Spectroscopic: A practical PB Inception Attack and Implications for Confidential Computing

Kaya Ercihan, Jonathan Müller

ZHAW
School of Engineering

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Summary

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Overview

Overview

- Consulted 17 main sources, 9 of them being papers:
  - 7 papers describing a total of 9 other side channel attacks
  - 2 papers describing various mitigations to side channel attacks
- Established contact with AMD regarding the vulnerability
- Designed understandable diagrams displaying how the attack works
- Created a github repository with the code and a readme explaining how to repeat the attack

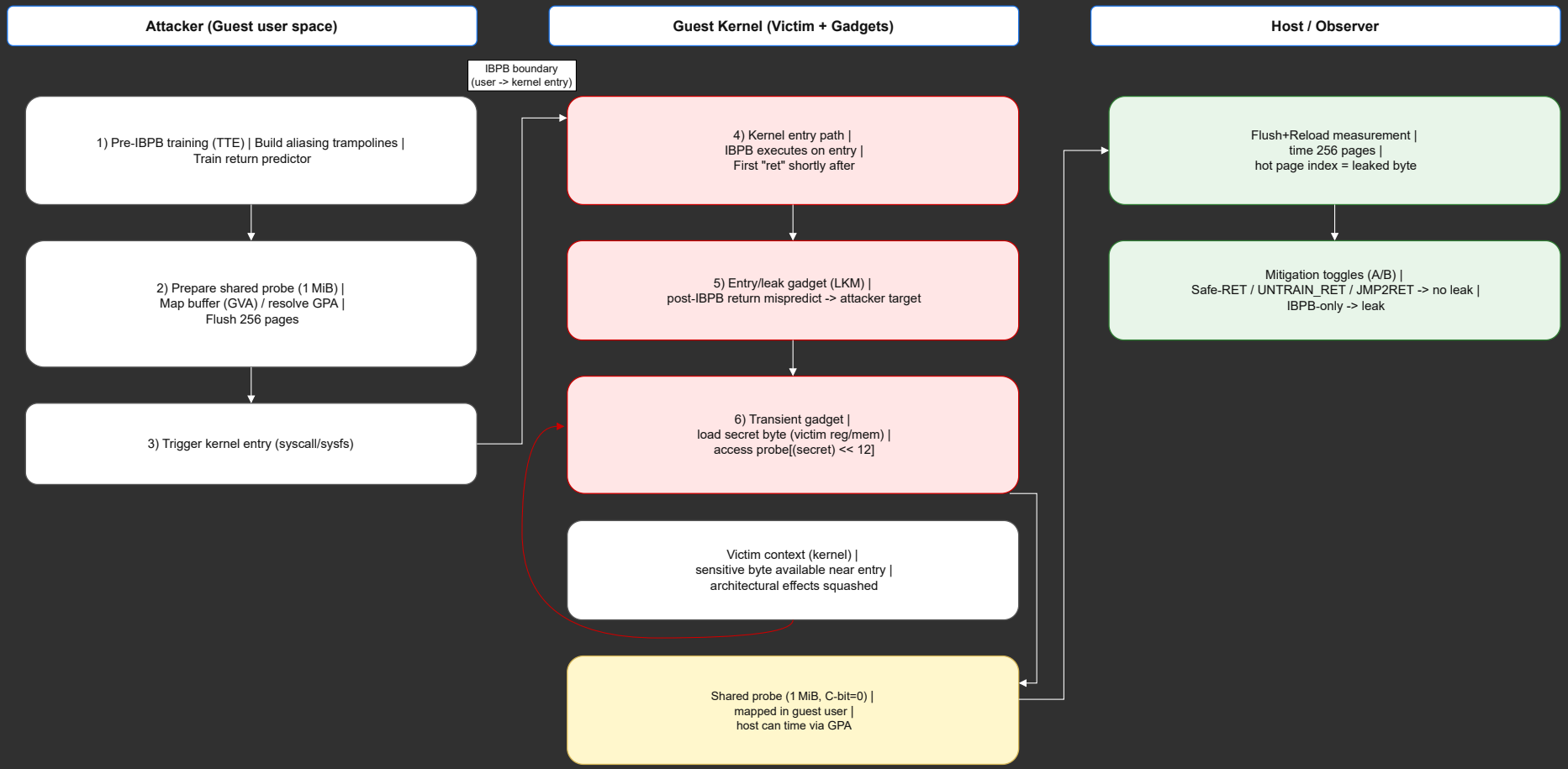
Related works

Related works

Attack name	Post-IBPB	Attack type	Attack model	Preconditions	Target processors	Mitigations	Side channel	CC Impact
RETBLEED [2]	No	Kernel-level speculative code execution targeting the Branch Target Buffer	Unprivileged User Process $\longrightarrow$ Kernel	RSB underflow to BTB fallback (Intel); BTB precedence over RSB (AMD); deep call stacks (Intel); cross-privilege BTB poisoning	AMD (Zen 1, Zen 2), Intel (Kaby Lake, Coffee Lake)	Intel (eIBRS and IBRS), AMD (jmp2ret)	Flush+Reload, Prime+Probe	Bypasses Retpoline; leaks arbitrary kernel memory; intra-guest leakage; host view requires shared side-channel
PB-RRSBA [1]	Yes	Exploit IP-based predictions of the Restricted RSB Alternate (RRSBA) predictor	Cross-process	RSB empty-state; IP-based RRSBA predictor active; IBPB execution; same-thread attacker/victim co-location	Intel (Golden Cove, Raptor Cove)	Enabling the RRSBA_DIS_U chicken bit	Flush+Reload	Leaks from IBPB-protected suid processes; shared library mappings used for cross-process exfiltration
PB-Inception [1]	Yes	Variant of Inception attack targeting Return Stack Buffer predictions	Cross-process	IBPB-on-entry active; TTE/Phantom training pre-IBPB; RSB persistence post-IBPB (AMD Zen 1/2)	AMD (Zen 1, Zen 2)	RSB stuffing	Secret-dependent cache side channel	Bypasses kernel/hypervisor protection (VMExit); host observation requires shared C-bit=0 mapping
PHANTOM [3]	No	Confuse the CPU's branch prediction unit by using asymmetric combinations of training and victim instruction types	Execute unprivileged code on top of a recent Linux kernel	Speculation before instruction decode; cross-privilege BTB aliasing; physically contiguous huge pages for Prime+Probe	AMD (Zen 1, Zen 2, Zen 3, Zen 4)	SuppressBPOnNonBr (AMD MSR), AutoIBRS (AMD Zen 4), IBPB	Flush+Reload, Prime+Probe	Bypasses AutoIBRS/-SuppressBPOnNonBr; enables transient fetch/decode leaks; host visibility needs shared memory

