School of Computer Science & Engineering

Trustworthy Systems Group

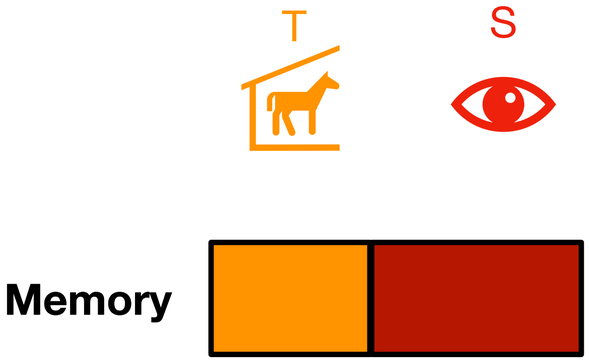
Clearing roadblocks to Time Protection verification for seL4

Dr Rob Sison

Senior Research Associate, UNSW Sydney

r.sison@unsw.edu.au

What is Time Protection?



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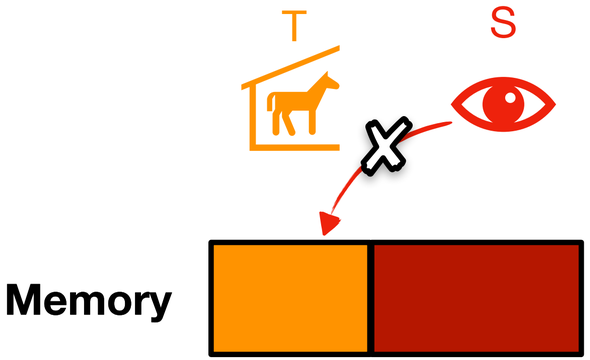

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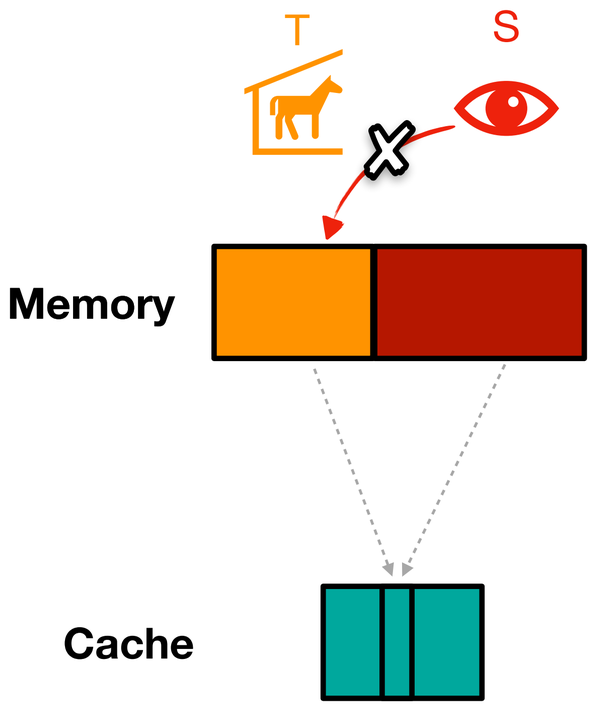

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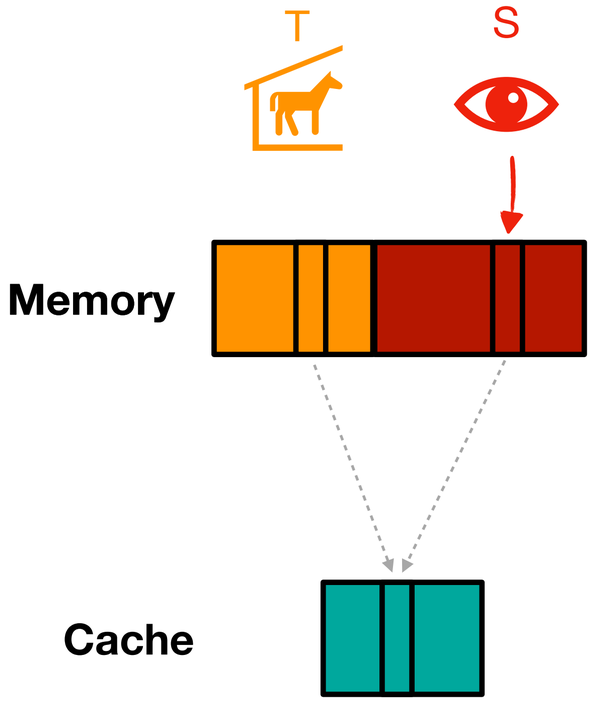

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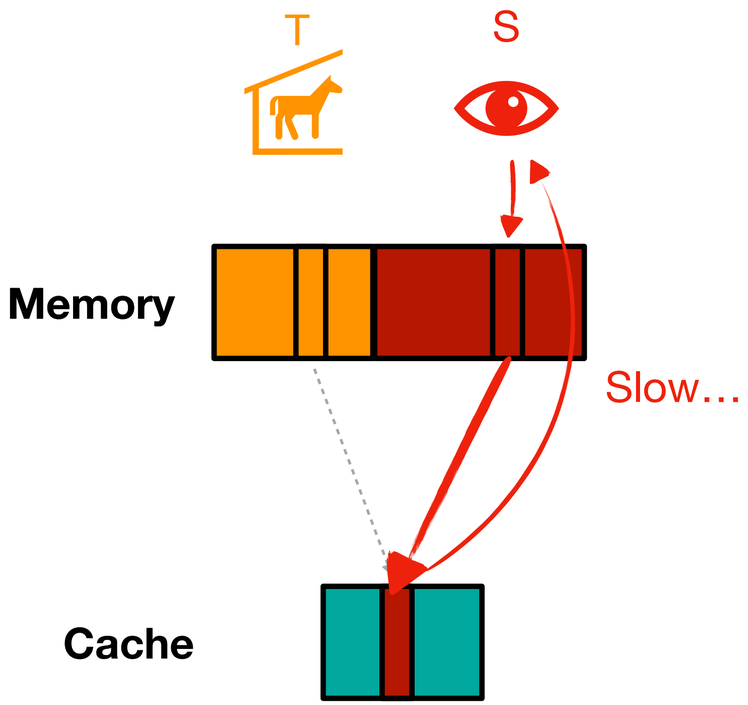

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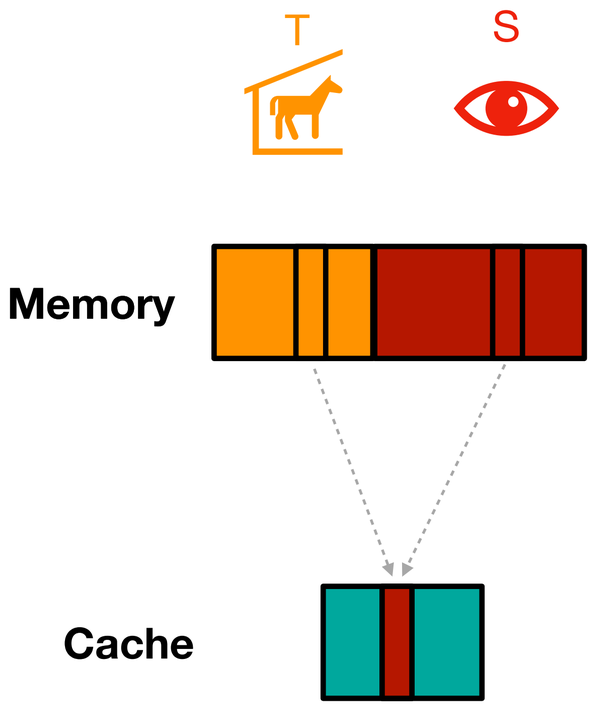

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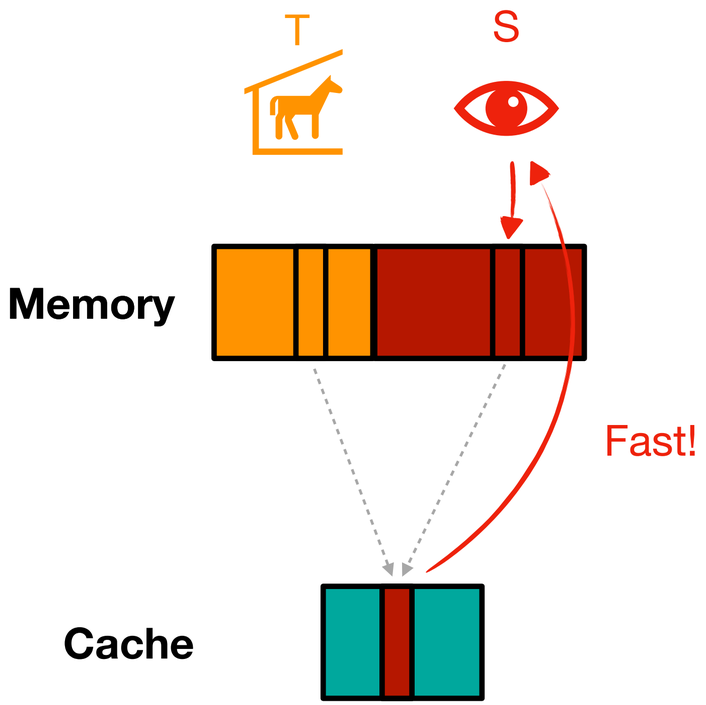

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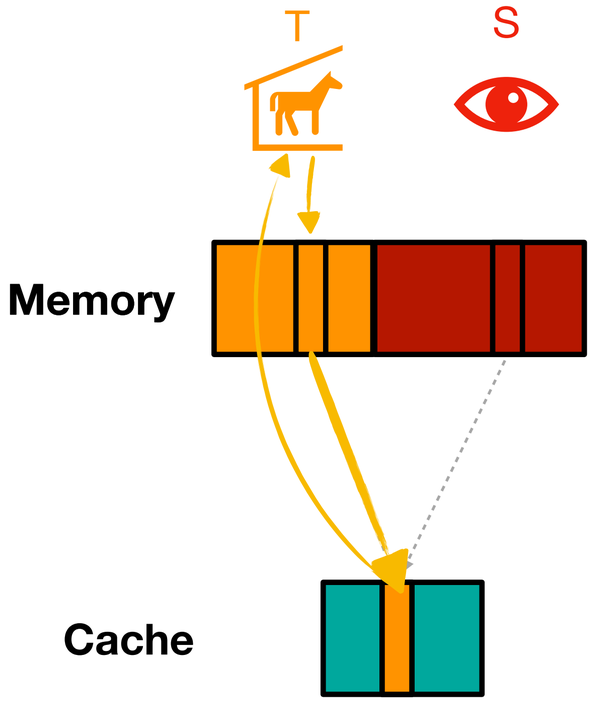

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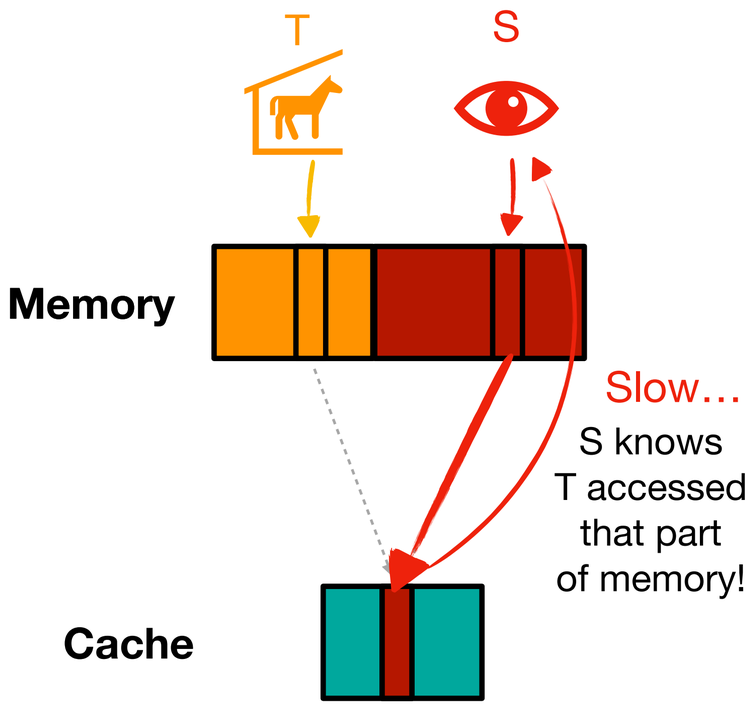

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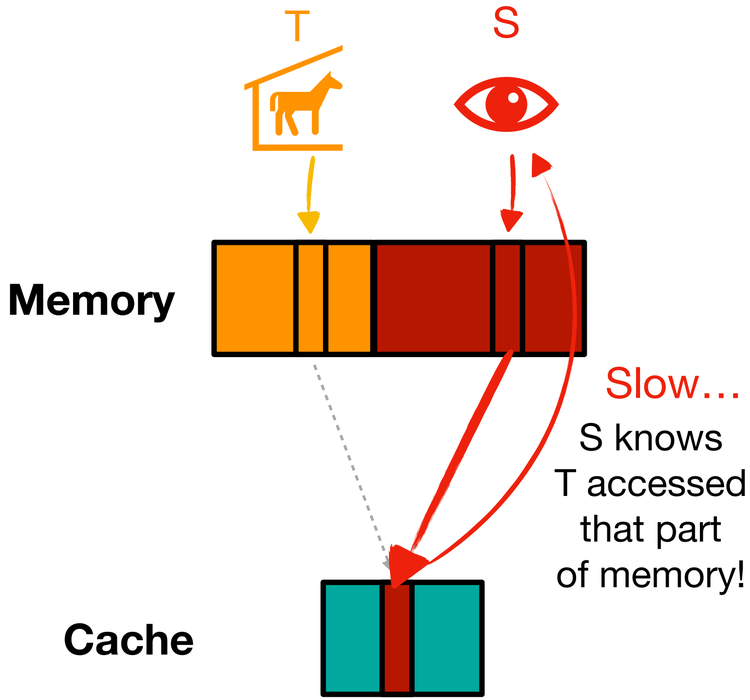

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Gernot Heiser

with
Yuval Yarom (U. Adelaide)
Tom Chothia (U. Birmingham)

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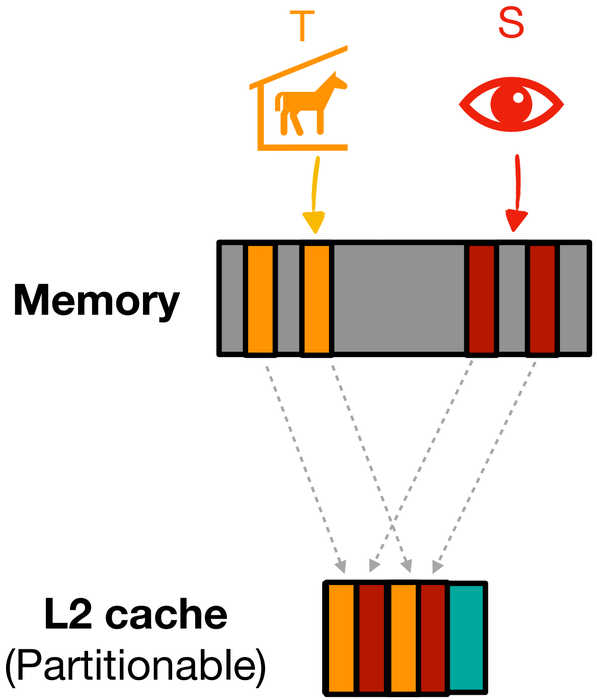

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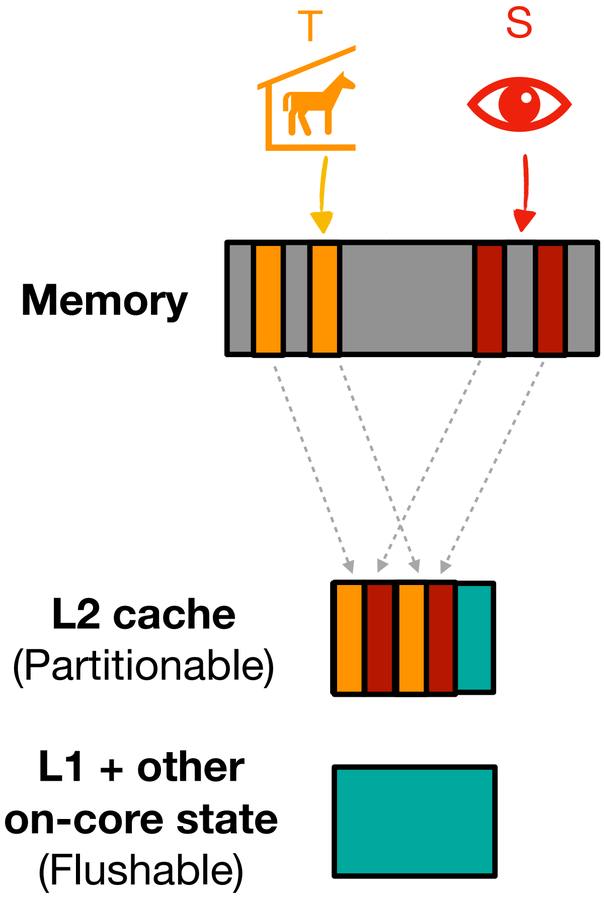

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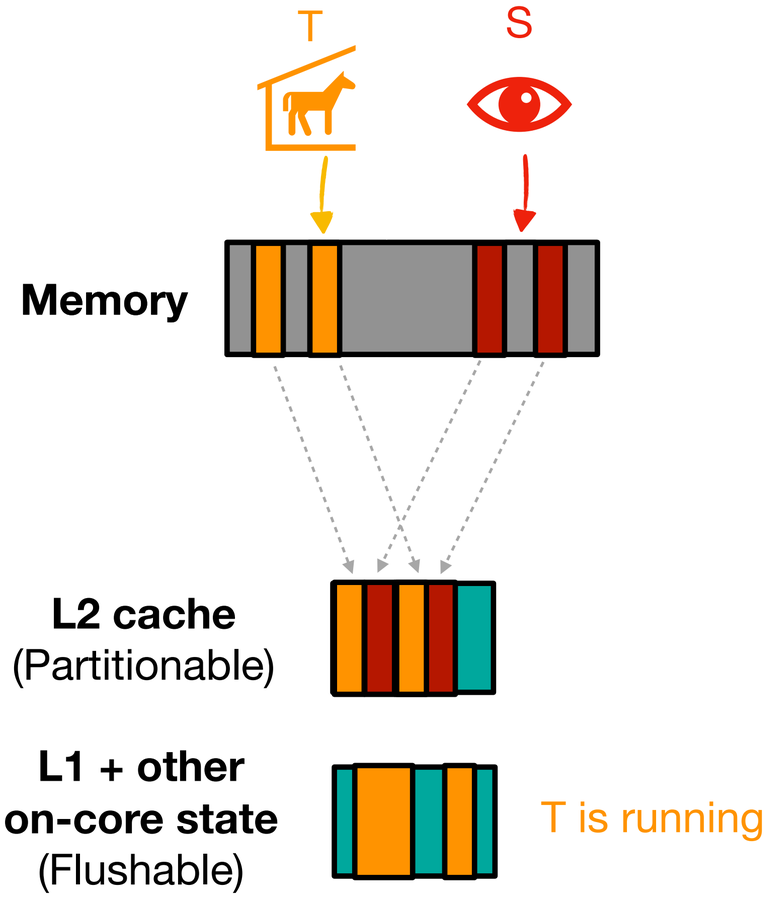

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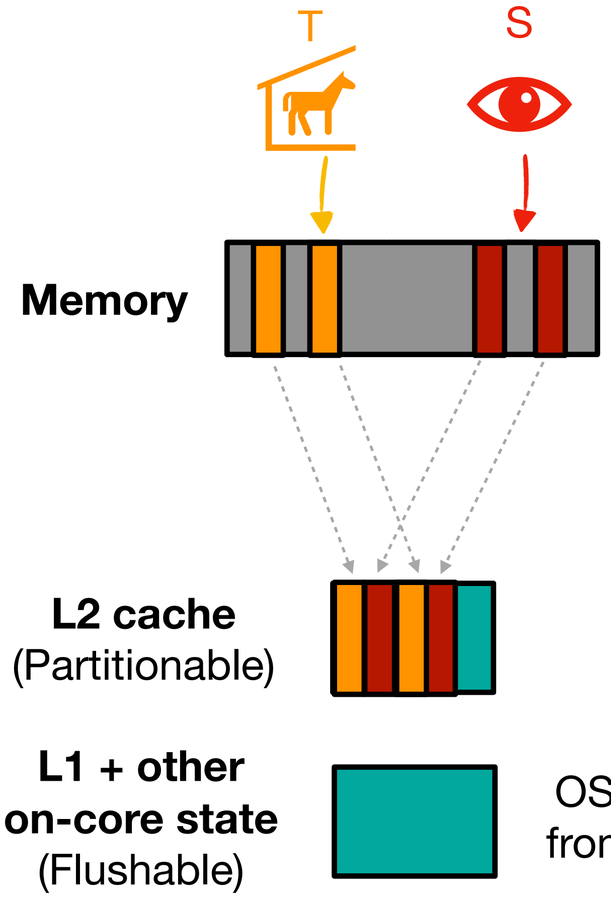

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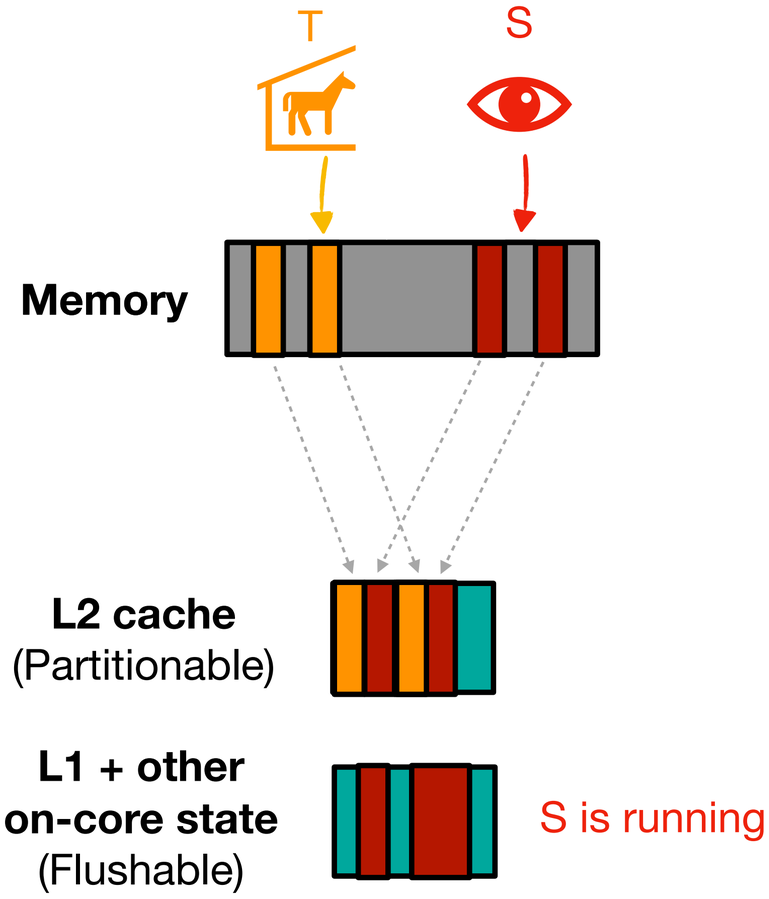

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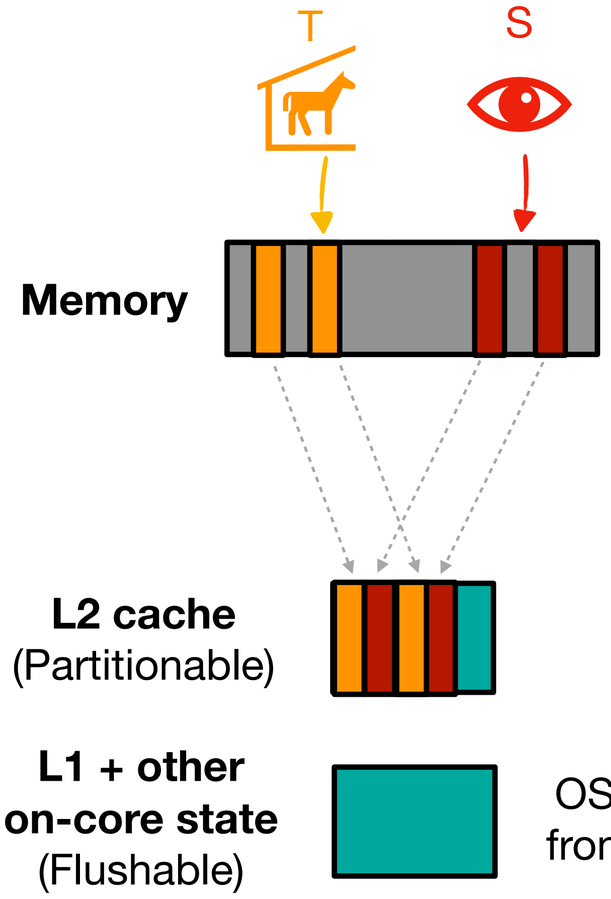

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The seL4 kernel and Time Protection

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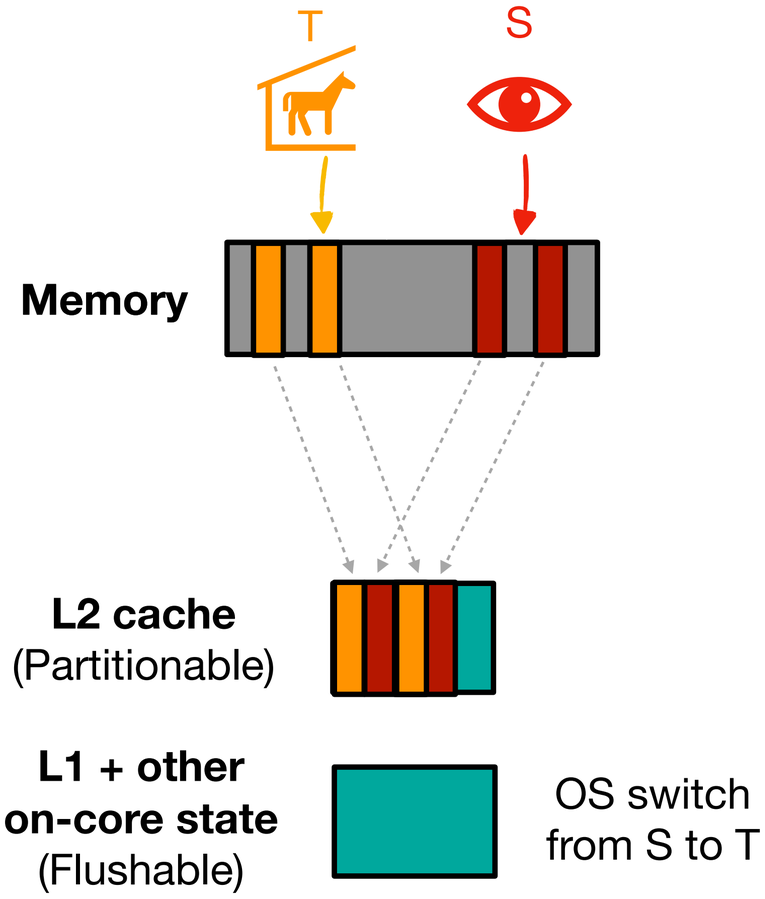

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seL4: World's first OS kernel with correctness proof!

