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SAINT-ETIENNE

COGITO

RUNTIME CODE GENERATION TO SECURE DEVICES

Damien Couroussé | CEA Grenoble

Workshop Interdisciplinaire sur la Sécurité Globale,
Paris 14 et 15 sept. 2017

PROJET FINANCÉ PAR L'ANR - PROJECT FUNDED BY ANR
ANR

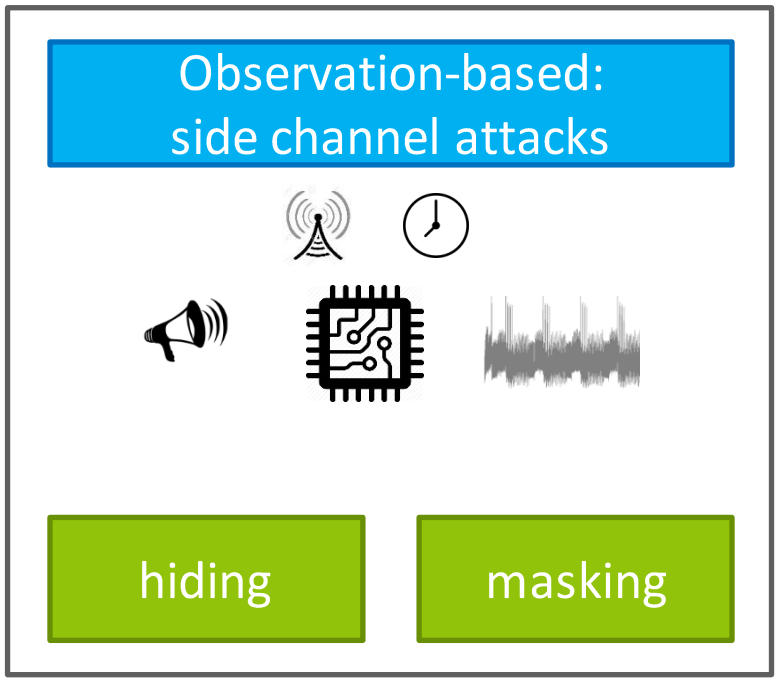
PROJECT OVERVIEW

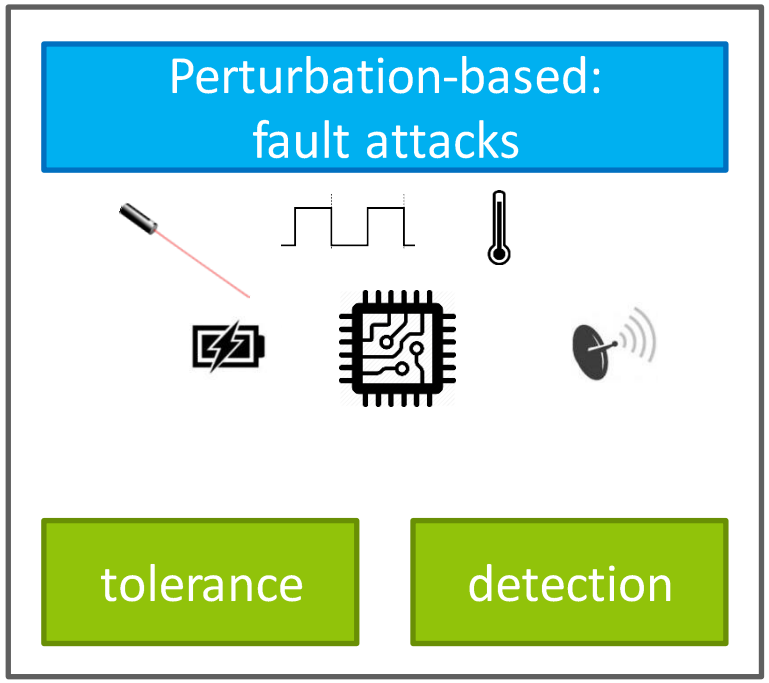
- **ANR INS 2013. 42 months -- October 2013 → March 2017**
- **Three institutes**
  - CEA
  - XLIM Limoges → INRIA Rennes – LHS
  - École Nationale Supérieure des Mines de Saint-Étienne
- **4 post-docs funded by the project**
  - Hassan Noura, CEA (2014-2015)
  - Hélène Le Bouder, INRIA Rennes (2015-2016)
  - Karim Abdellatif, ENMSE (2015-2016)
  - Abderrahmane Seriai, CEA (2016-2017)
- **Project participants**
  - Karim Abdellatif (ENMSE), Thierno Barry (CEA), Nicolas Belleville (CEA), Damien Couroussé (CEA), Philippe Jaillon (ENMSE), Jean-Louis Lanet (INRIA), Hélène Le Bouder (INRIA), Hassan Noura (CEA), Olivier Potin (ENMSE), Bruno Robisson (CEA), Abderrahmane Seriai (CEA)

PHYSICAL ATTACKS

One of the major threats against secure embedded systems

- The only effective class of attacks against crypto-systems
- Relevant in many cases against cyber-physical systems: bootloaders, firmware upgrade, reverse-engineering, etc.





