SECOMP: Formally Secure Compilation of Compartmentalized C Programs

Cătălin Hrițcu, MPI-SP, Bochum

Joint work with
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Secure Compilation of Vulnerable Source Programs

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- **Insecure languages like C enable devastating vulnerabilities**

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- Mitigate vulnerabilities by compartmentalizing the program

Compartment 1

Compartment 2

Compartment 3

Compartment 4

Compartment 5

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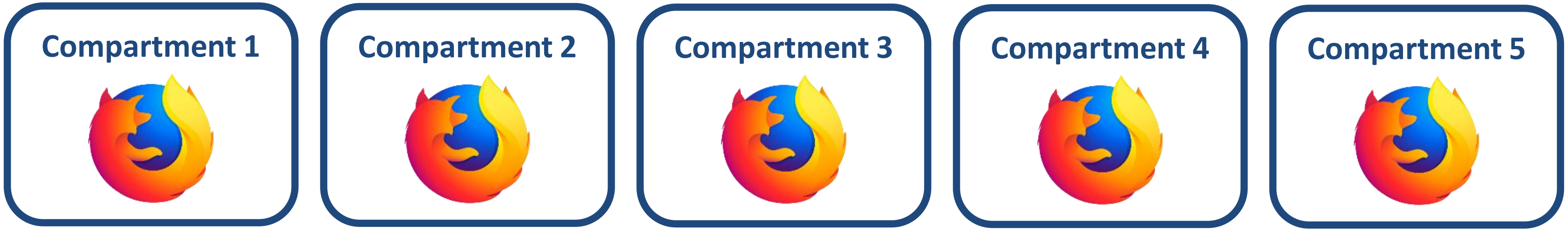
- **Insecure languages like C enable devastating vulnerabilities**
- **Mitigate vulnerabilities by compartmentalizing the program**
- **We don't know which compartments will be compromised**



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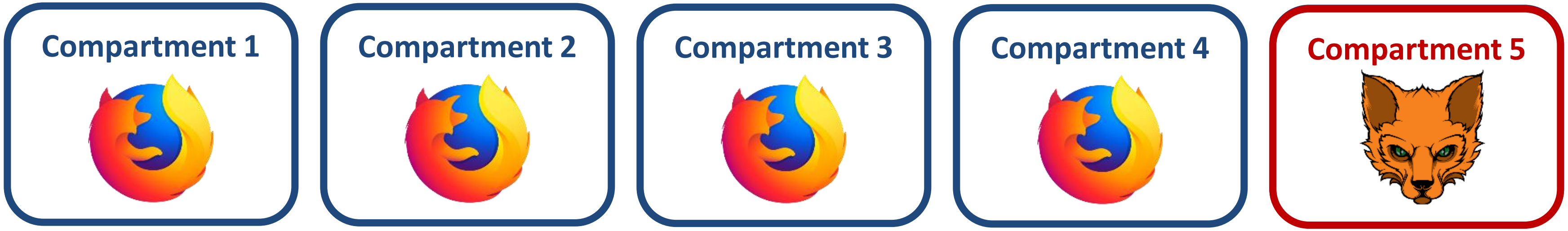

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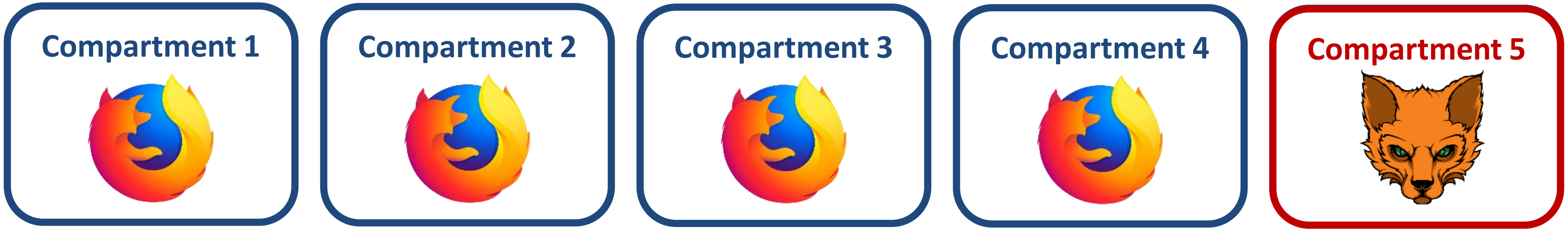

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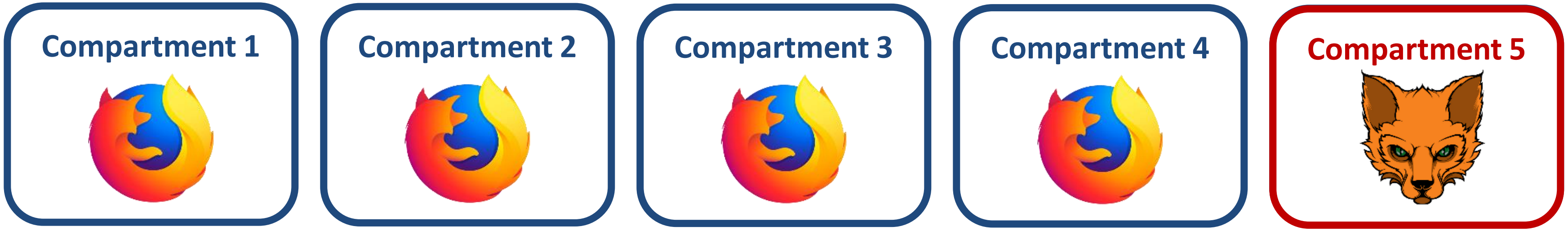

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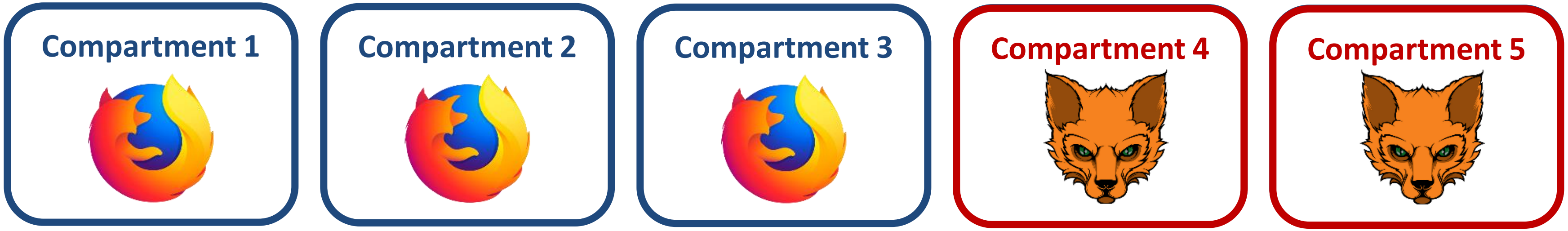