Attack flow & Reporting

Spectroscopic attack flow

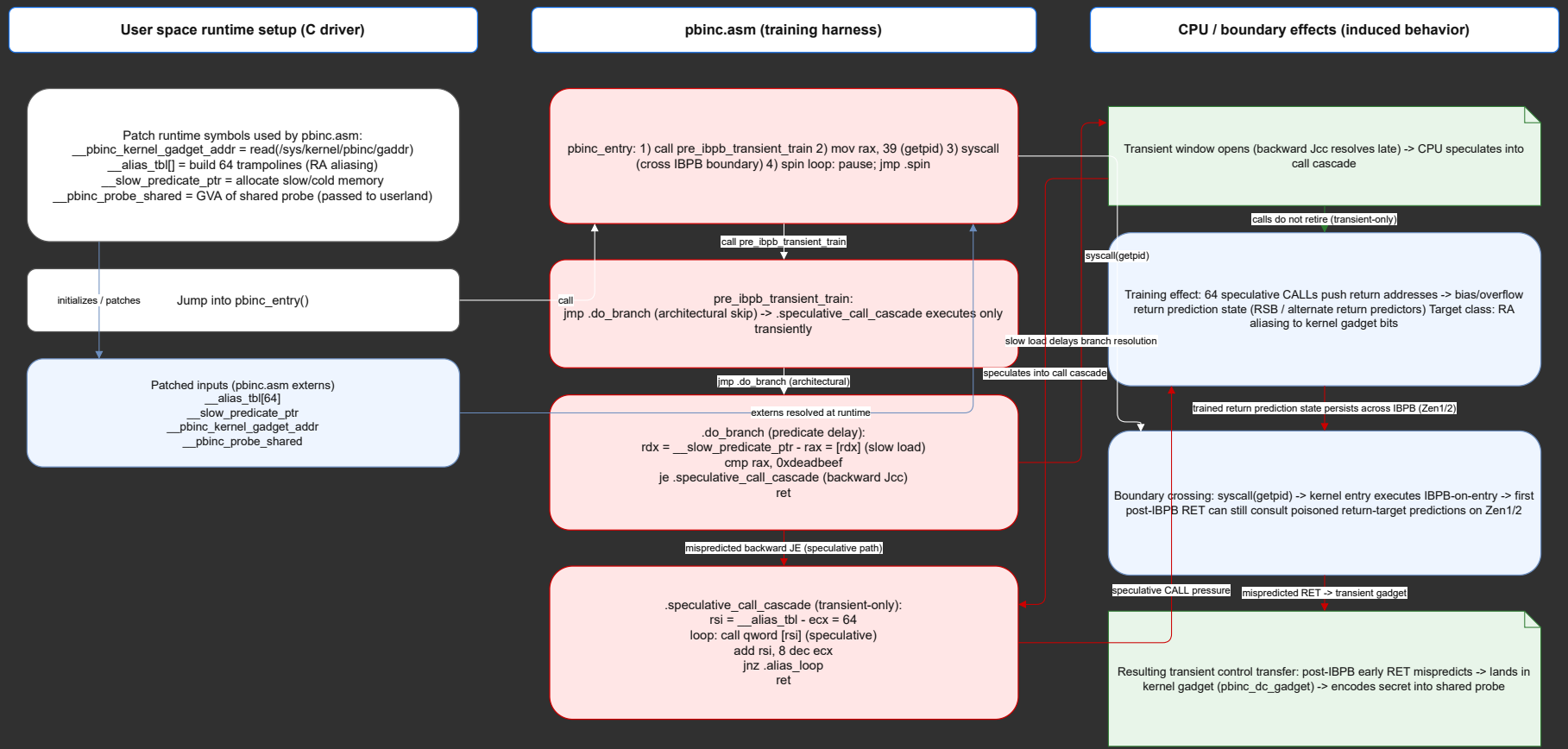


Report to AMD

We reported the exploit and are currently in contact with AMD

