ENFORCING CONTROL-FLOW INTEGRITY IN VIRTUALIZED ENVIRONMENTS ON ARM PLATFORMS

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MOTIVATION AND CONTEXT

Can we really trust our embedded devices?
Imagine if this will happen on our cars or trains.

iOS 14.4 and iPadOS 14.4

Released January 26, 2021

WebKit

Available for: iPhone 6s and later, iPad Air 2 and later, iPad mini 4 and later, and iPod touch (7th generation)

Impact: A remote attacker may be able to cause arbitrary code execution. Apple is aware of a report that this issue may have been actively exploited.

Description: A logic issue was addressed with improved restrictions.

CVE-2021-1871: an anonymous researcher

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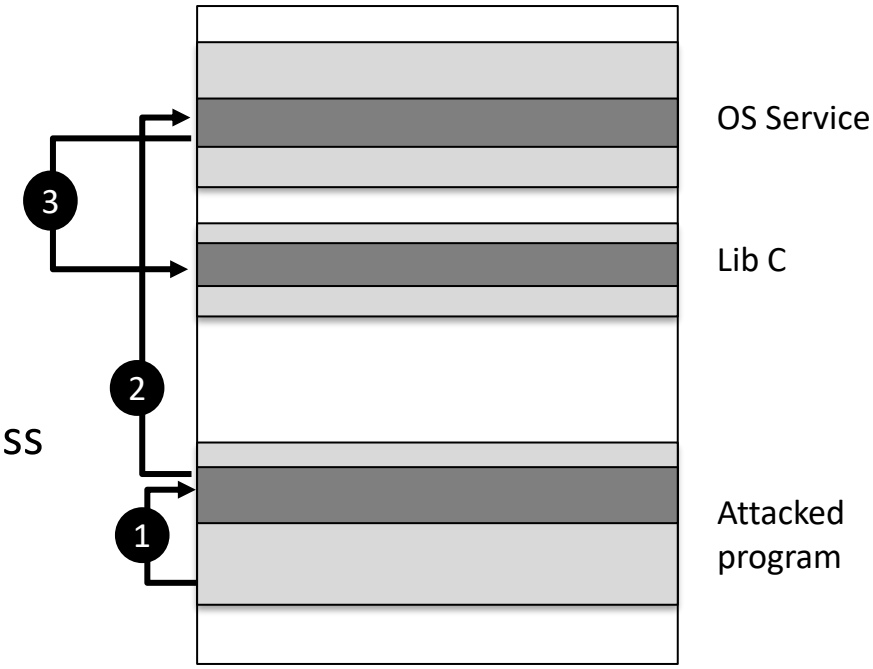
Susceptible to attacks

- **Code-Reuse-Attacks**
  - Re-use existent piece of code
  - I.e. flow deviated to gain root access
- Return-Oriented programming



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Mitigation technique

- Address space layout randomization (ASLR)
- **Integrity check of control flow (CFI)**

INTRODUCTION

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void foo() { ... }

void main() {
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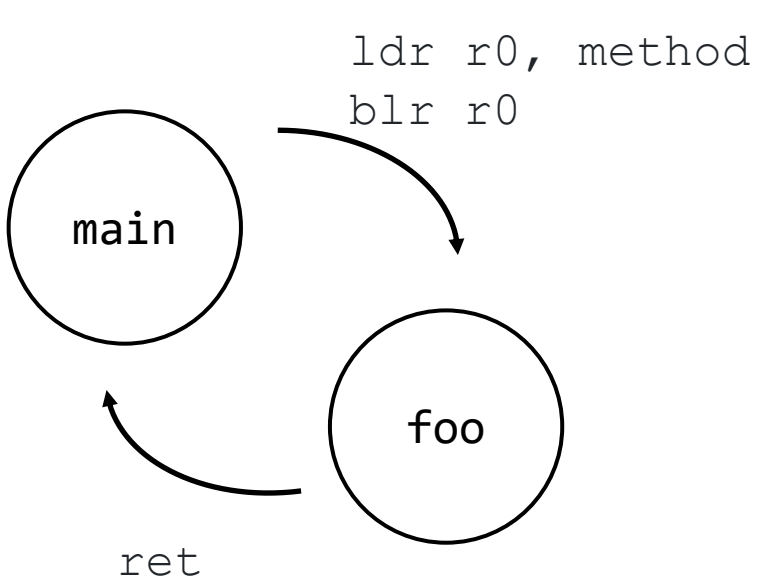