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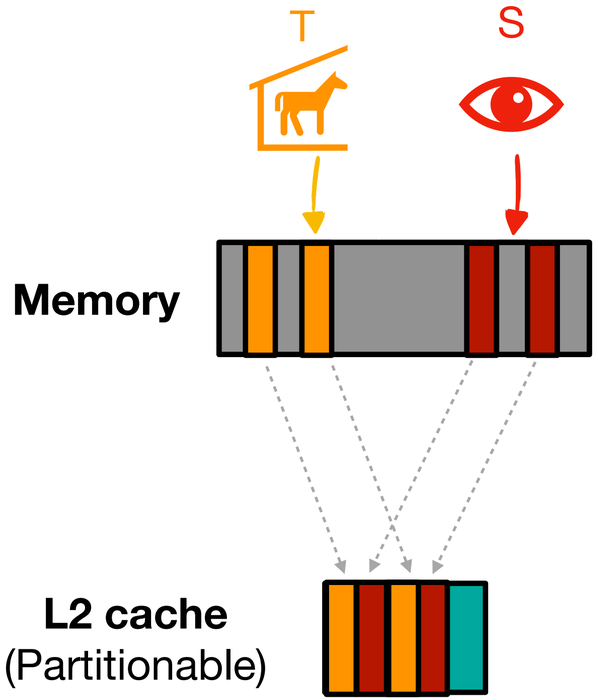

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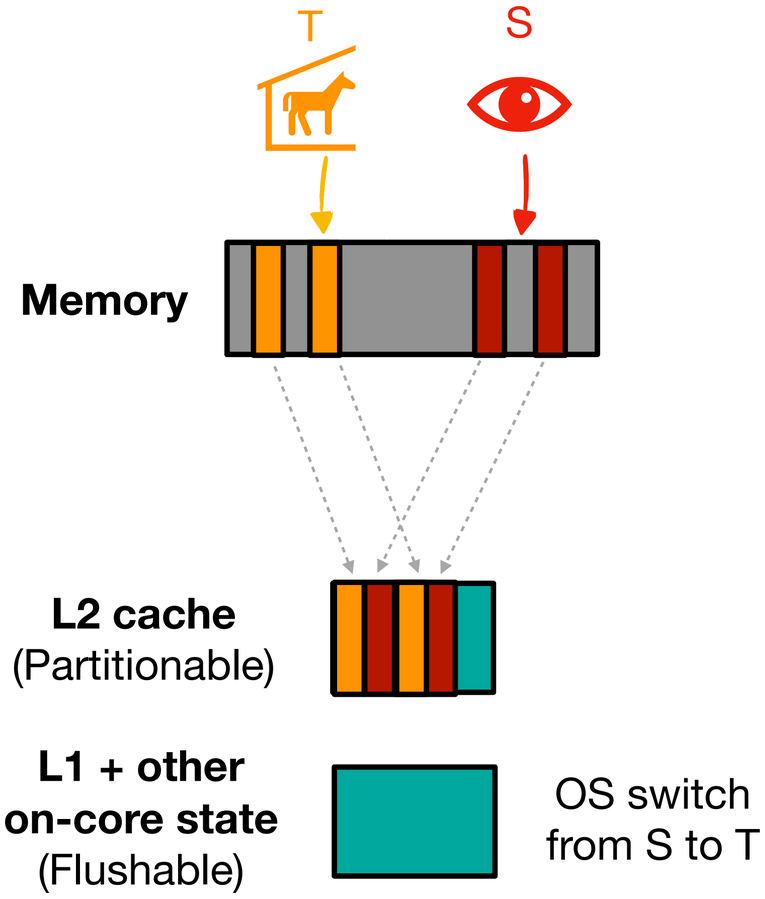

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seL4: World's first OS kernel with correctness proof!


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Rob Sison


Nils Wistoff


Curtis Millar


Toby Murray


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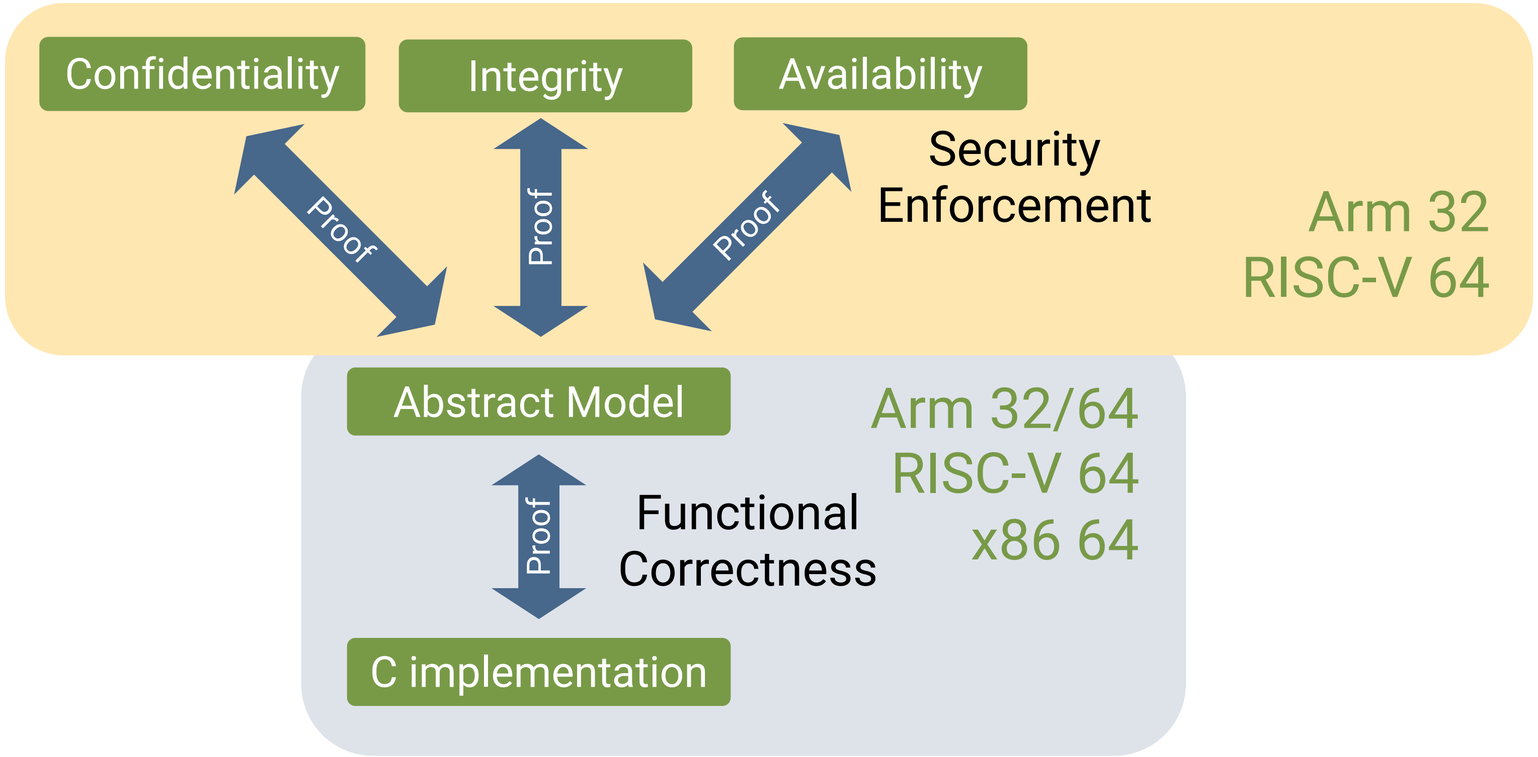

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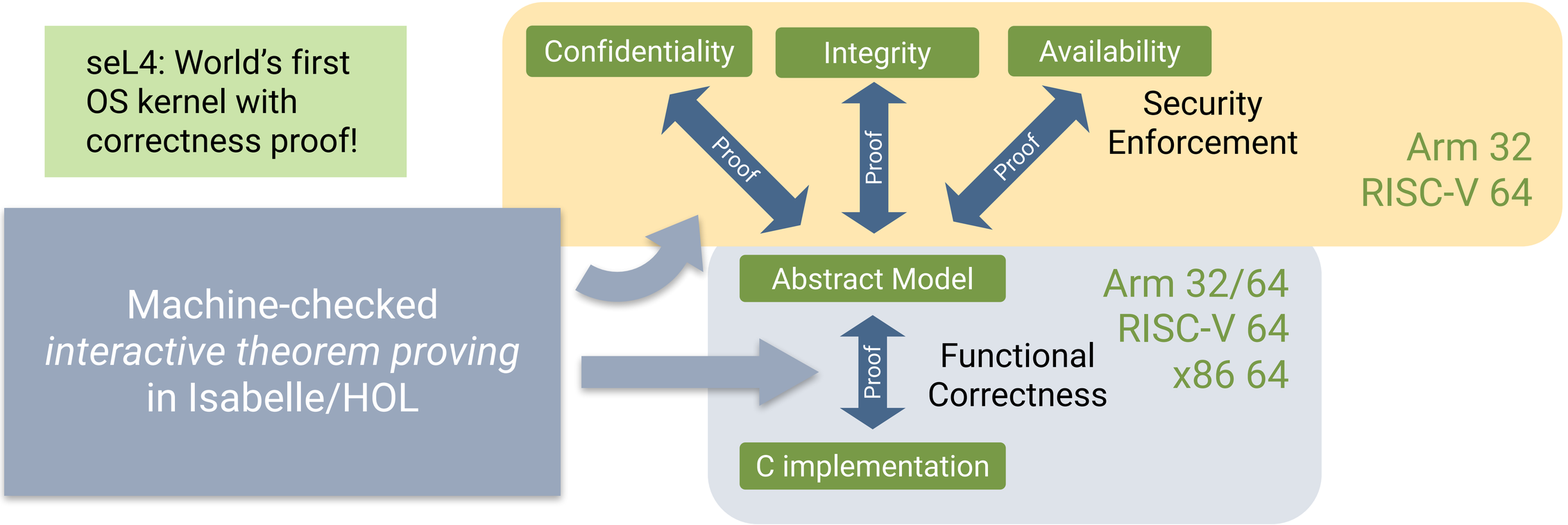

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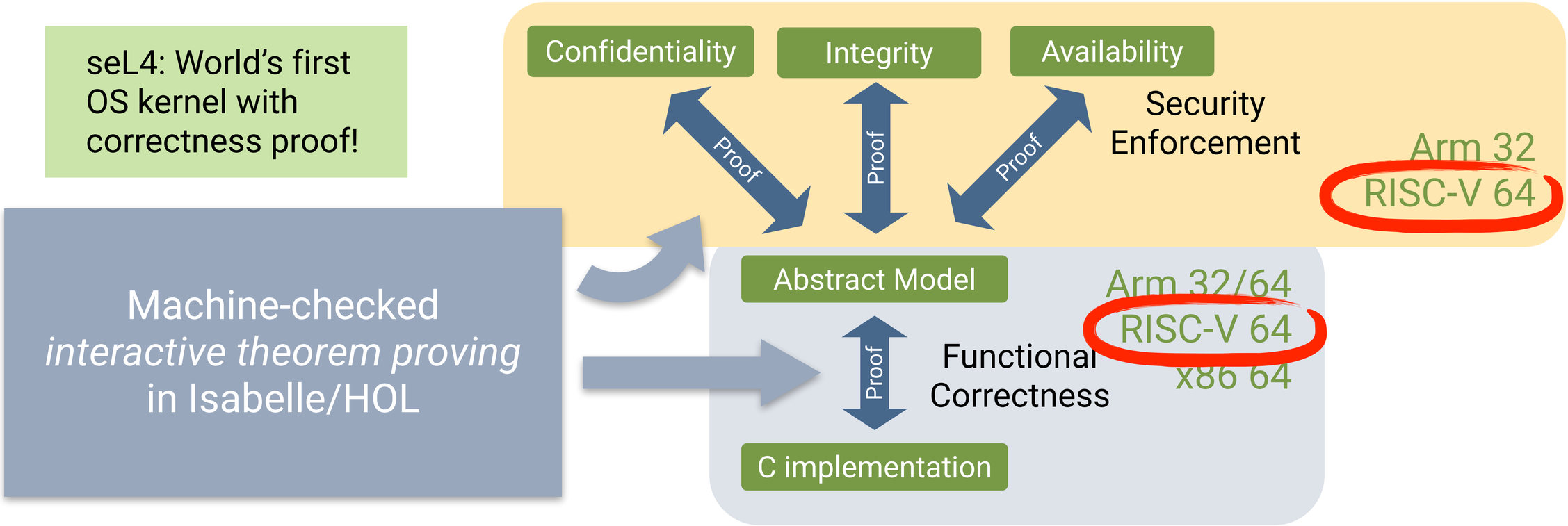

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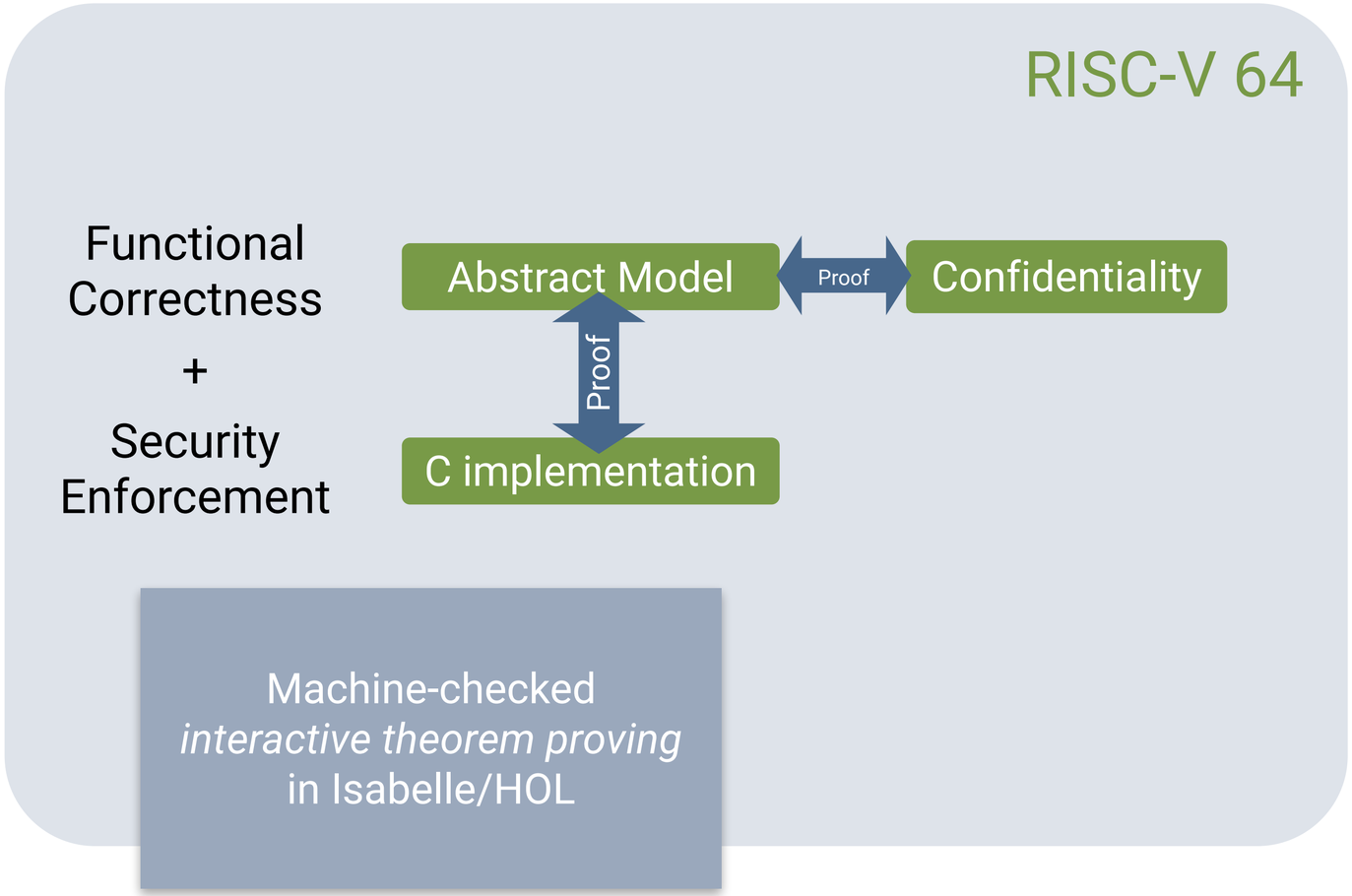

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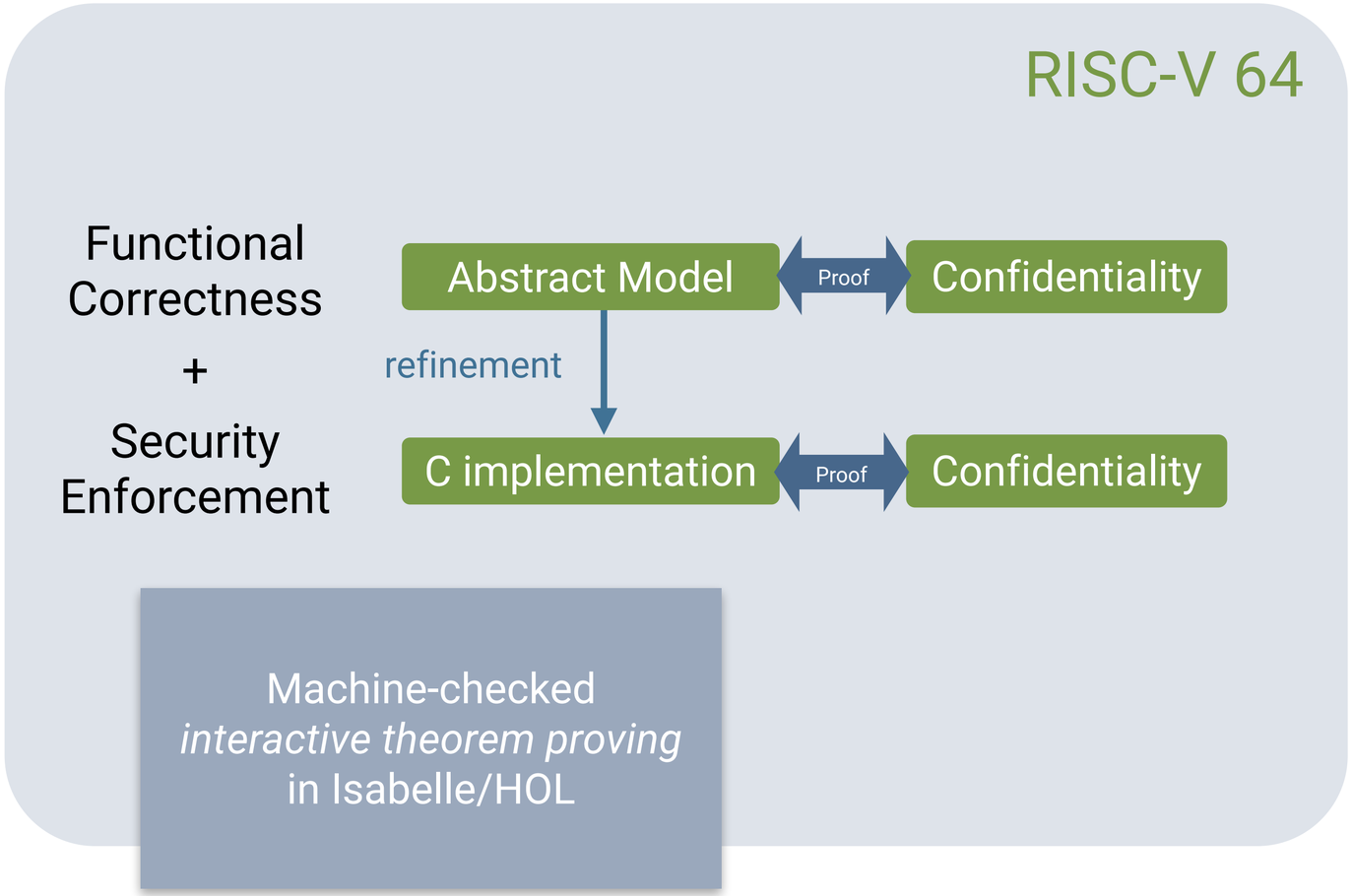

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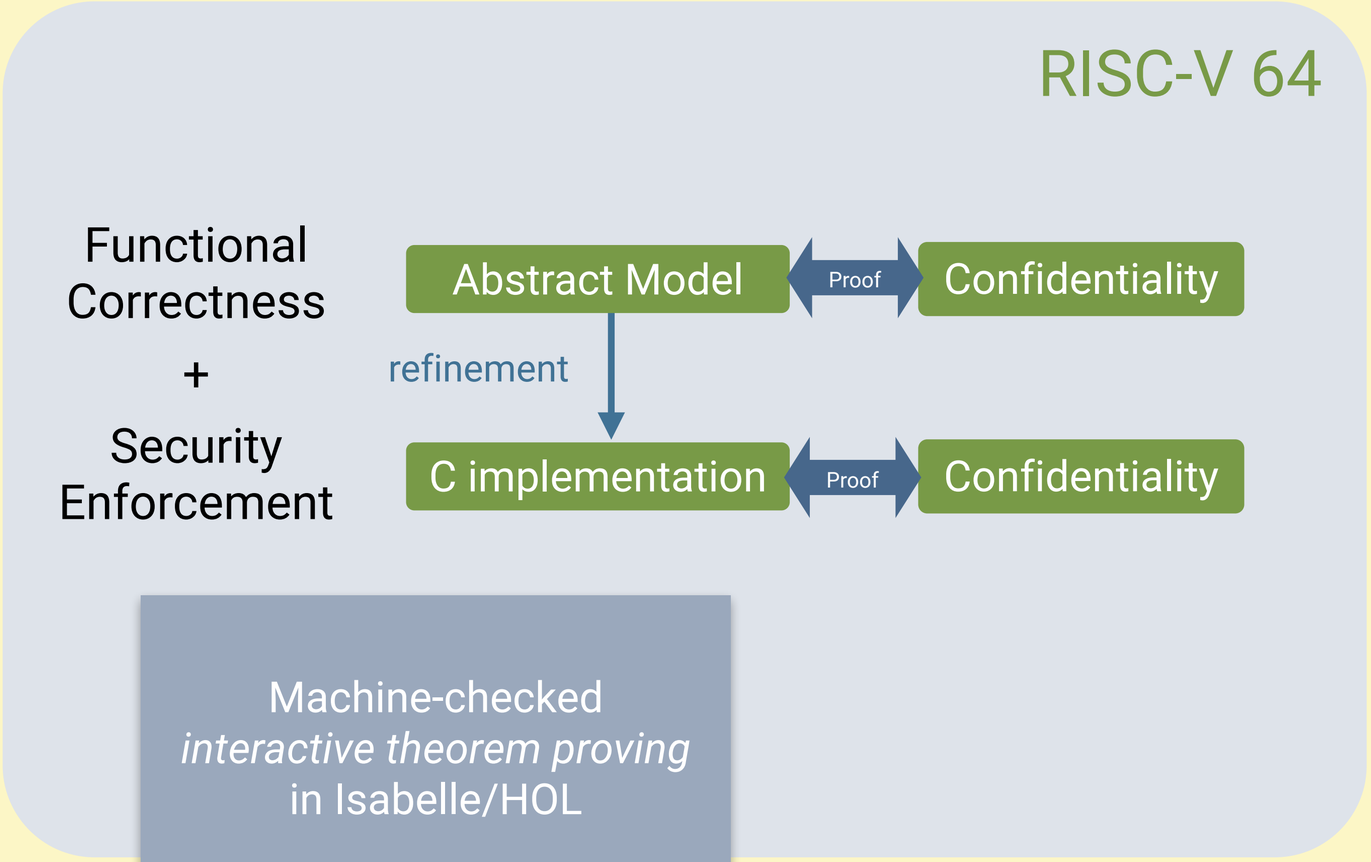
Time protection verification for seL4

The plan 2 years ago… *(presented at FM-OZ'24)*



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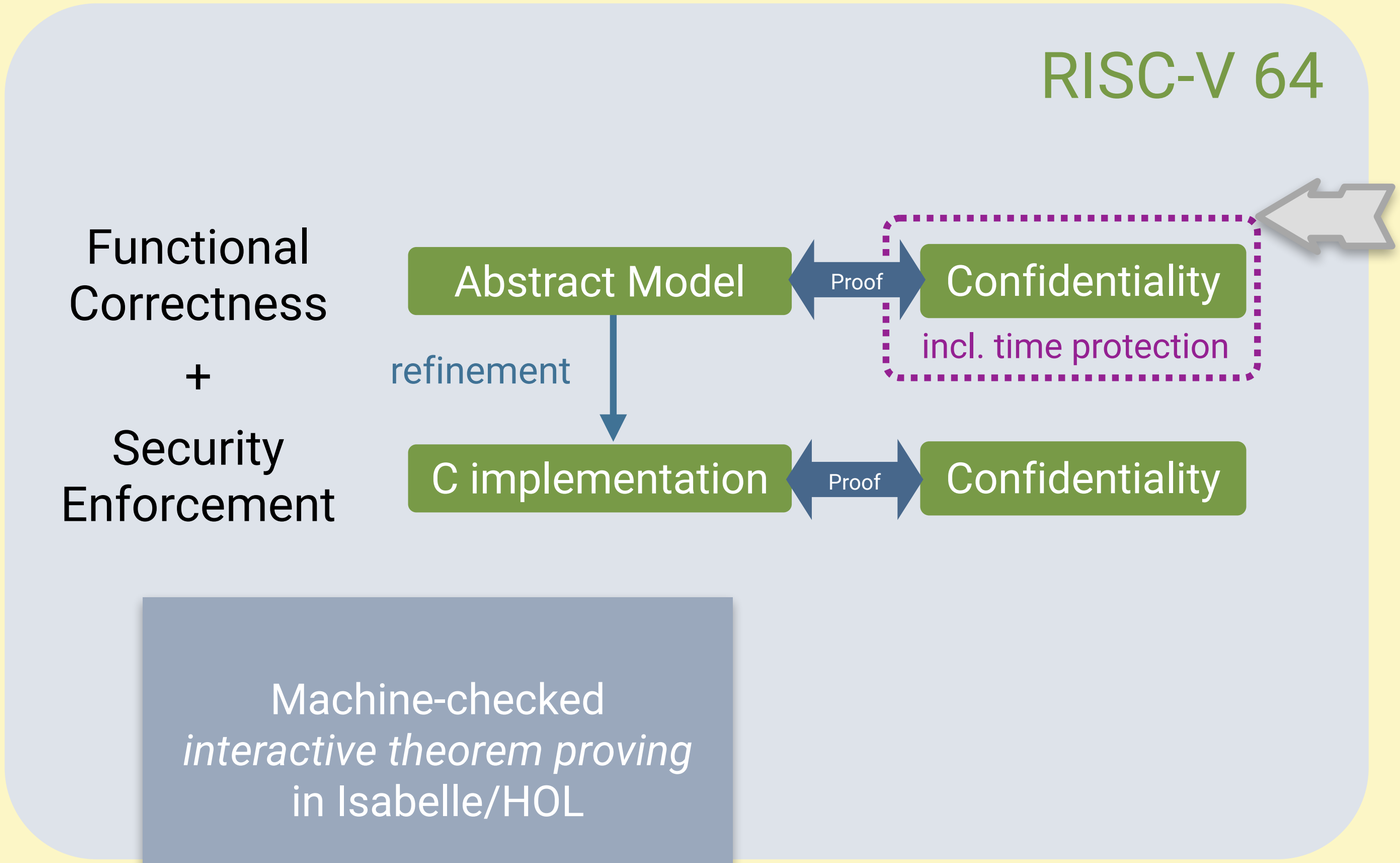

