Extensible Virtual Call Integrity

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ESORICS 2022

NUS
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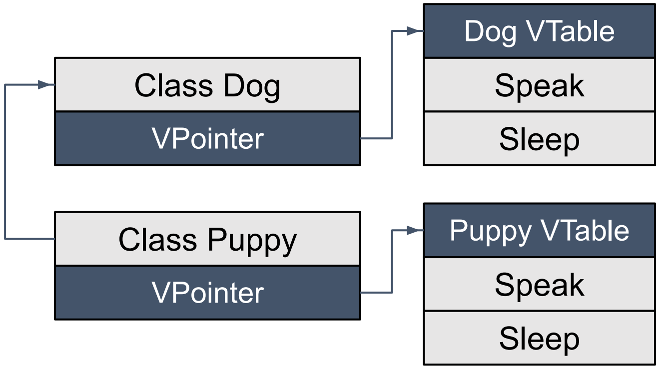

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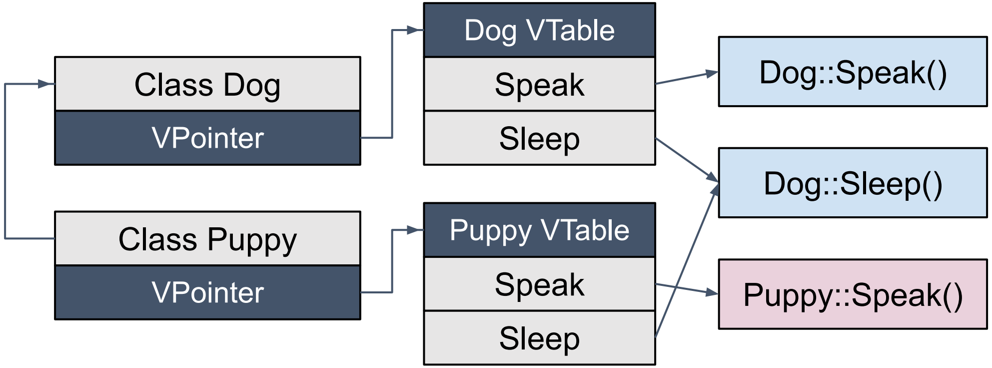
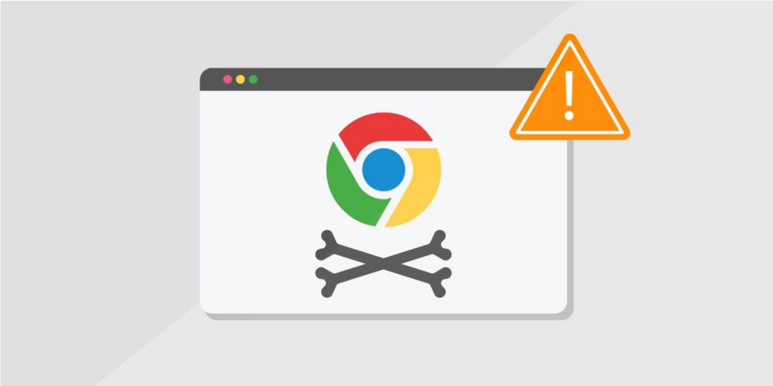
Supported Data Structure: Virtual Table/ Virtual Pointer

- VPointer: the pointer points to VTable
- VTable: the mapping from name to method



Is Virtual Call Secure?

Memory errors widely exist in all kinds of applications



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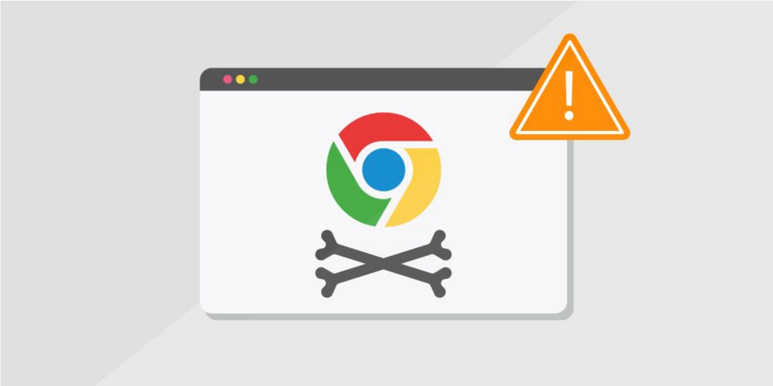

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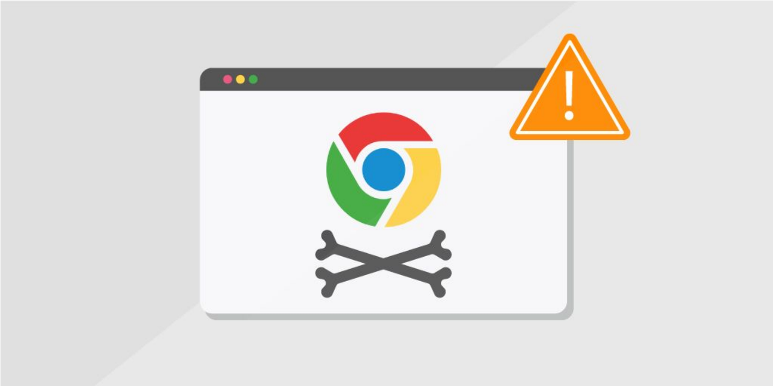

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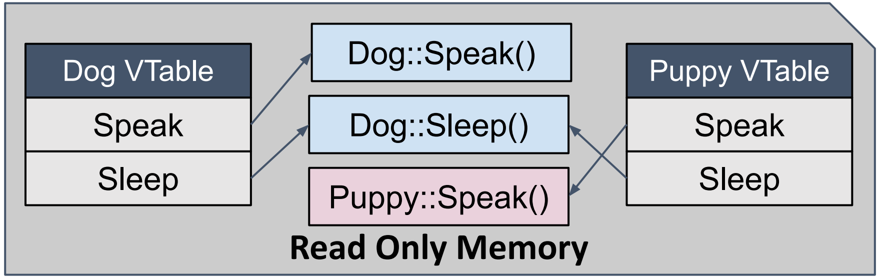

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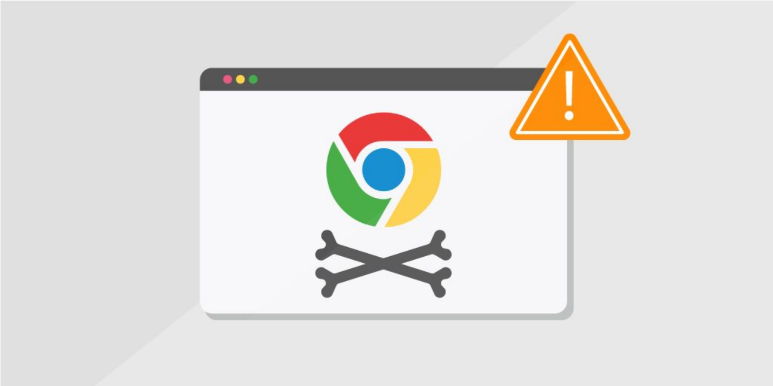