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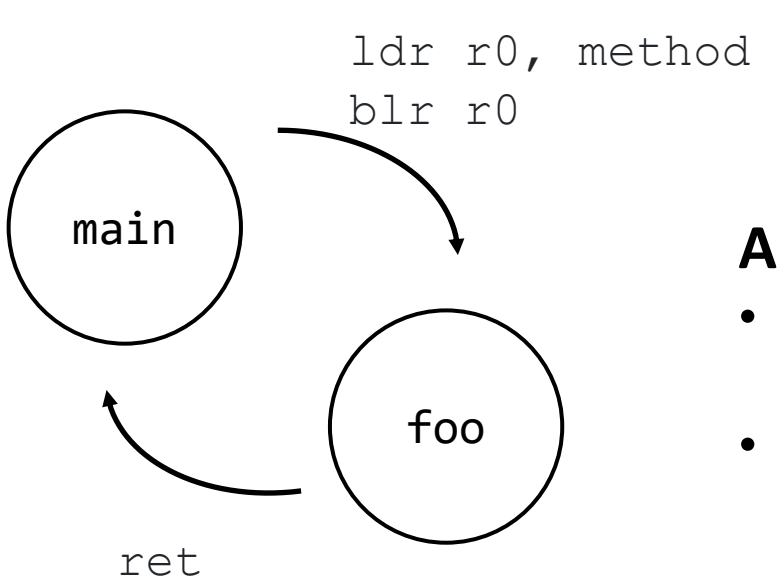
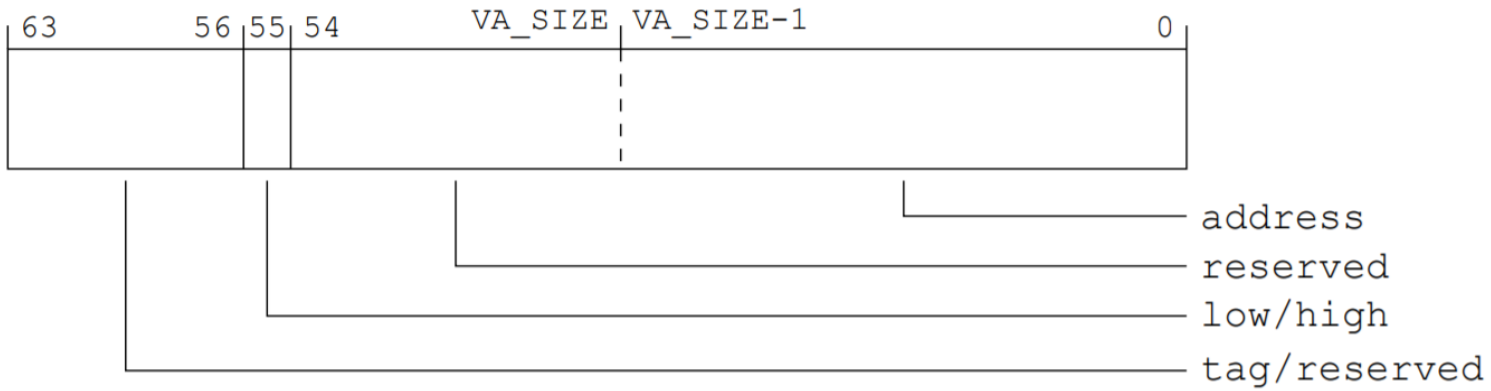


ARM introduced hw supports:

- Branch Targets Identification (**BTI**)
  - Forward branch protection
- Pointer Authentication Code (**PAC**)
  - Backward branch protection