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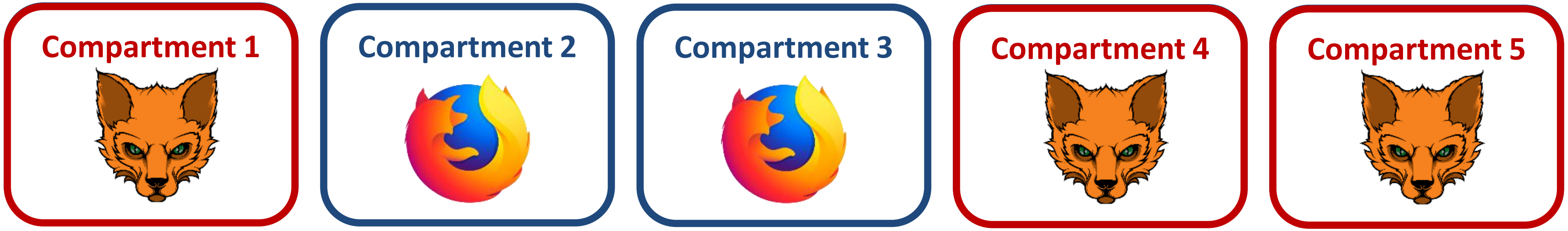

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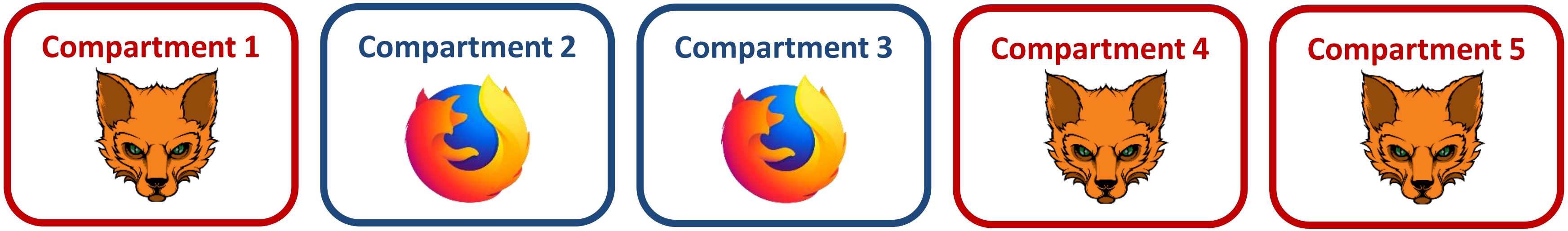

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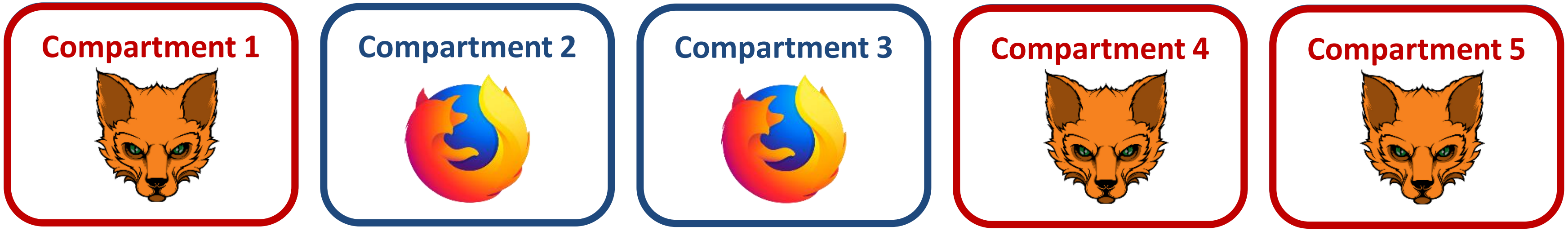
  - every compartment should receive protection until compromised
- Formalized this as a **variant of robust safety preservation** [CCS'18]



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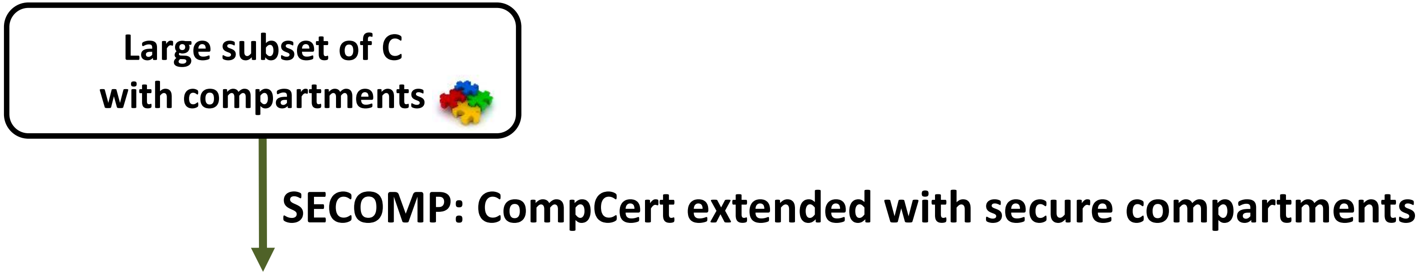
Security Enforcement

Large subset of C
with compartments 🧩

Security Enforcement



Large subset of C
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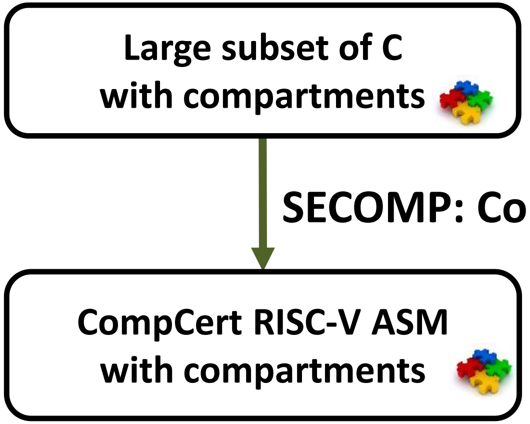
SECOMP: CompCert extended with secure compartments

Security Enforcement



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CompCert RISC-V ASM
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magically secure semantics

