Alligator in Vest: A Practical Failure-Diagnosis Framework via Arm Hardware Features

Yiming Zhang[1,2], Yuxin Hu[1], Haonan Li[1] , Wenxuan Shi[1] , Zhenyu Ning[3,1], Xiapu Luo[2], Fengwei Zhang[1]

[1]Southern University of Science and Technology, [2]The Hong Kong Polytechnic University, [3]Hunan University

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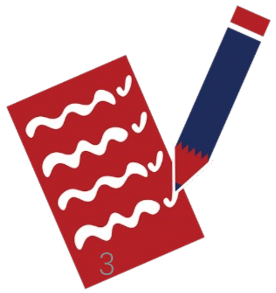
➢ To overcome the limitations, we propose a novel hardware-assisted framework on Arm named ***Investigator*** for failure diagnosis in production

Agenda



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- Background
- Investigator: Analyzer for Failure Diagnosis in Production Environments
- Experimental Results
- Summary and Future Work

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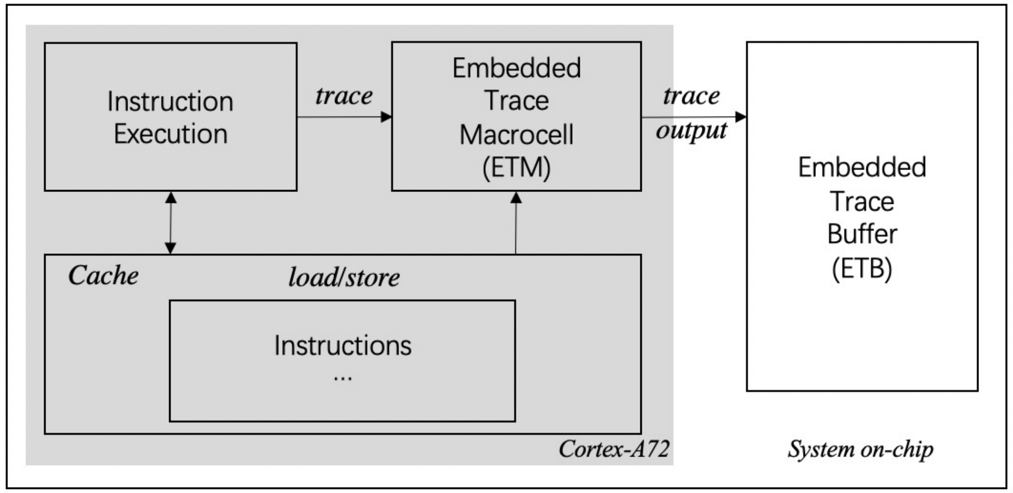
- ETM (Embedded Trace Microcell)
  - It is a hardware feature of Arm.



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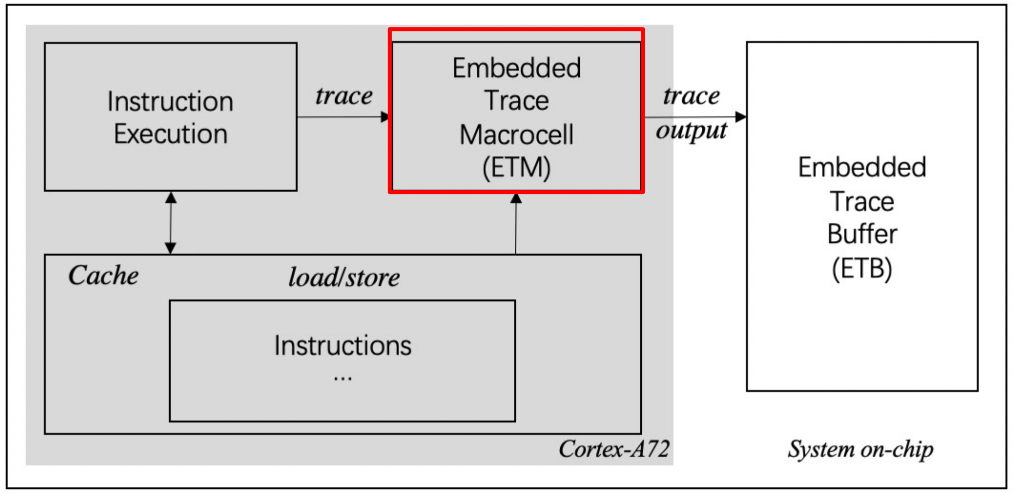

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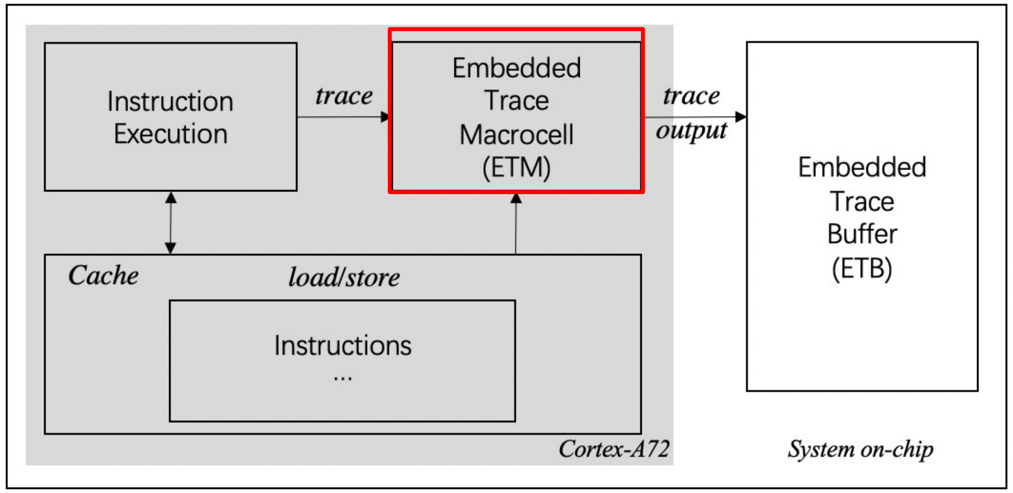

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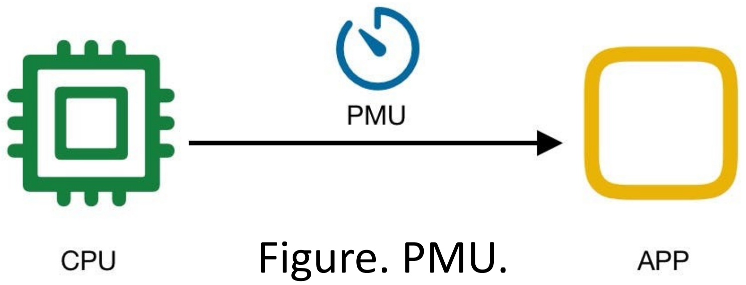