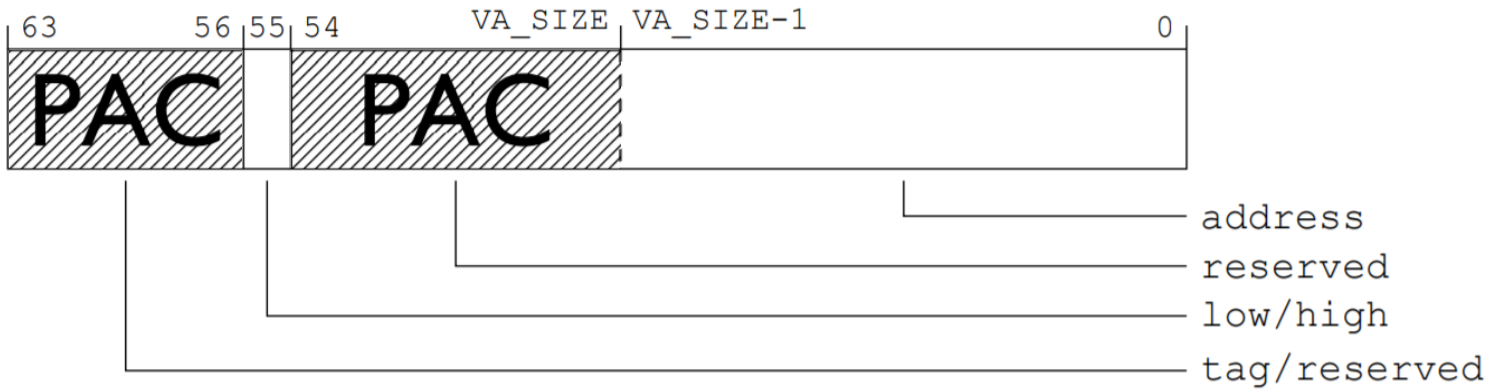
Pointers in AArch64:

- Address represented on `[0:VA_SIZE]`
- Typically `VA_SIZE = 48`
- Empty `[VA_SIZE:54]` and `[56:63]`



AArch64 Pointer Authentication Codes (PAC):

- Hardware-based CFI
- Leverages empty space on 64-bit virtual addresses
- Append a Message Authentication Code (MAC)



BACKGROUND

Introduced two insns:

- PAC
- AUTH

PAC Creation takes:

- A pointer
- A 64-bit context
- A 128-bit secret key

PAC algorithm ‘H’ can be:

- QARMA
- Implementation defined

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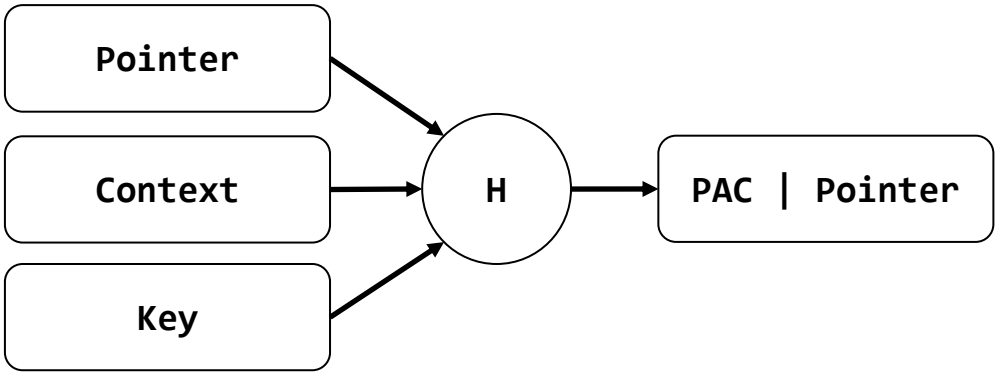