FM'23: Define time protection for OS kernels ✓

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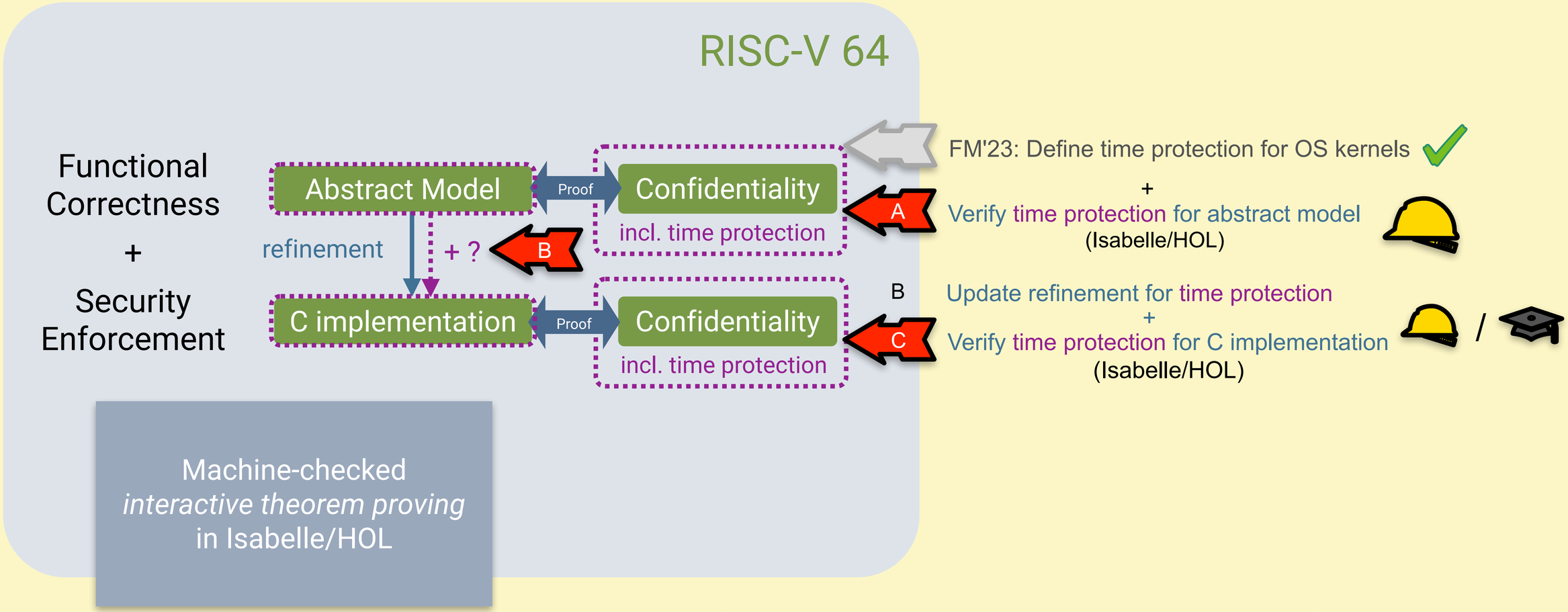

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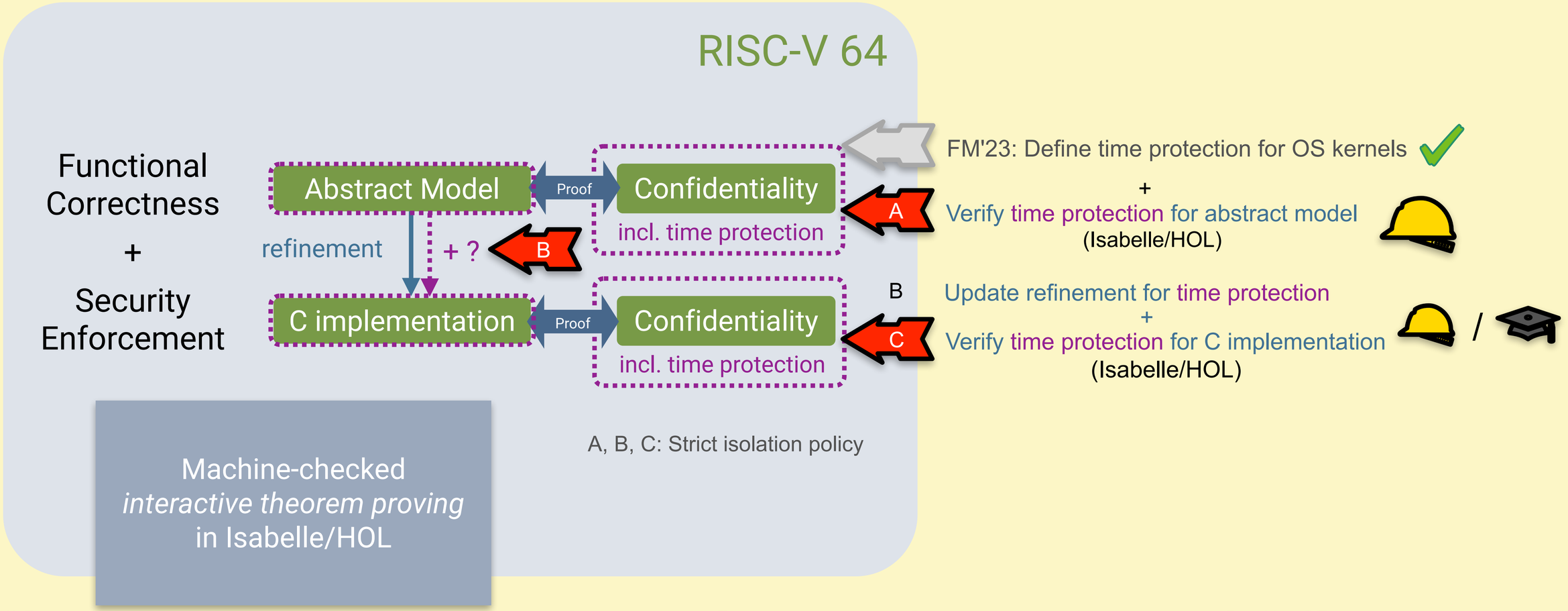

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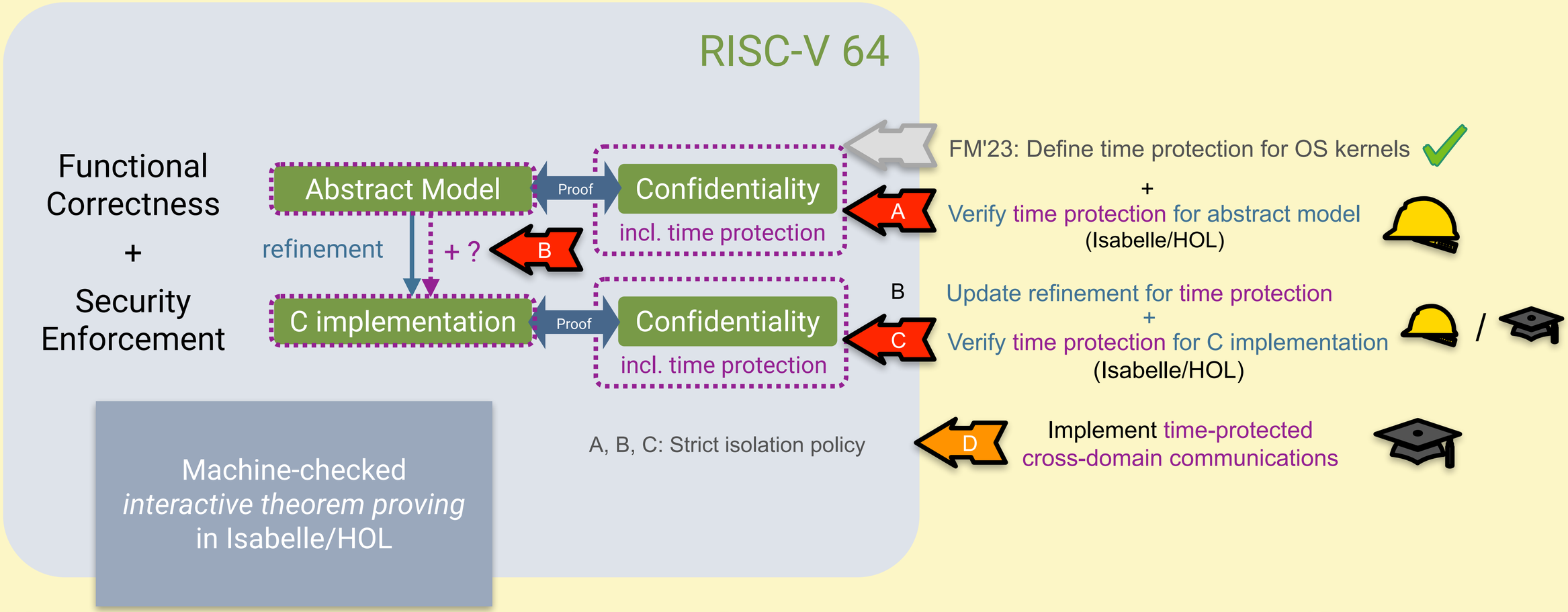

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Time protection verification for seL4

The status today:

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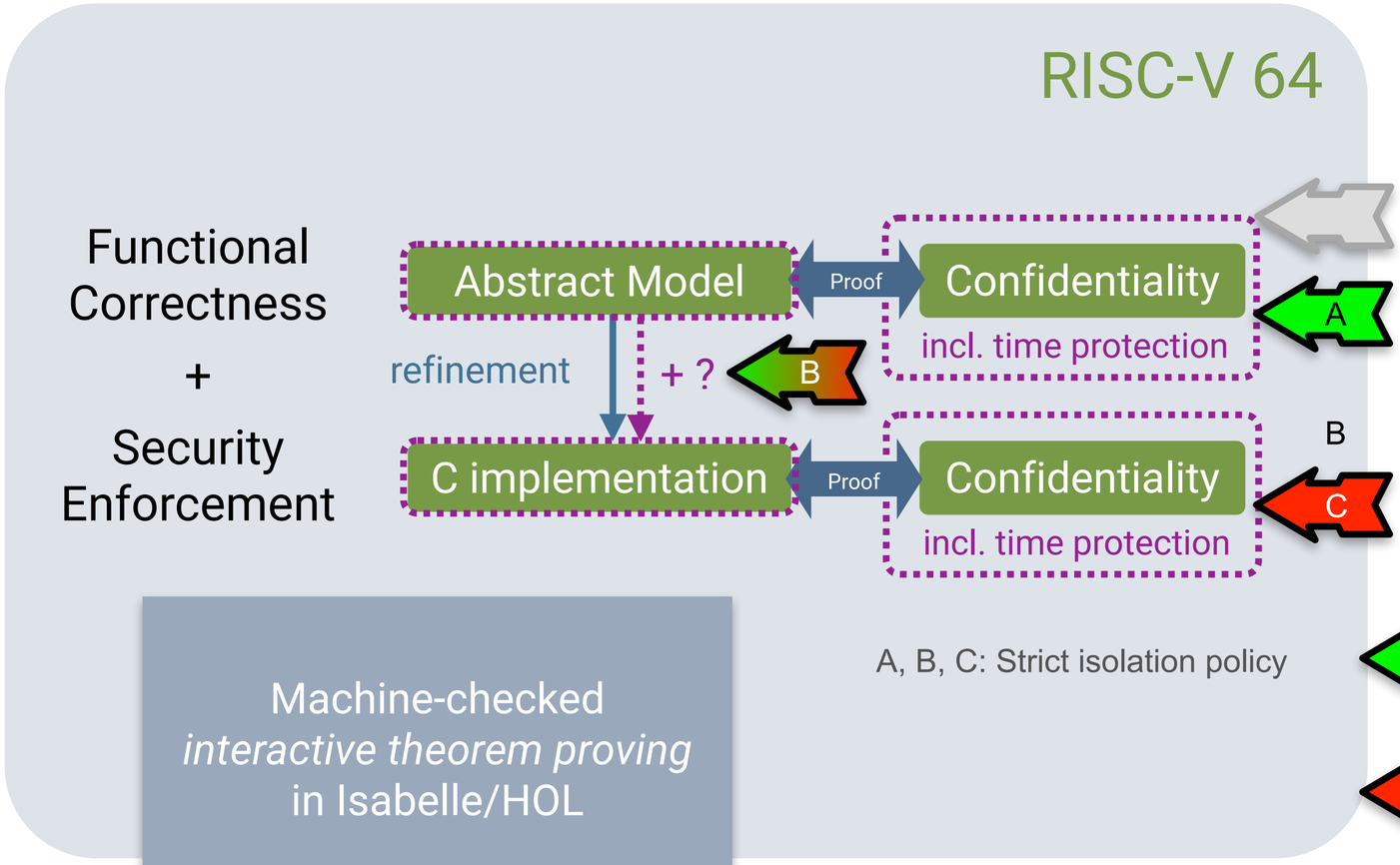

FM'23: Define time protection for OS kernels ✓

+

A — Verify time protection for abstract model (Isabelle/HOL) ✓

B — Update refinement for time protection

+

C — Verify time protection for C implementation (Isabelle/HOL)

D — Implement time-protected cross-domain communications ✓

E — Verify time-protected cross-domain communications

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Time protection verification for seL4

Since the plan 2 years ago…

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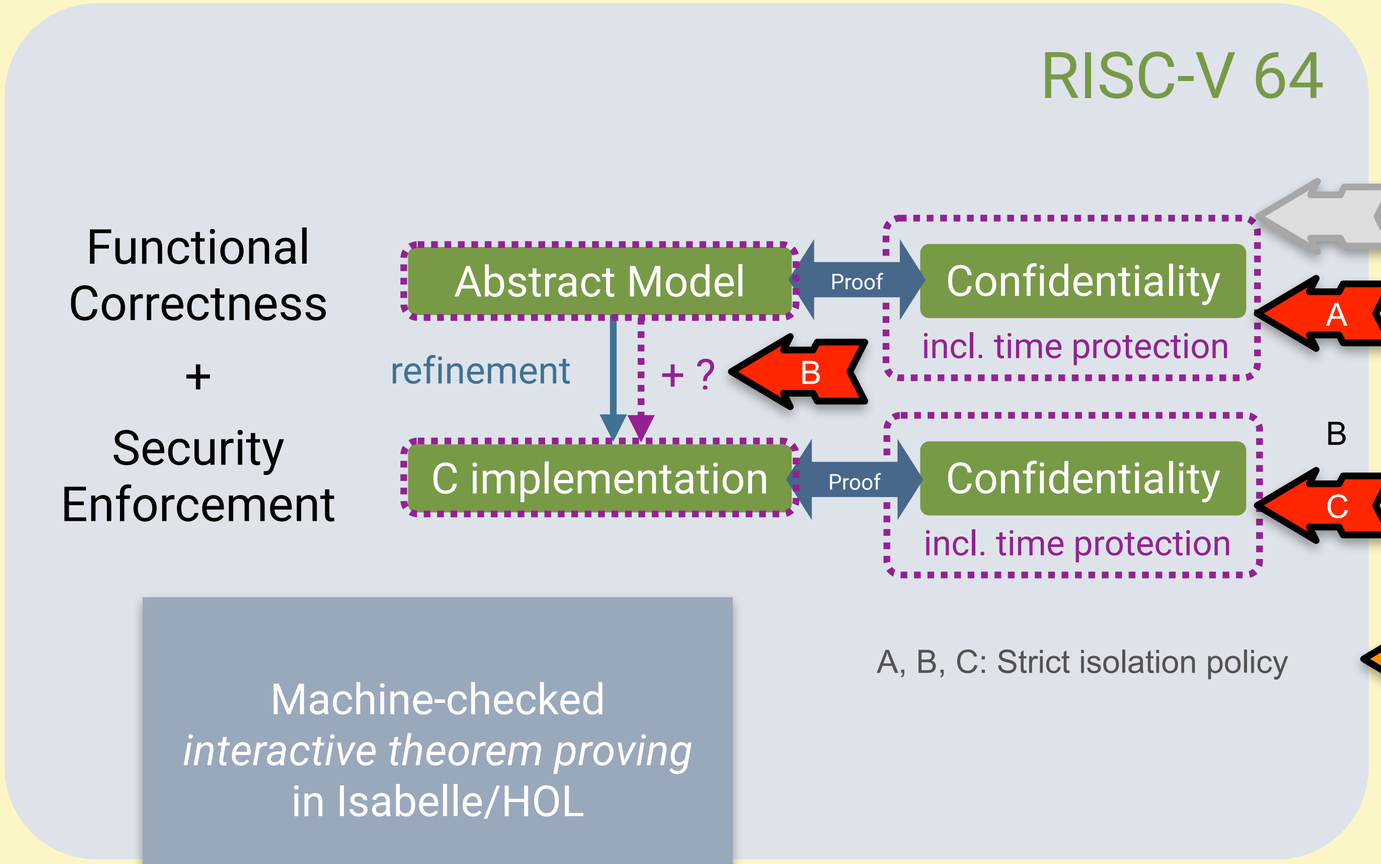

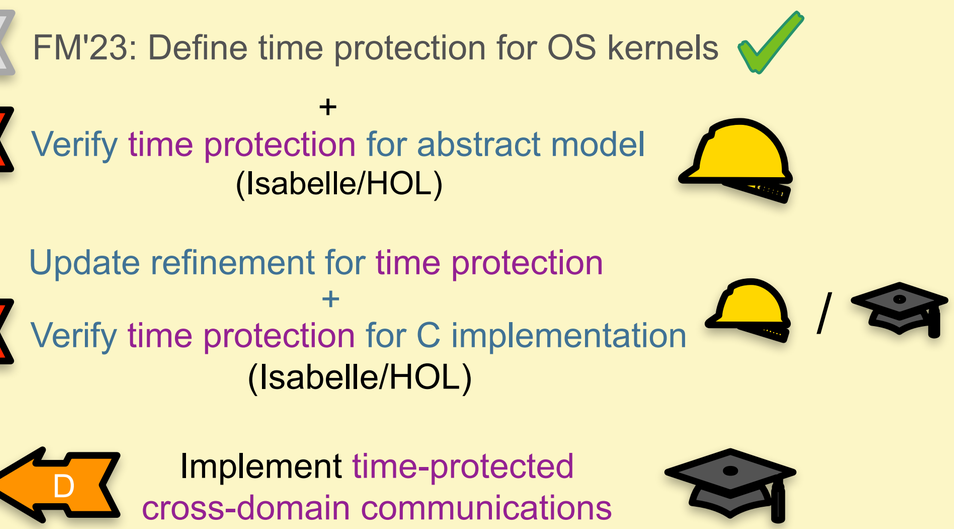

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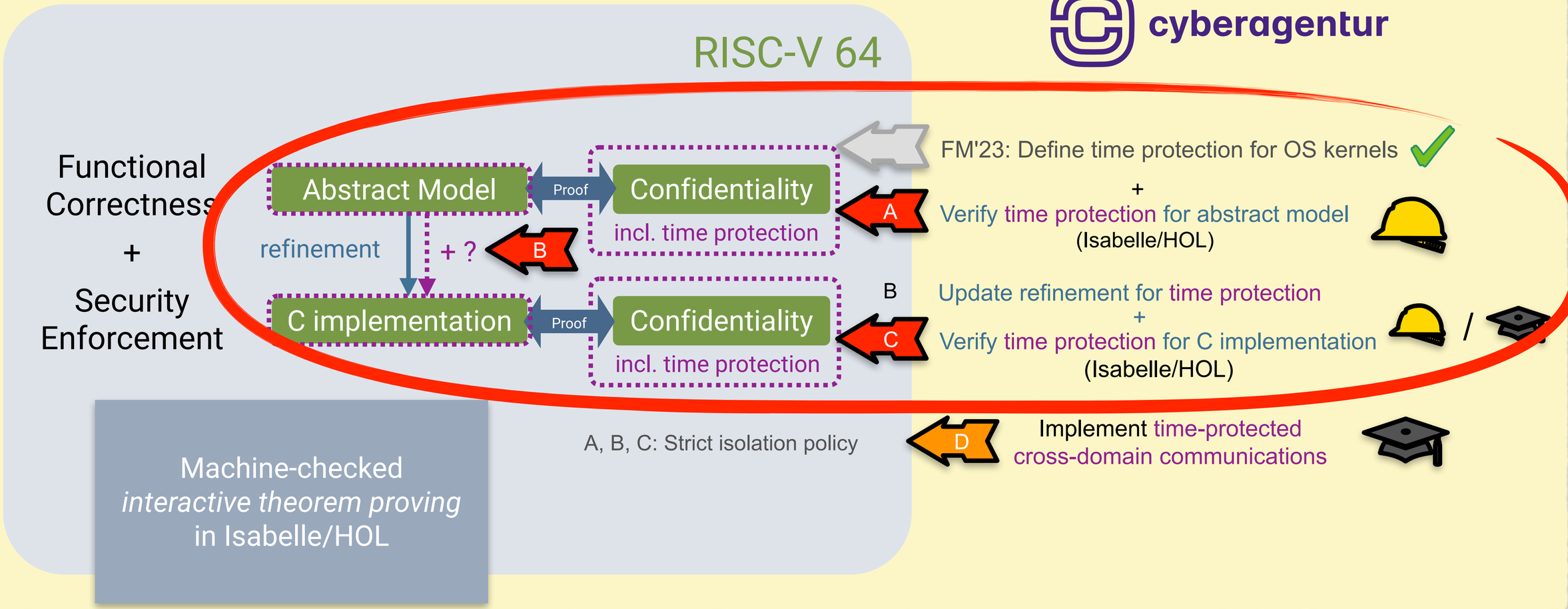

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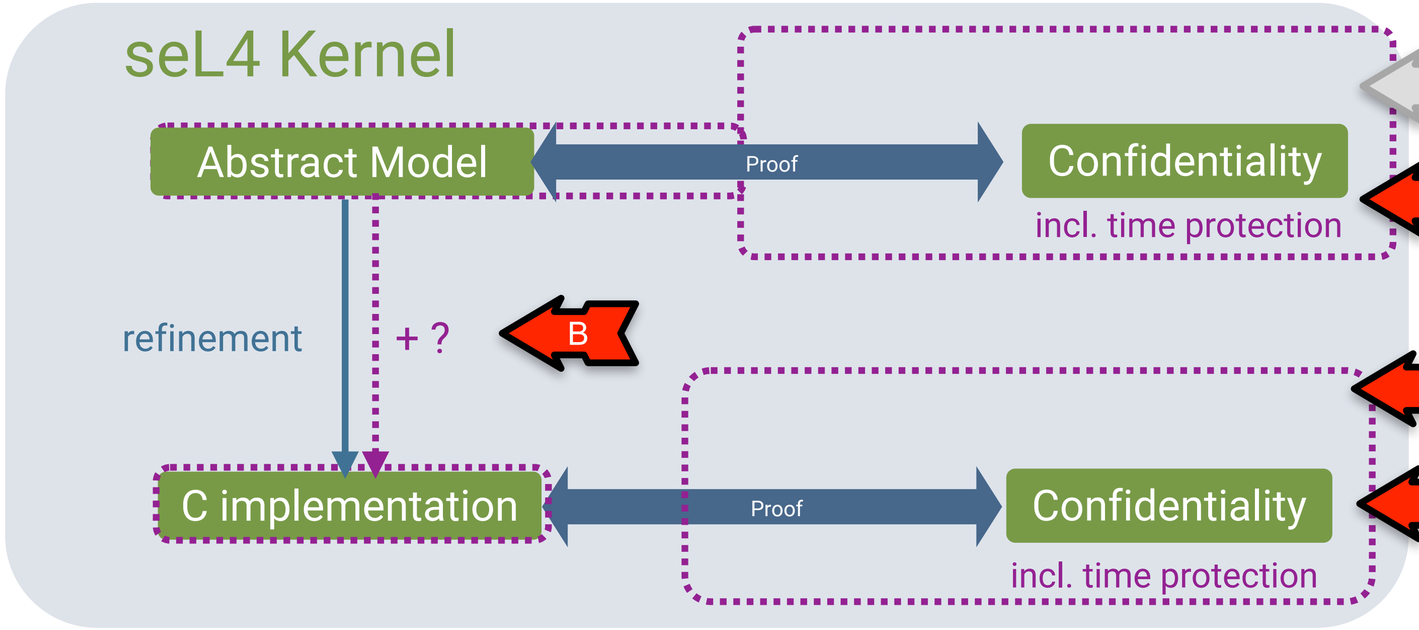
Originally planned approach… (FM-OZ'24)



FM'23: Define time protection for OS kernels ✓

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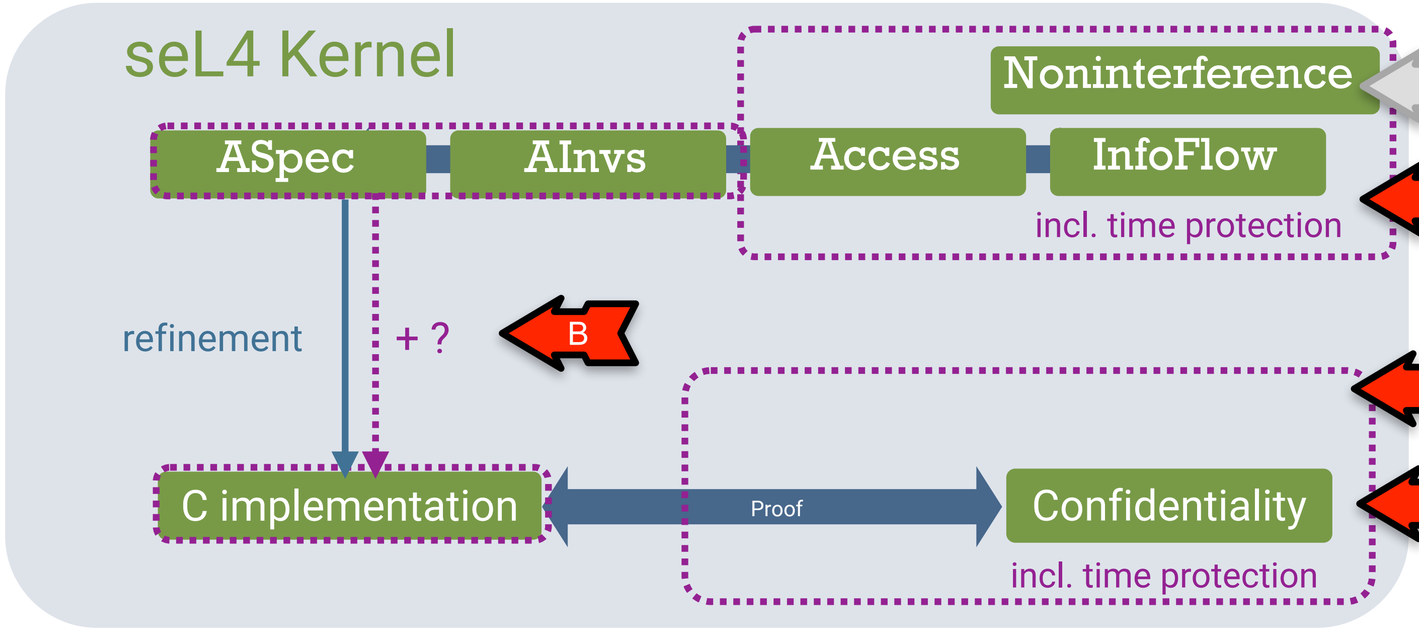