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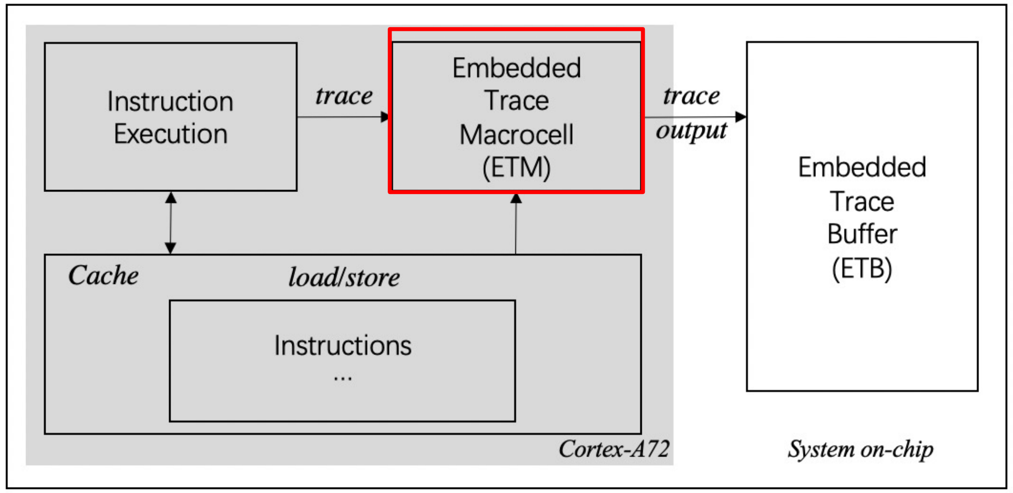

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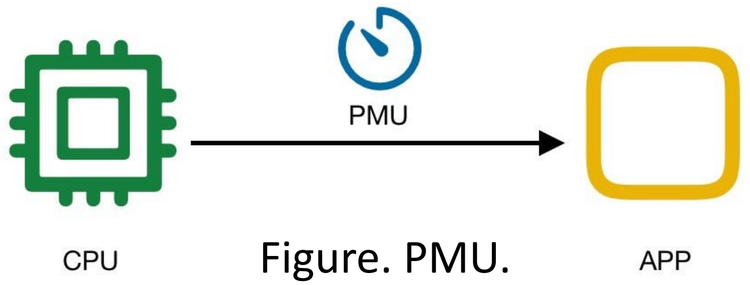

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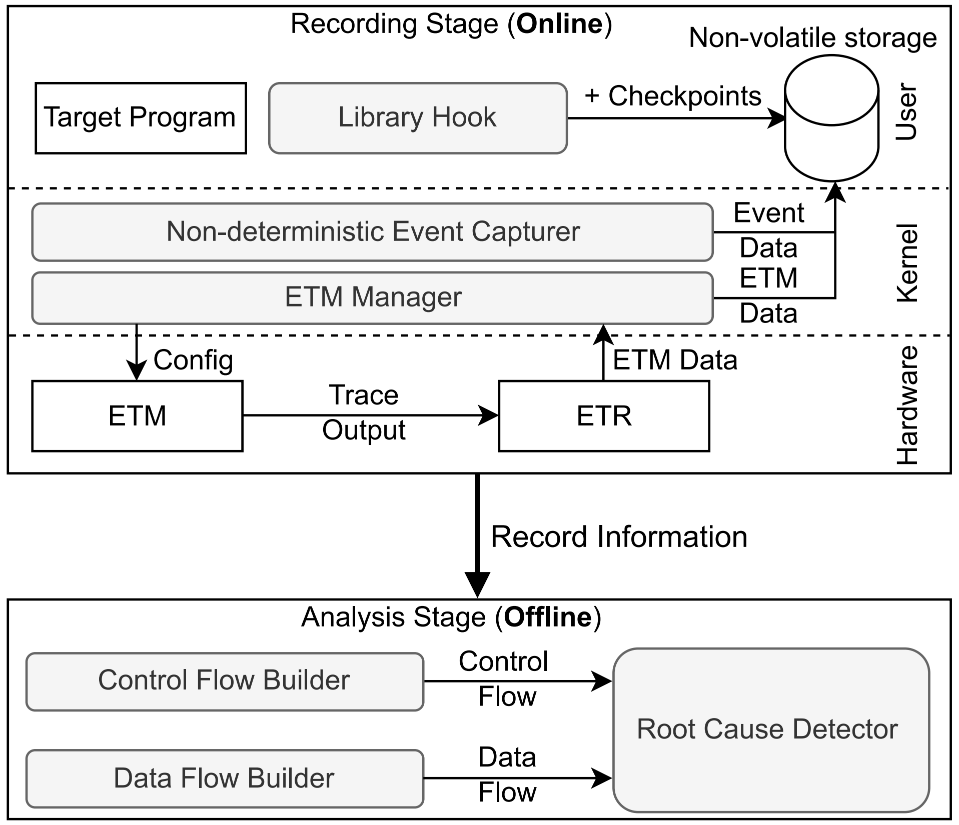

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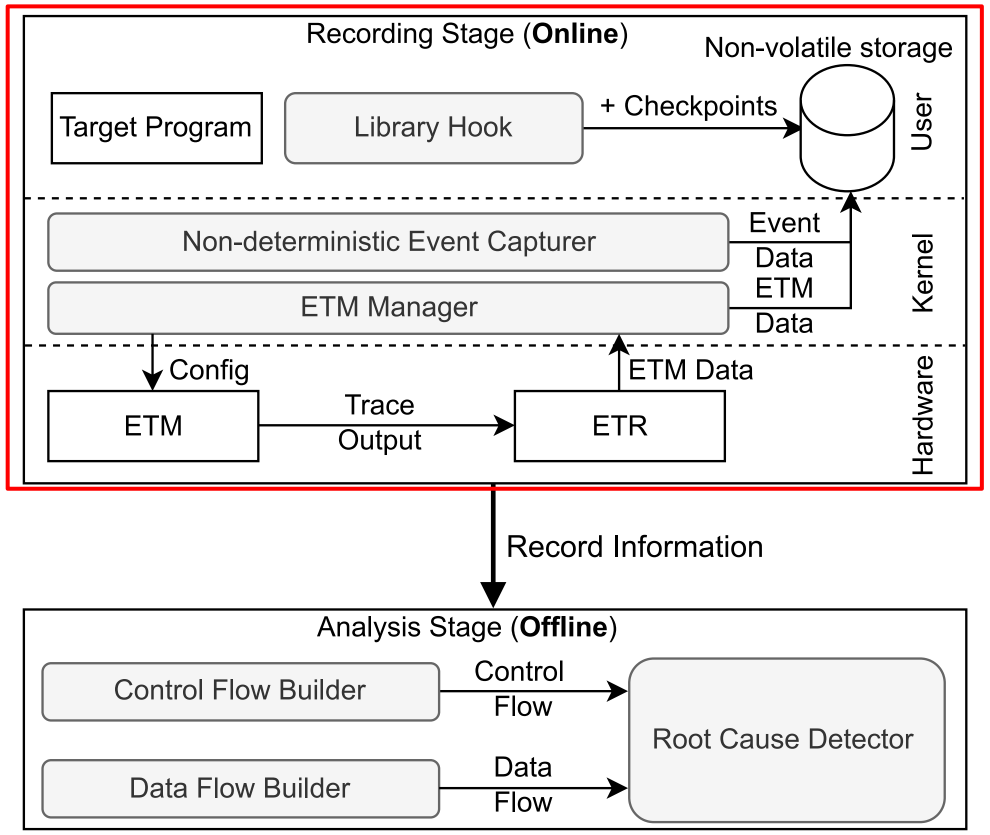