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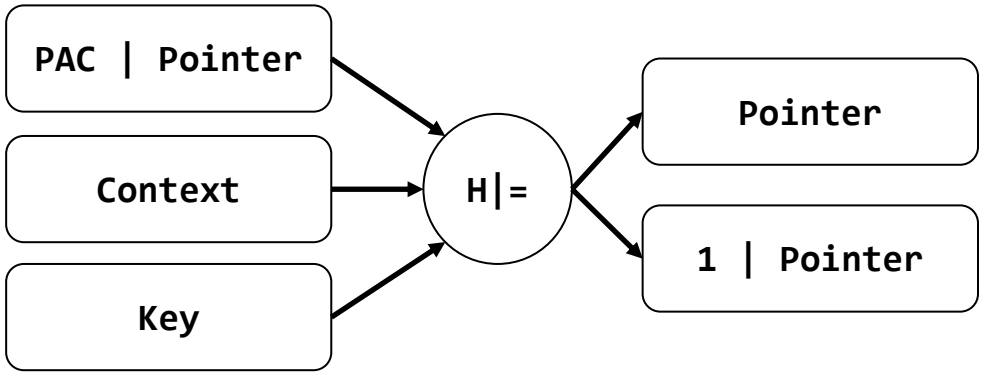

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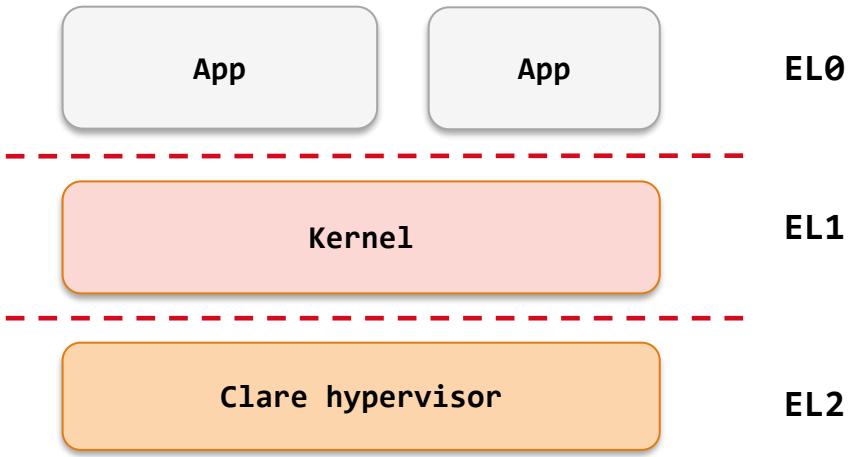
Leverage on virtualization to counteract these issues!