Application-part visualizations

Assembly-Level Gadget Walkthrough



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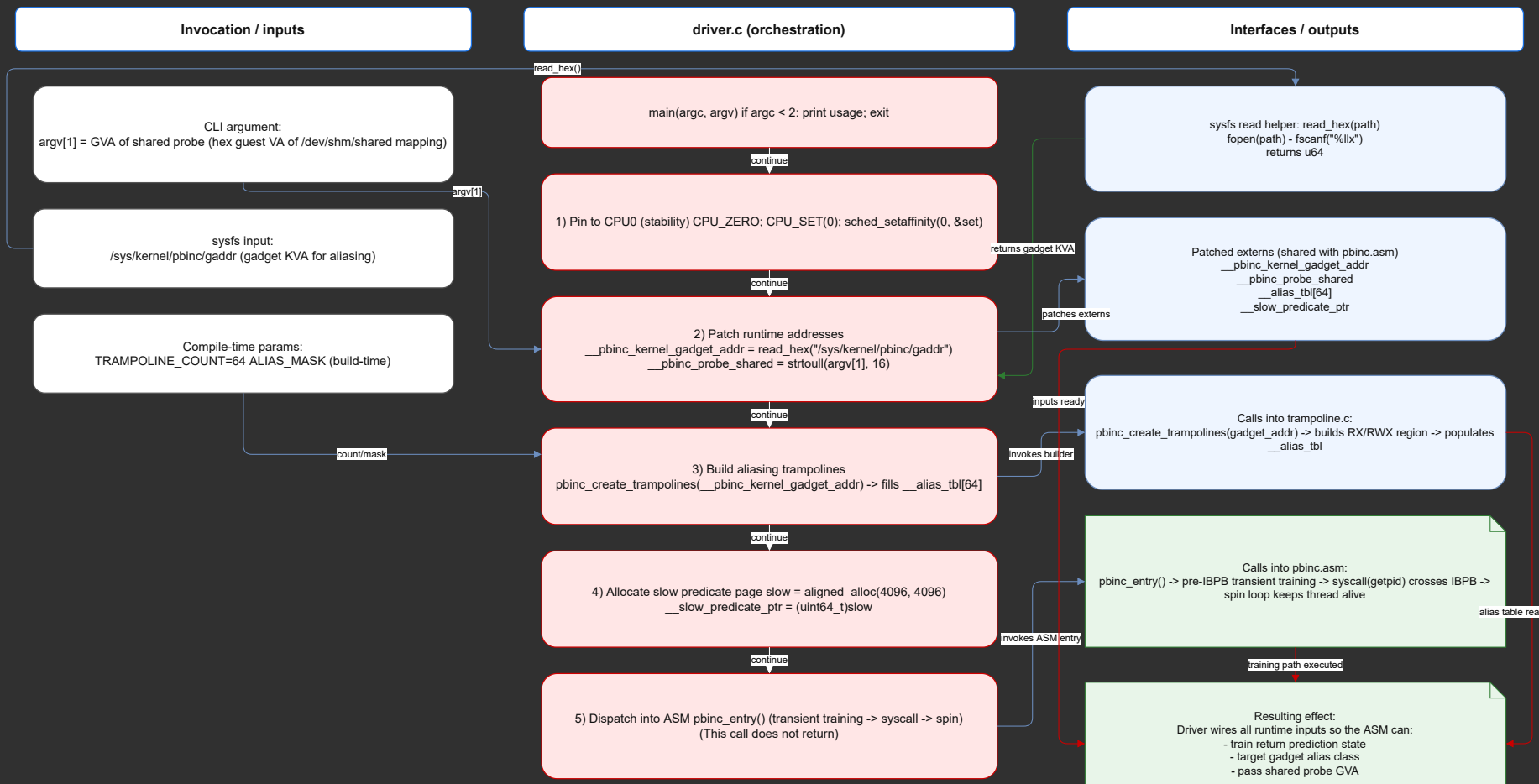