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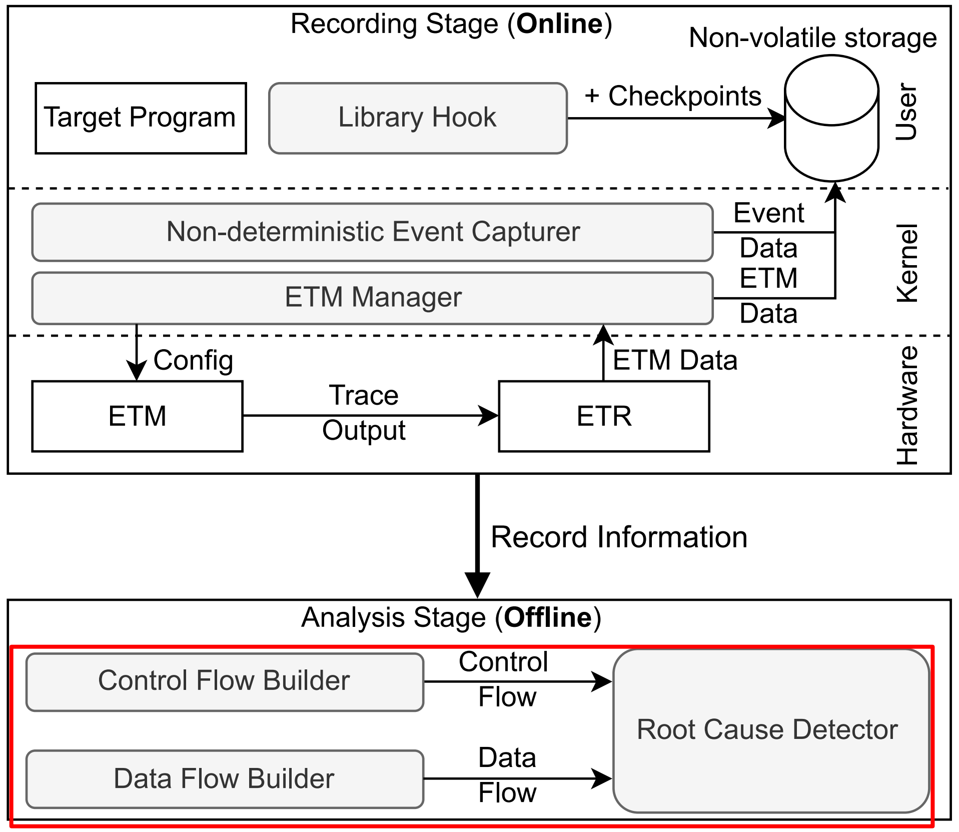

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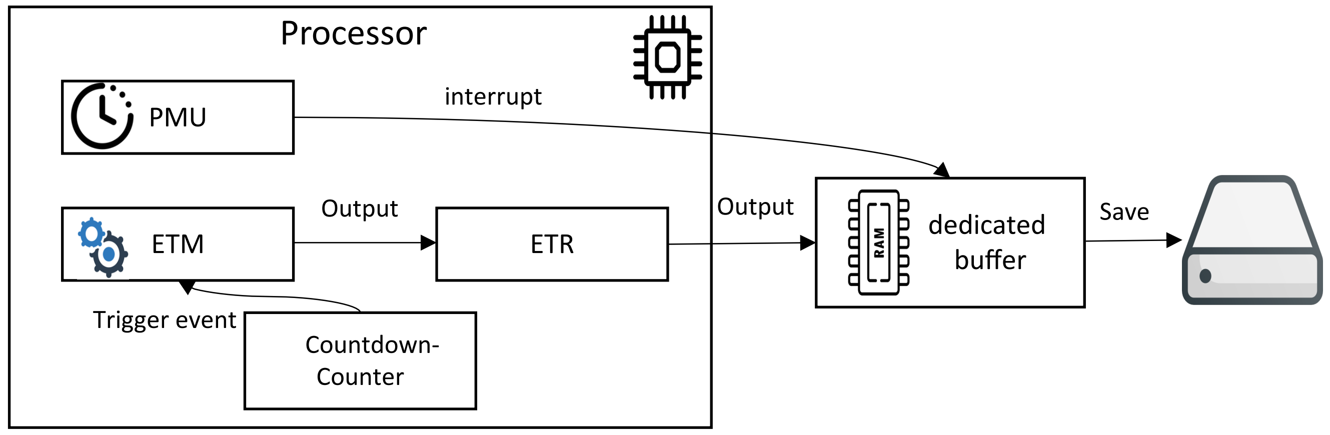

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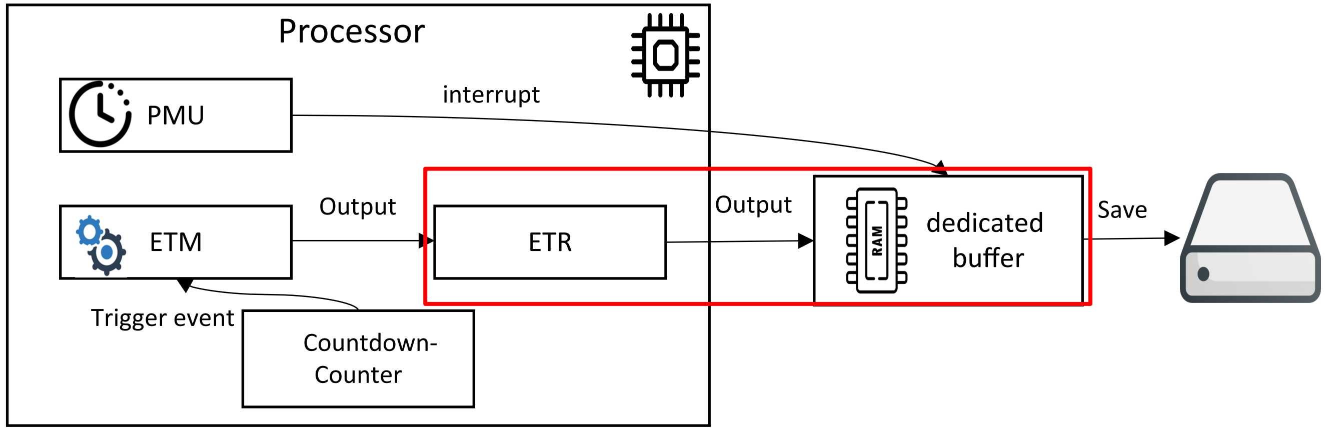

