Formally Verified Security

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New MPI for Security & Privacy
in Bochum

Formally Verification is Getting Real

Firefox

Mozilla shipping EverCrypt verified crypto library

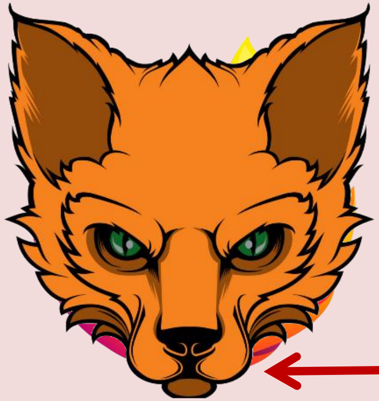
(also used by Microsoft, Linux, ...)

Formal verification milestone:

40.000+ lines of highly-efficient code, proved to be free of vulnerabilities, functionally correct, and side-channel resistant

Formal Verification is Still Limited

Firefox



20.000.000 lines
all unverified

Can we protect?

EverCrypt

40.000 lines of F*

insecure interoperability:

if Firefox is compromised it can break security of verified code

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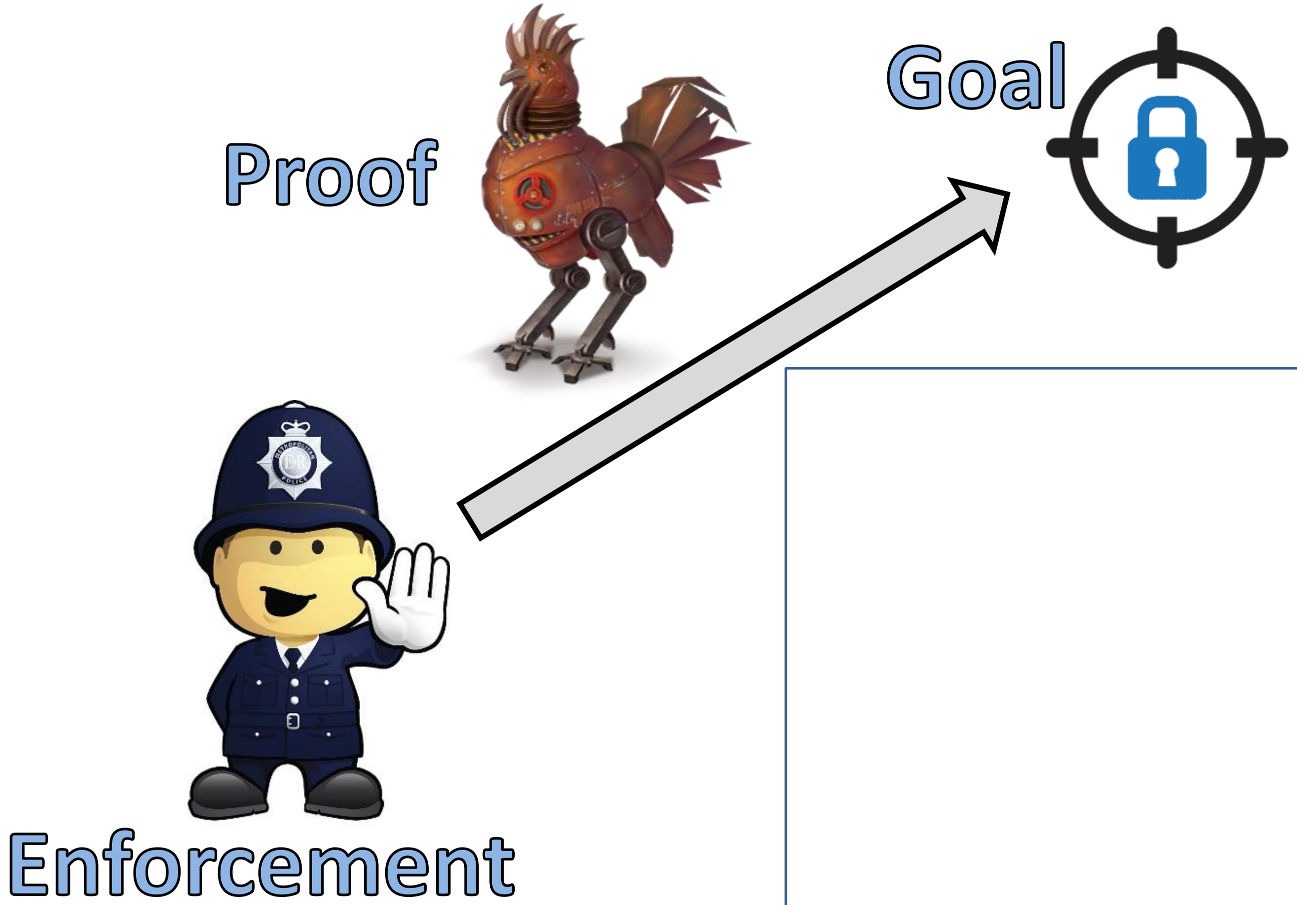