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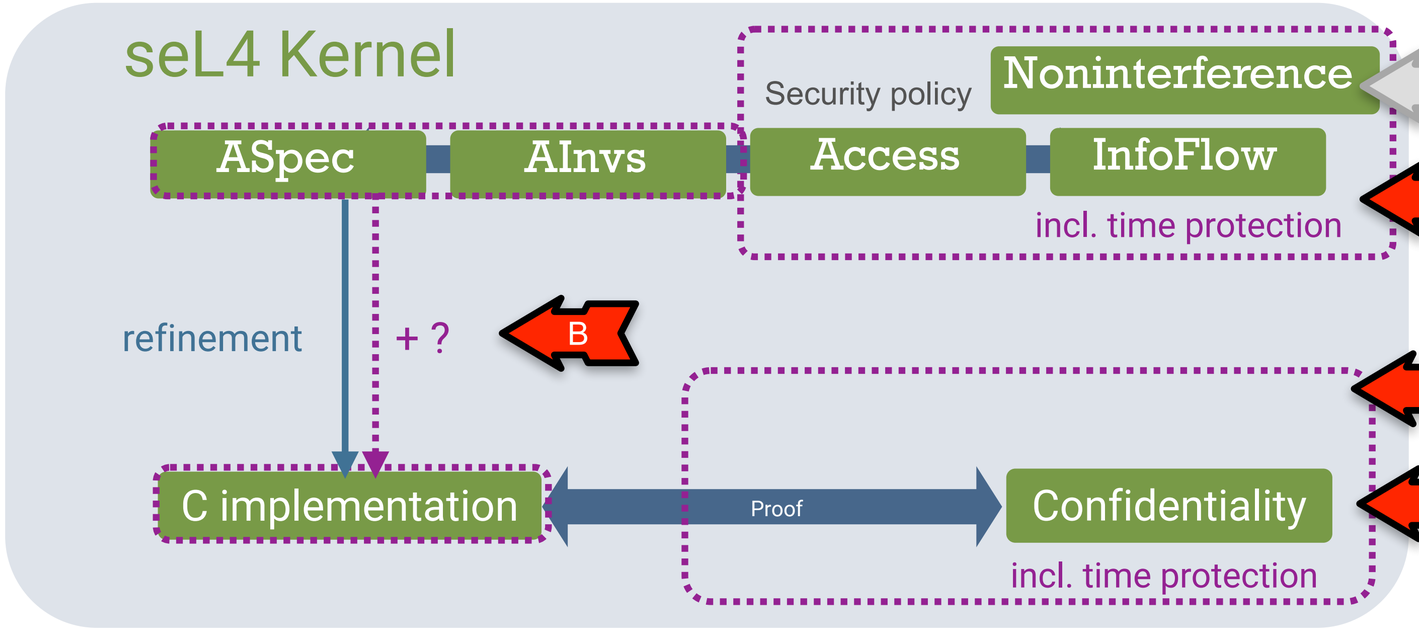

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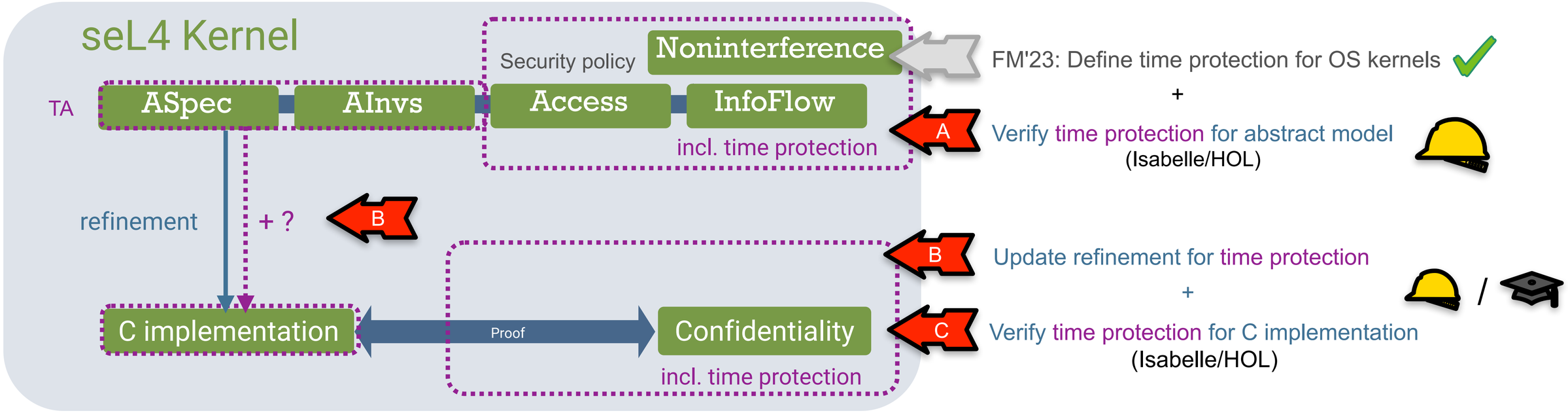

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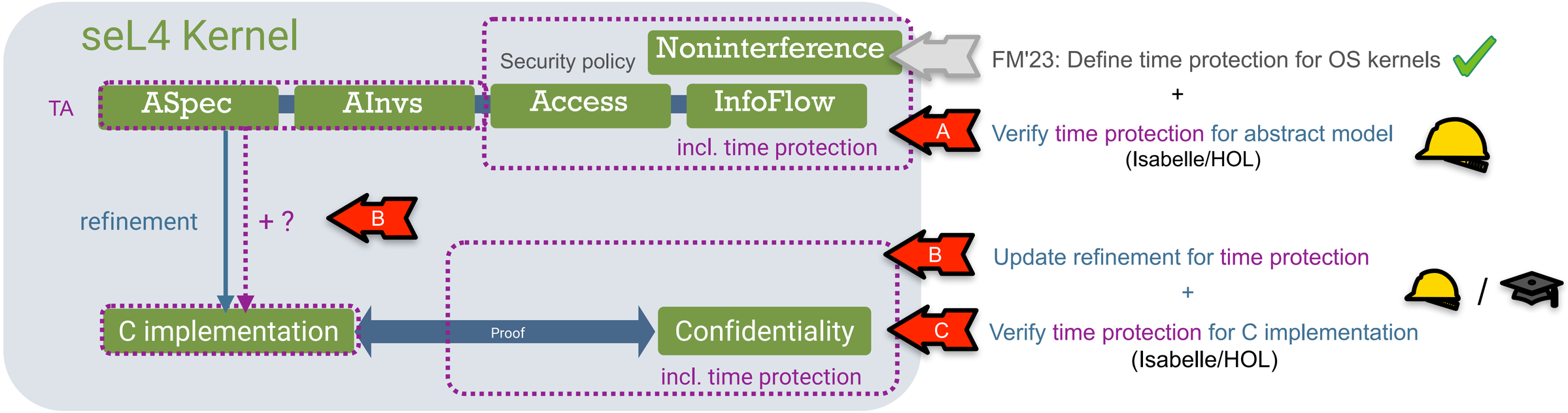

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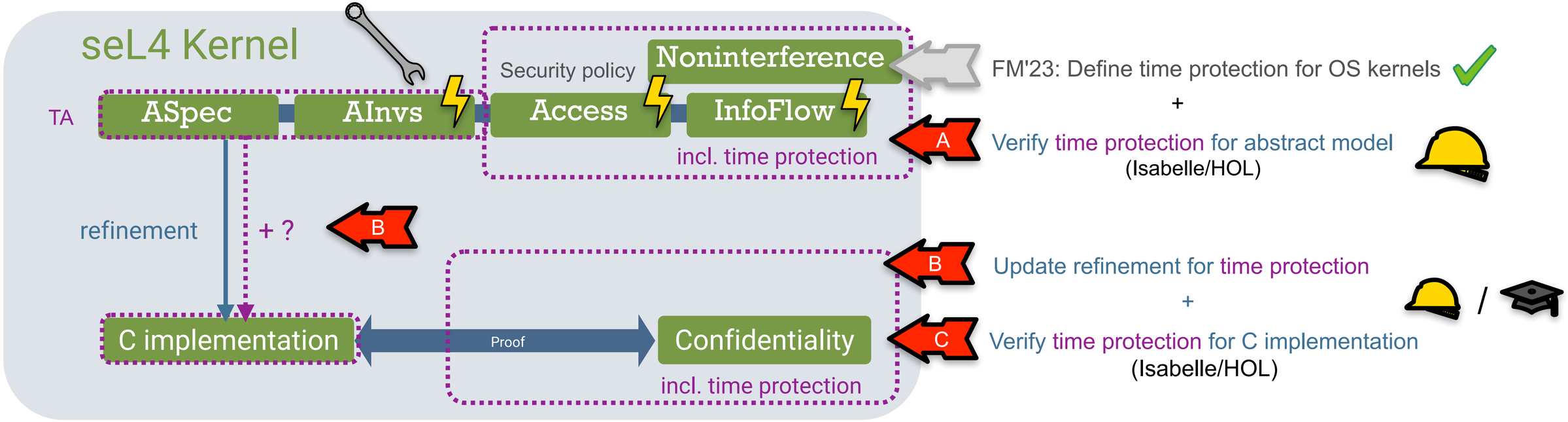

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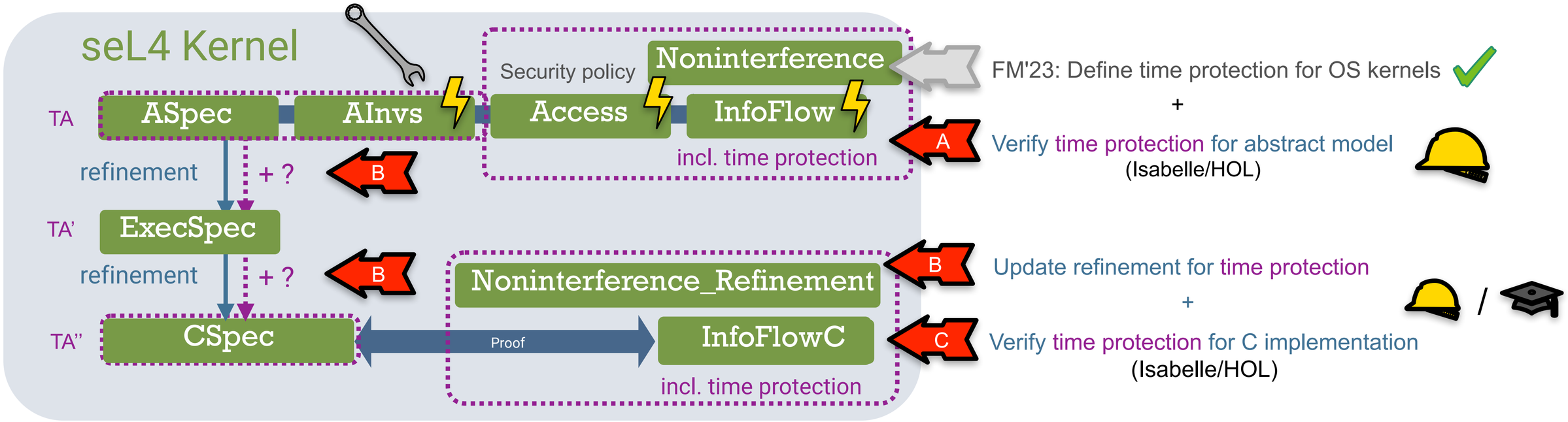

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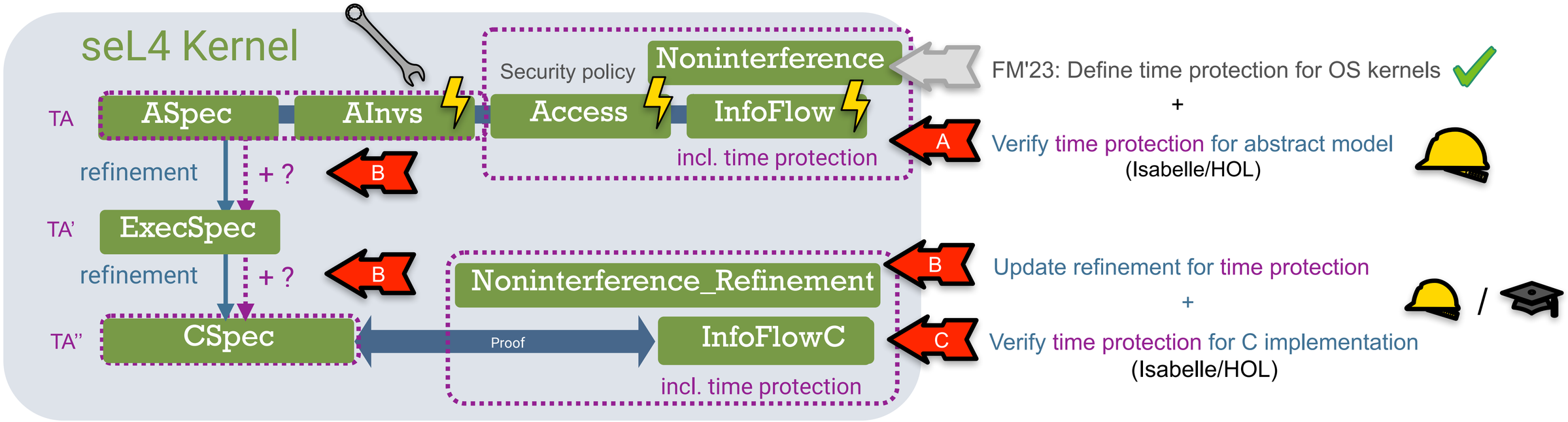

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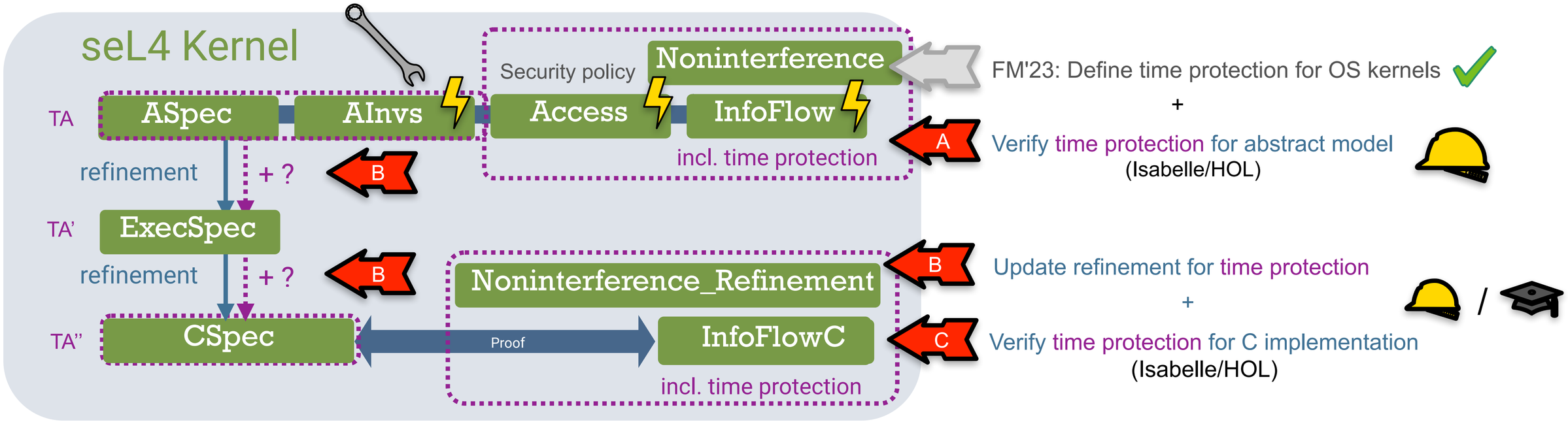

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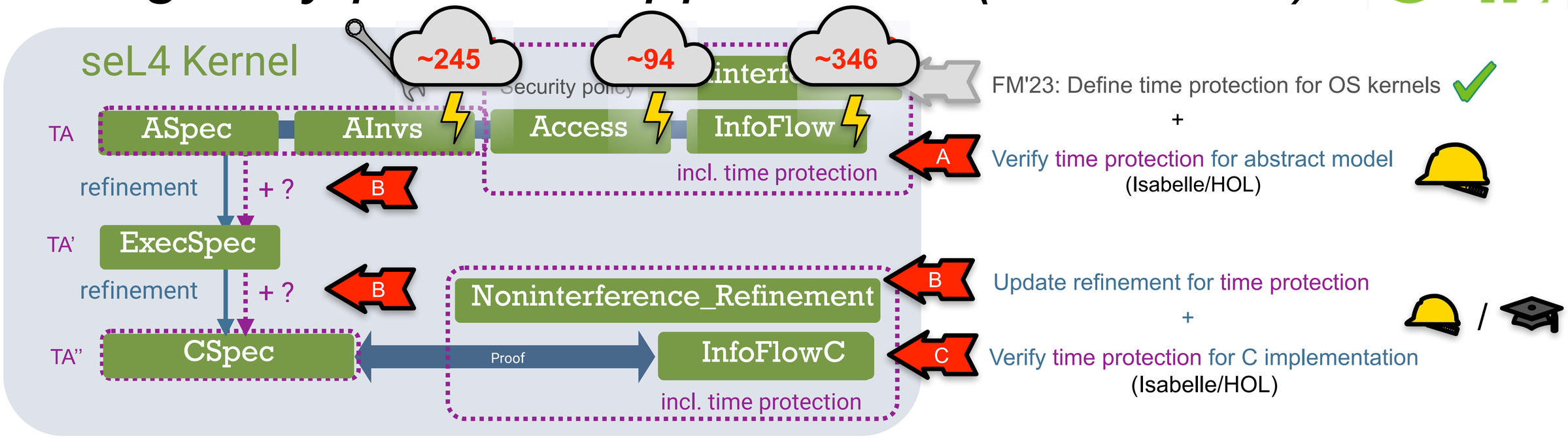

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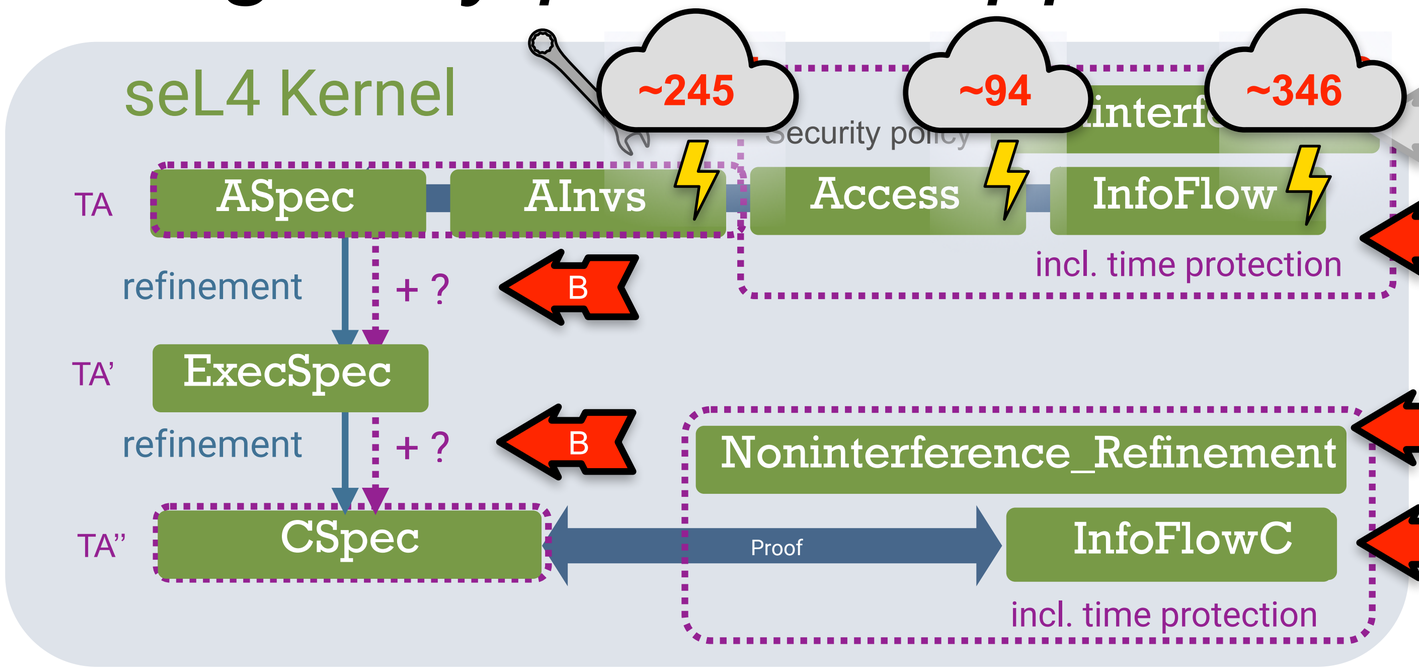

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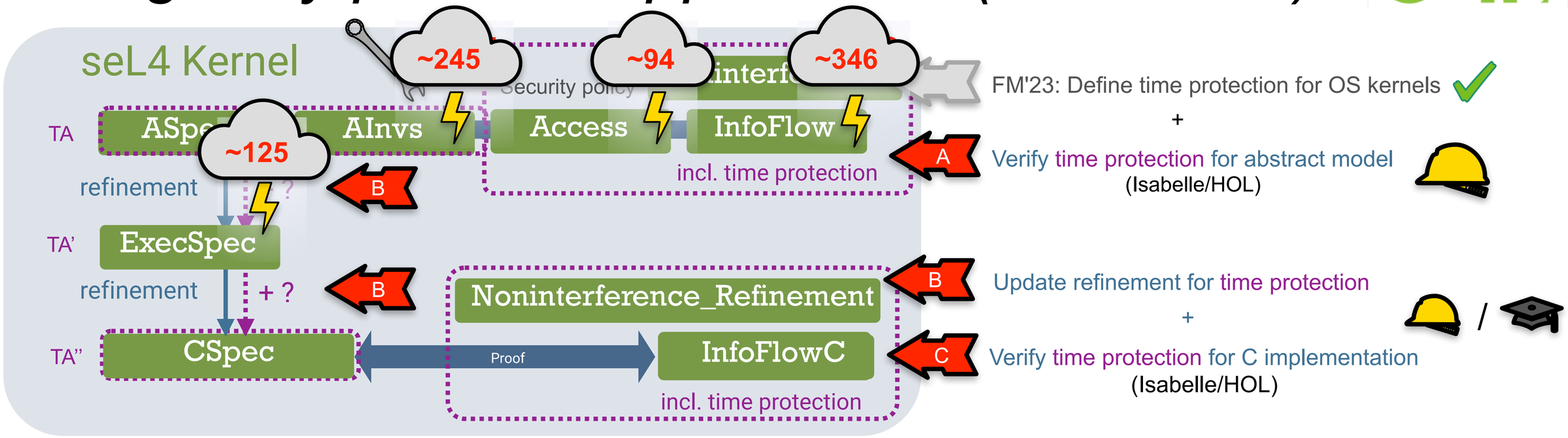

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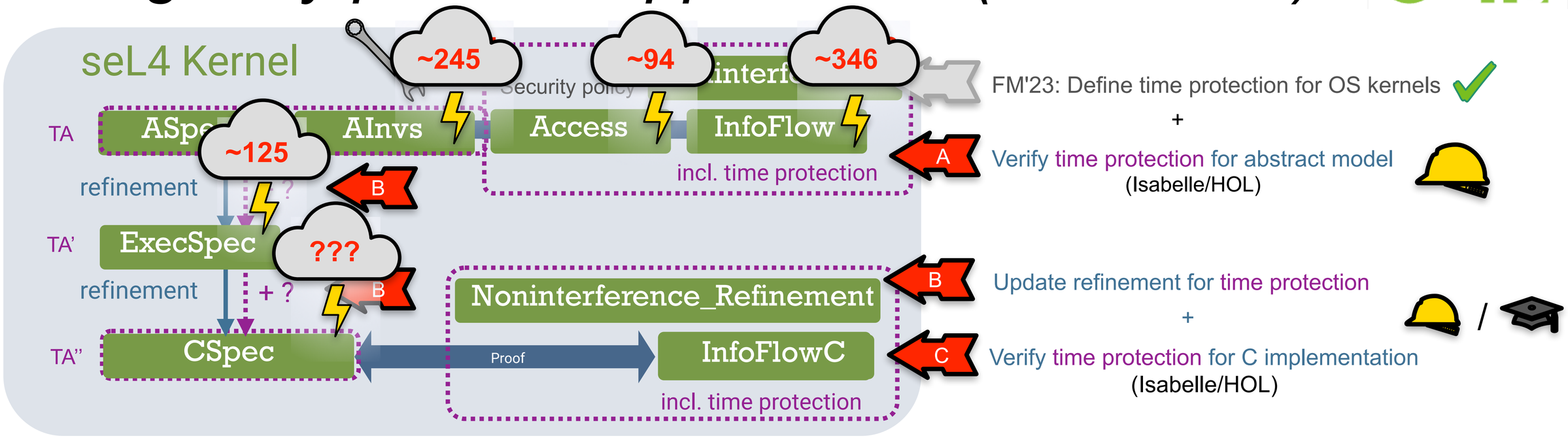

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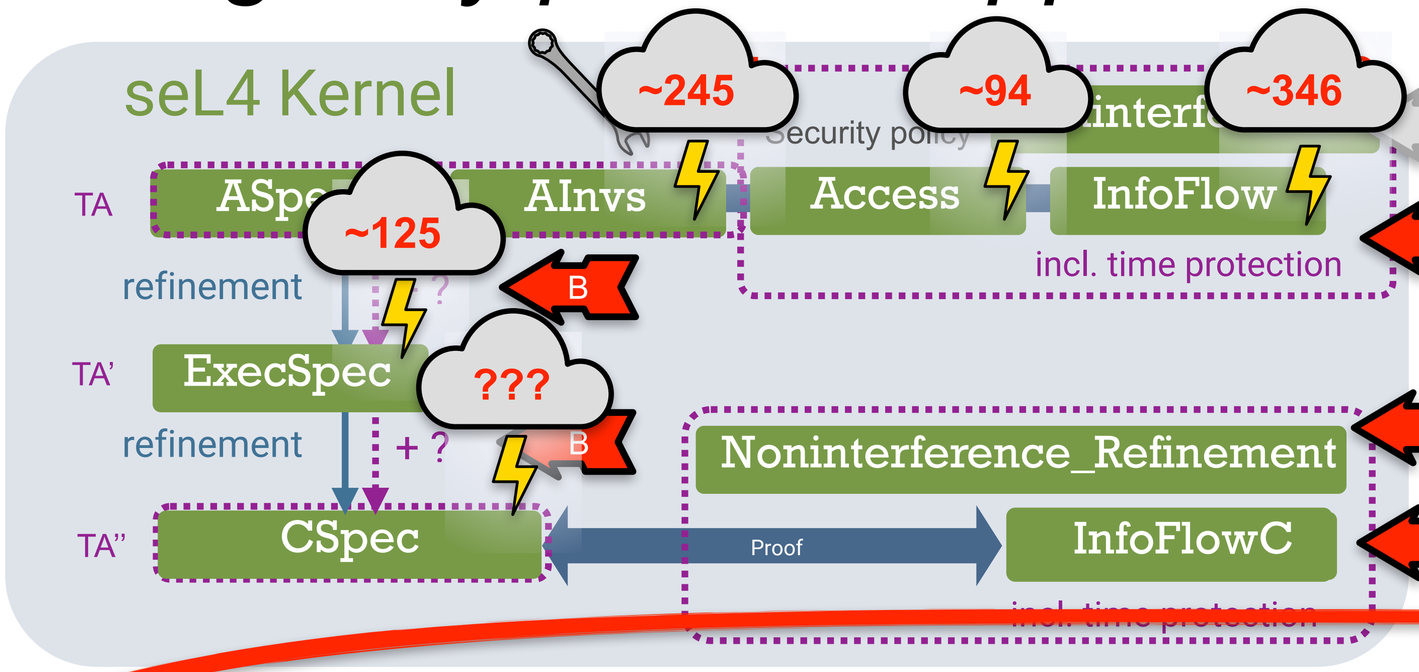