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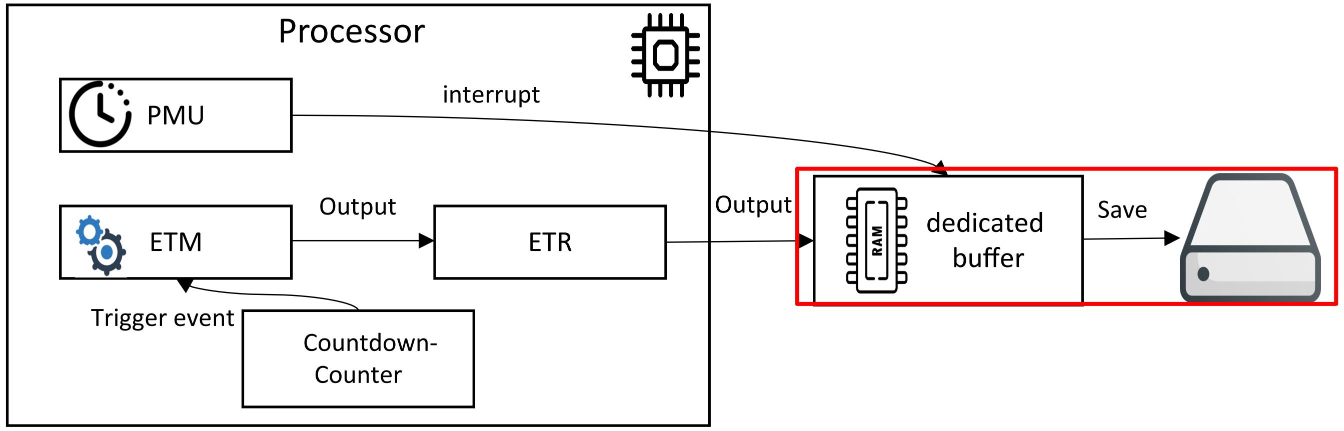

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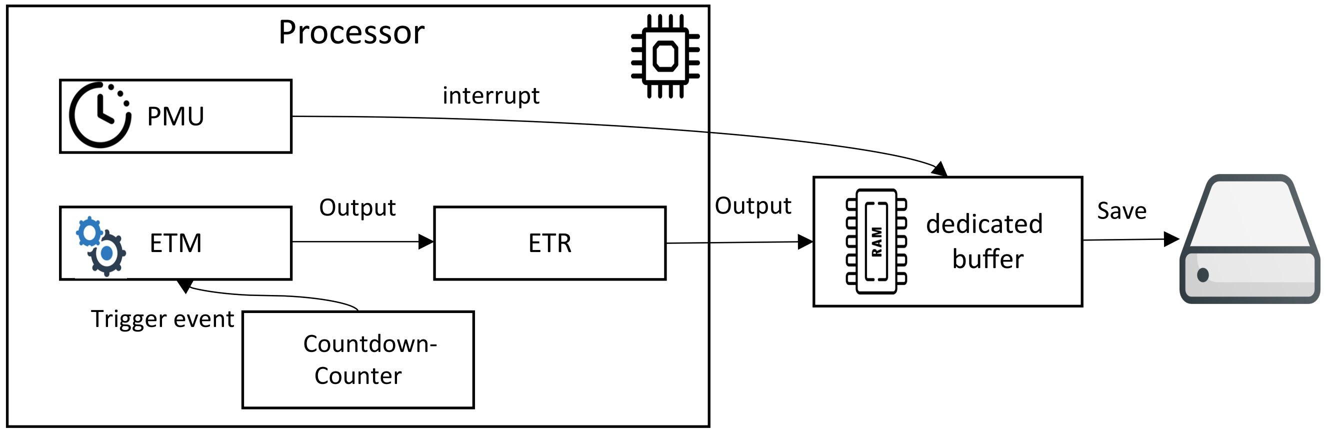

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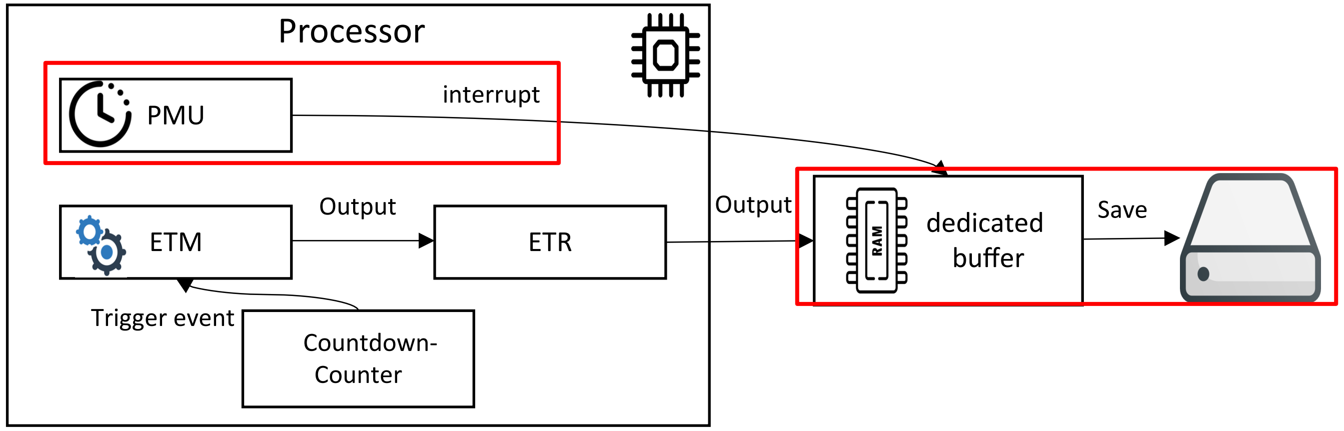