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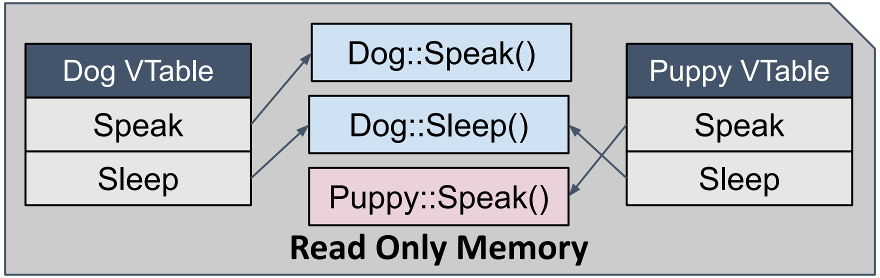

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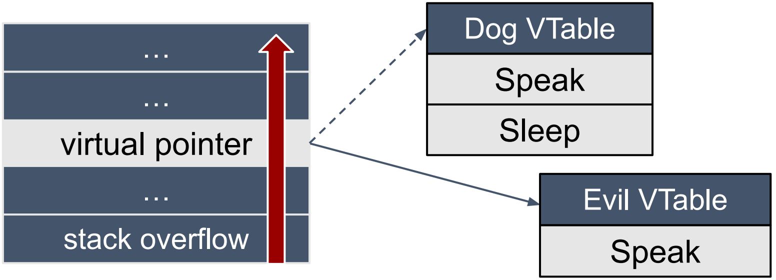

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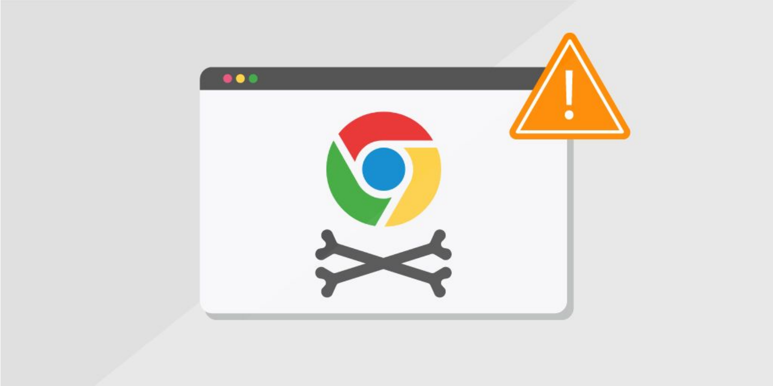

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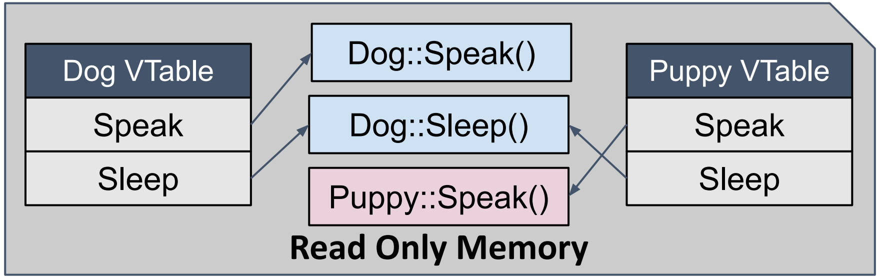

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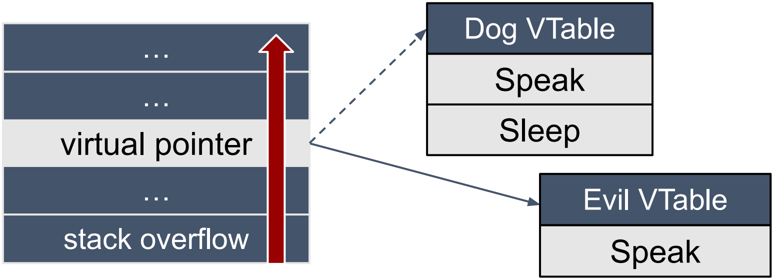

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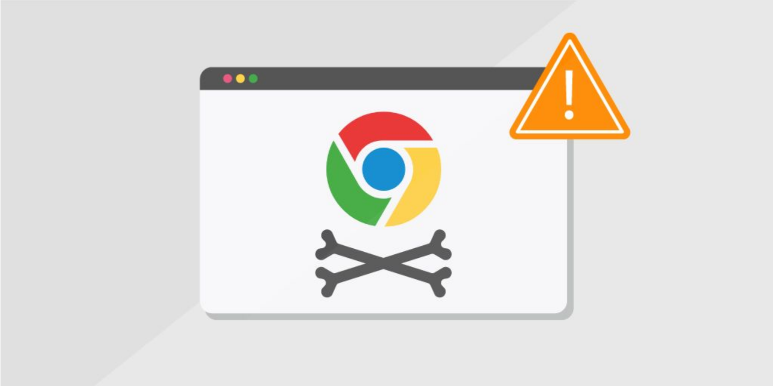

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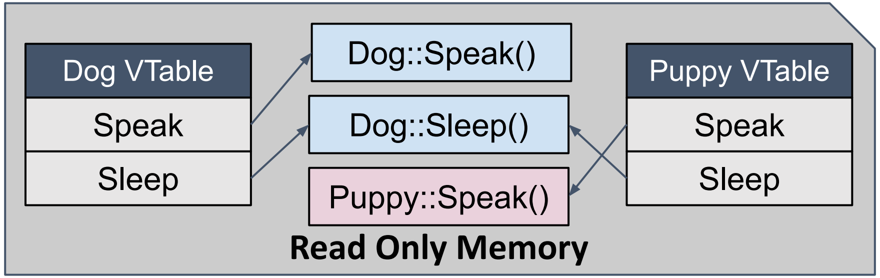

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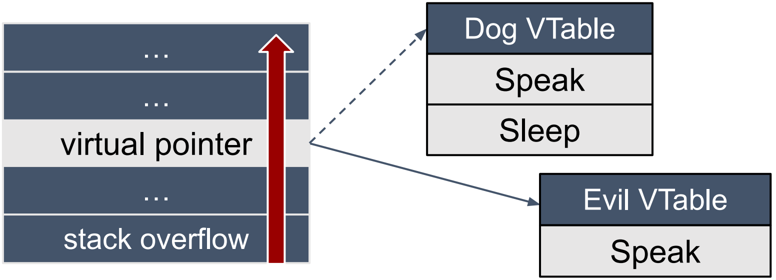

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Research Solution: Virtual Control Flow Integrity(VCFI)