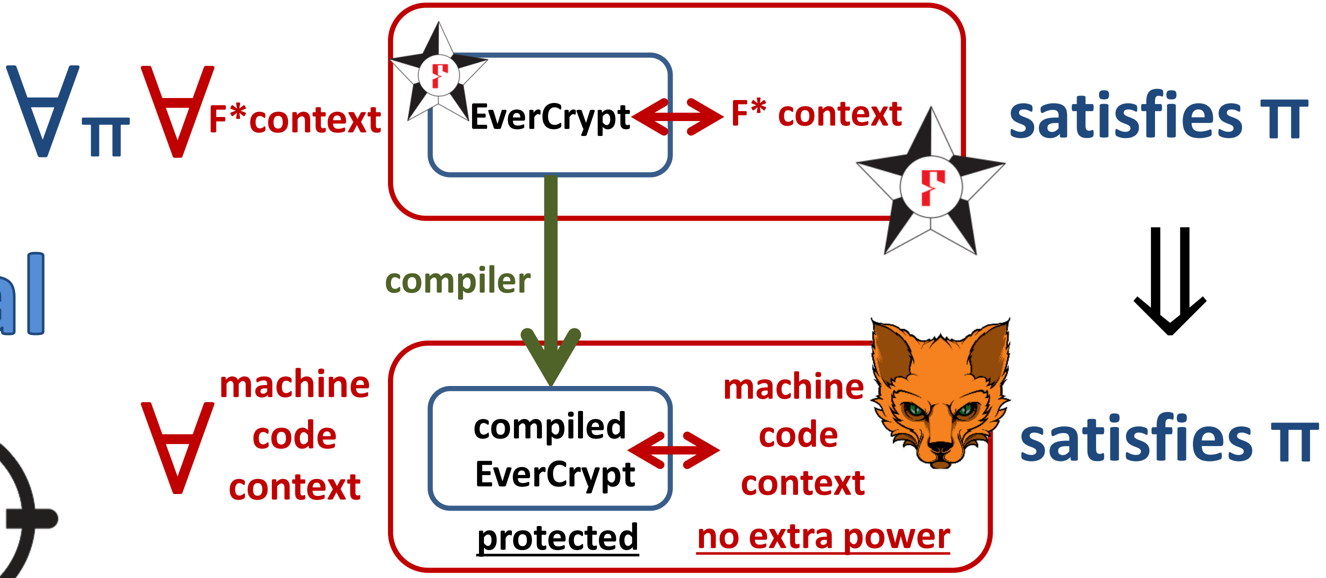
Proof

Goal

Enforcement

1. Security Goal

Formal security definition



$\forall_{\pi}$ $\forall$ F*context

EverCrypt ⟷ F* context

satisfies π

compiler

⇓

$\forall$ machine code context

compiled EverCrypt ⟷ machine code context

satisfies π

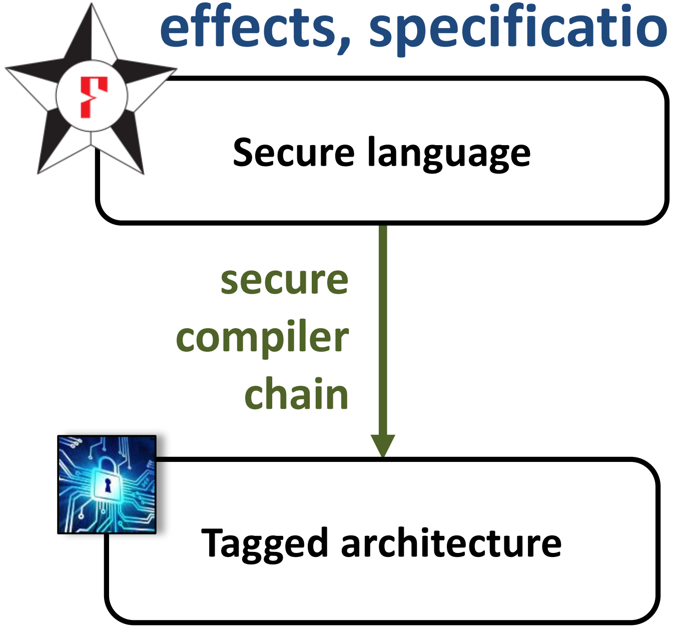
<u>protected</u>

<u>no extra power</u>

2. Security Enforcement

many cool abstractions:
types, modules, functions, effects, specifications, ...

to achieve our goal need to protect these abstractions all the way to machine code



Secure language

secure compiler chain

Tagged architecture

Hardware-accelerated enforcement

3. Security Proof

Formally verifying the security of this compilation chain

- such proofs **very difficult** (wrong conjectures survived for decades)
  and tedious (e.g., 250 pages for toy compiler)
- **more scalable proof techniques**
- **develop proofs as programs**
  - **machine-checked proofs in the Coq proof assistant**

- **simple prototype compiler already verified in Coq**
  - **working on making this realistic**

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