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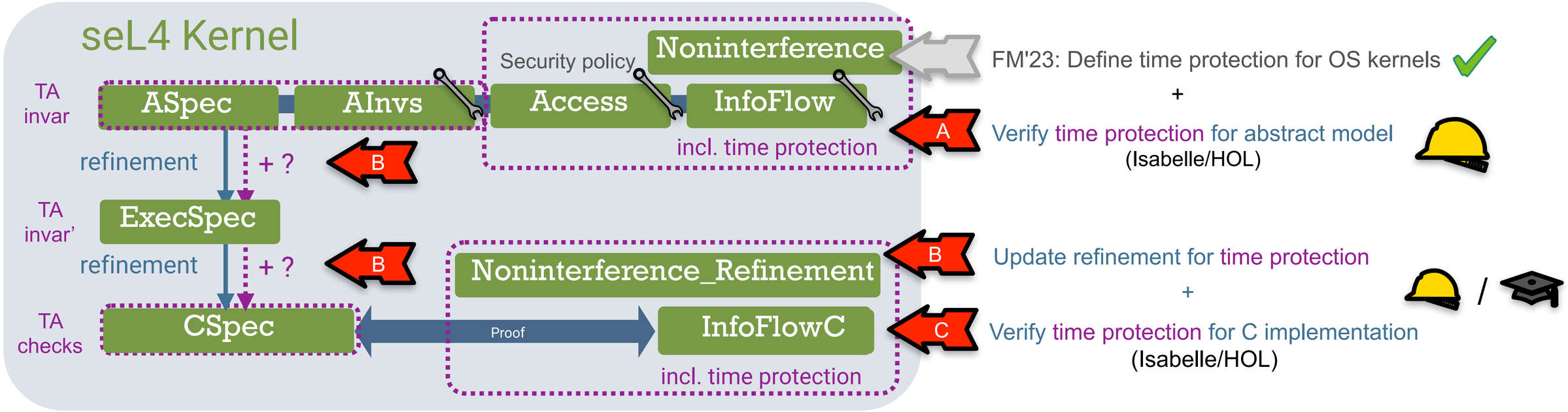

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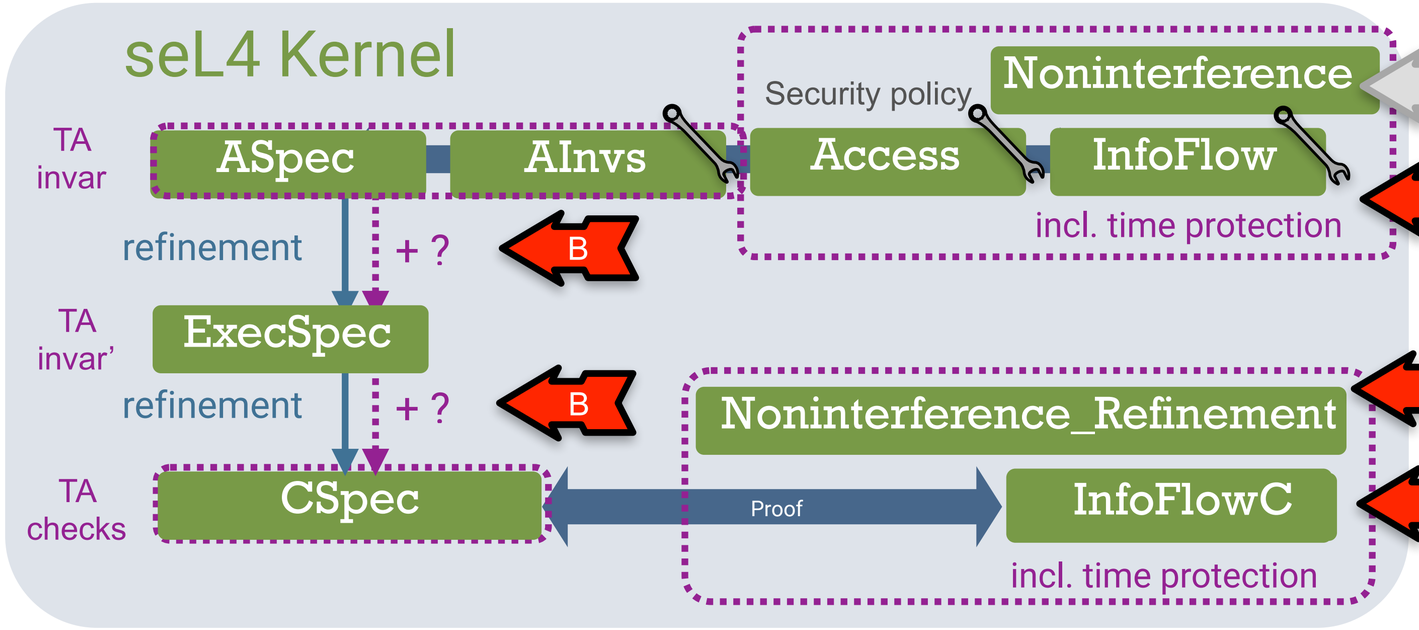

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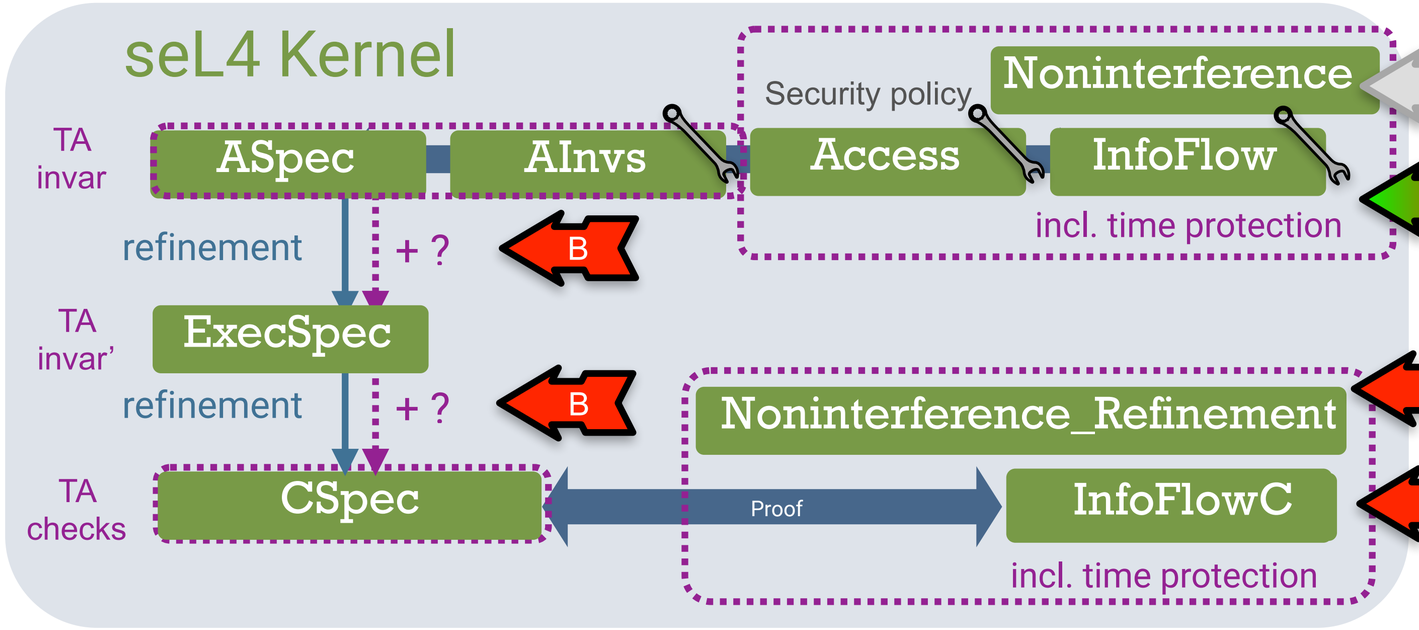

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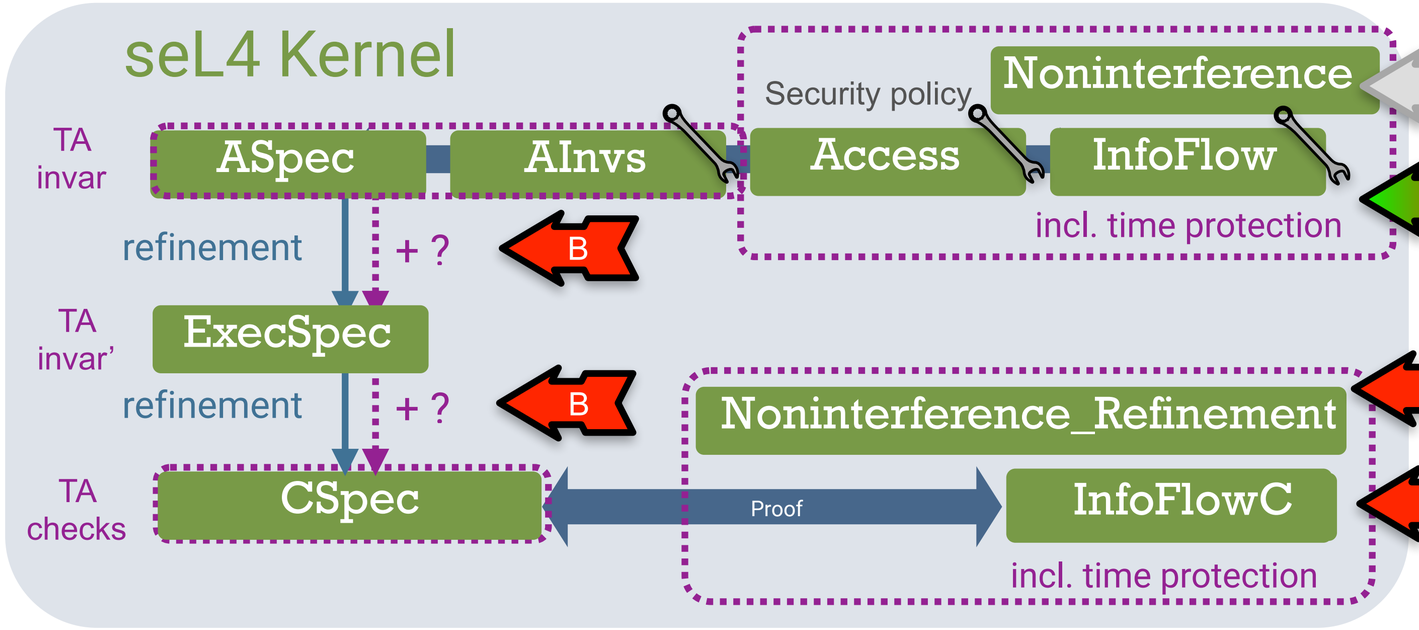

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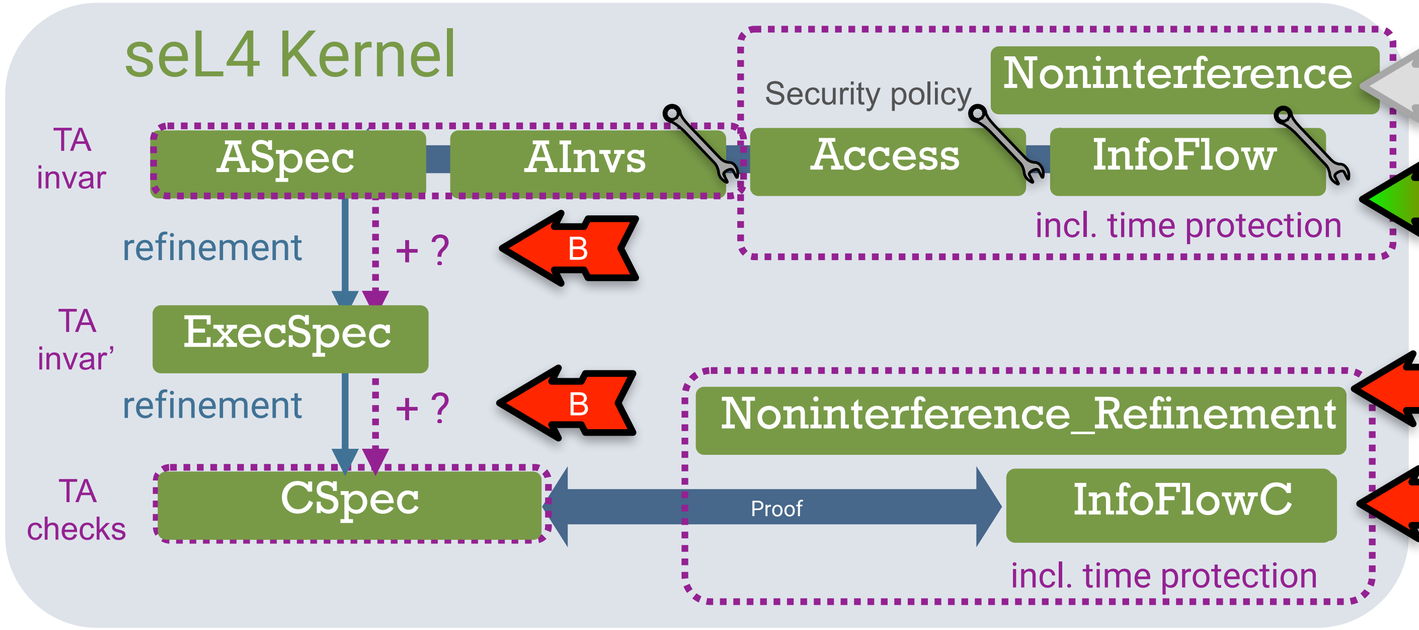

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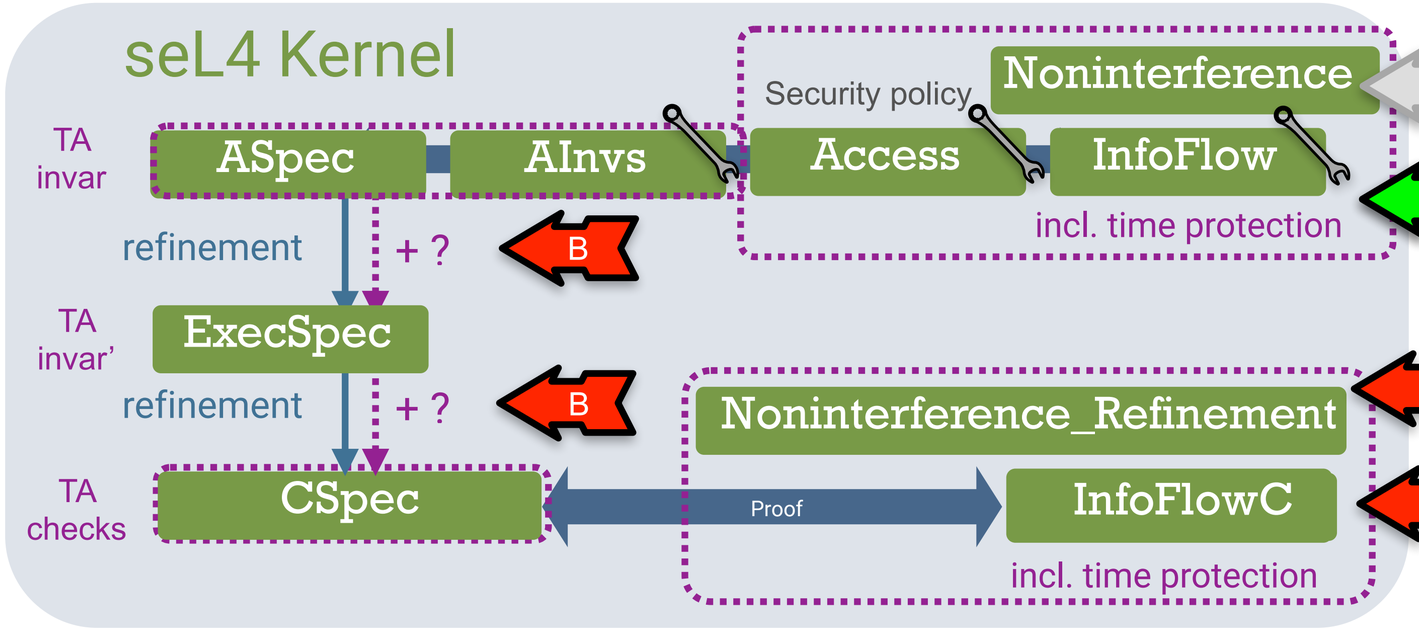

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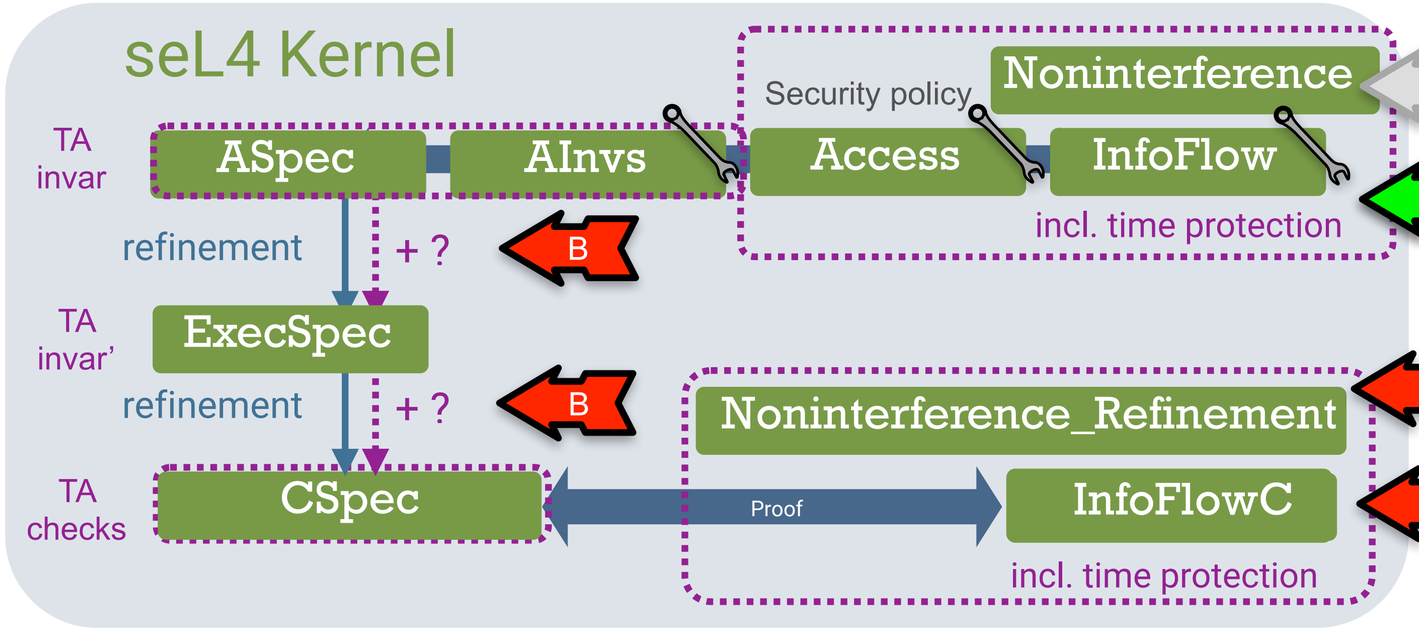

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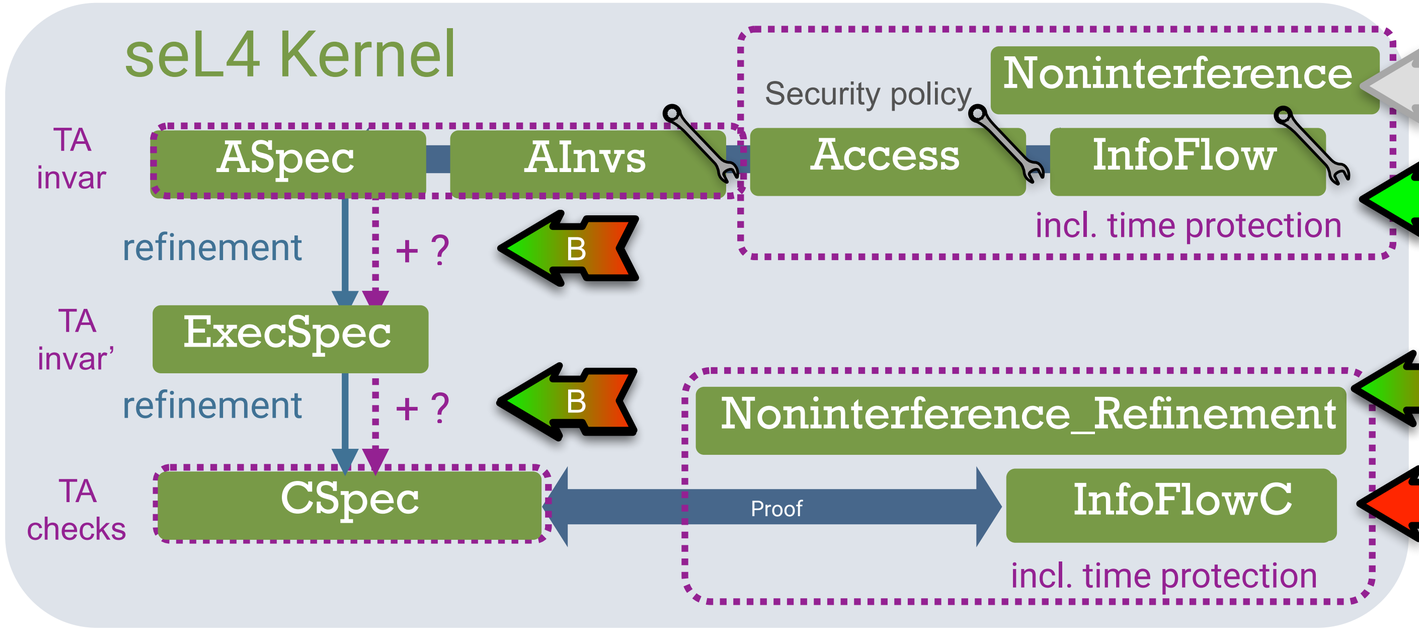

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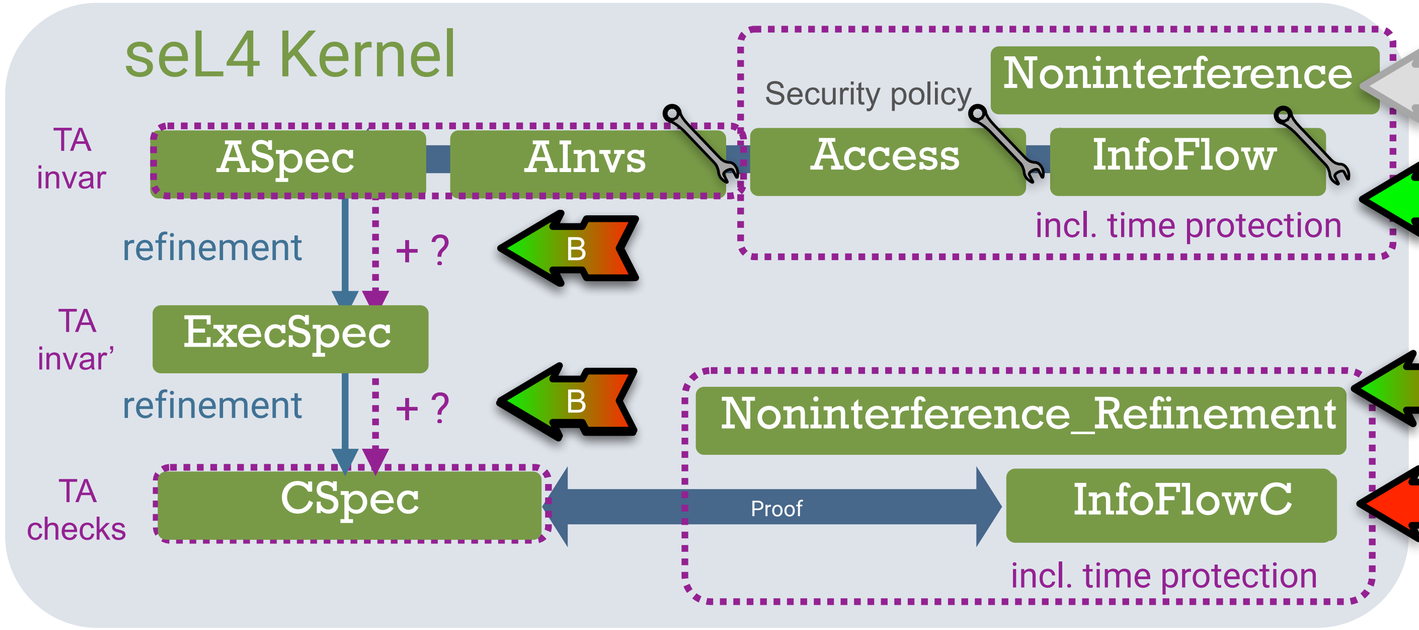
What's next?