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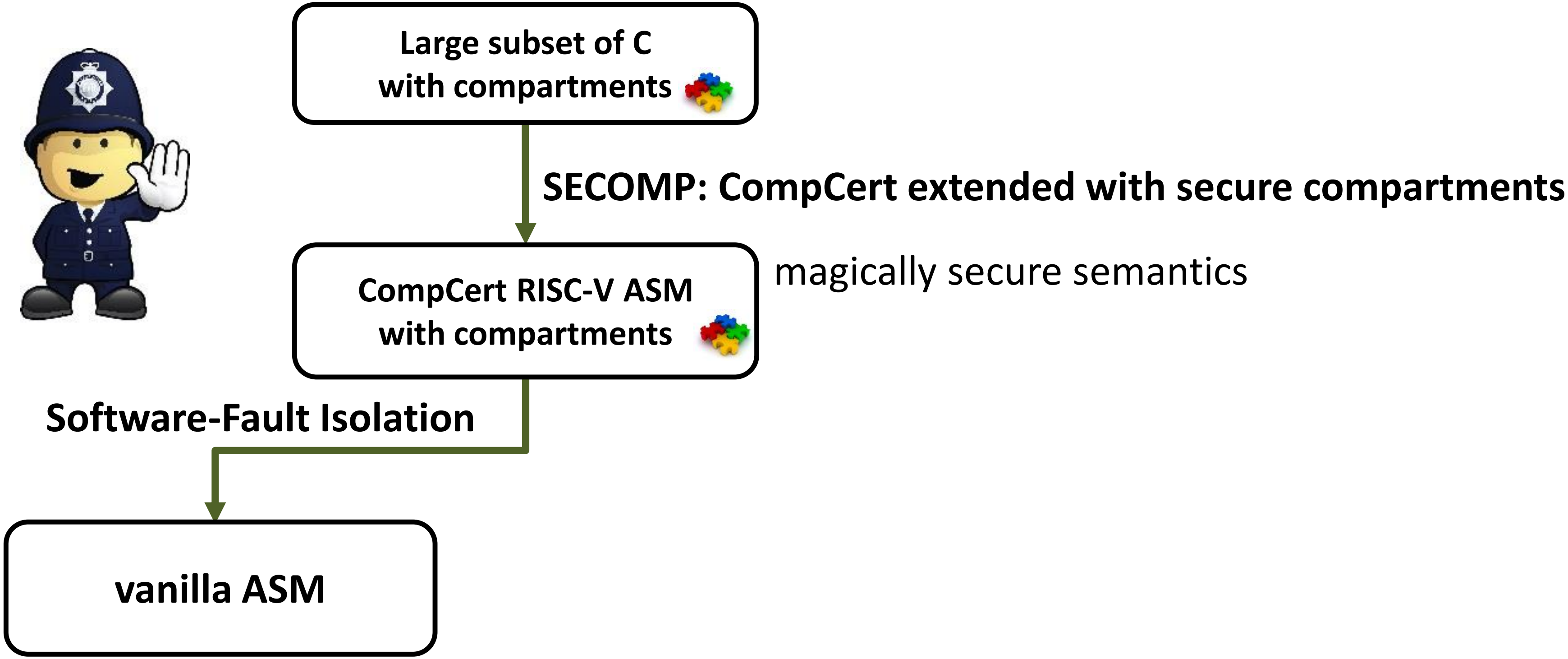

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Software-Fault Isolation

vanilla ASM

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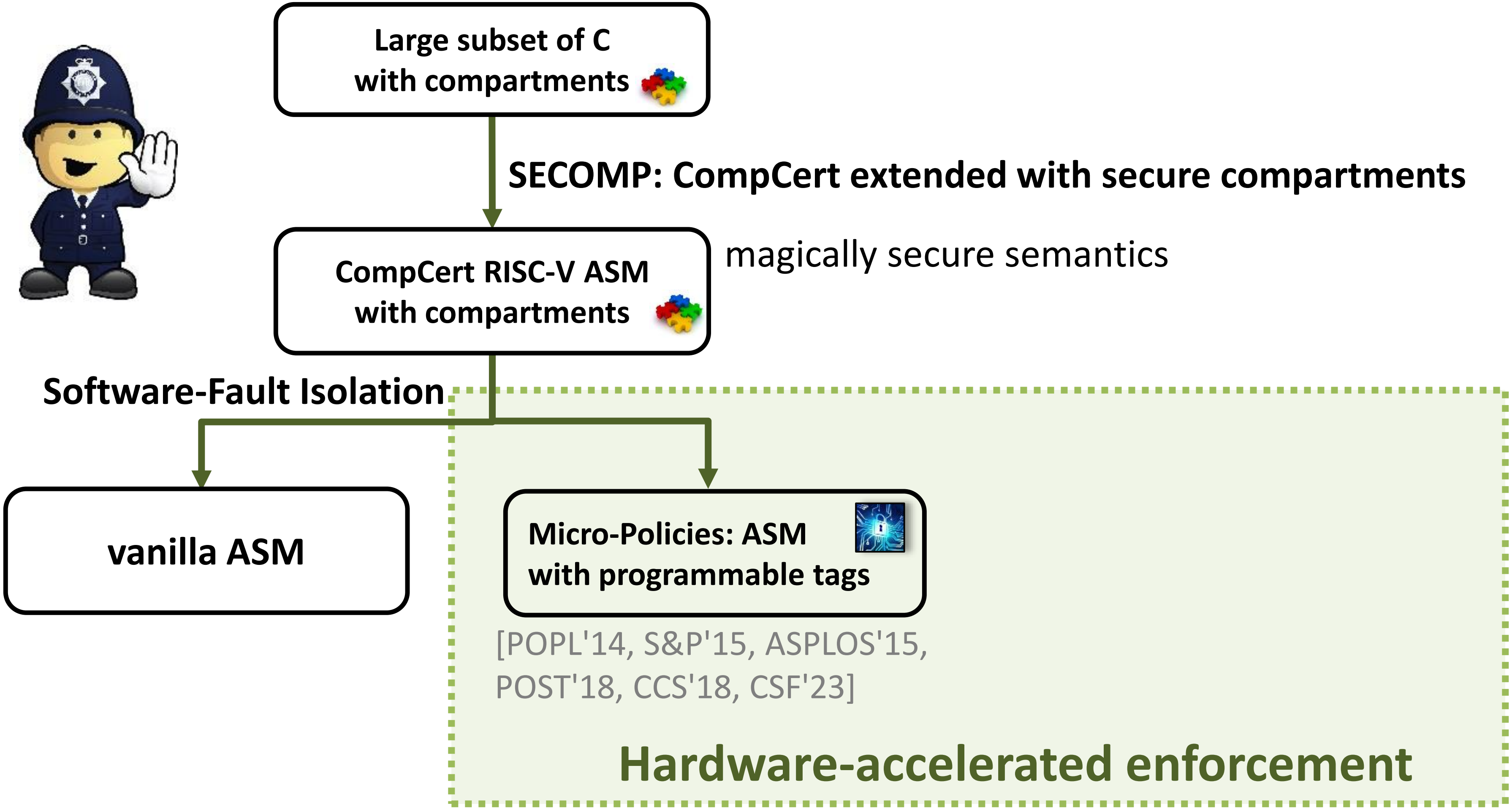

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Micro-Policies: ASM
with programmable tags

[POPL'14, S&P'15, ASPLOS'15,
POST'18, CCS'18, CSF'23]

Hardware-accelerated enforcement

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Done for simplified languages, yet to be ported to RISC-V