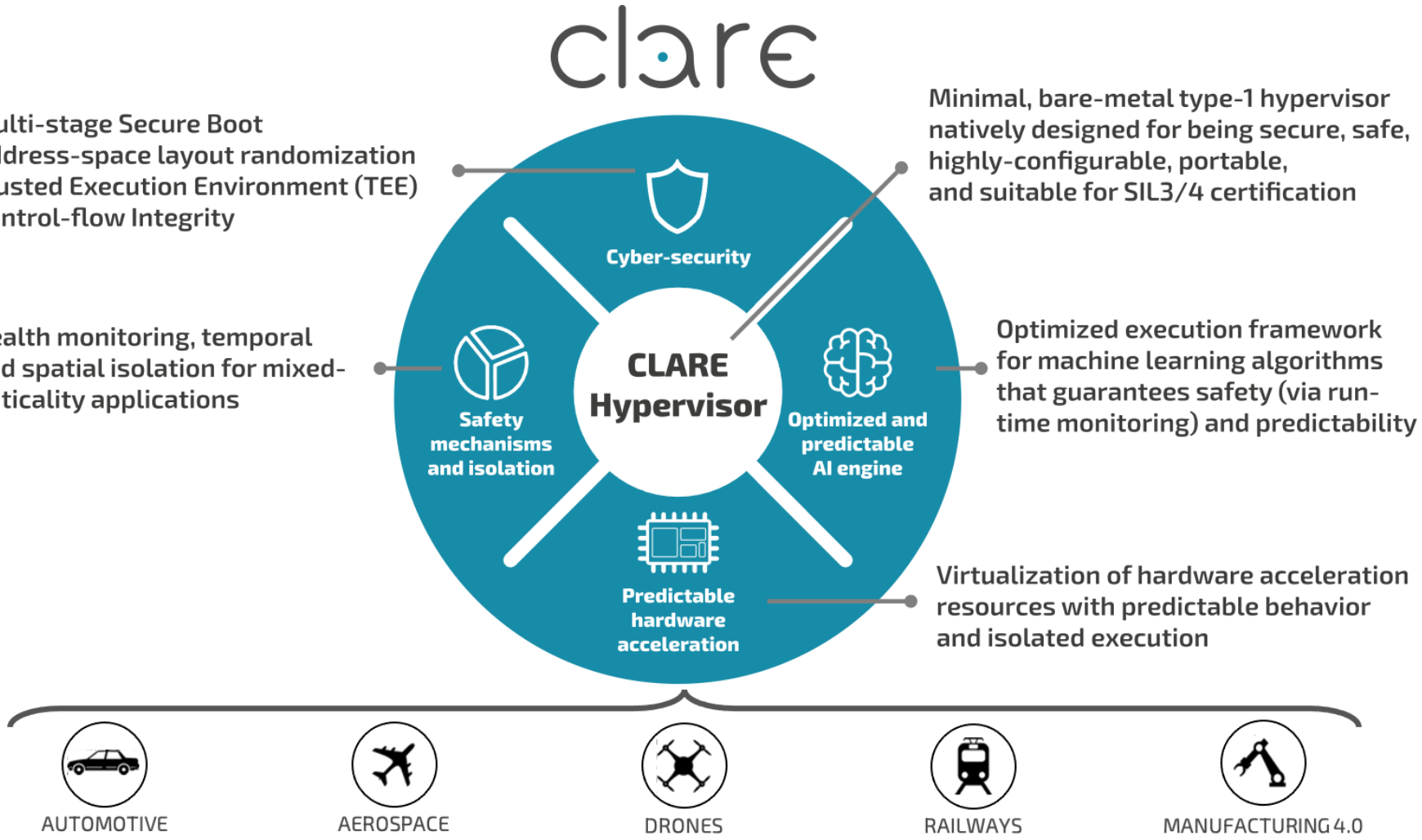
PROPOSED APPROACH

Leverage on CLARE hypervisor to:

1. Improve key management
2. Provide PA to all AArch64 SoC



CLARE IN A NUTSHELL



Check it out @ clare.santannapisa.it

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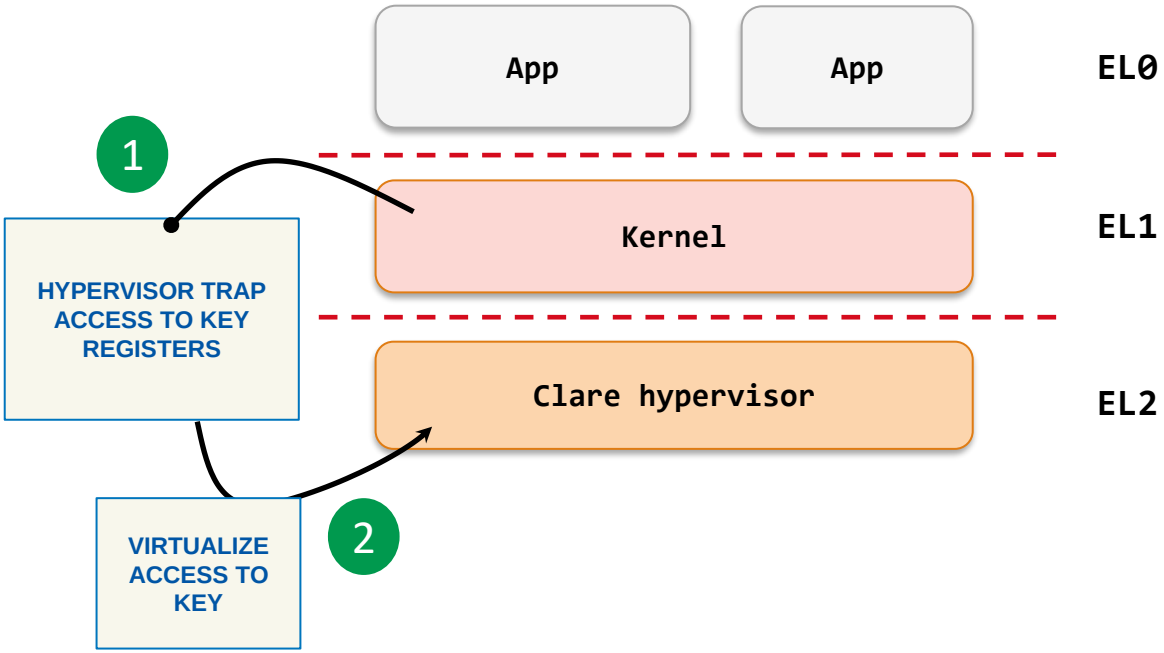