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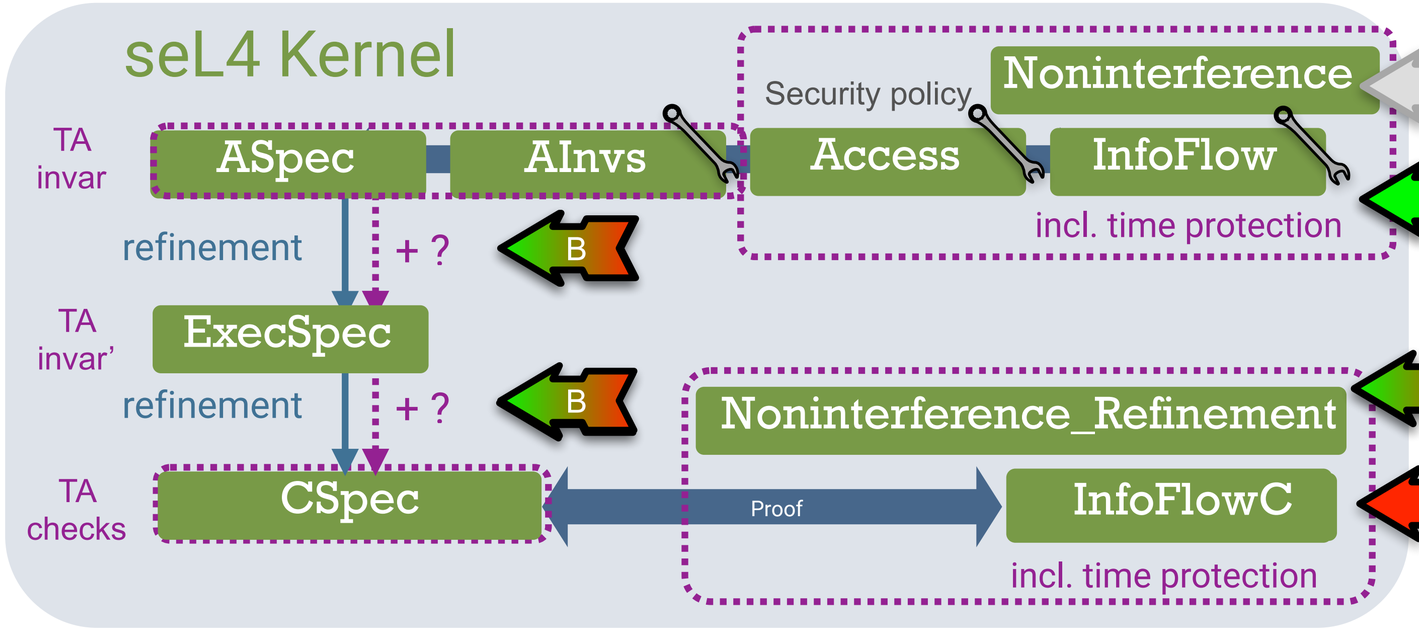
What's next? Refinement



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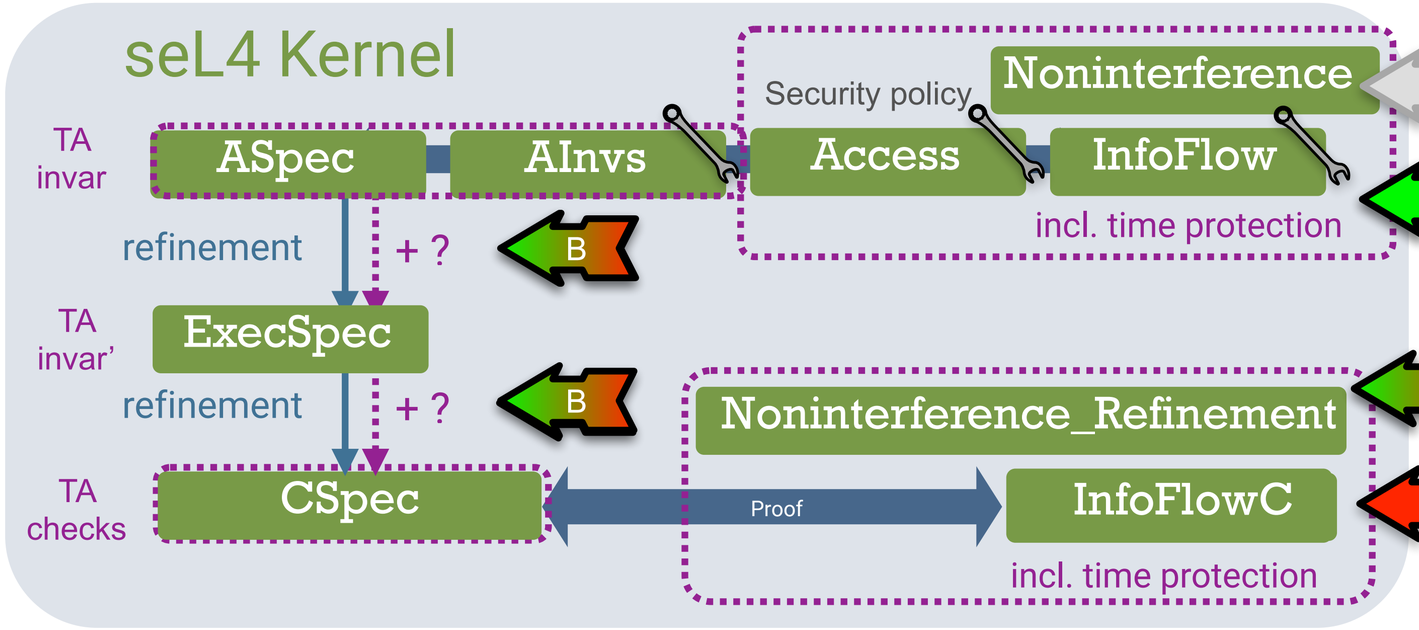

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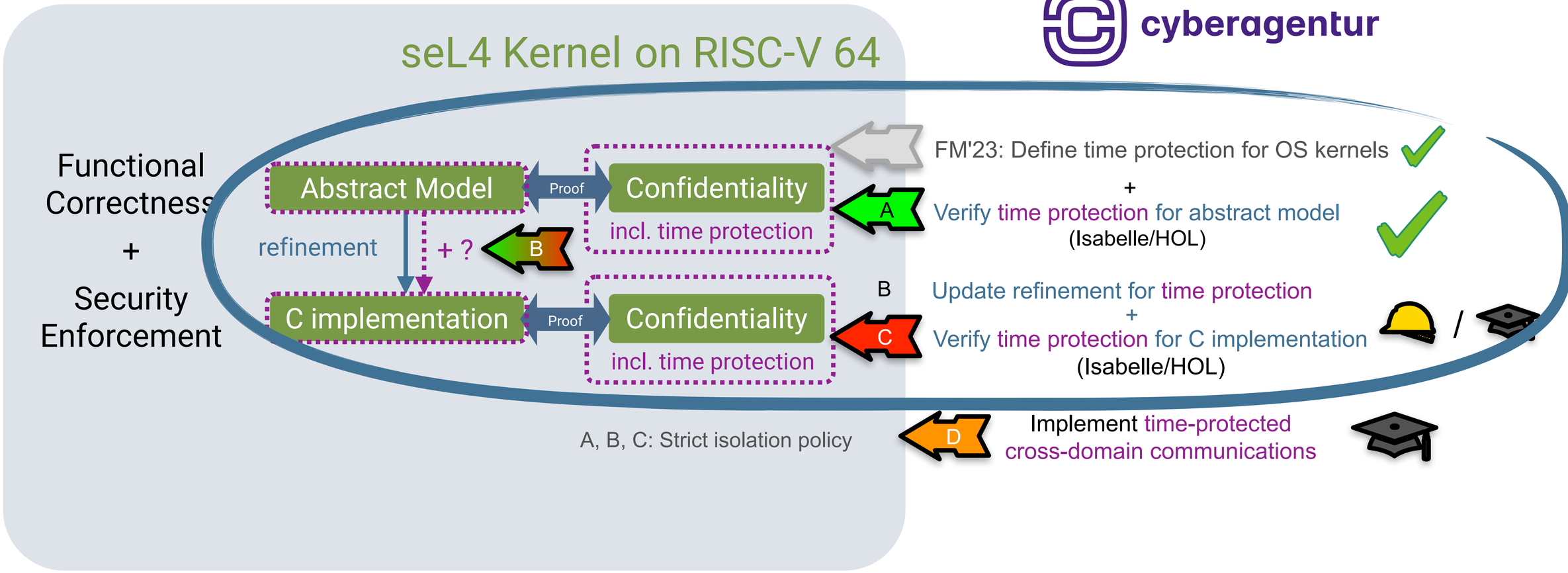
Time protection verification for seL4

Since the plan 2 years ago…

Thanks to funding from cyberagentur



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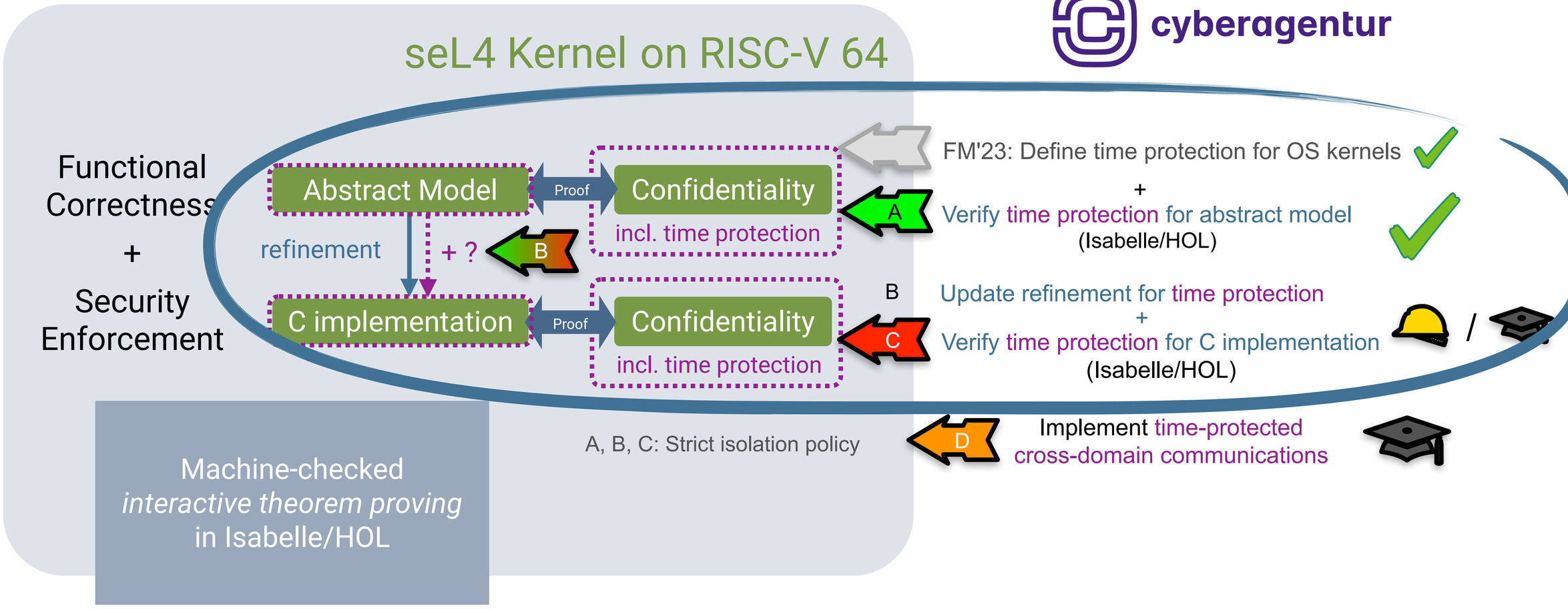

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Time protection verification for seL4

The status today:

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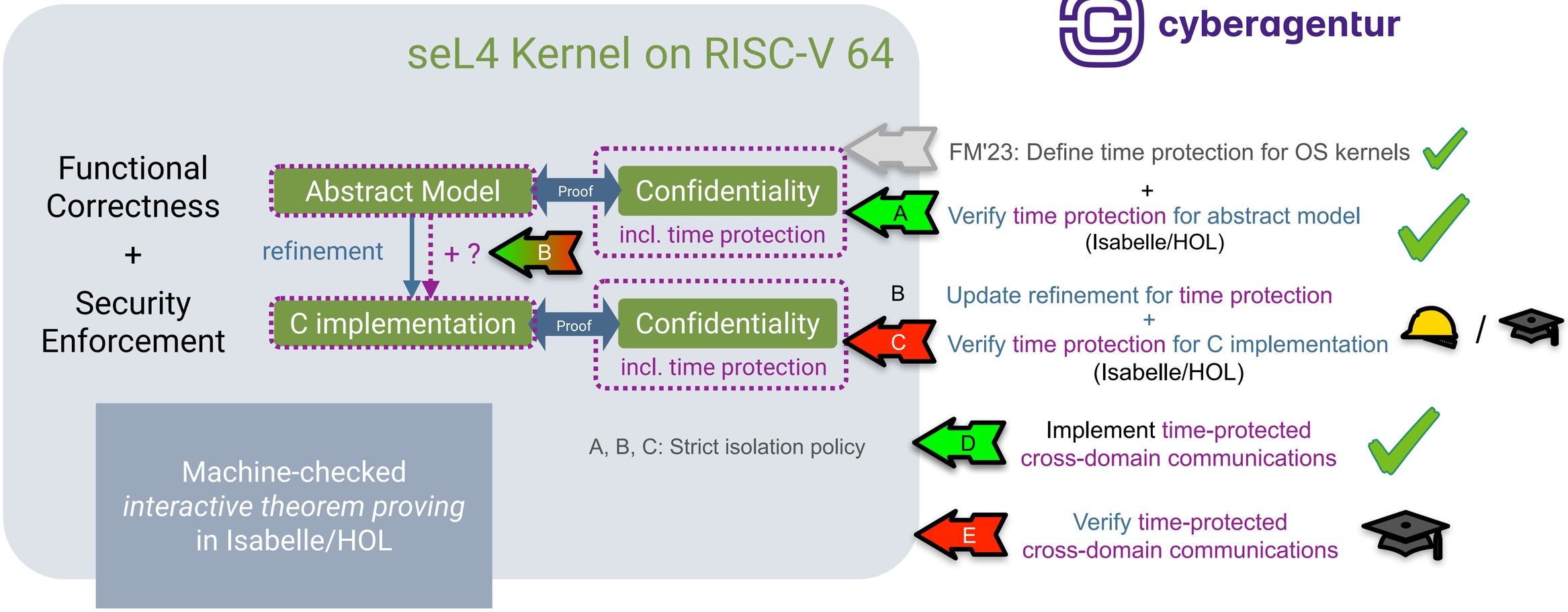

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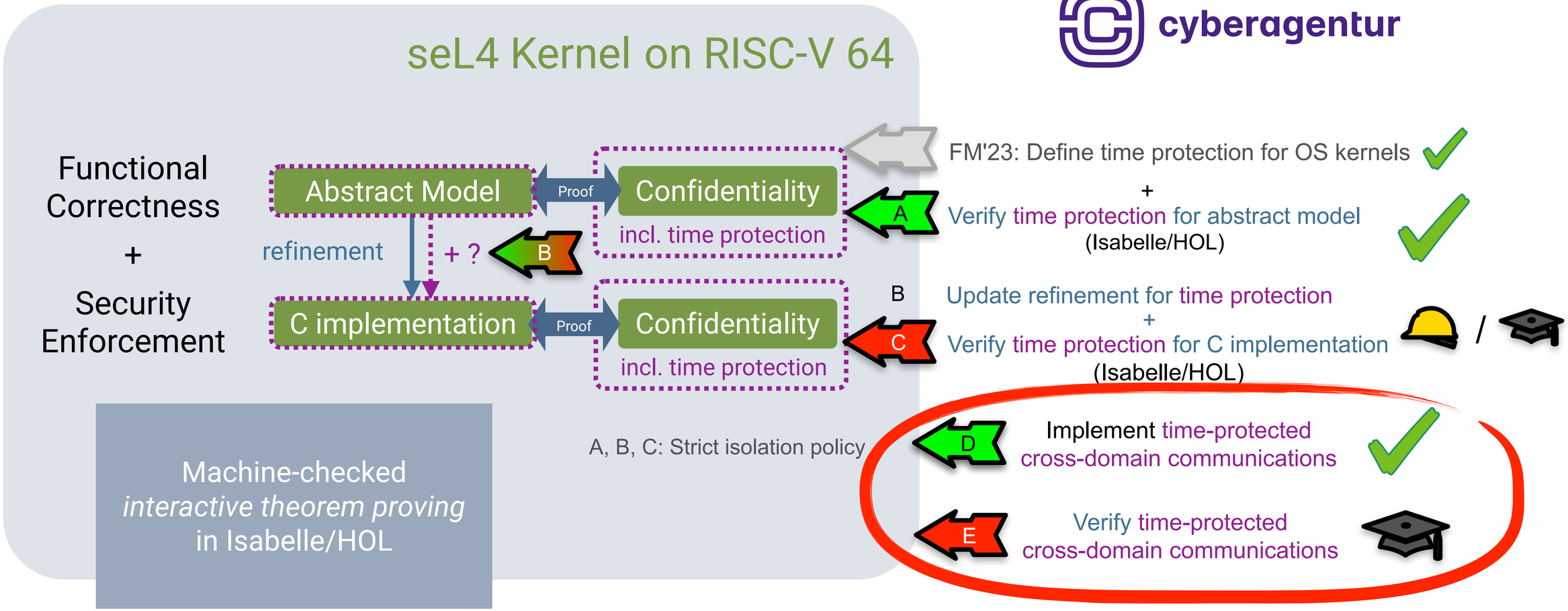

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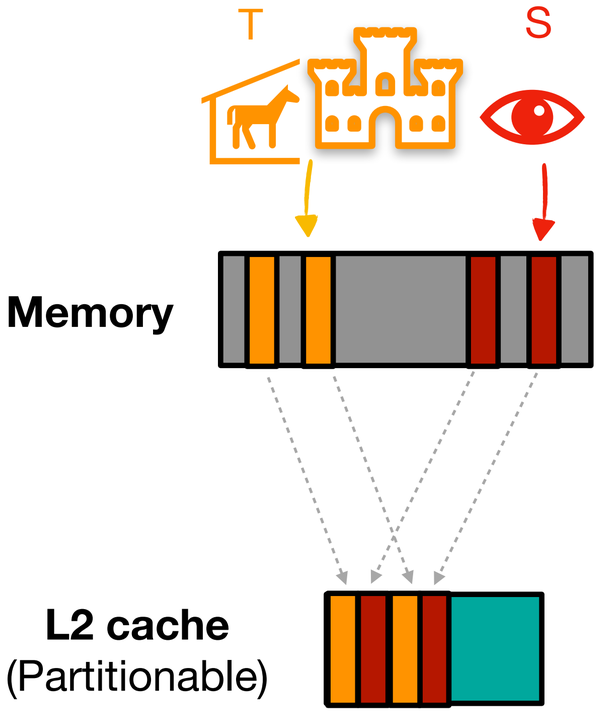
What are time-protected communications?



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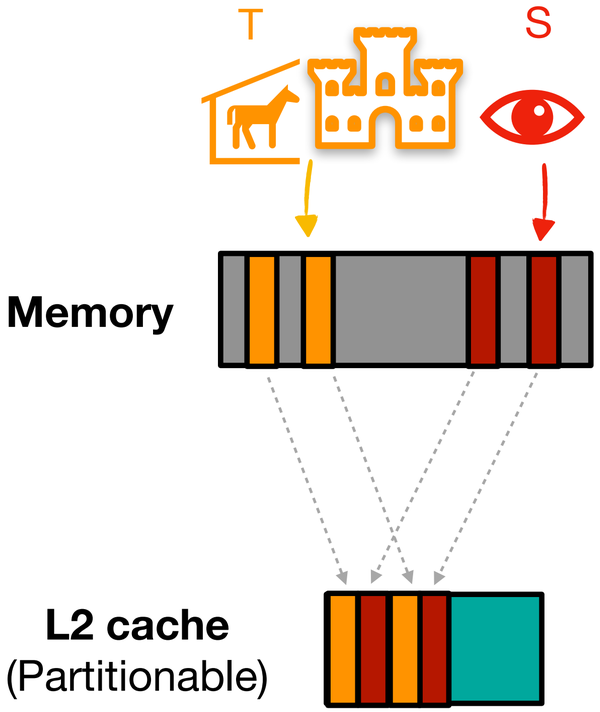

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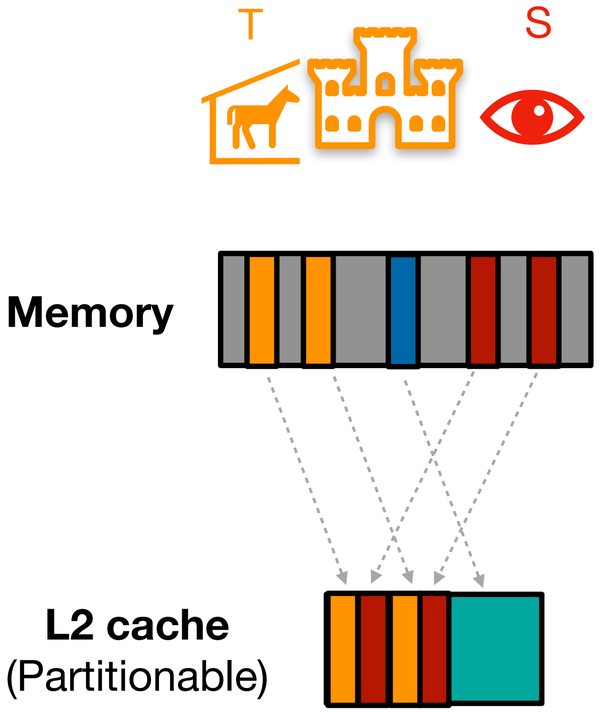

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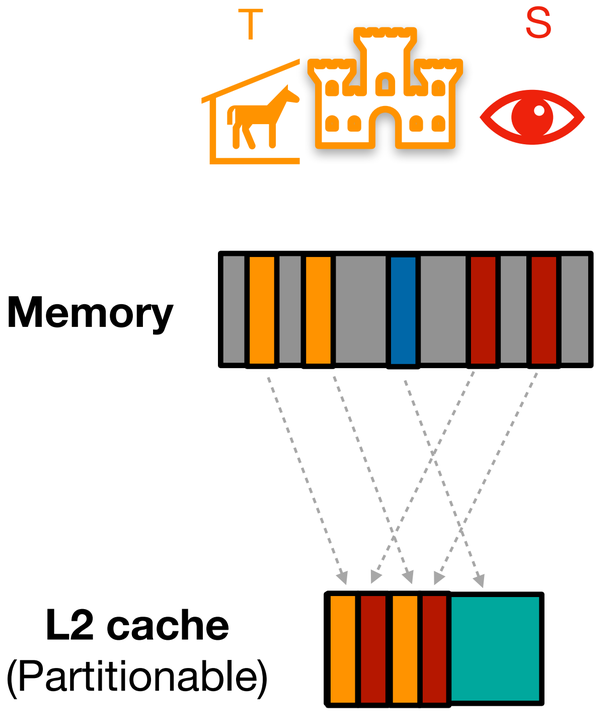

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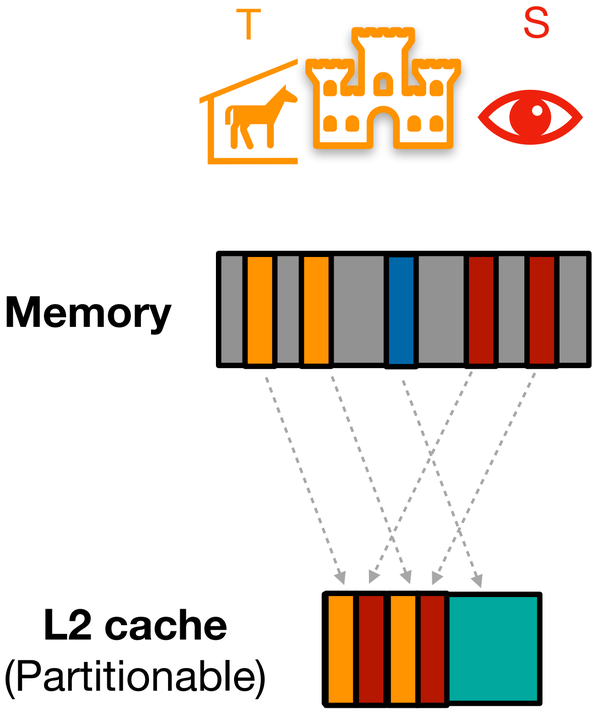

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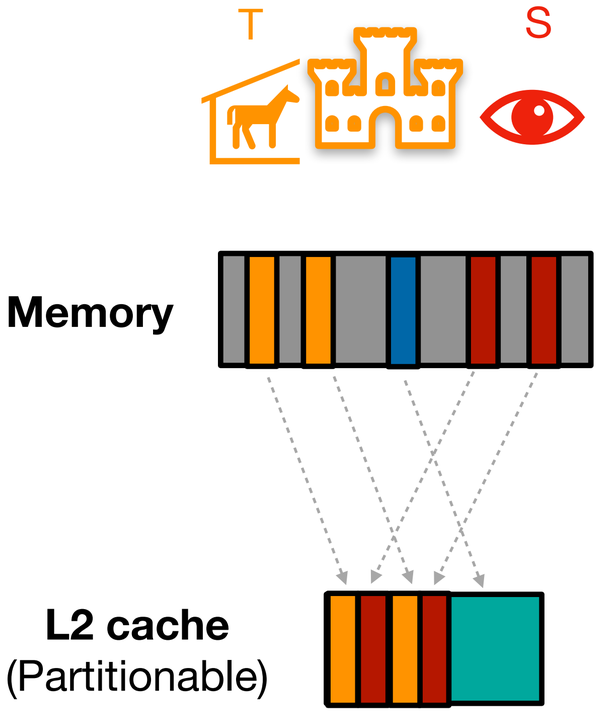

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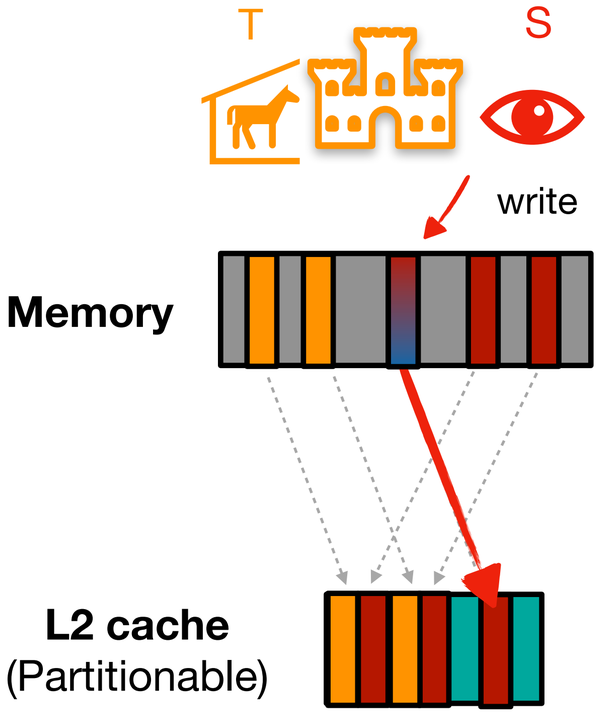

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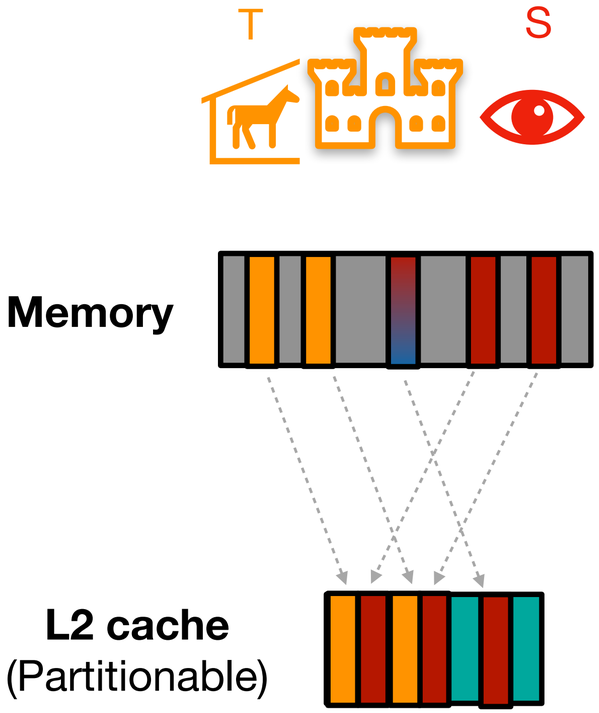

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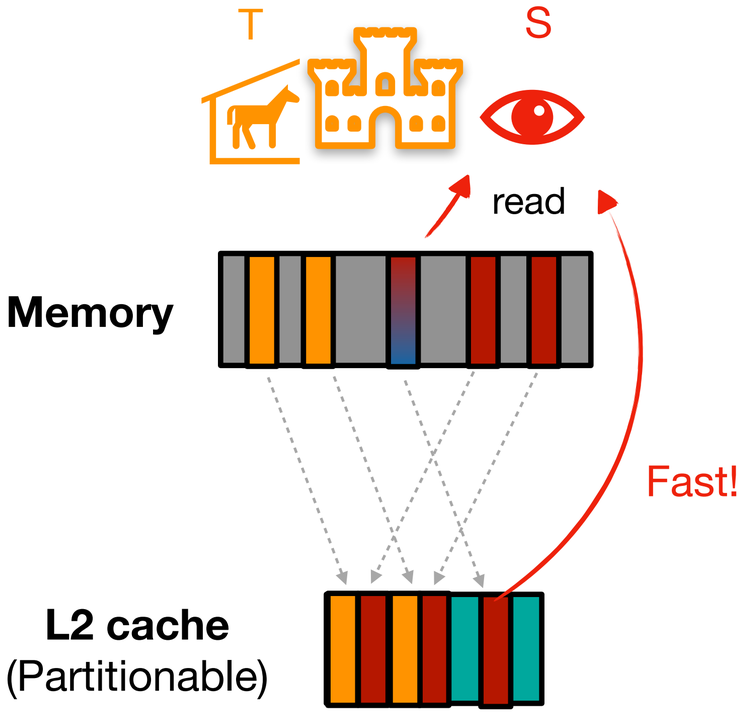