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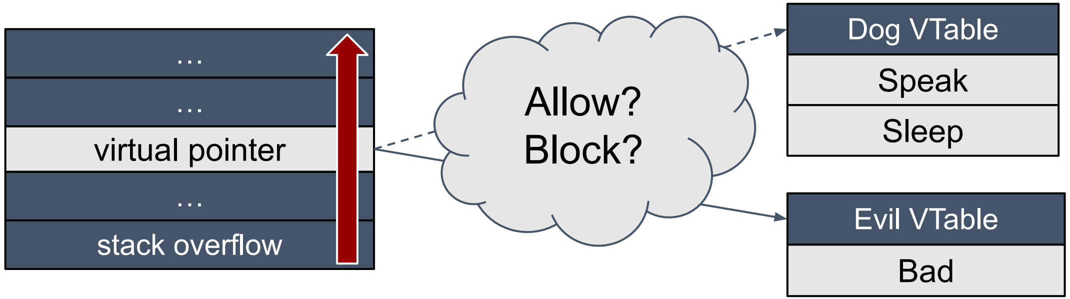

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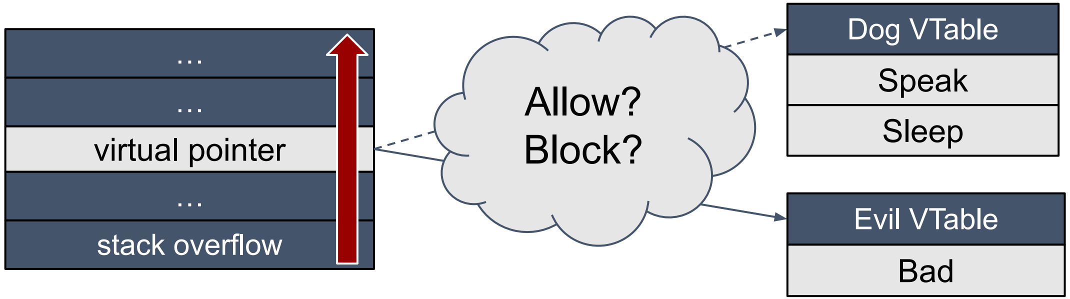

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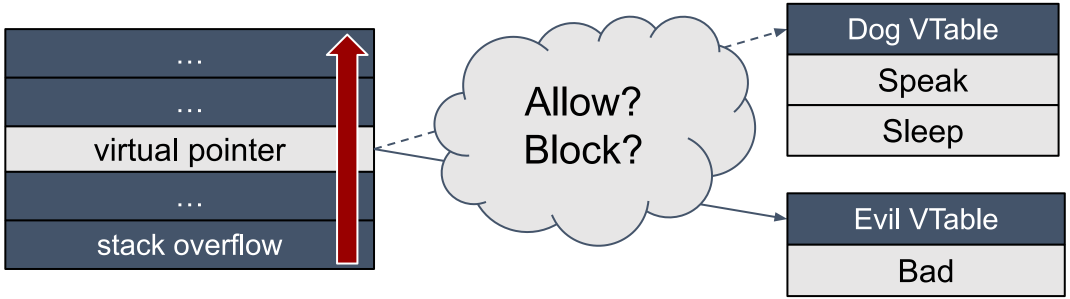

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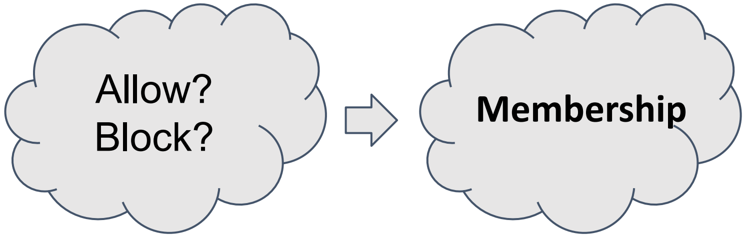

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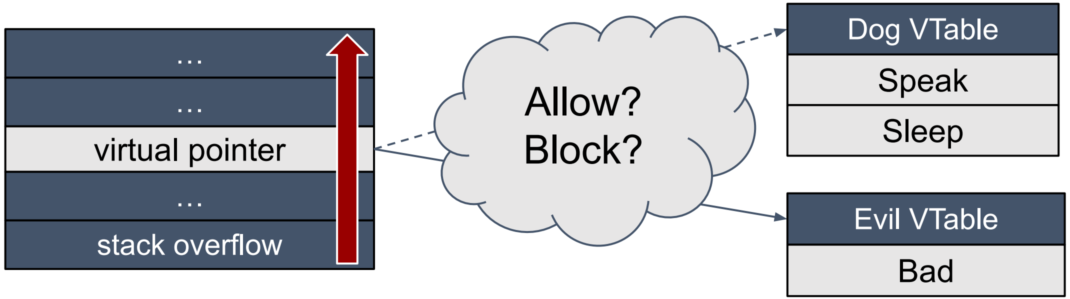

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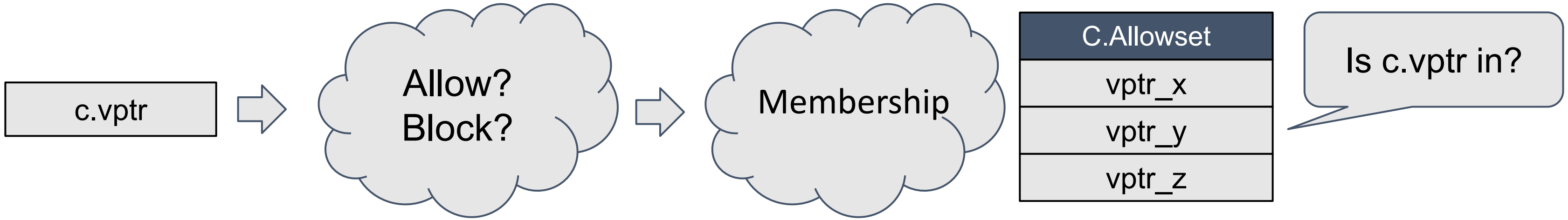

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Accurate, efficient, extensible, secure, etc.