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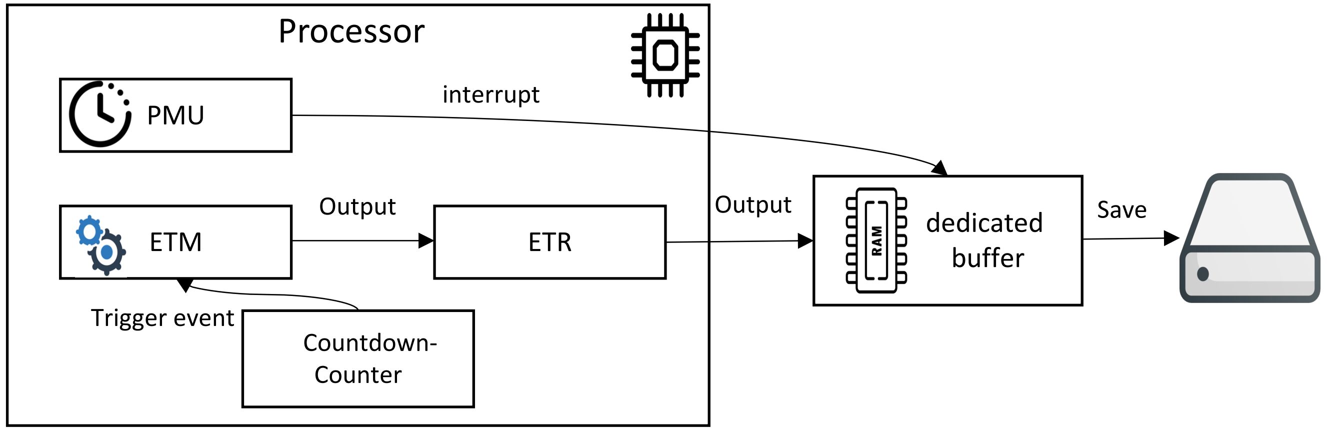

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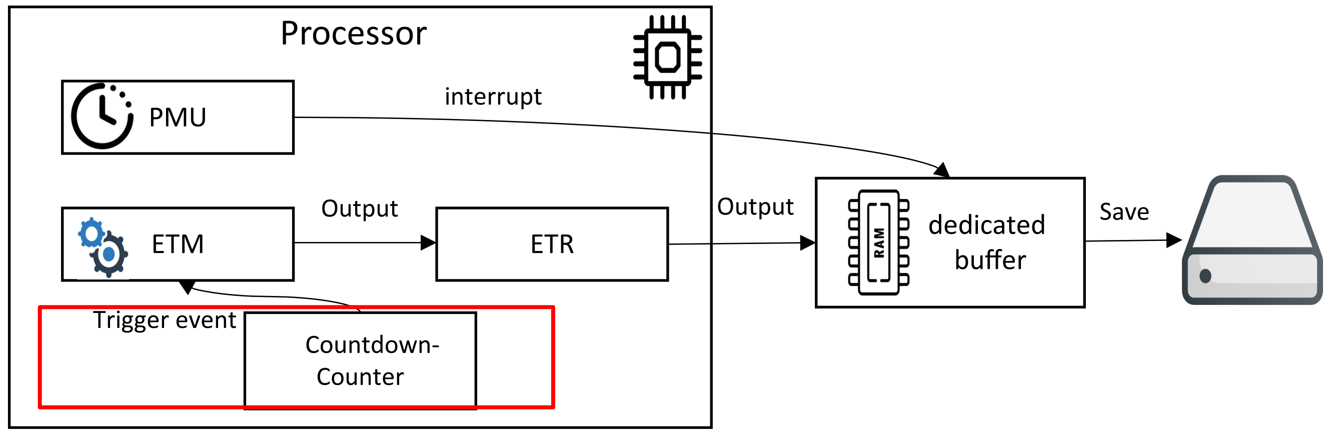

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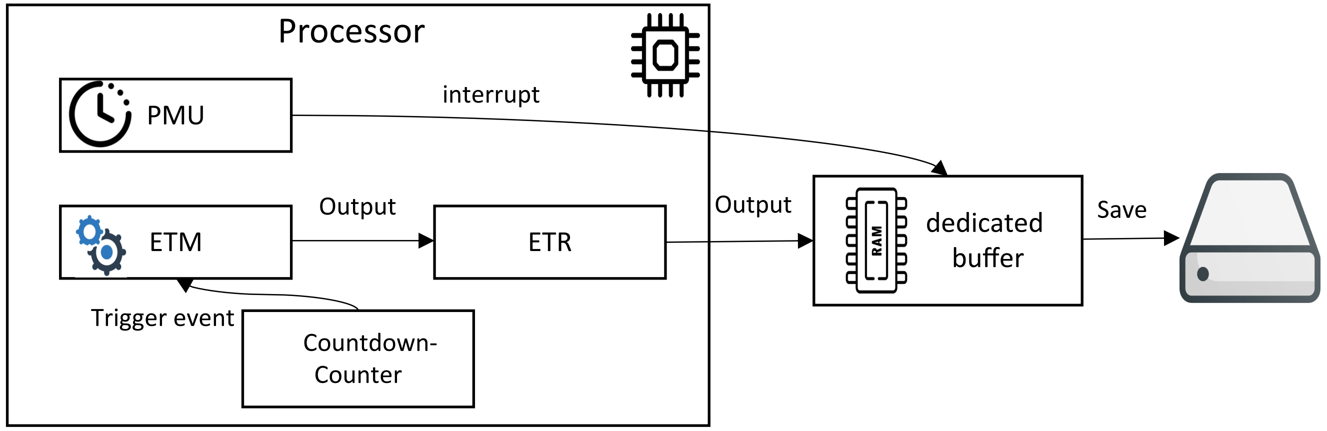
- ➢ Filtered tracing
  - Context ID and Address range.



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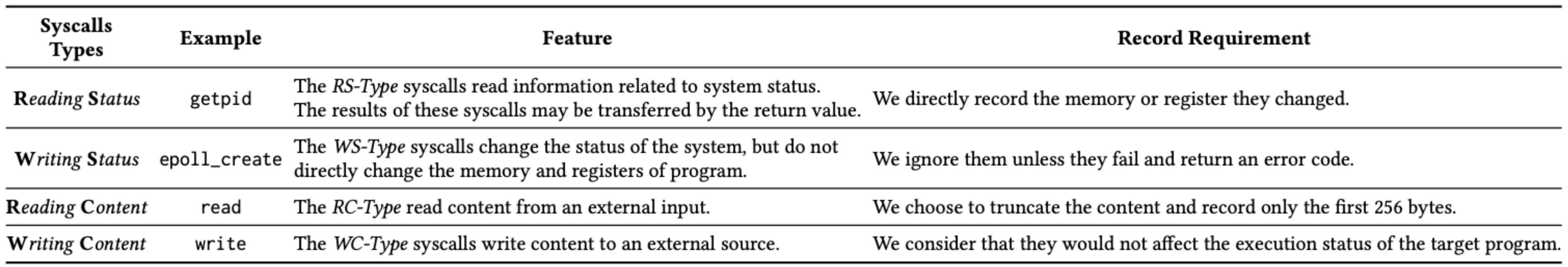

Syscalls Types	Example	Feature	Record Requirement
Reading **S**tatus	`getpid`	The *RS-Type* syscalls read information related to system status. The results of these syscalls may be transferred by the return value.	We directly record the memory or register they changed.
Writing **S**tatus	`epoll_create`	The *WS-Type* syscalls change the status of the system, but do not directly change the memory and registers of program.	We ignore them unless they fail and return an error code.
Reading **C**ontent	`read`	The *RC-Type* read content from an external input.	We choose to truncate the content and record only the first 256 bytes.
Writing **C**ontent	`write`	The *WC-Type* syscalls write content to an external source.	We consider that they would not affect the execution status of the target program.