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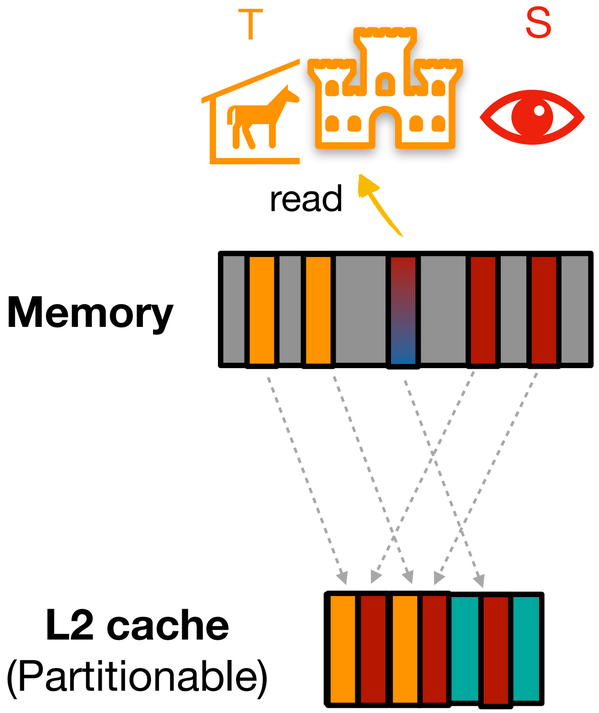

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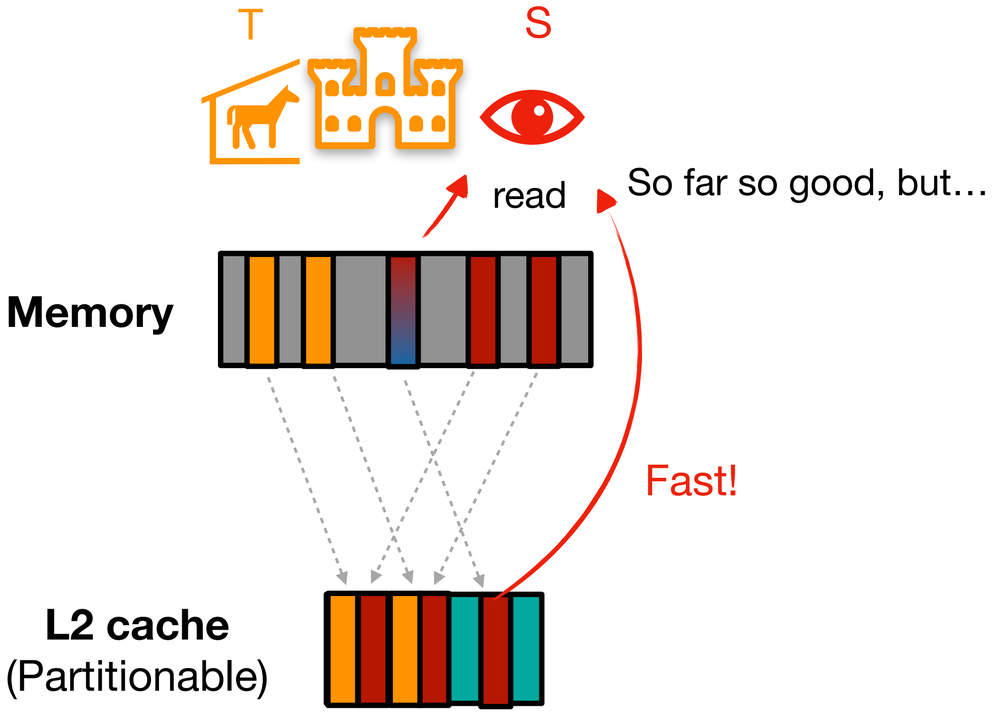

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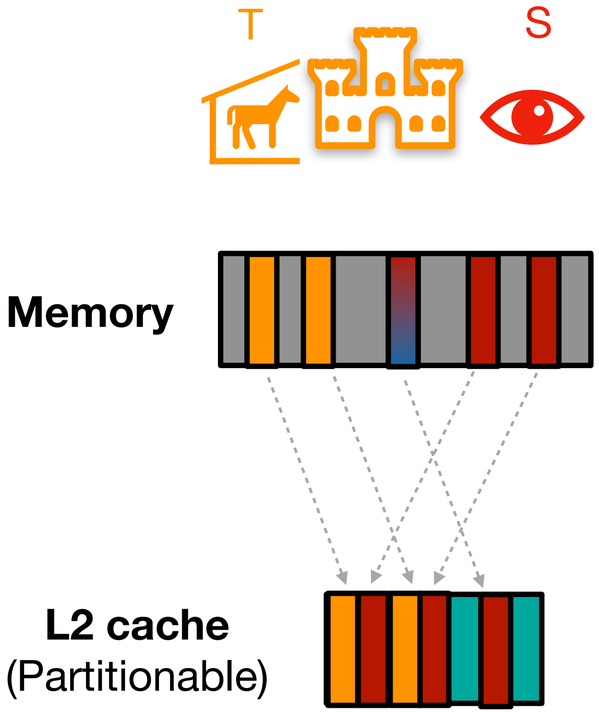

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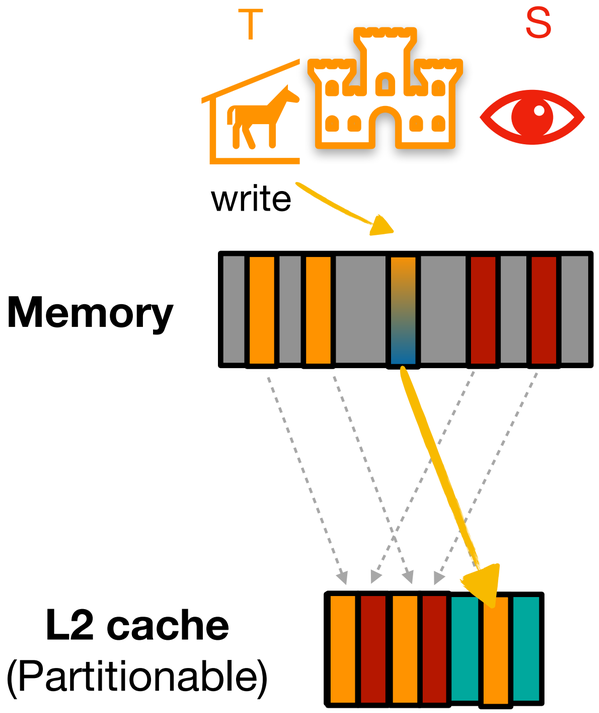

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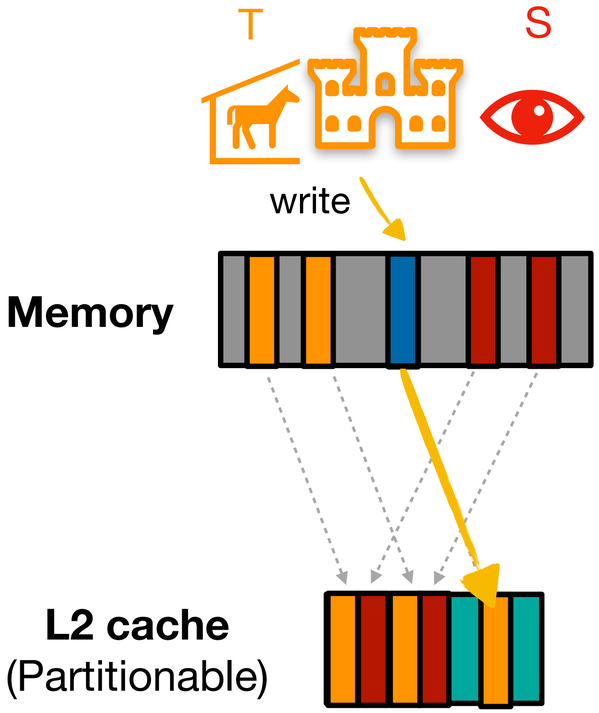

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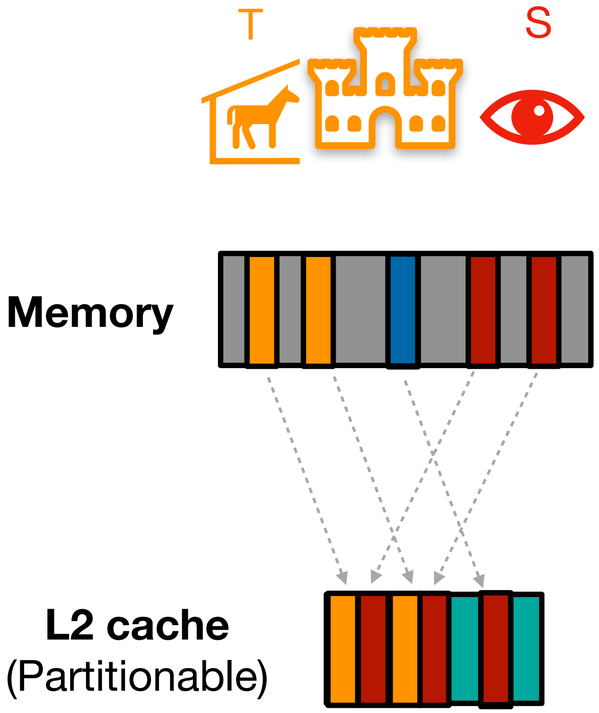

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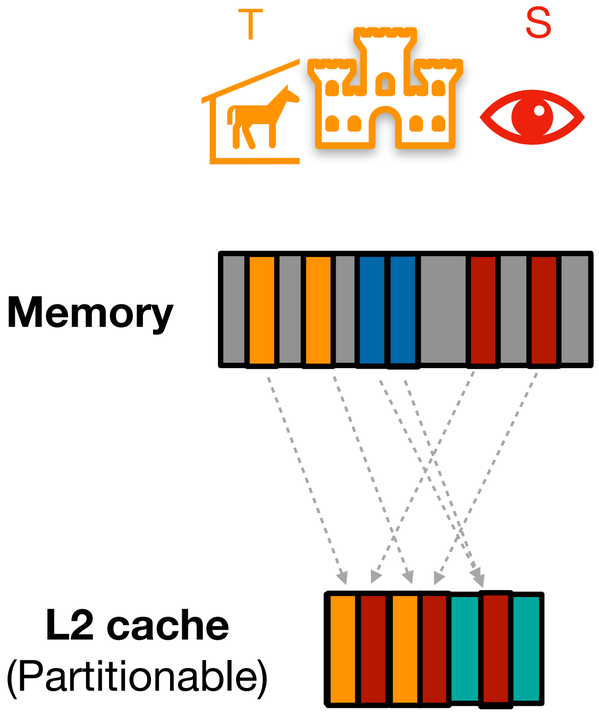

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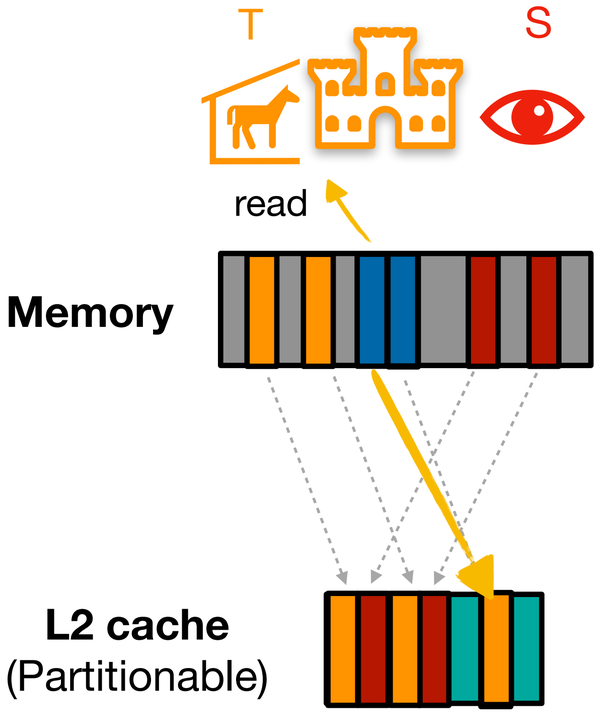

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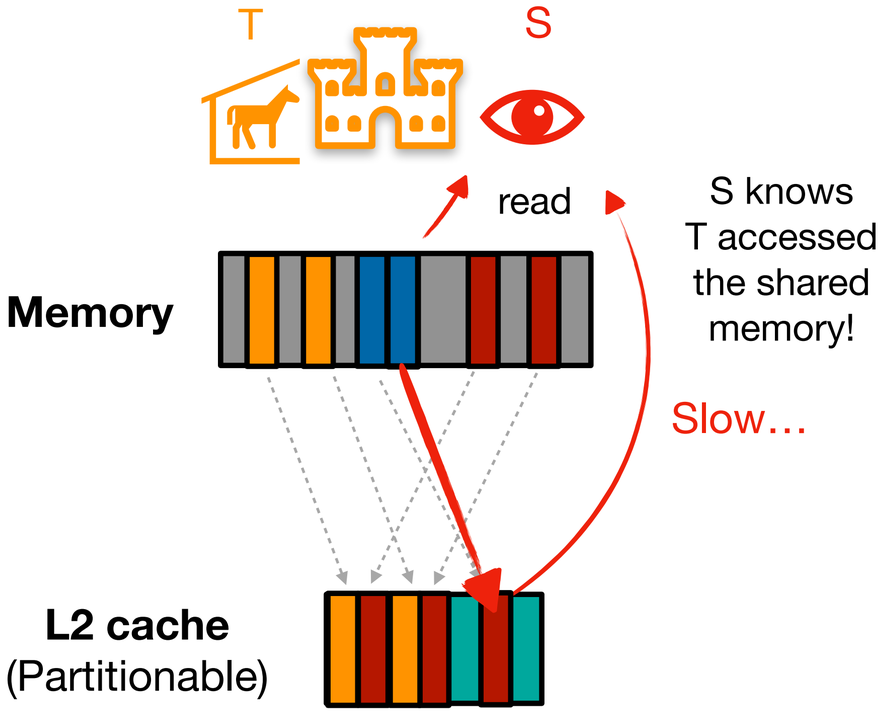

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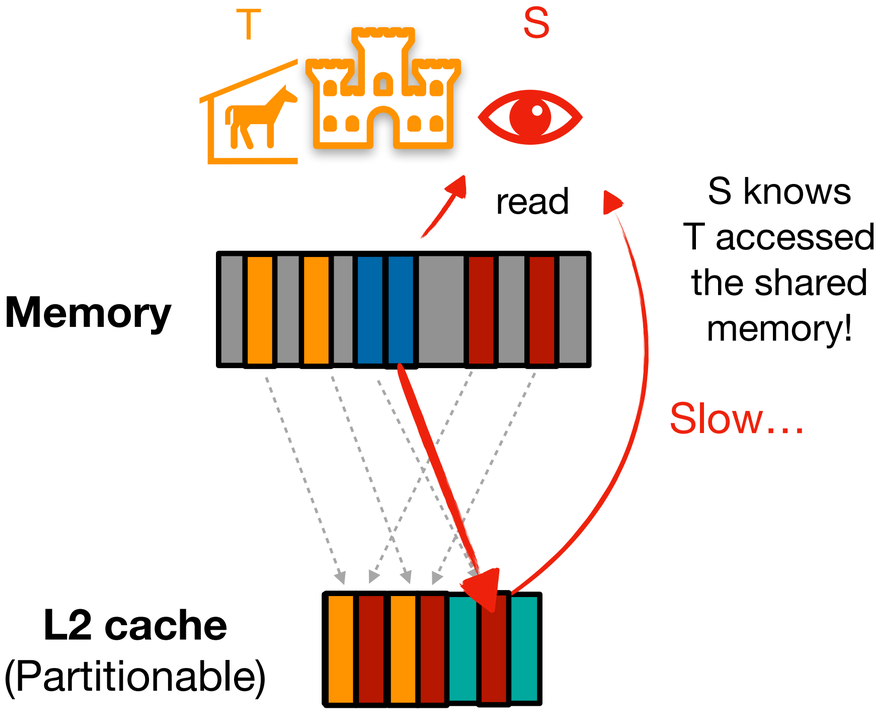

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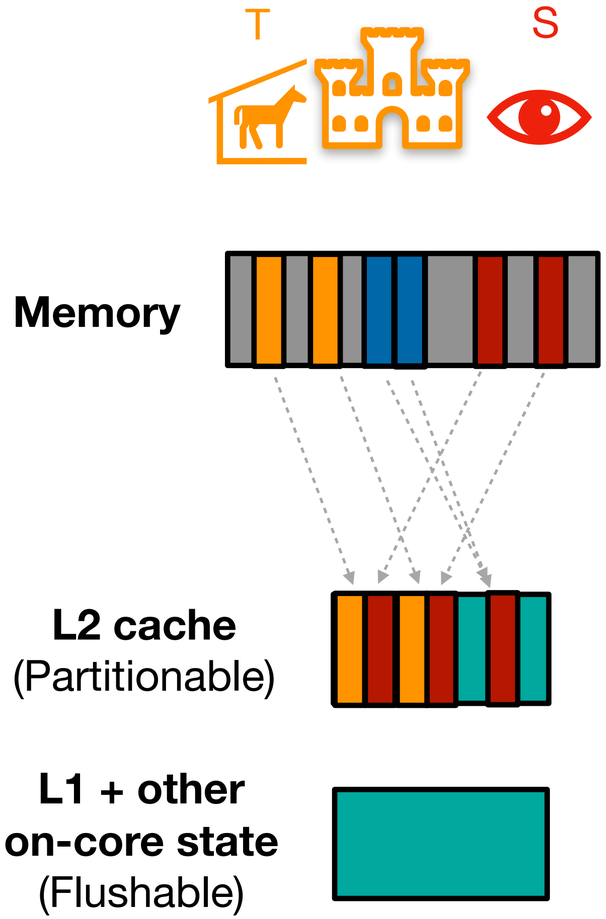

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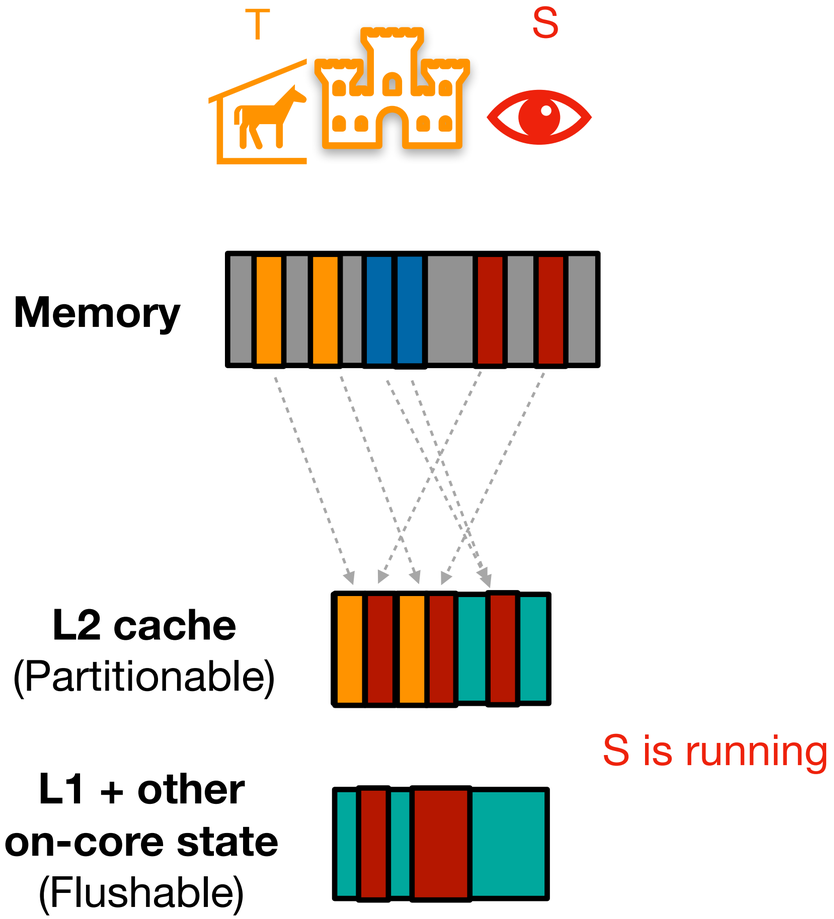

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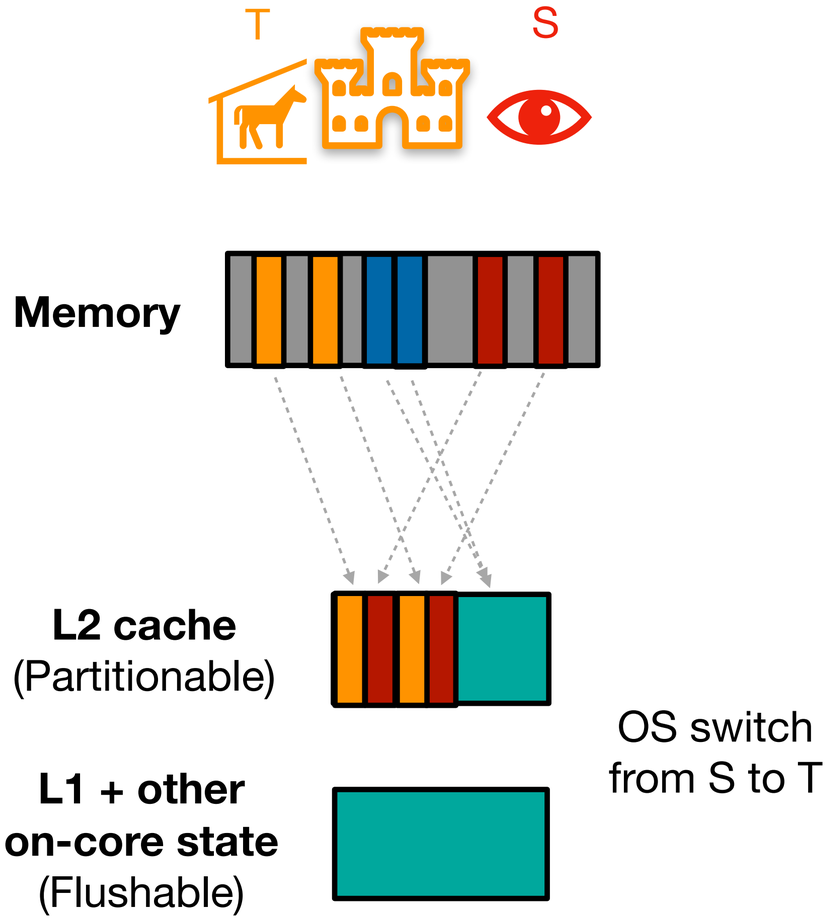

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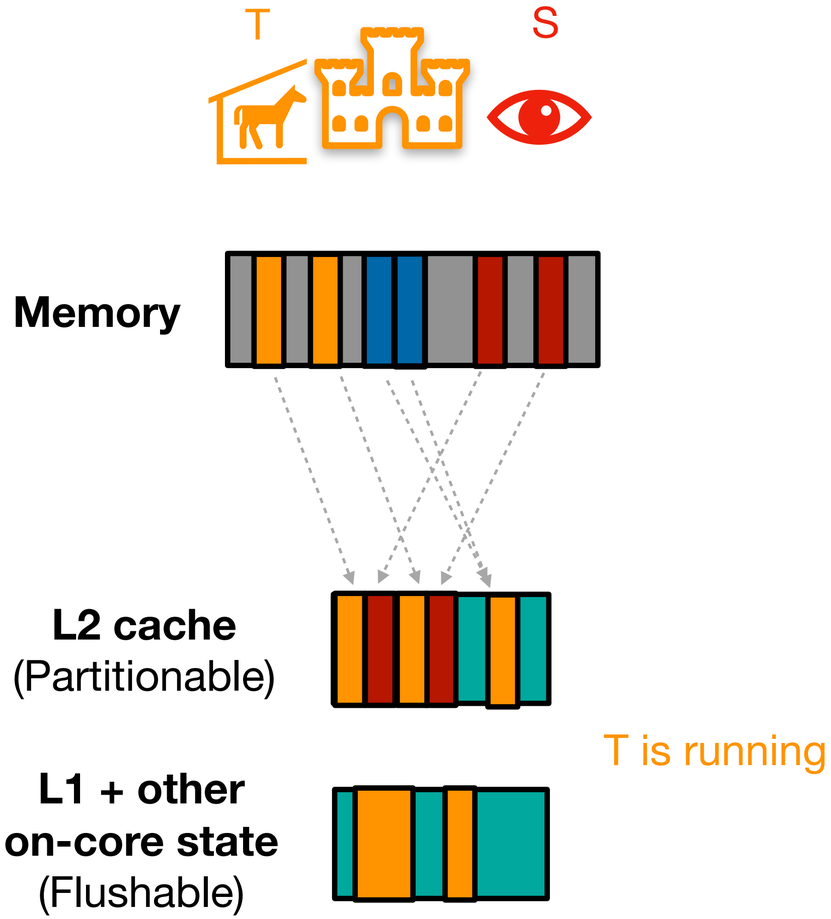

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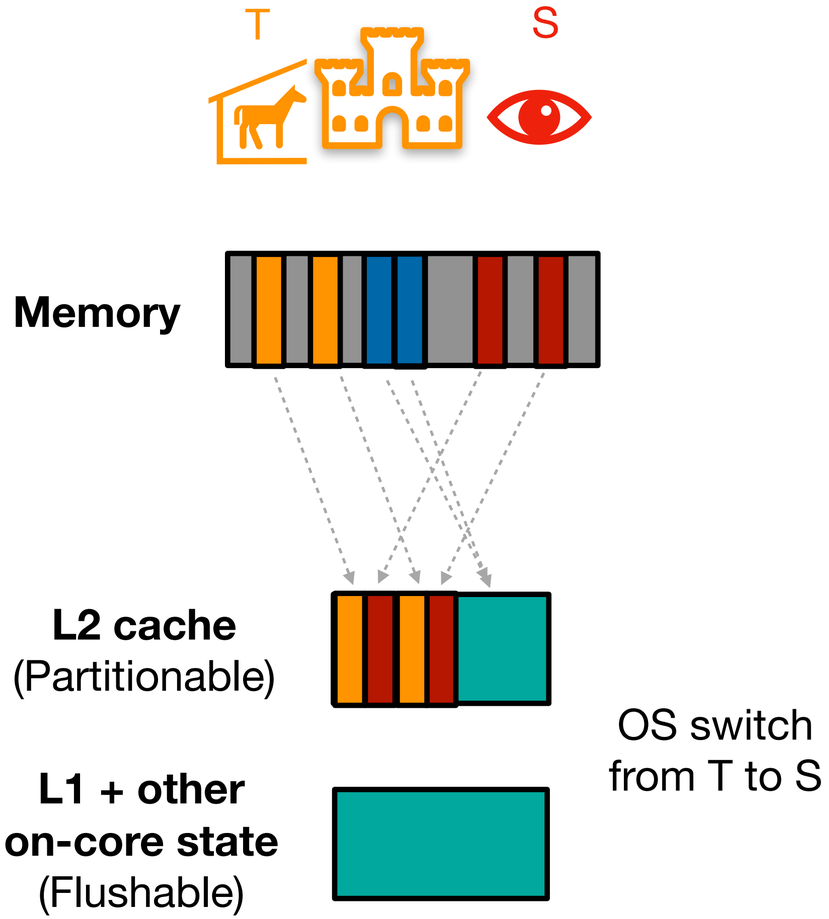