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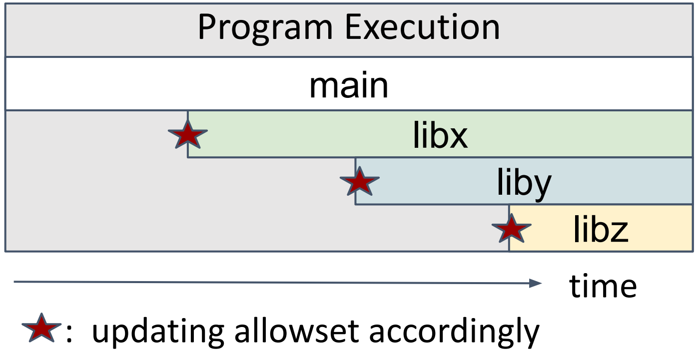

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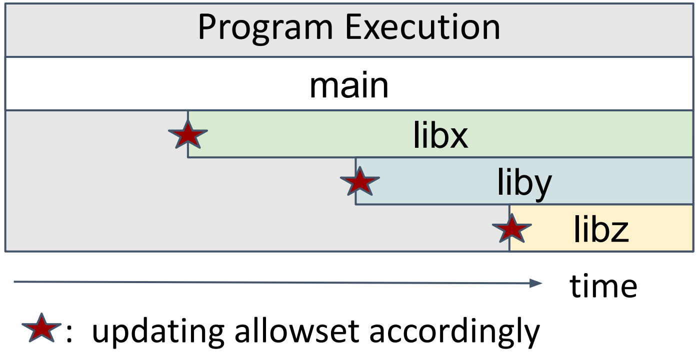

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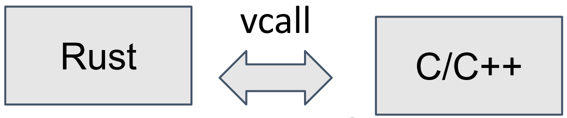

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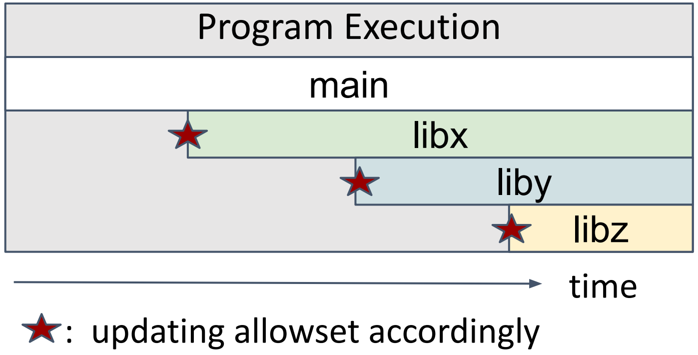

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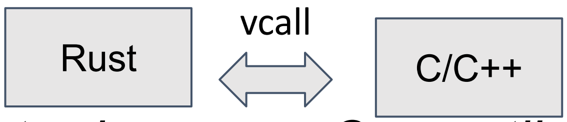

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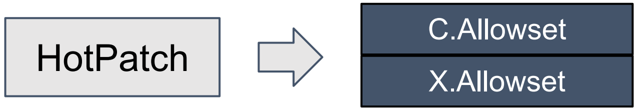

Ad-hoc Extension

Existing Works

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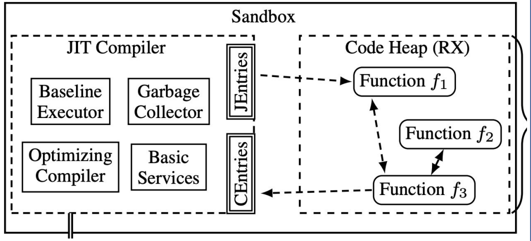
MCFI&RockJIT



* Sandbox
* Type-based policy
* High overhead

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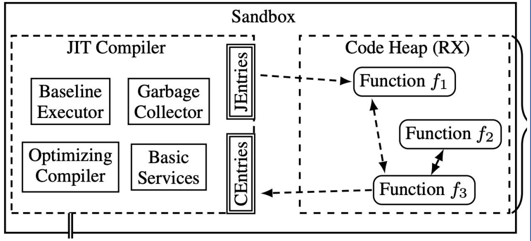

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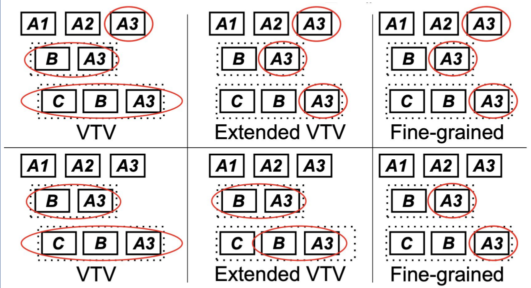

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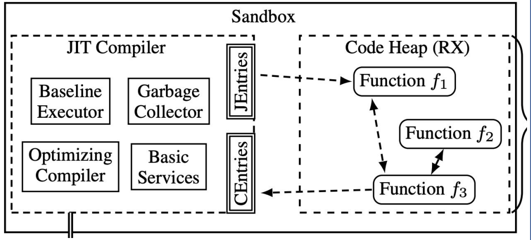

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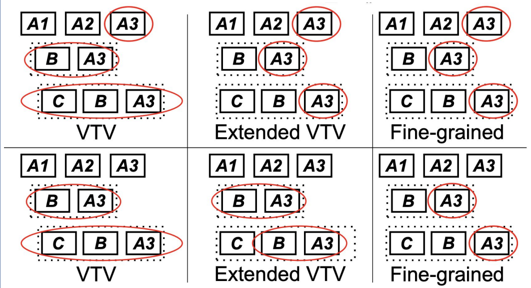

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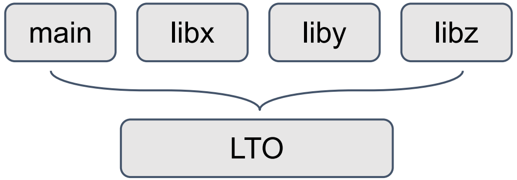

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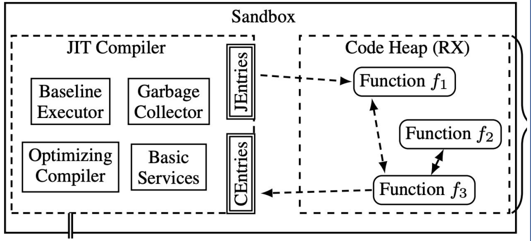

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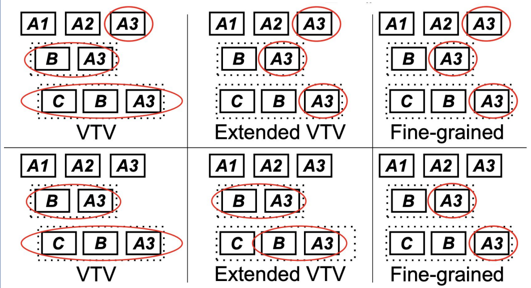

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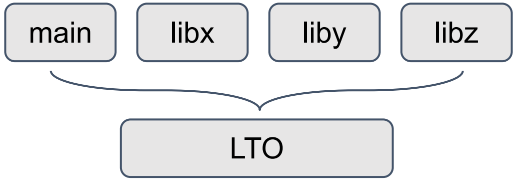