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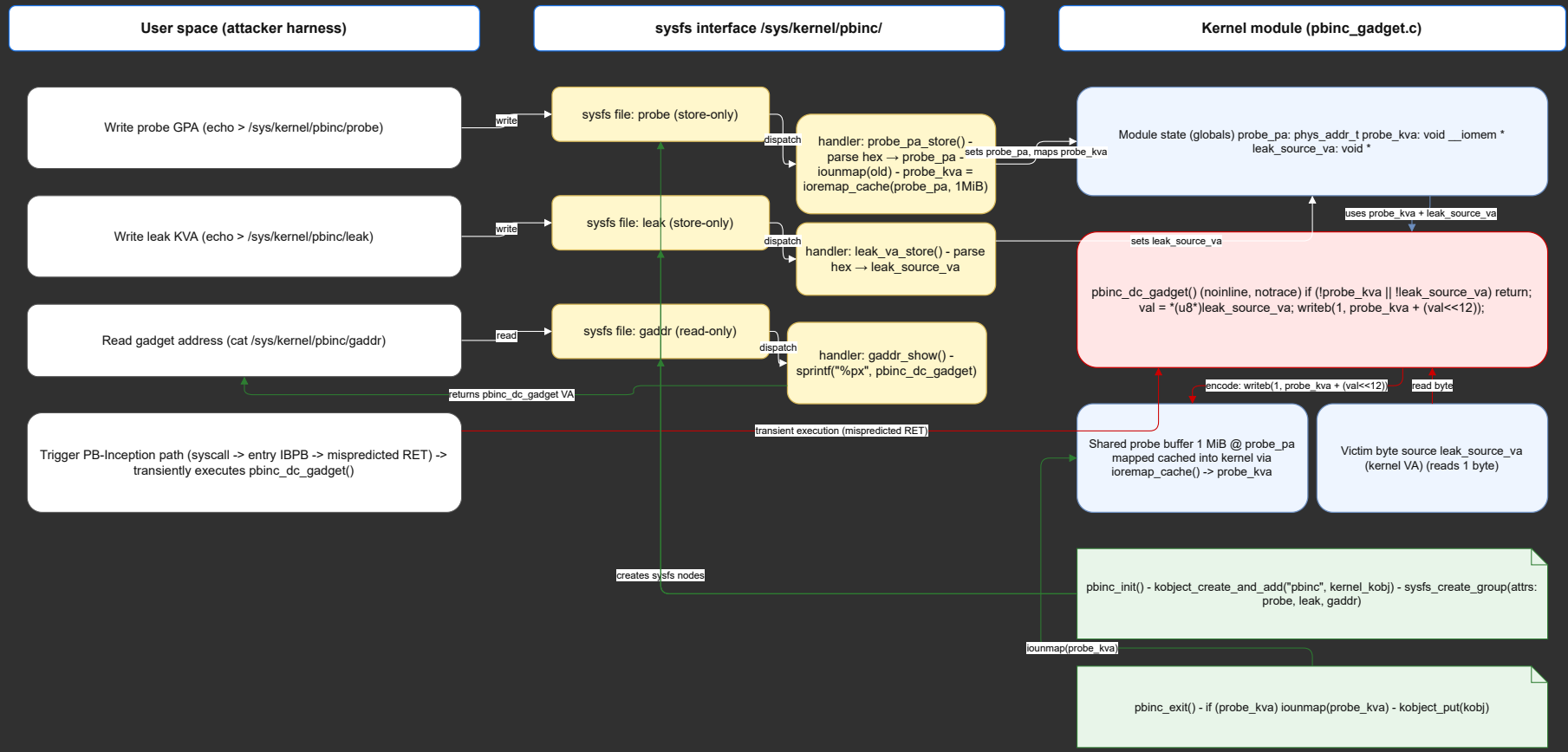