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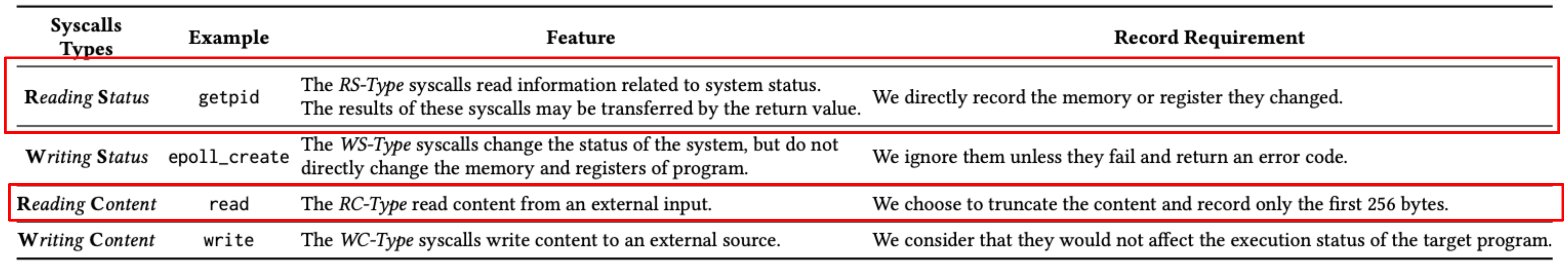

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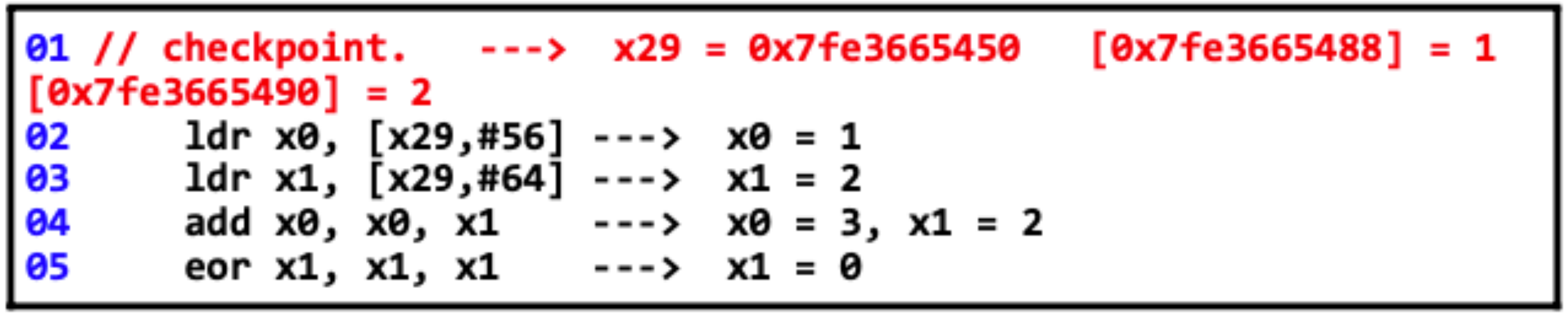

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[0x7fe3665490] = 2
02      ldr x0, [x29,#56] --->  x0 = 1
03      ldr x1, [x29,#64] --->  x1 = 2
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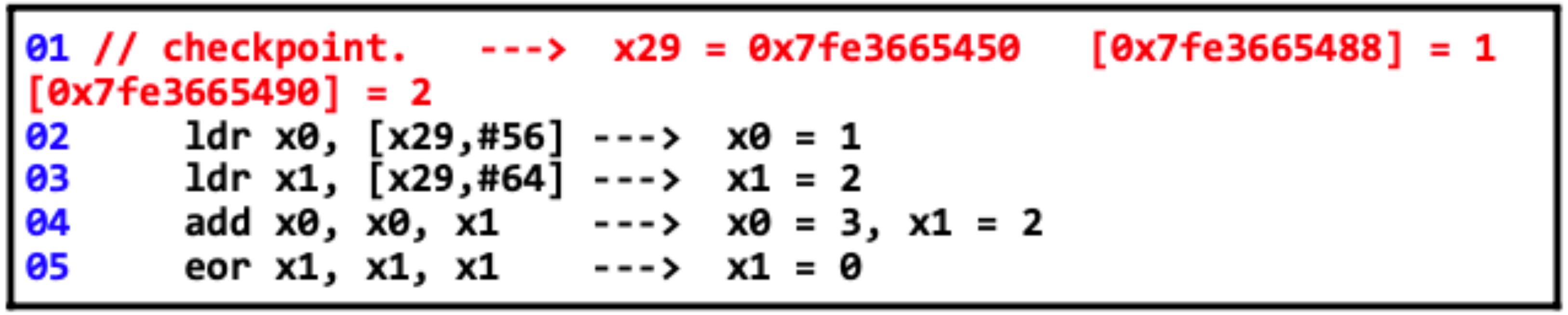
  - for syscalls that cannot be inferred, recovers the data flow by parsing recorded information



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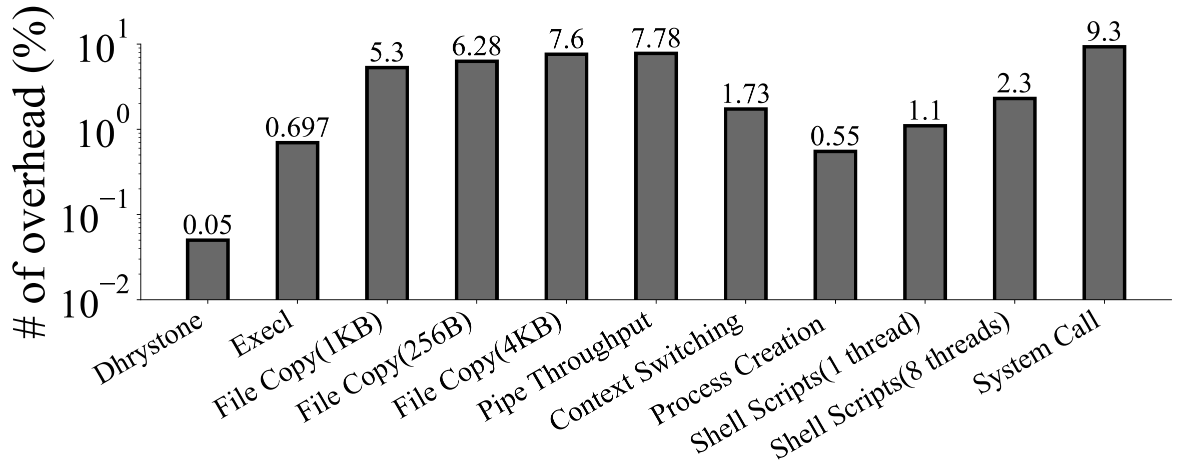