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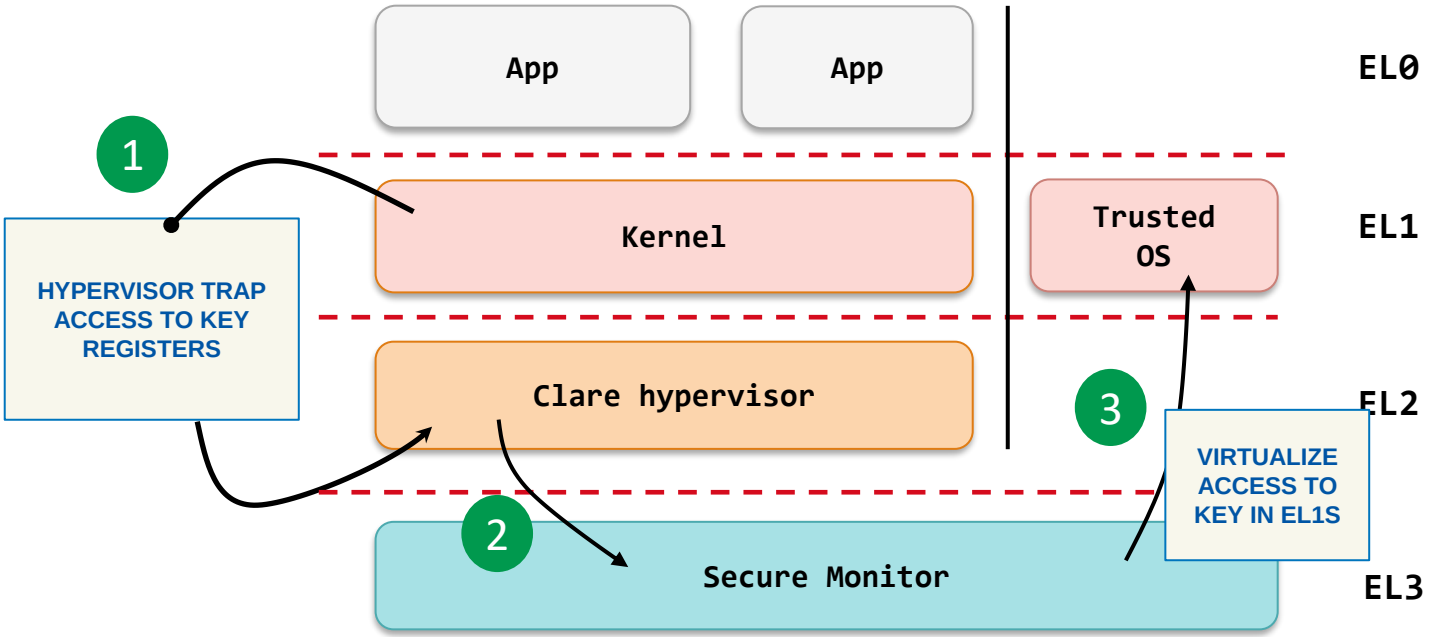