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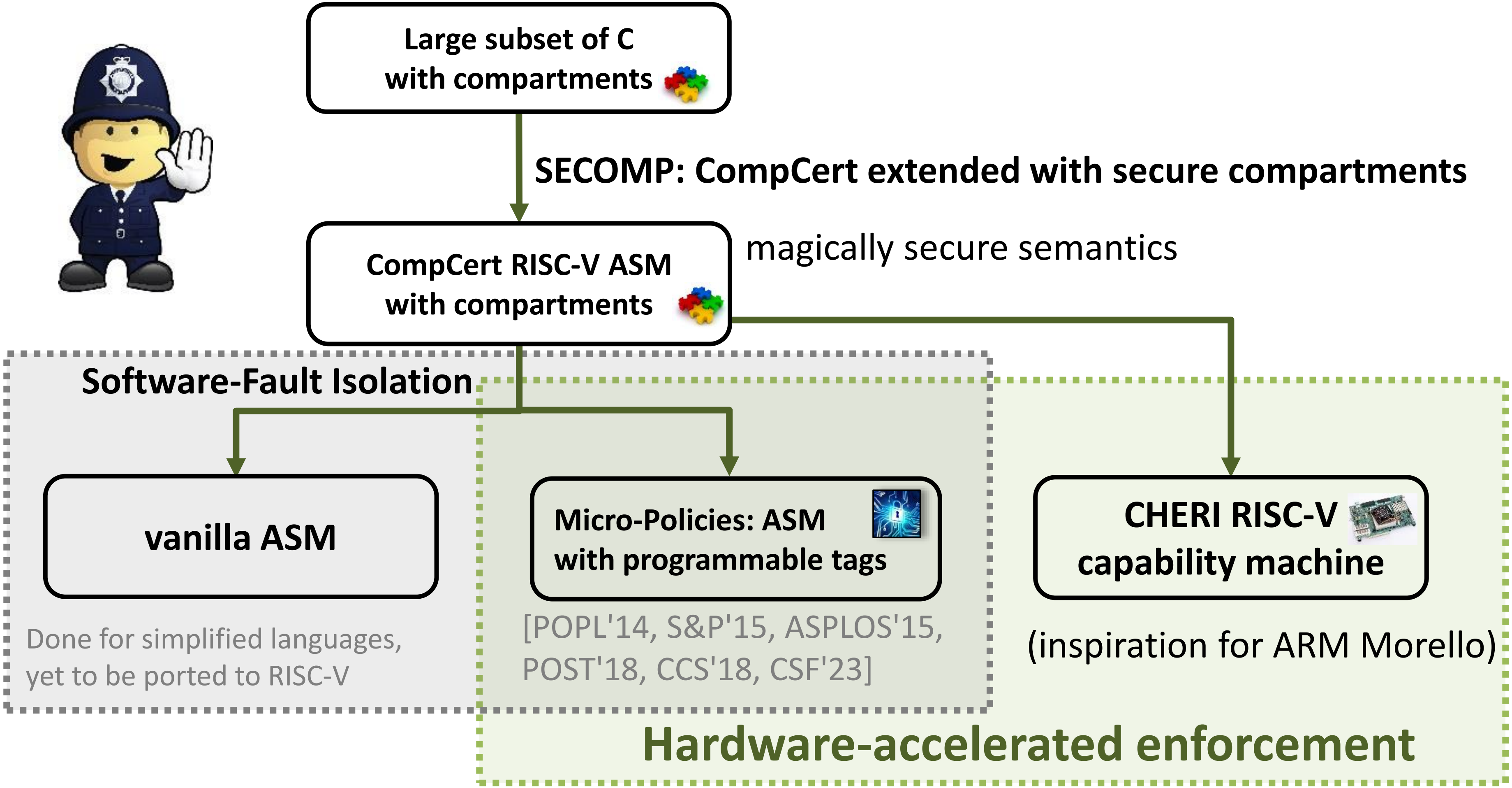

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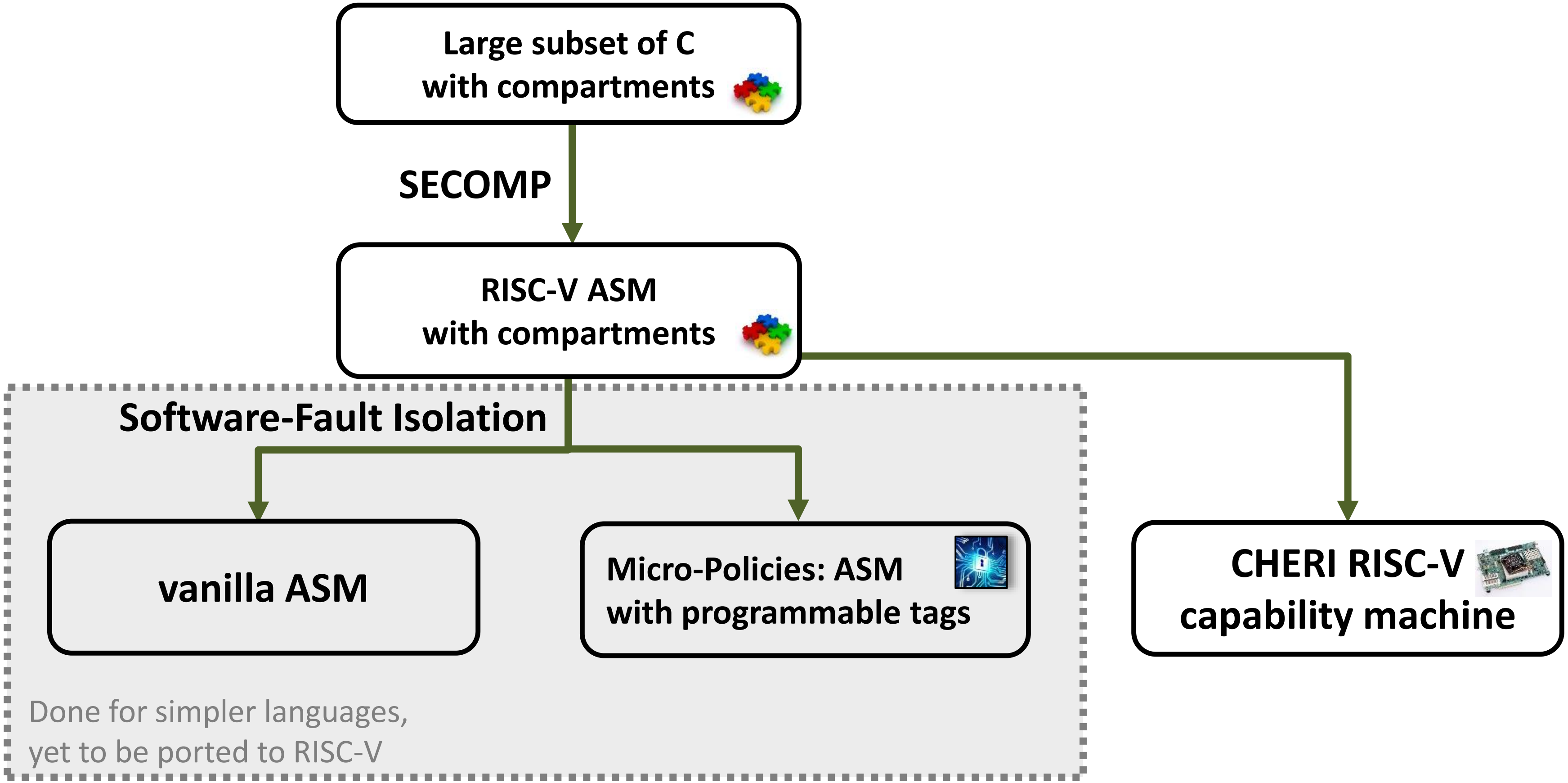
CHERI RISC-V capability machine