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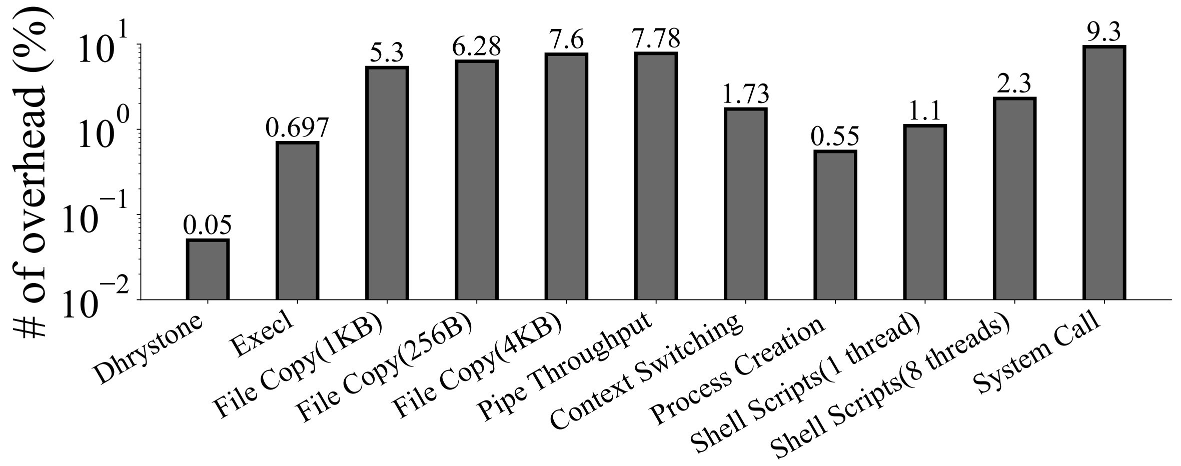

- Comparison between Investigator and REPT [6], a state-of-the-art diagnosis tool that is designed for in-production deployment on x86 architecture:
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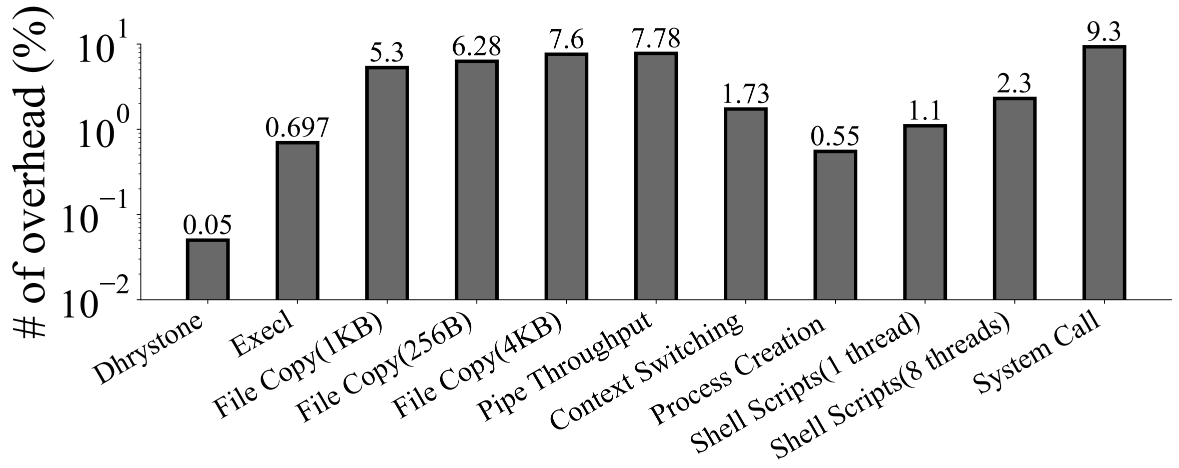

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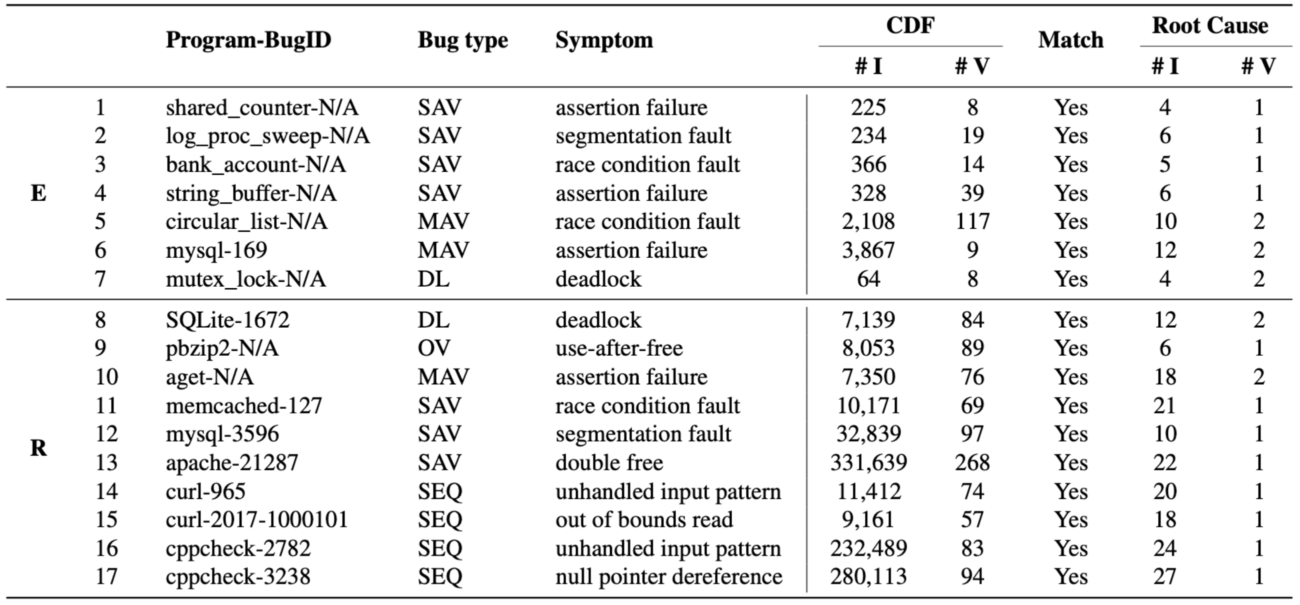