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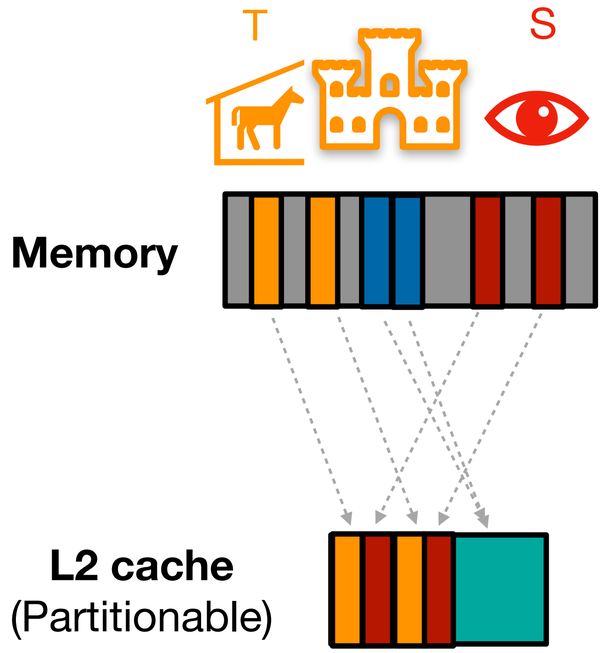
Time-protected communications in seL4

seL4 on RISC-V

D

Implement time-protected cross-domain communications



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Time-protected communications in seL4

seL4 on RISC-V

D

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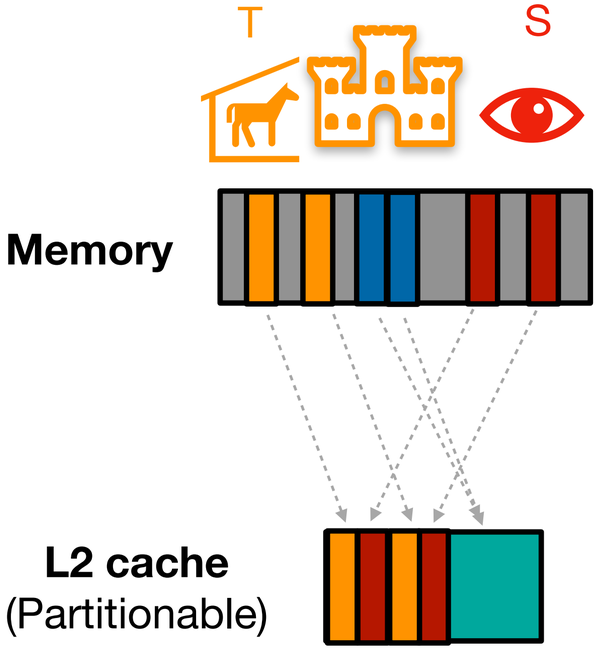
Varun Sethu
BE Thesis



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Time-protected communications in seL4

seL4 on RISC-V

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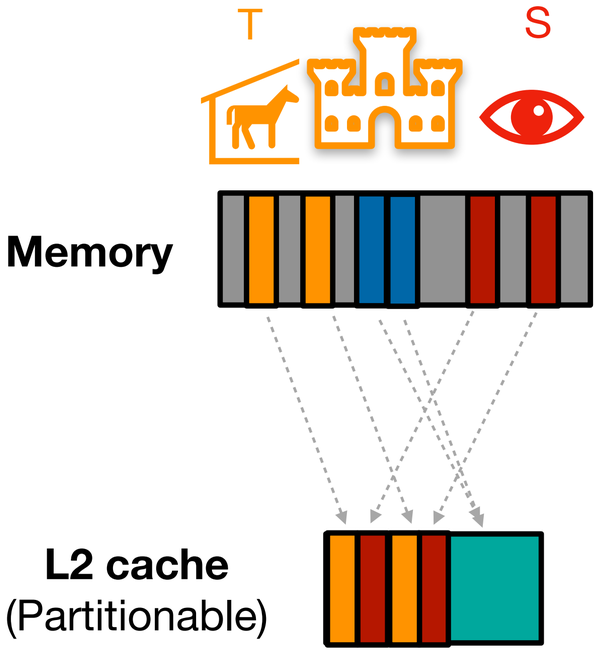

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Time-protected communications in seL4

seL4 on RISC-V

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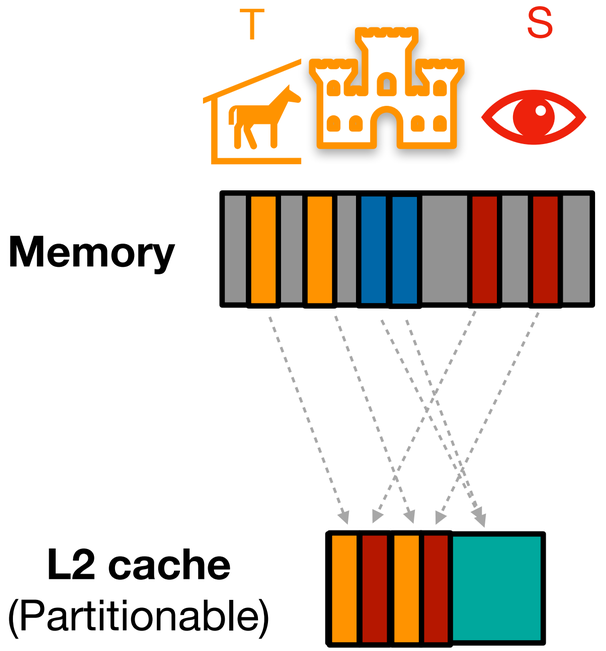

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Time-protected communications in seL4

seL4 on RISC-V

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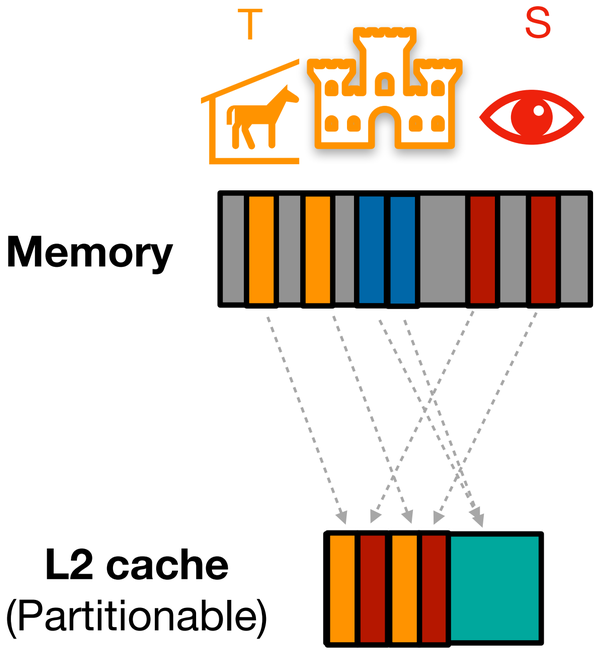
Varun Sethu
BE Thesis



We need *targeted flush* for partitionable L2 caches to enforce T ~/> S while allowing T <~ S

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Time-protected communications in seL4

seL4 on RISC-V

D

Implement time-protected cross-domain communications

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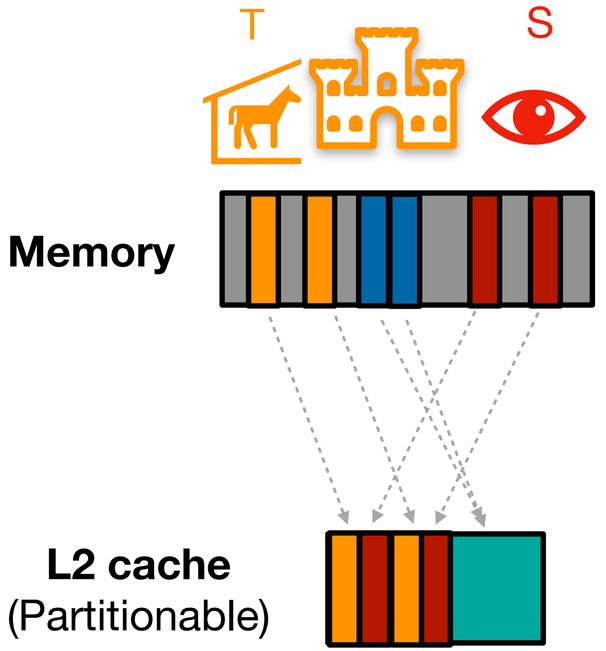
BE Thesis

Continuing on from



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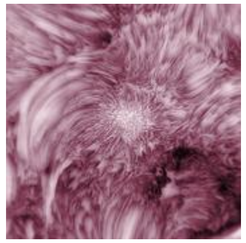
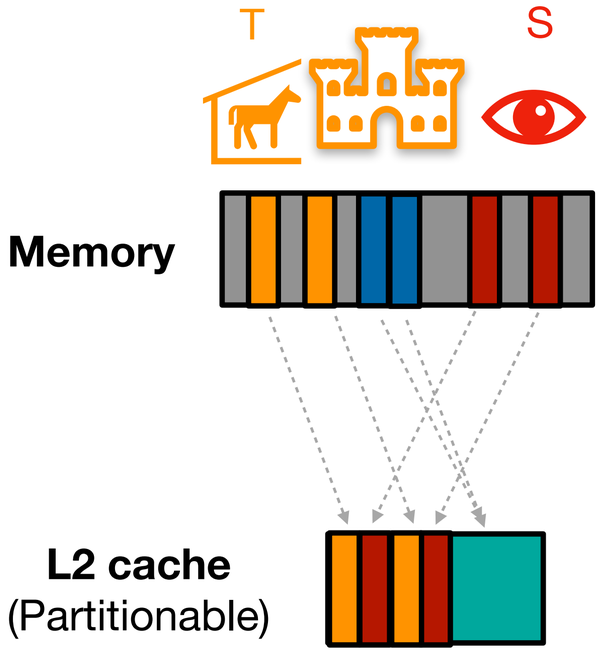


Julia Vassiliki



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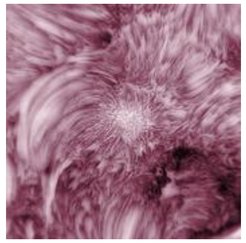
Varun Sethu
BE Thesis

Continuing on from



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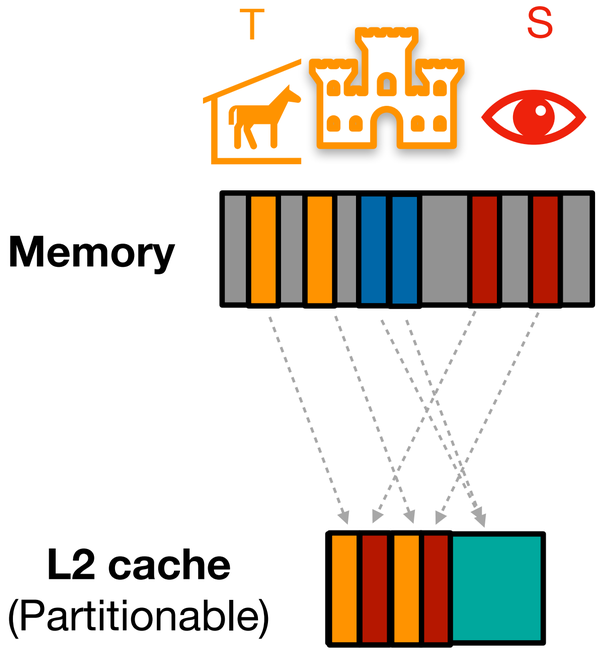

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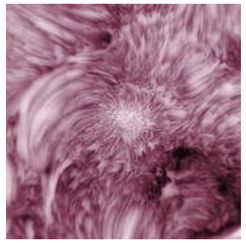
- Now we're using *dynamically partitionable last-level cache* (DPLLC) i.e. dedicated HW support on RISC-V Cheshire
  - Supports targeted flush of partitions
  - Adding needed time padding on flush

Varun Sethu
BE Thesis

Continuing on from



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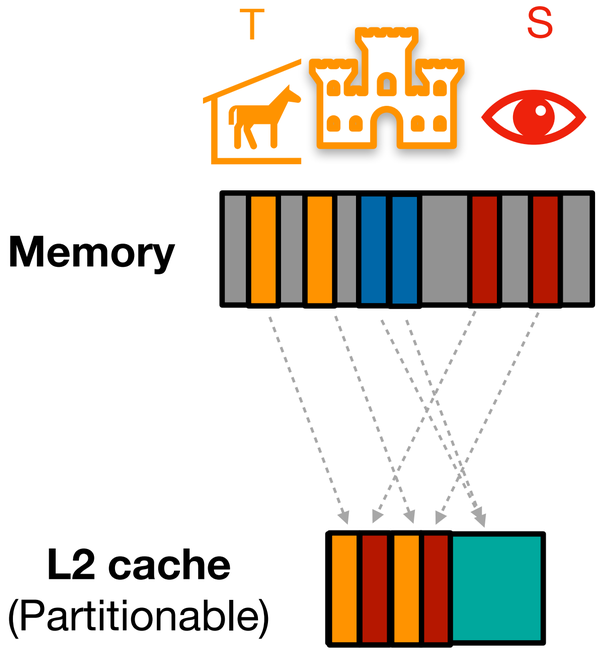

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Verifying seL4 time-protected communications

seL4 on RISC-V

FM'23: Define time protection for OS kernels

Implement time-protected cross-domain communications

Verify time-protected cross-domain communications

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Verifying seL4 time-protected communications

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FM'23: Define time protection for OS kernels

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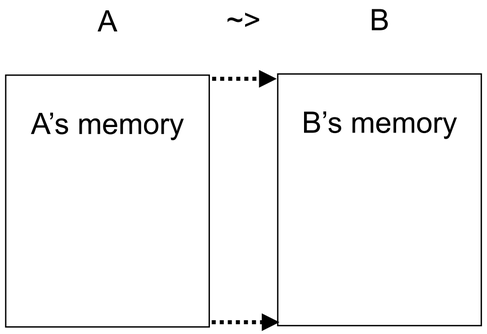
Verify time-protected cross-domain communications



From prior seL4 infoflow proofs [Murray et al. 2012, 2013]:
"all or nothing" policies

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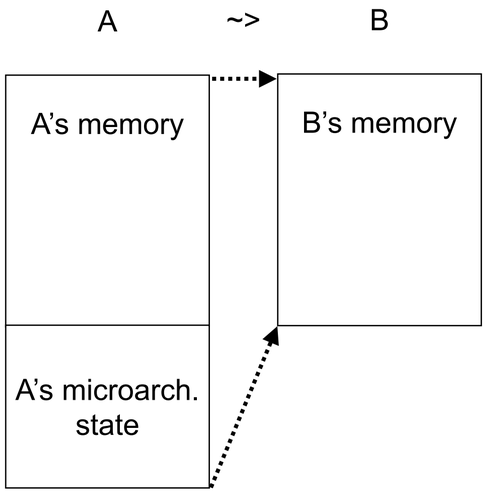

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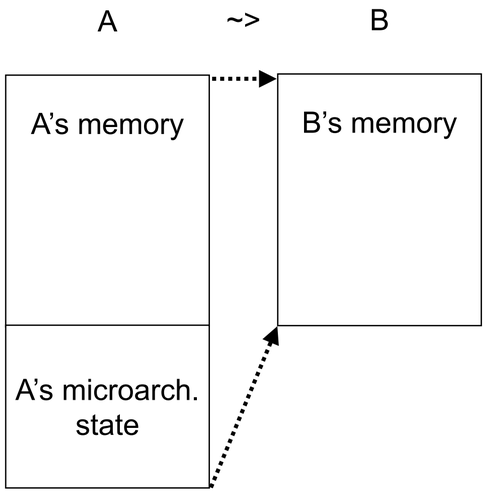

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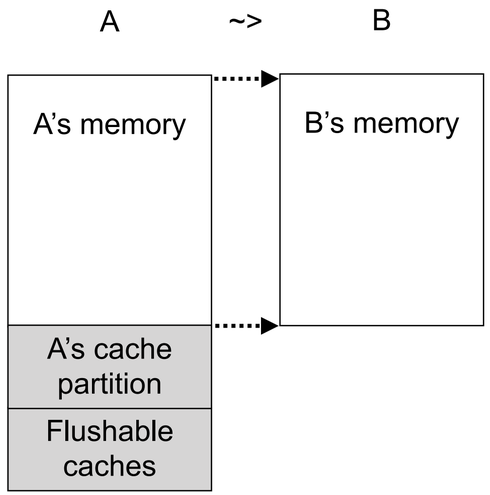

Need *spatial precision* to *allow some flows* but *exclude others*

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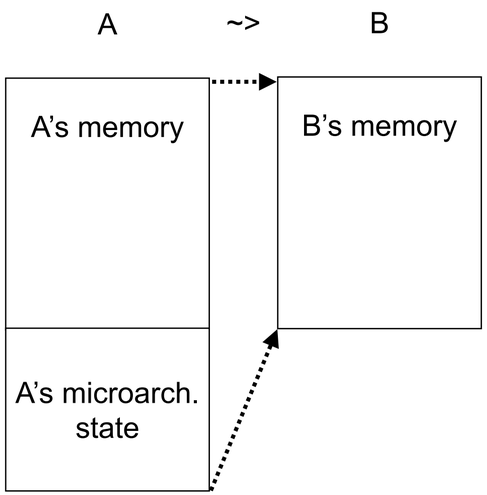
Thanks to Australian Research Council funding



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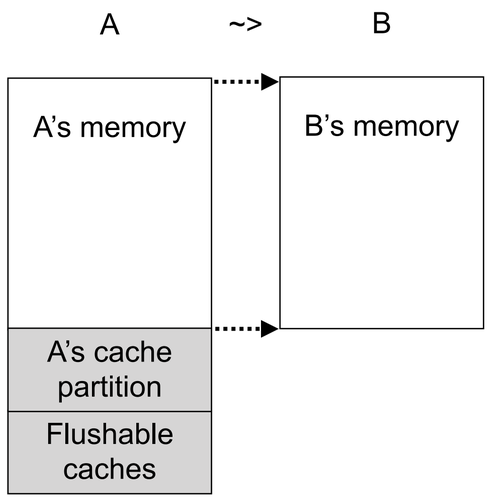

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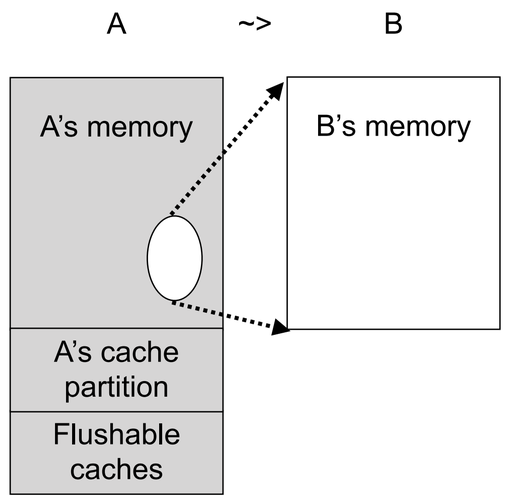

Our FM'23 paper [Sison et al. 2023] allows infoflow policies with arbitrary *spatial* and *temporal* precision

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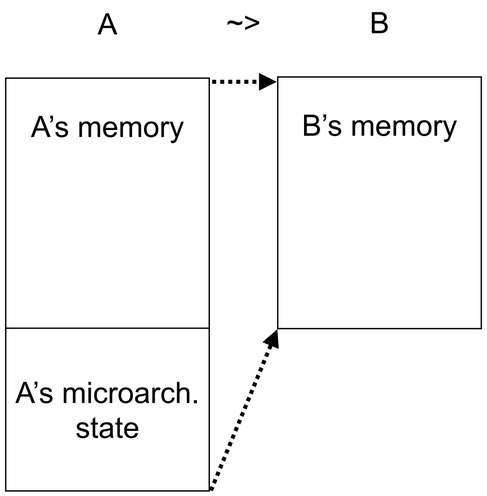
Thanks to funding from cyberagentur



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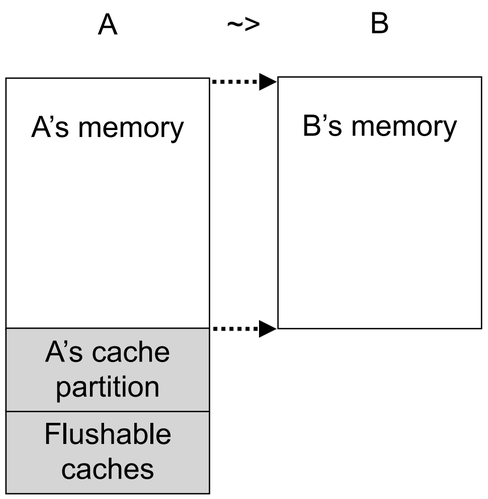

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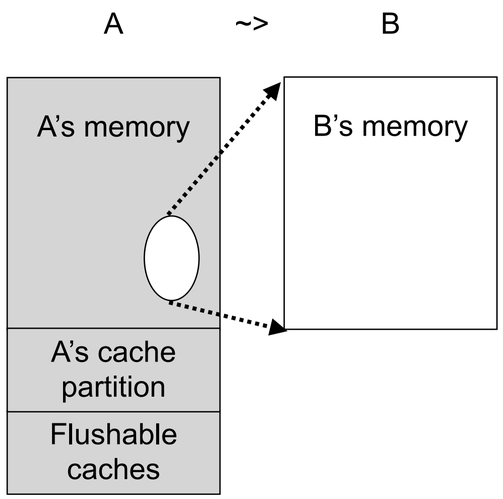

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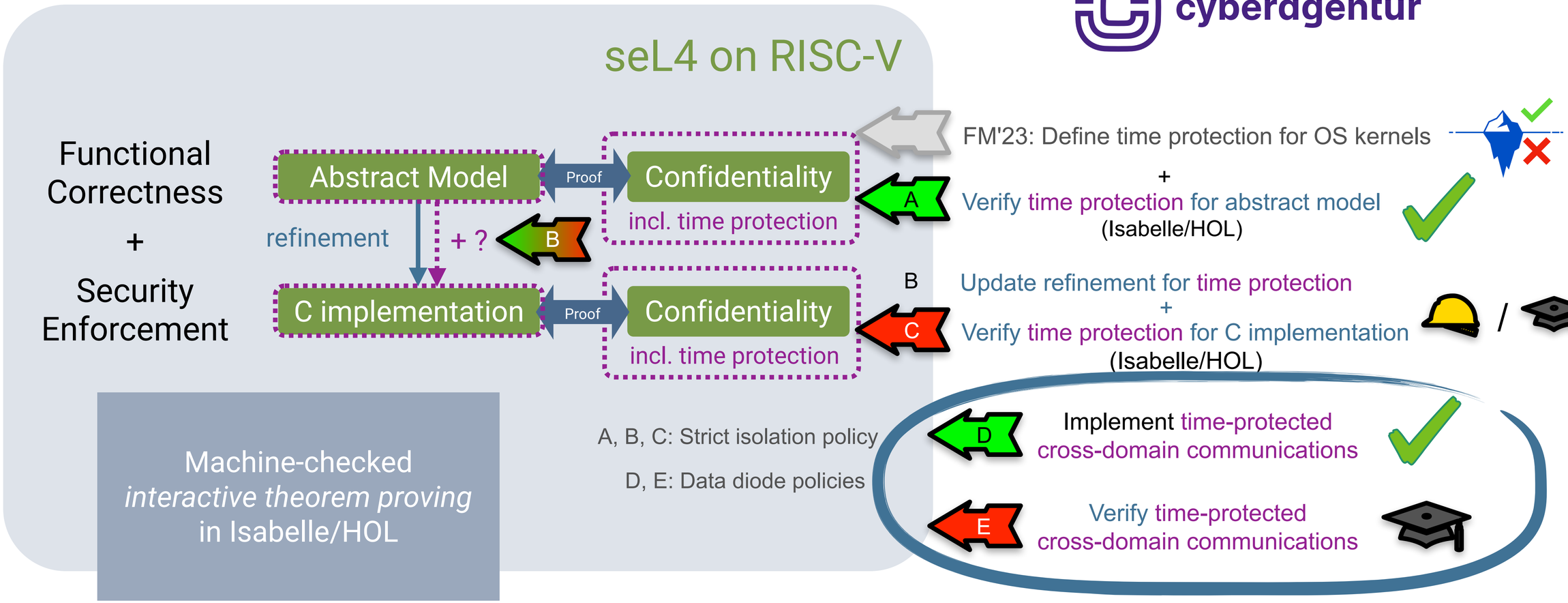
Time protection verification for seL4

The status today:

Thanks to funding from

cyberagentur



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The status today:

Thank you!
Q&A

Thanks to funding from

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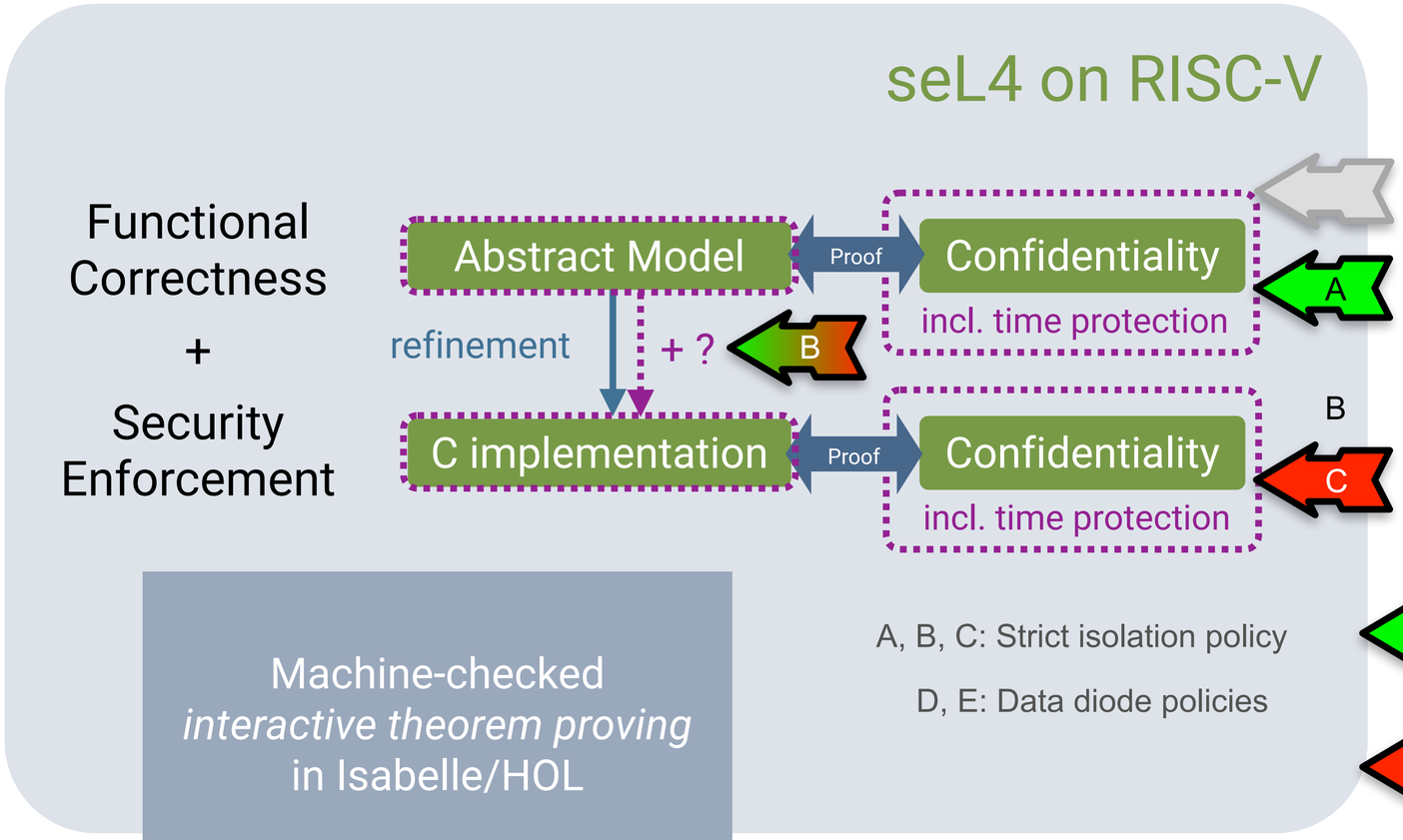

FM'23: Define time protection for OS kernels

+

A — Verify time protection for abstract model (Isabelle/HOL)

B — Update refinement for time protection

+

C — Verify time protection for C implementation (Isabelle/HOL)

D — Implement time-protected cross-domain communications

E — Verify time-protected cross-domain communications

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