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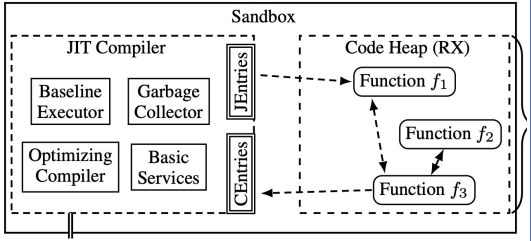

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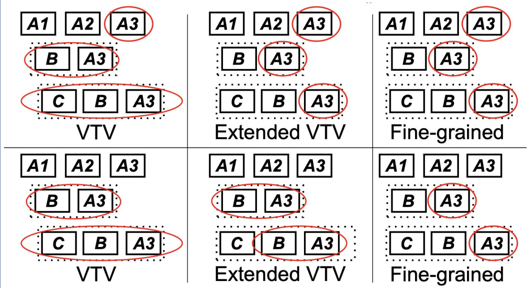

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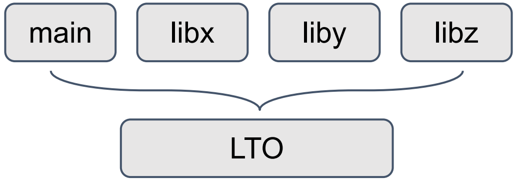

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☹ None of them are widely deployed in real applications

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Insight: Approximate Membership Query Filter

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⭐ **Insight: Approximate Membership Query Filter**

Approximate Membership Query Filter (AMQ-Filter) is the space-efficient probabilistic data structure that supports approximate membership queries.

Then, Why not use AMQ-Filter to implement VCFI?

Bloom Filter

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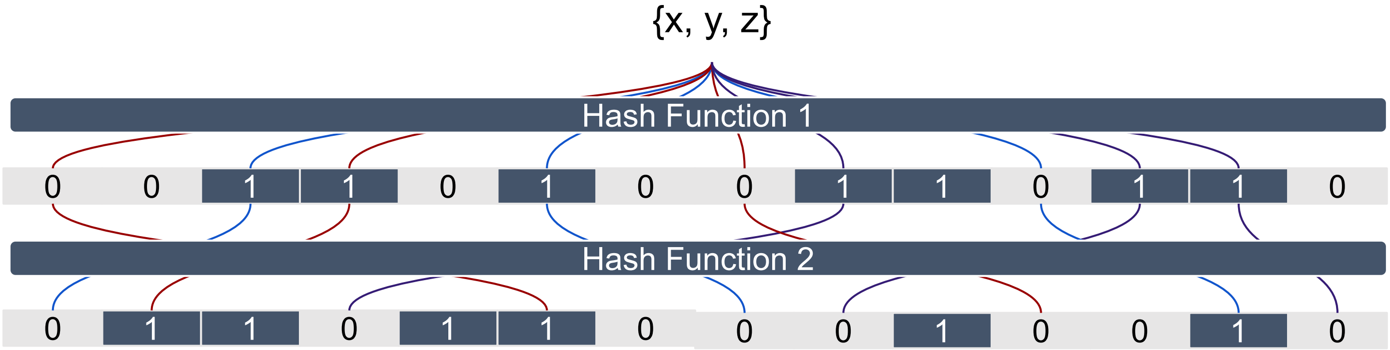

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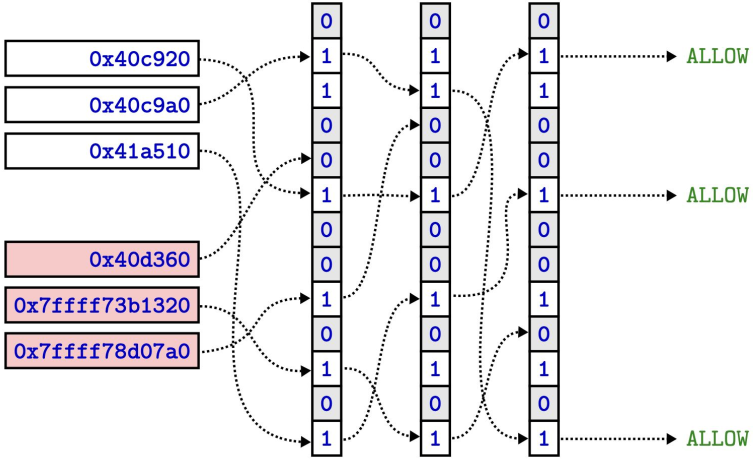

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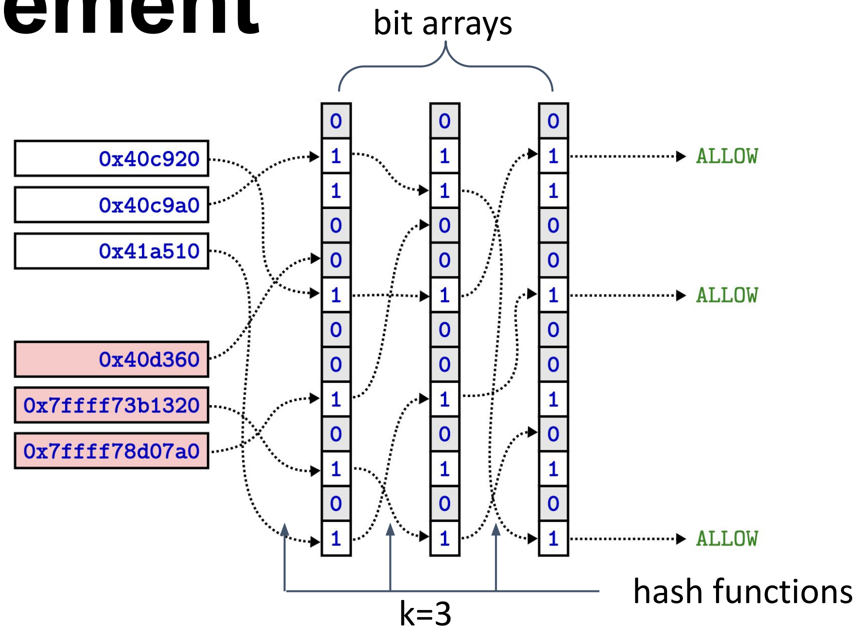

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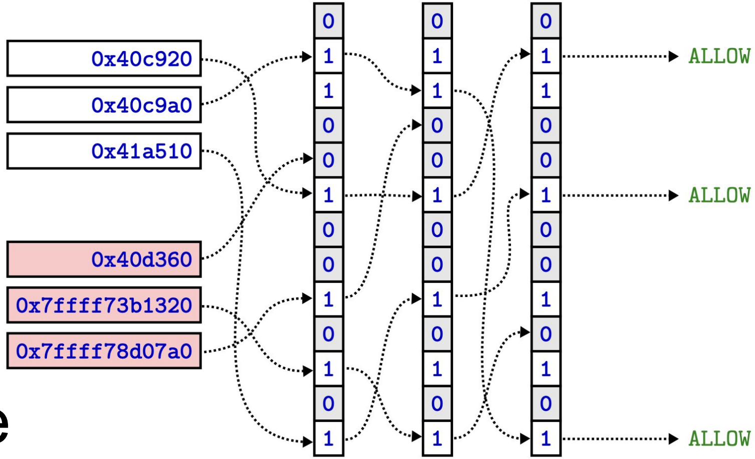

