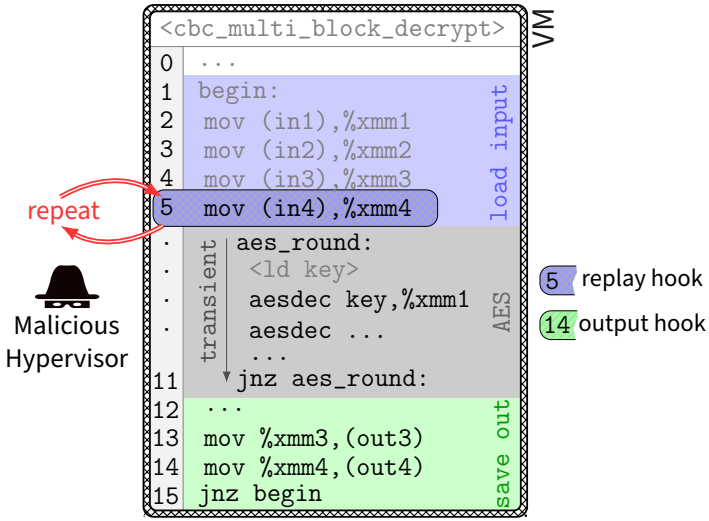
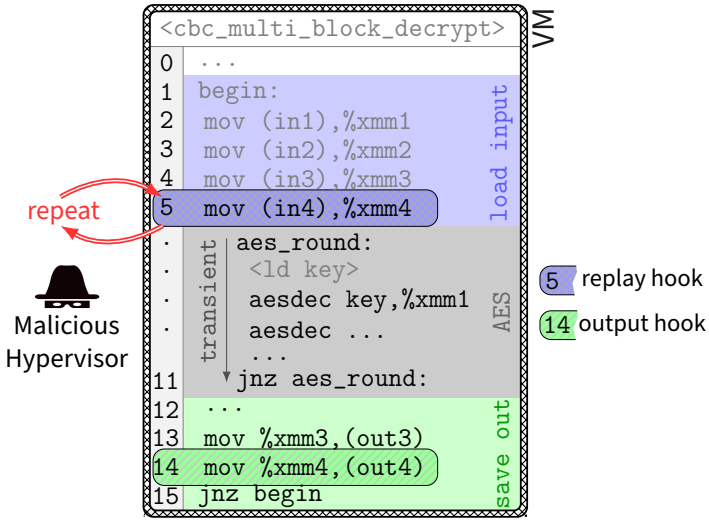
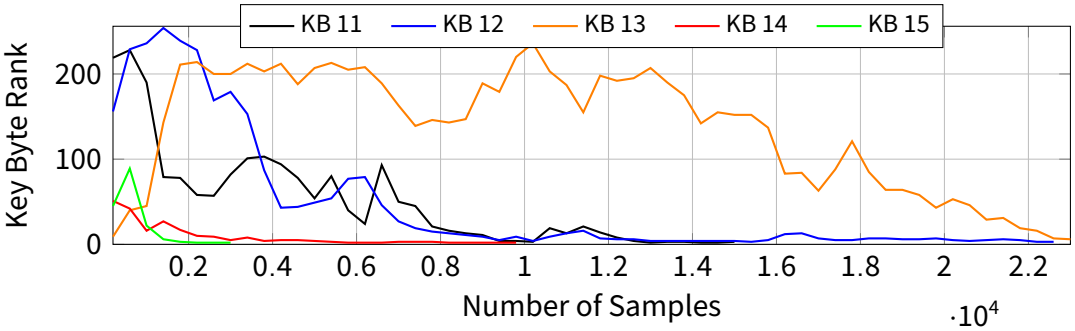


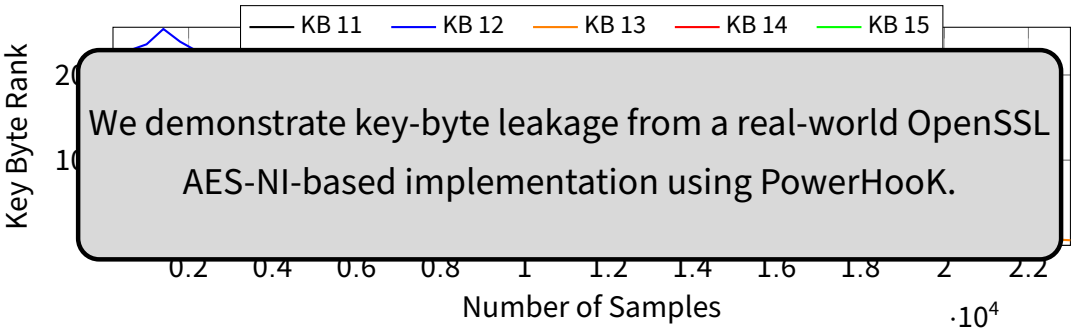
Real-World Attack Case Study



Real-World Attack Case Study: Evaluation



Real-World Attack Case Study: Evaluation



We demonstrate key-byte leakage from a real-world OpenSSL AES-NI-based implementation using PowerHooK.

Conclusion

Transient-replay power side channels against **AMD SEV VMs**

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PowerHooK:
Enabling Software-Based Power Side Channels Against AMD SEV Technologies via Transient-Execution Replay

SCIENCE
PASSION
TECHNOLOGY

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Andreas Kogler[2] Rishub Nagpal[1] Stefan Mangard[1]

[1]Graz University of Technology [2]Graz University of Technology Alumni

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