(inspiration for ARM Morello)

Hardware-accelerated enforcement

Secure Compilation Proofs in Coq



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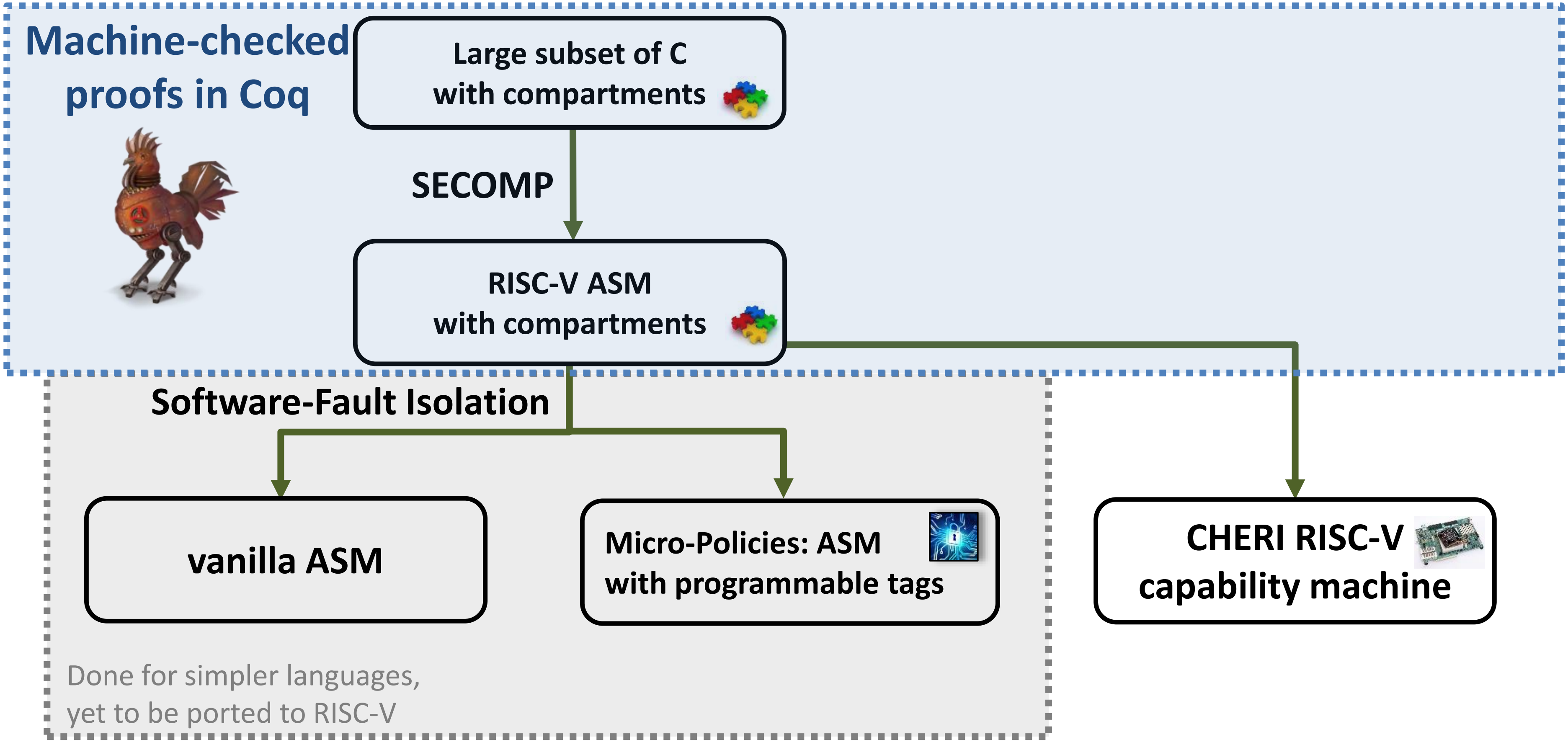

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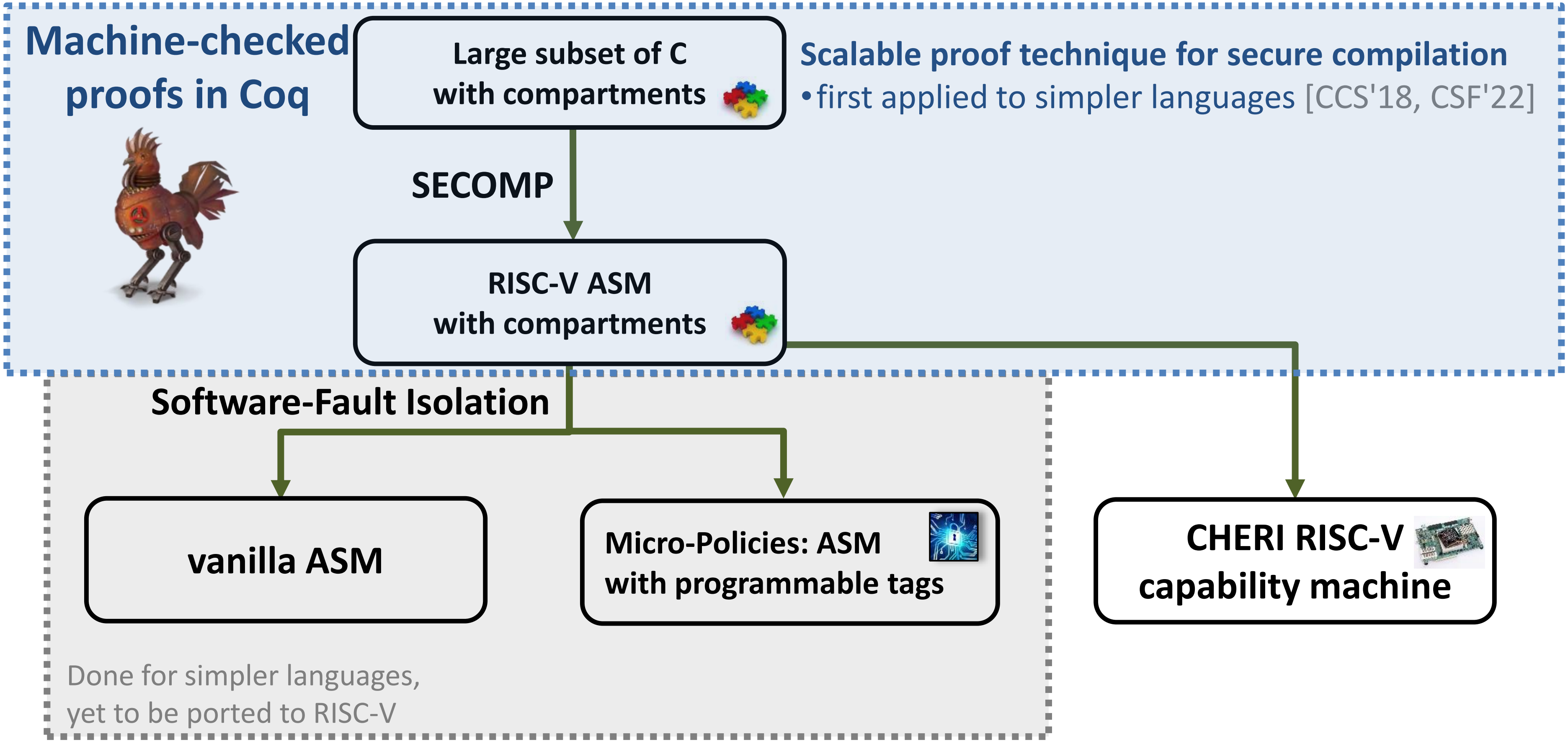