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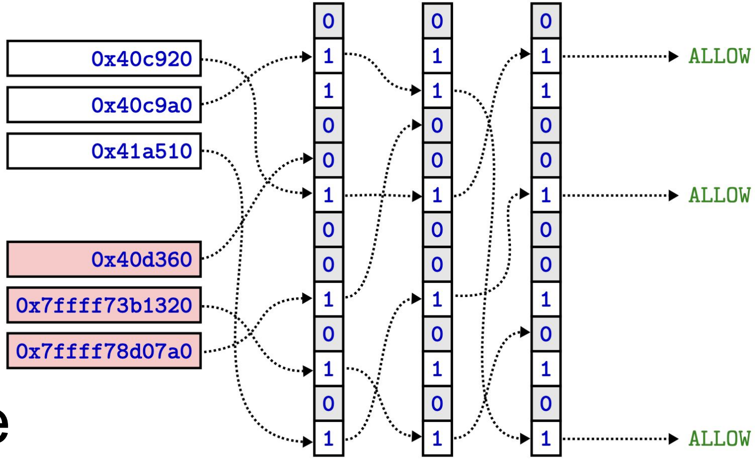

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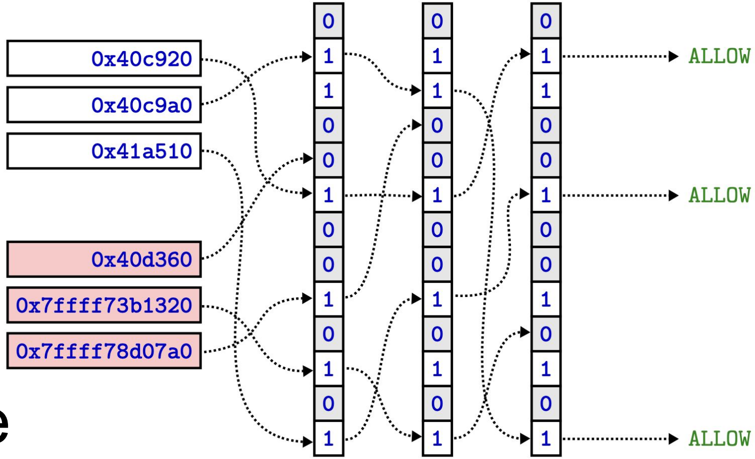

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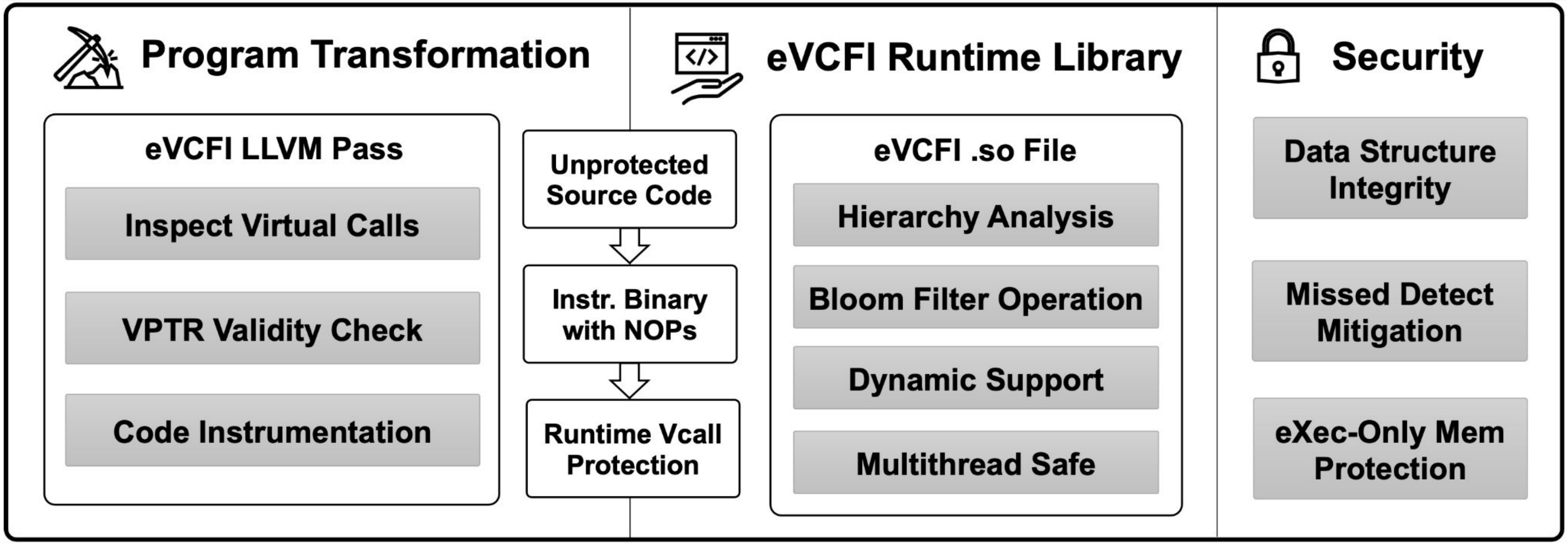
Only { all `1` hits in 3 tests } indicates the Valid VCall.

{ any `0` miss in 3 tests } indicates the Invalid VCall.