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	5	circular_list-N/A	MAV	race condition fault	2,108	117	Yes	10	2
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	7	mutex_lock-N/A	DL	deadlock	64	8	Yes	4	2
R	8	SQLite-1672	DL	deadlock	7,139	84	Yes	12	2
	9	pbzip2-N/A	OV	use-after-free	8,053	89	Yes	6	1
	10	aget-N/A	MAV	assertion failure	7,350	76	Yes	18	2
	11	memcached-127	SAV	race condition fault	10,171	69	Yes	21	1
	12	mysql-3596	SAV	segmentation fault	32,839	97	Yes	10	1
	13	apache-21287	SAV	double free	331,639	268	Yes	22	1
	14	curl-965	SEQ	unhandled input pattern	11,412	74	Yes	20	1
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	16	cppcheck-2782	SEQ	unhandled input pattern	232,489	83	Yes	24	1
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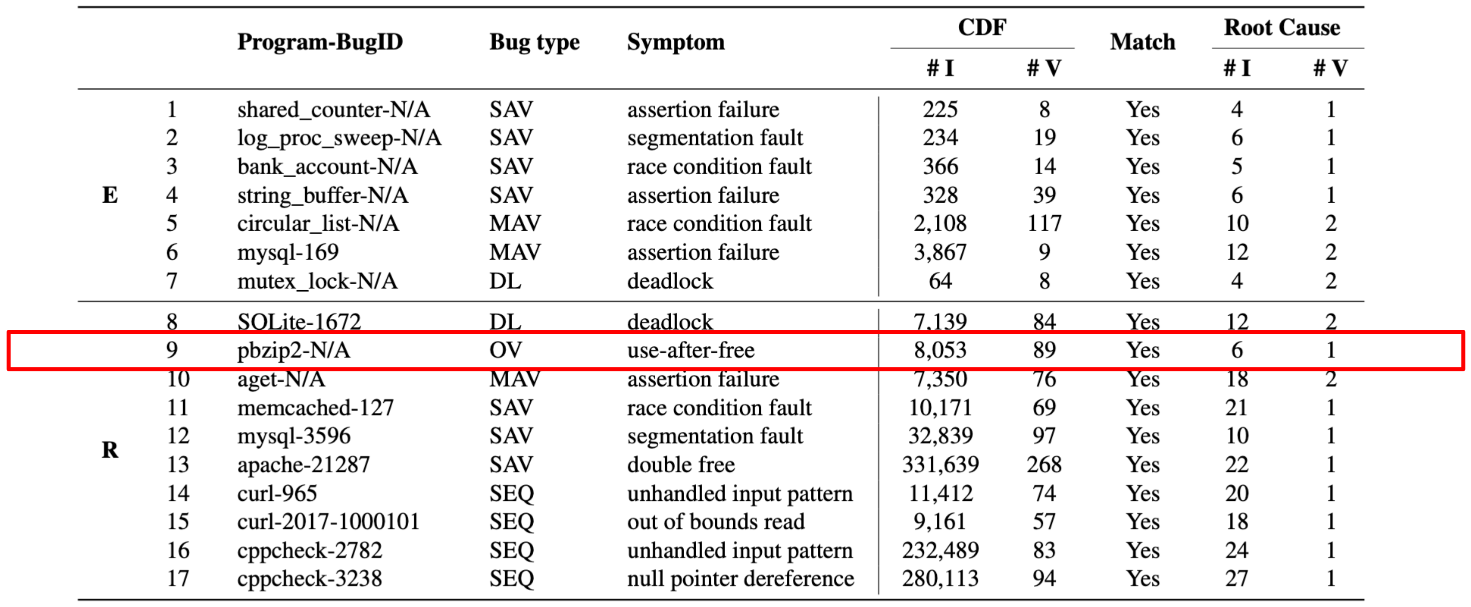

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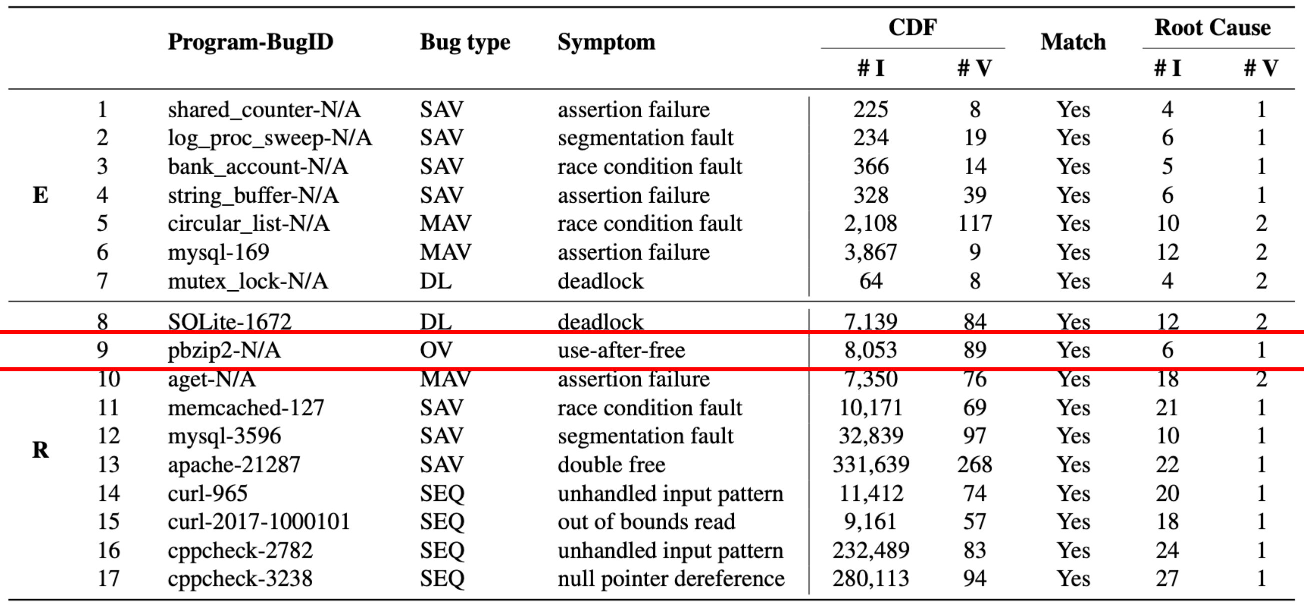

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	9	pbzip2-N/A	OV	use-after-free	8,053	89	Yes	6	1
	10	aget-N/A	MAV	assertion failure	7,350	76	Yes	18	2
	11	memcached-127	SAV	race condition fault	10,171	69	Yes	21	1
	12	mysql-3596	SAV	segmentation fault	32,839	97	Yes	10	1
	13	apache-21287	SAV	double free	331,639	268	Yes	22	1
	14	curl-965	SEQ	unhandled input pattern	11,412	74	Yes	20	1
	15	curl-2017-1000101	SEQ	out of bounds read	9,161	57	Yes	18	1
	16	cppcheck-2782	SEQ	unhandled input pattern	232,489	83	Yes	24	1
	17	cppcheck-3238	SEQ	null pointer dereference	280,113	94	Yes	27	1

- Effectiveness: Patches indicating the location that the developers fix the bug match our diagnosis results

Summary and Future Work

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❖ Extend Investigator to support other root cause diagnosis methods

Thanks for listening!

Q & A

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