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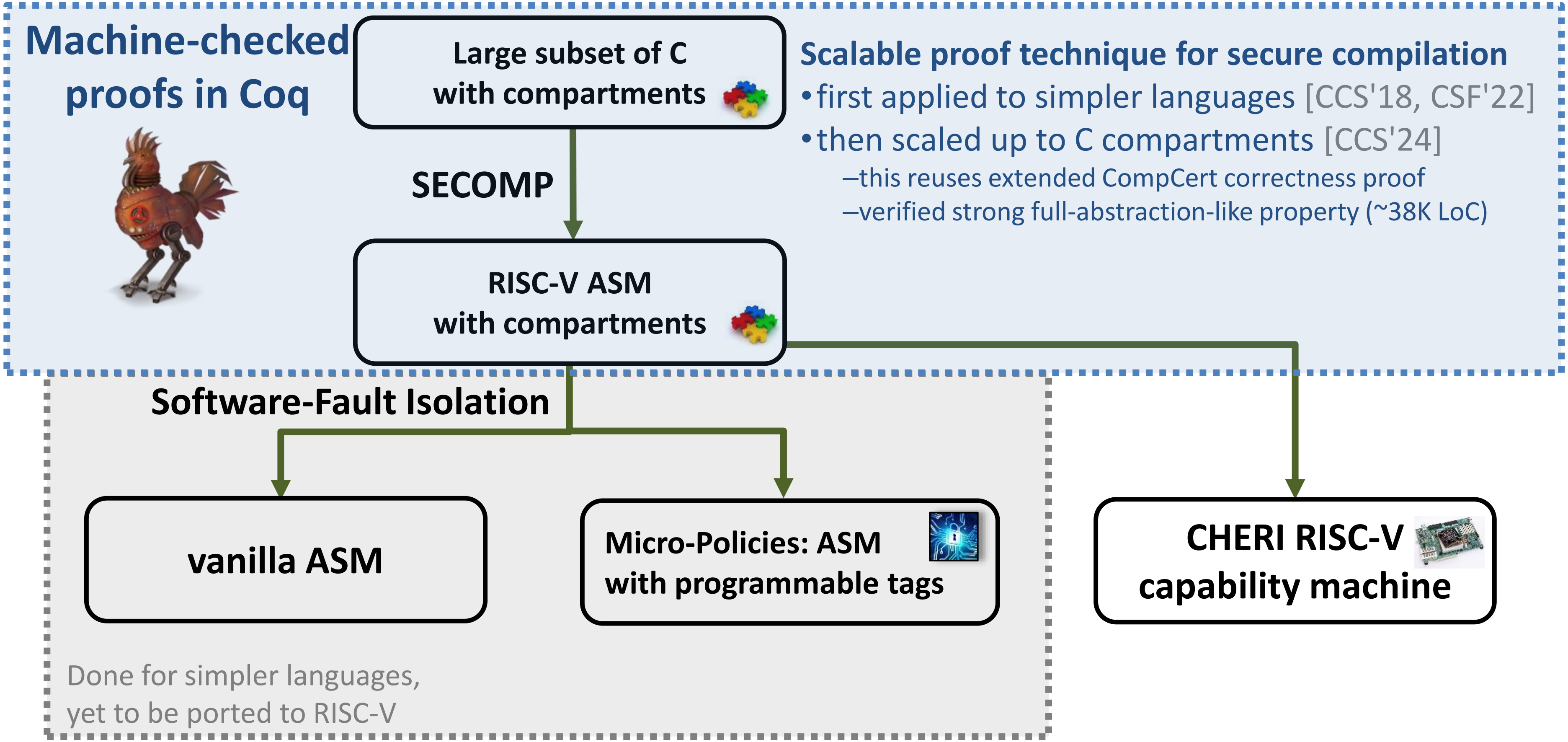