EVCFI Overview



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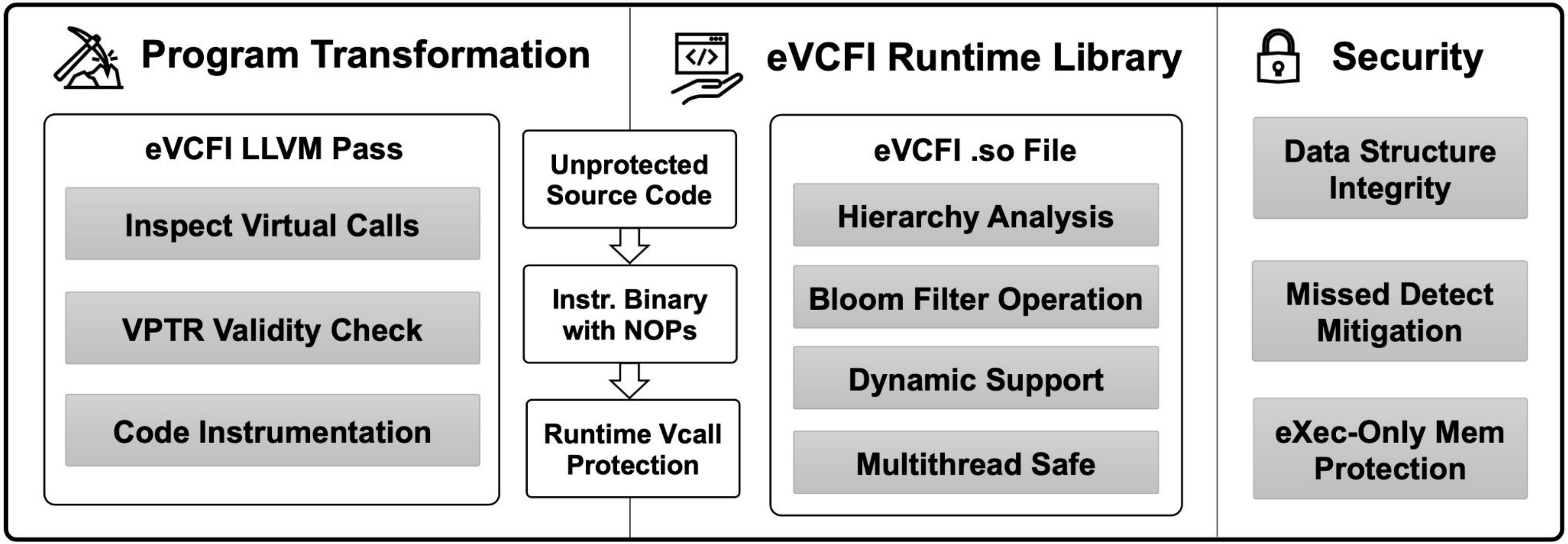

Static – LLVM Pass: static allowset analysis

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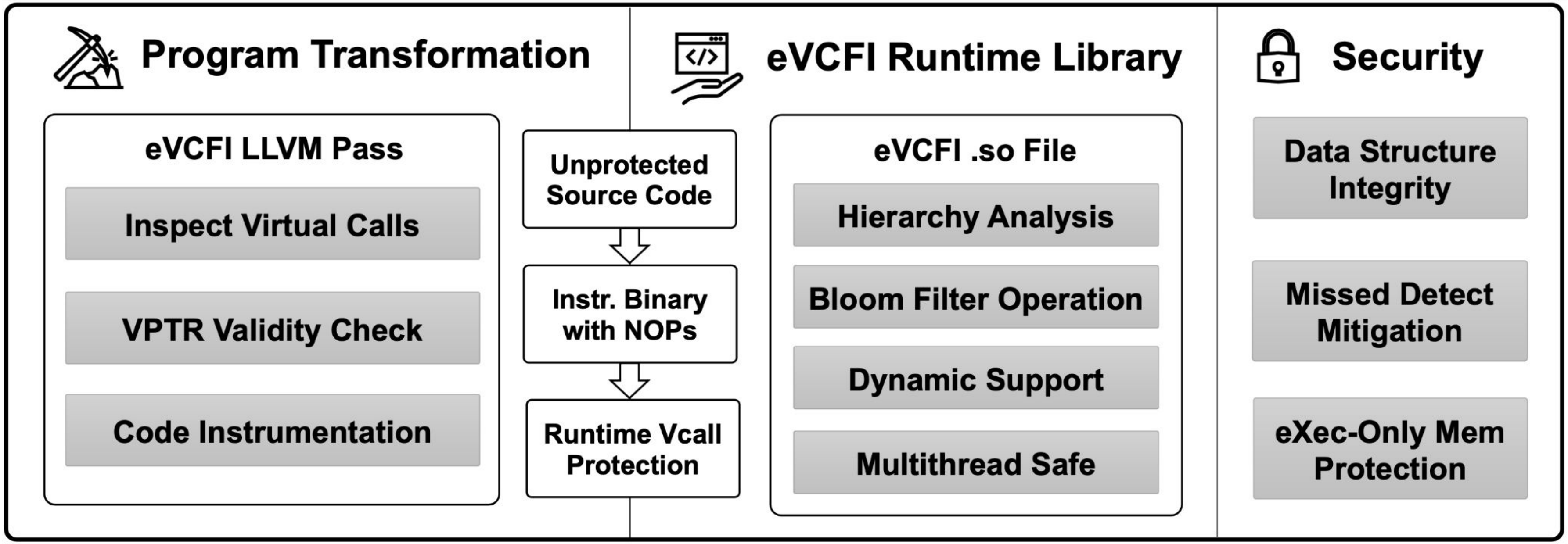

Static – LLVM Pass: static allowset analysis

Dynamic – Runtime: updating allowset dynamically

EVCFI Design

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movabs $SALT,%rdi    # Load 64-bit SALT
imul %rax,%rdi       # Multiply
xor %esi,%esi        # Zero accumulator
crc32q %rdi,%rsi     # CRC32
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```
mov (%rdi),%rax       # Load vptr
...                   # Hash into %rsi
movabs $BLOOM,%rdx    # Load Bloom base
testb $0,(%rdx,%rsi)
jnz .LOK              # Entry non-zero?
ud2                   # Invalid vptr
.LOK:
...                   # Repeat for k > 1
...                   # Setup parameters
callq *INDEX(%rax)    # Call virtualFn()
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VCALL Hardening

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VCALL Hardening

Efficiency: only 8*k instructions to complete vcall hardening

EVCFI Design – Security

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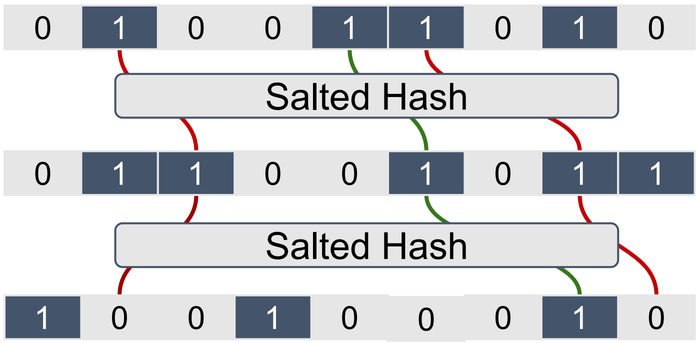
- Hash Collision (Miss Detection)



BF is inherently probabilistic

EVCFI Design – Security

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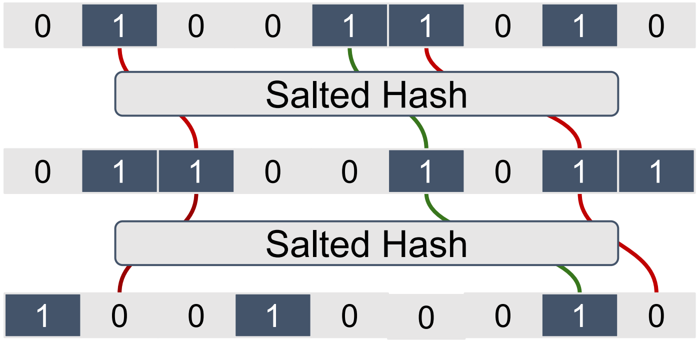