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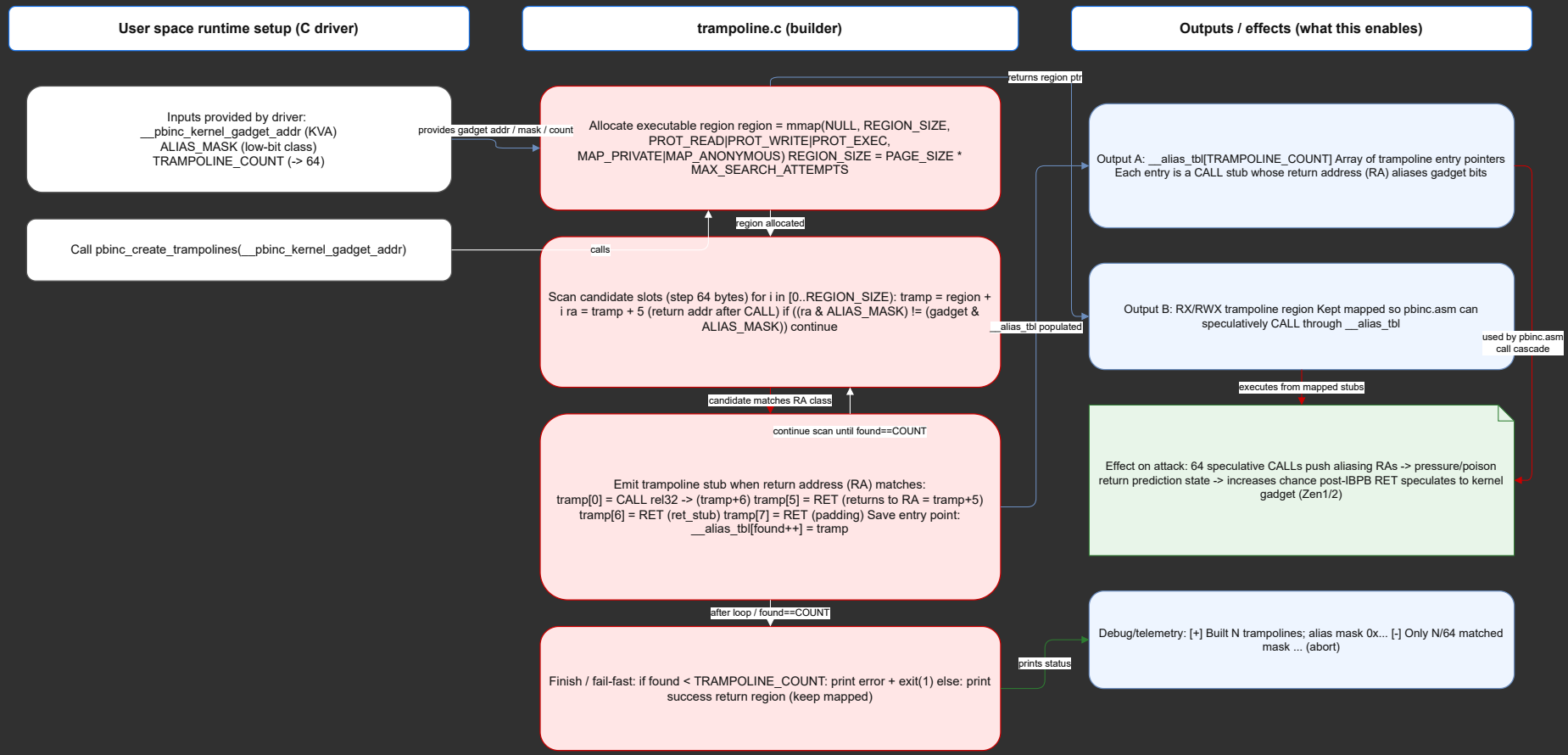

Thanks for your attention!

Sources I

1. Wikner, J. & Razavi, K. *Breaking the Barrier: Post-Barrier Spectre Attacks.* in *IEEE Symposium on Security and Privacy* (2025). https://comsec.ethz.ch/wp-content/files/ibpb_sp25.pdf.
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3. Wikner, J., Trujillo, D. & Razavi, K. *Phantom: Exploiting Decoder-detectable Mispredictions.* in *56th Annual IEEE/ACM International Symposium on Microarchitecture (MICRO '23)* (2023). https://comsec.ethz.ch/wp-content/files/phantom_micro23.pdf.