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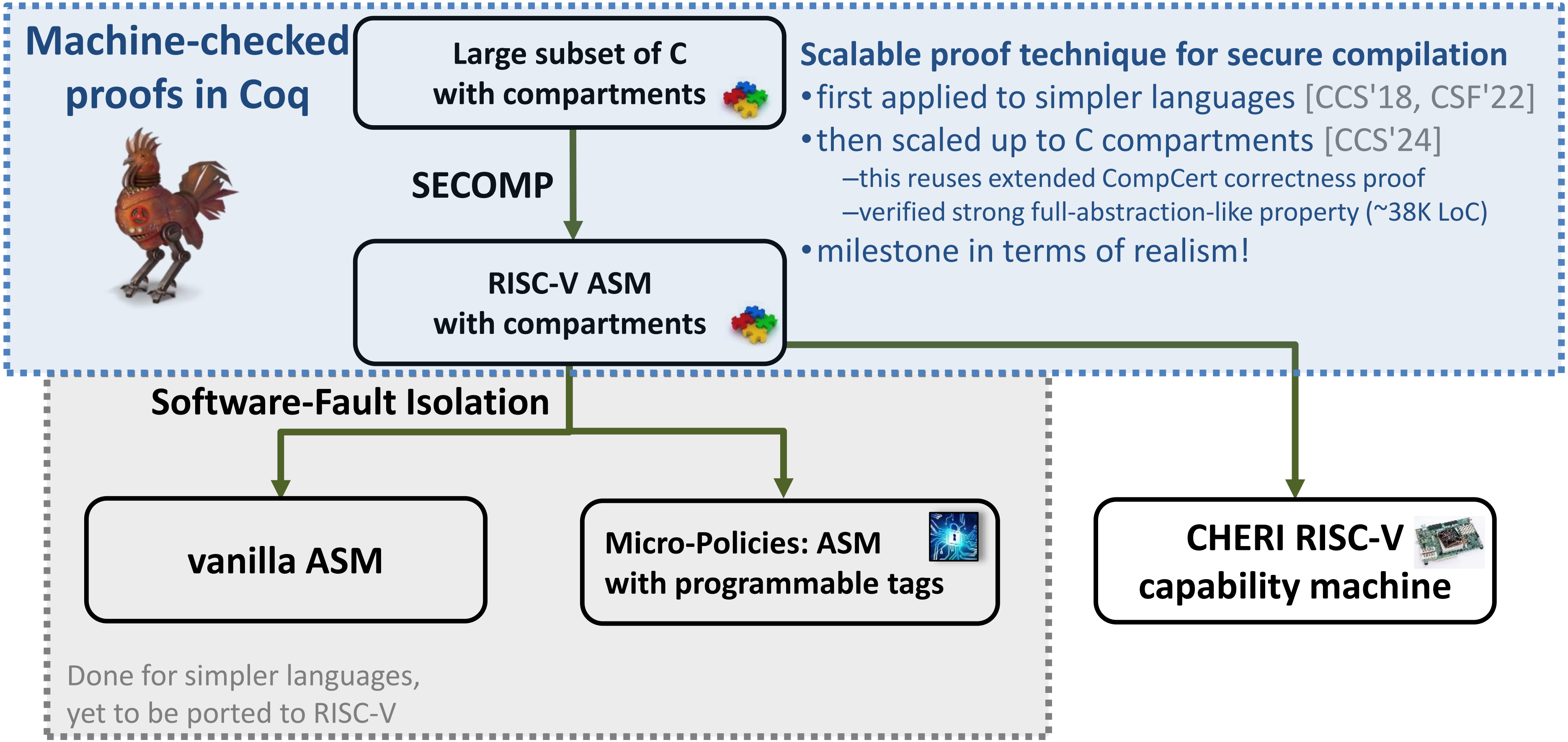

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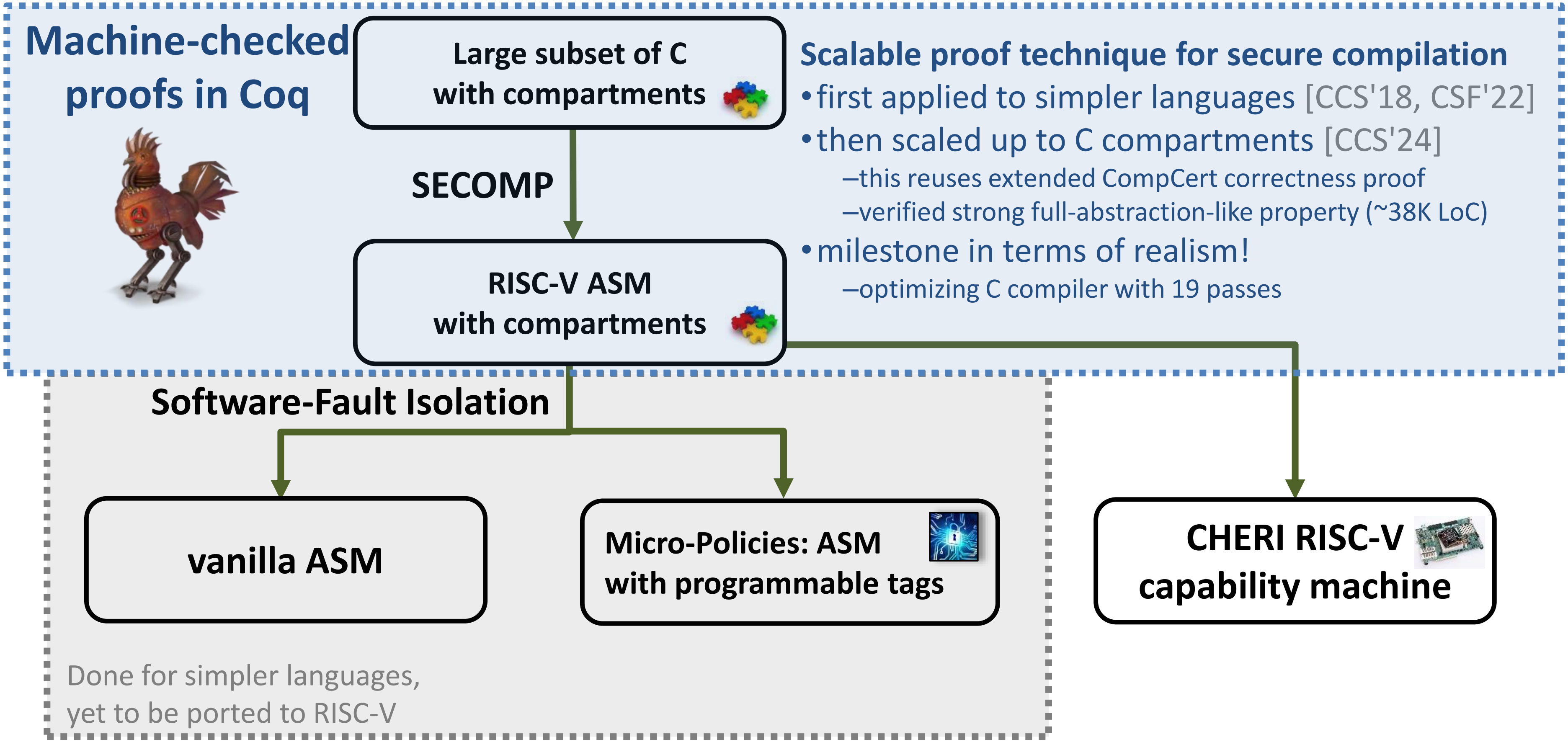