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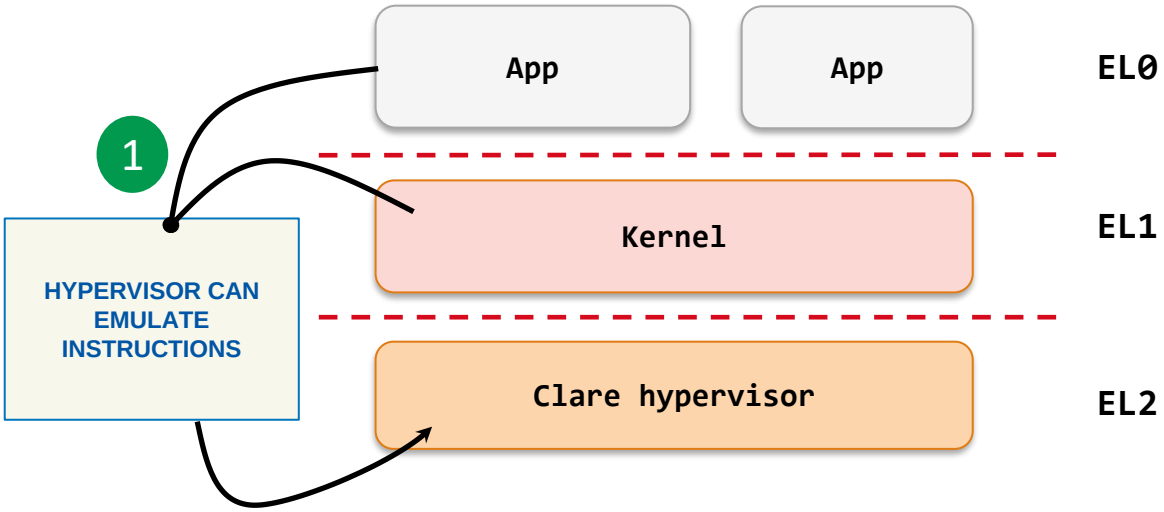
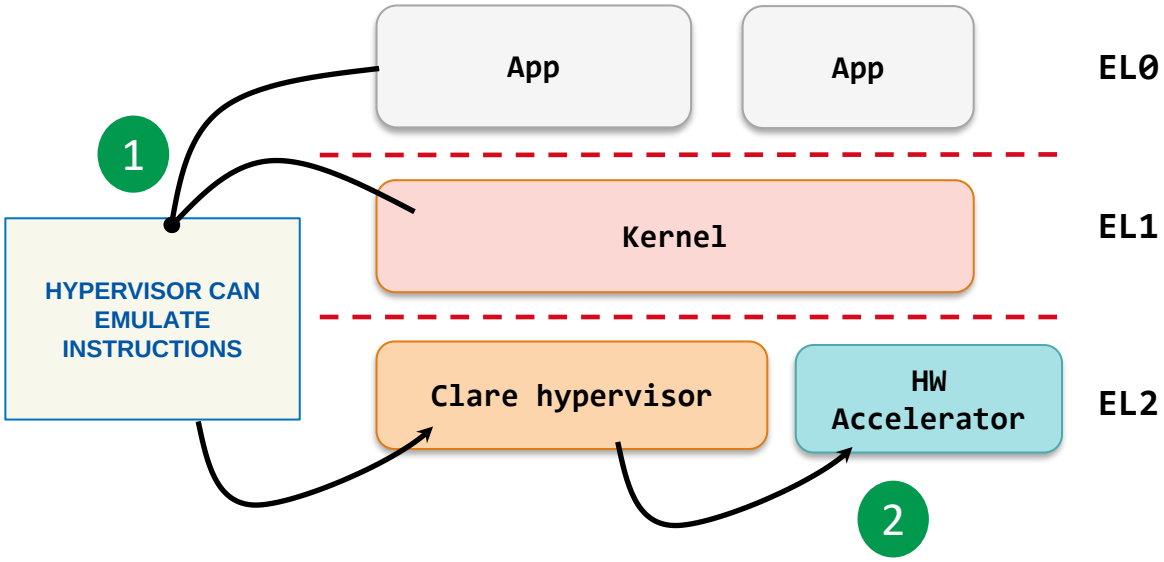


Leverage on CLARE hypervisor to:

1. Improve key management
2. Provide PA to all AArch64 SoC
    1. PA can be HW accelerated
    2. **Clare** can detect attacks



CONCLUSIONS & FUTURE WORKS

Advances in embedded system connectivity and technologies need to be followed by corresponding advancements in associated security protection!

Future directions

- Measure aggregate overhead when protecting 1 domain out of N
- Apply PAC in selective way (only “more at risk” processes)
- Simplify access to PAC features
- Fully integrate the stack for production in **CLARE** hypervisor

THANK YOU

QUESTIONS?

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