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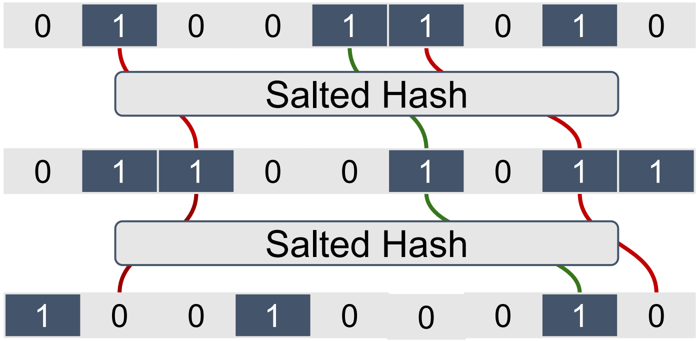

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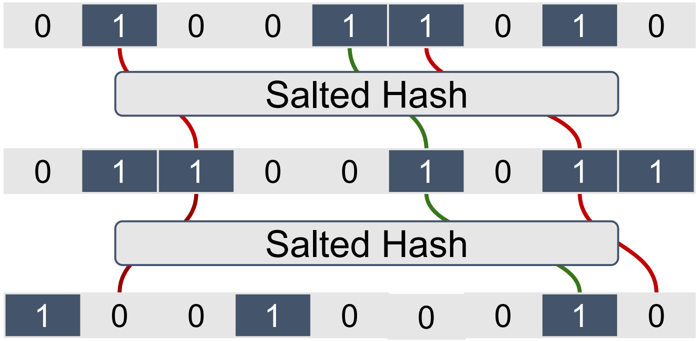

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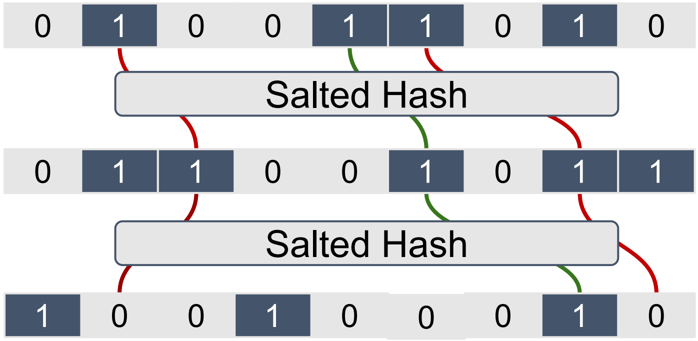

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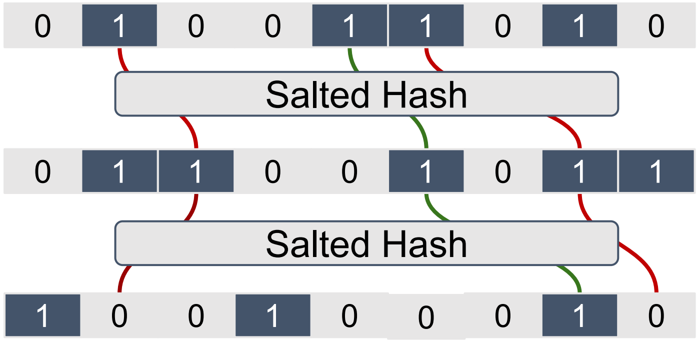

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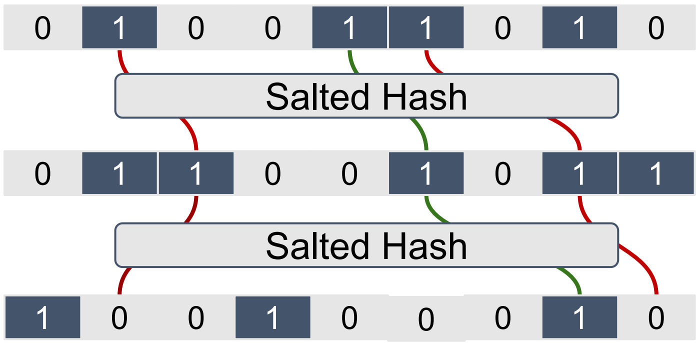

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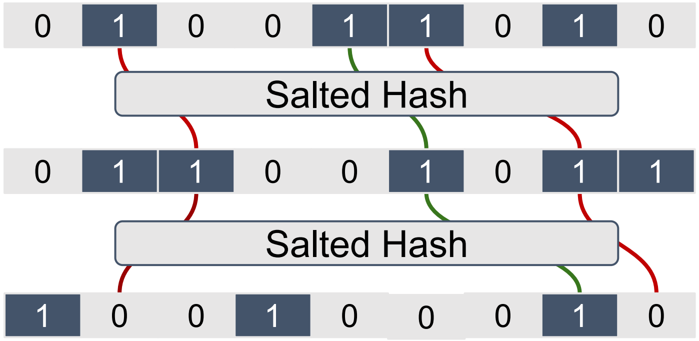

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Evaluation – Overall Comparison

○: unprotected ◔/◕: partially protected ●: fully protected -: not applicable

VCFIs	Policies		Features		Static Overhead		
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eVCFI is the first VCFI that achieves efficiency and extensibility

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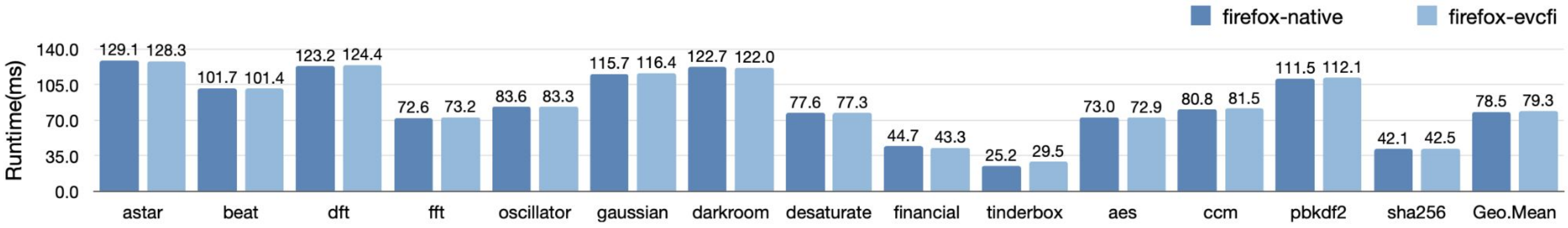

- With high efficiency, eVCFI only incurs 1.01% slowdown

Summary

- We propose a novel Extensible-VCFI (EVCFI)
  - The first AMQ-based VCFI
- EVCFI is efficient, extensible, and secure
- EVCFI can support the Firefox, one real-world challenging application for extensibility, which has not been supported by existing VCFIs

Thanks