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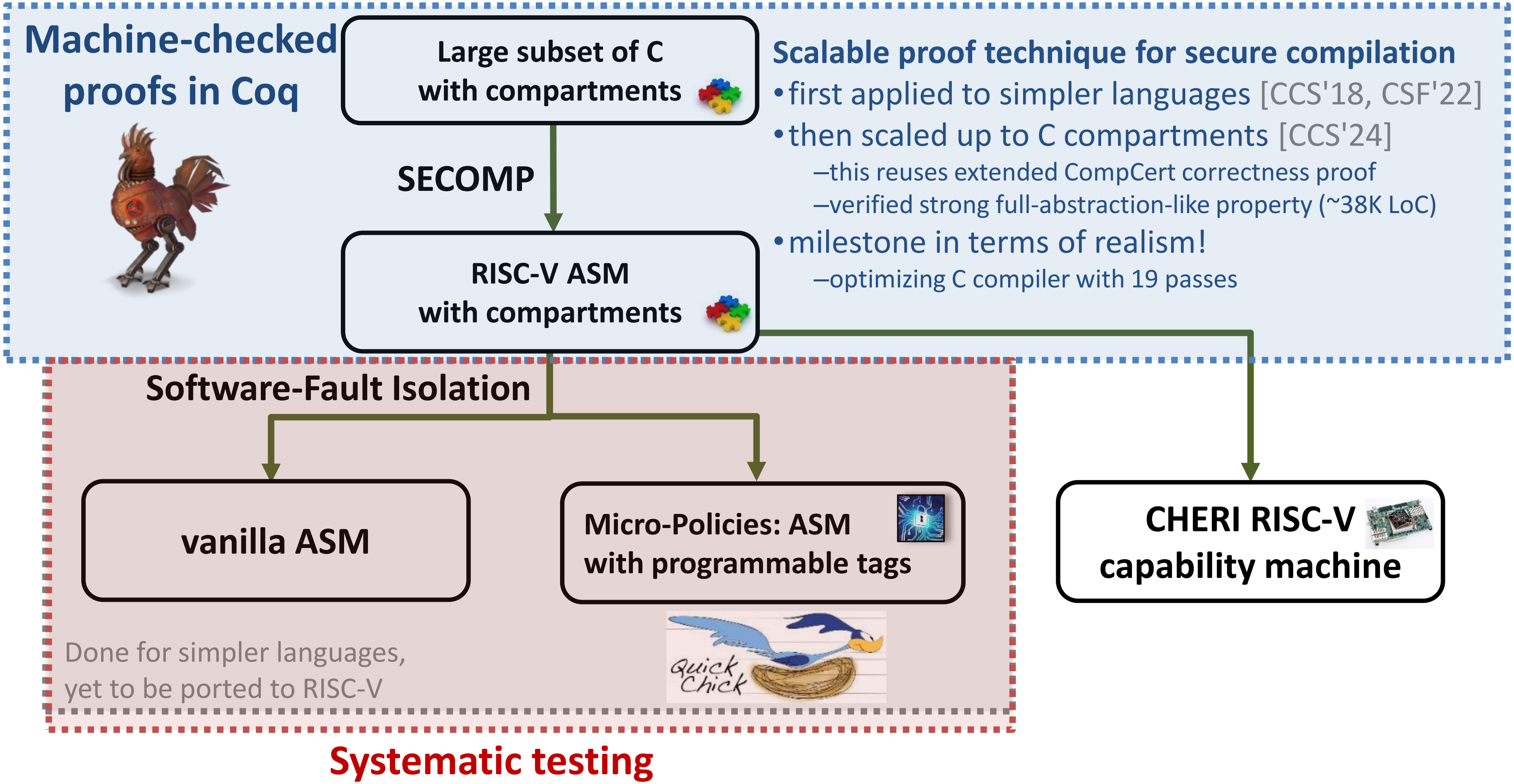

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Systematic testing

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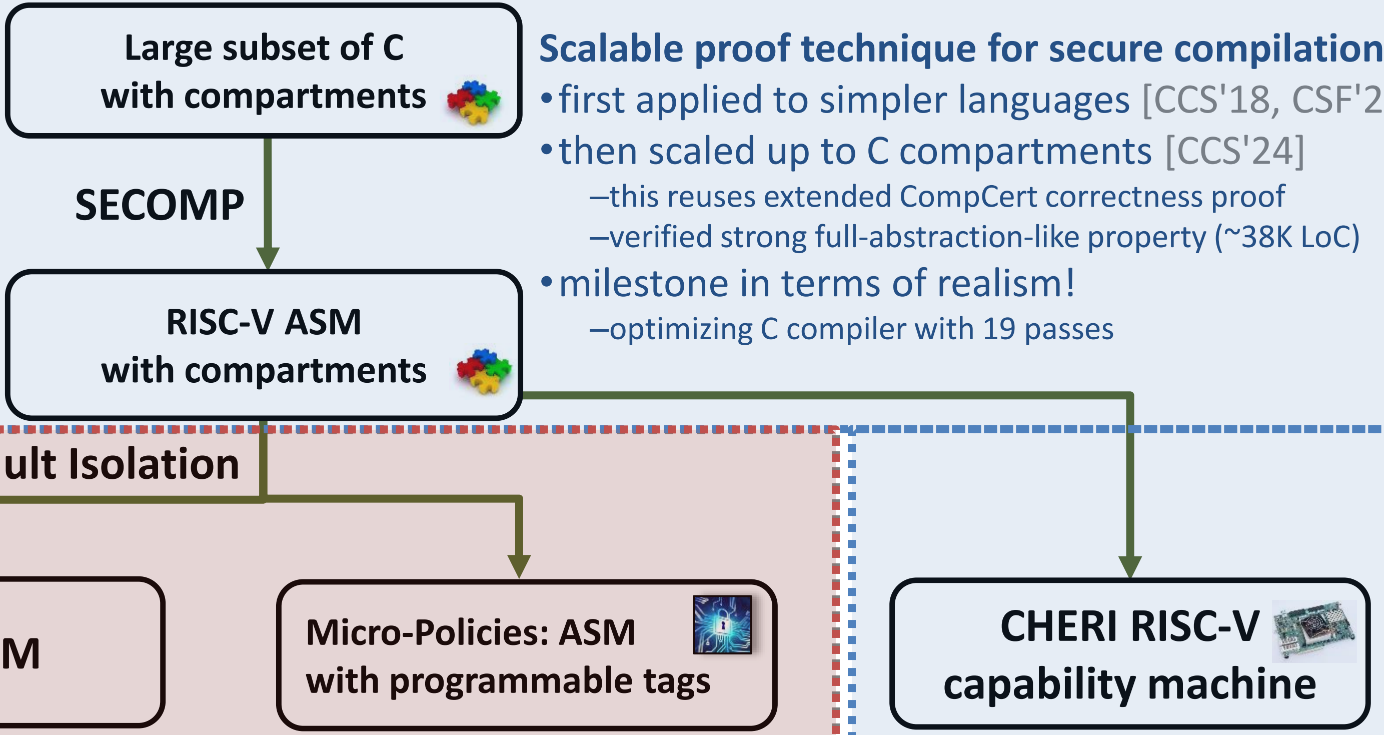

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Big verification challenge for the future

Systematic testing

Future Plans on Formally Secure Compilation

Verify capability backend

Future Plans on Formally Secure Compilation

Better Proof Techniques

Verify capability backend

Future Plans on Formally Secure Compilation

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Capability passing

Verify capability backend

Future Plans on Formally Secure Compilation

Preserve data confidentiality

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Future Plans on Formally Secure Compilation

Stronger Security Goals

Preserve data confidentiality

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Future Plans on Formally Secure Compilation

SPECTRE

Stronger Security Goals

Preserve data confidentiality
against micro-architectural side-channel attacks,
for compartmentalized programs in F*, C, or Wasm

Better Proof Techniques

Capability passing

Verify capability backend

Future Plans on Formally Secure Compilation

Stronger Security Goals

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Realistic Enforcement

Capability passing

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ARM Morello
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