- **One of the major threats against secure embedded systems**
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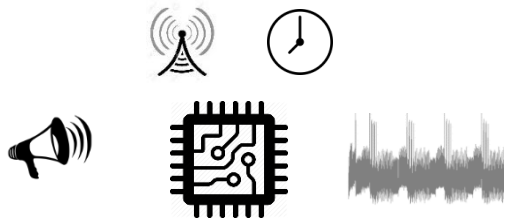
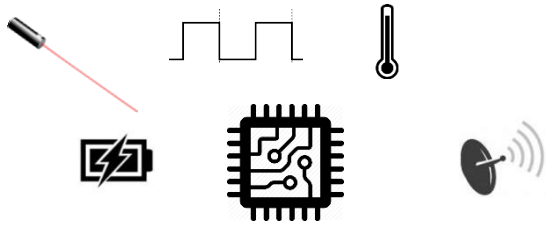
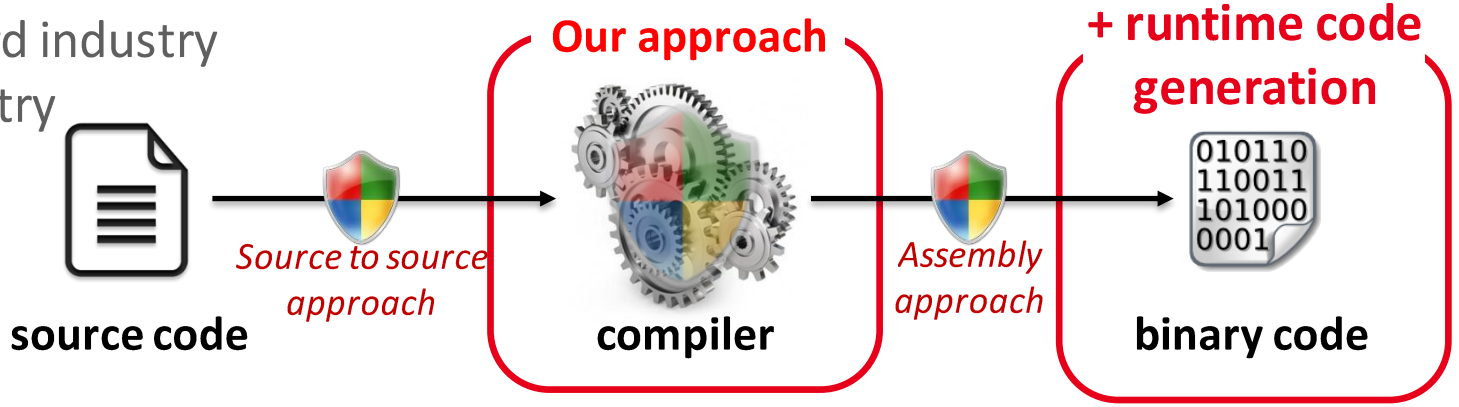
Observation-based: side channel attacks	Perturbation-based: fault attacks





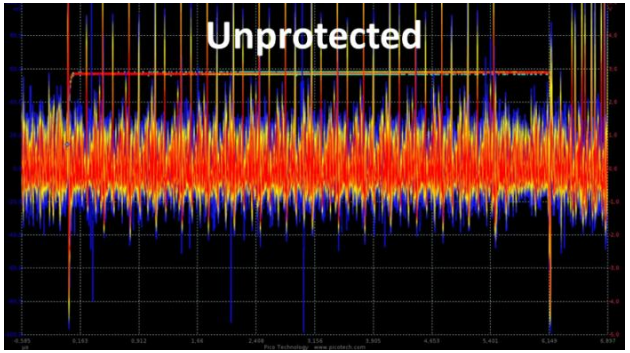
- **Application of software countermeasures**
  1. SmartCard industry
  2. IoT industry

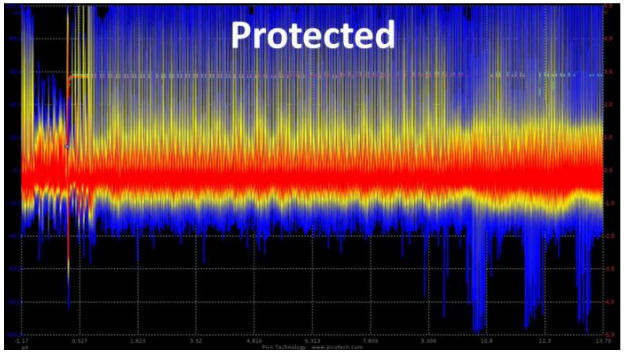


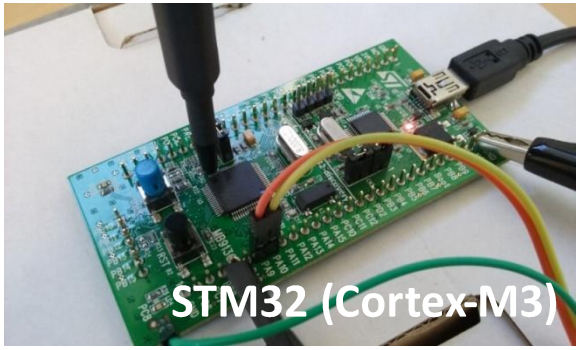
COGITO: CODE POLYMORPHISM

Code polymorphism: regularly changing the behavior of a (secured) component, at runtime, while maintaining unchanged its functional properties,

- Protection against physical attacks: side channel & fault attacks
  - Changes the **spatial** and **temporal** properties of the secured code
  - Can be combined with other state-of-the-Art HW & SW Countermeasures
- Implementation with runtime code generation







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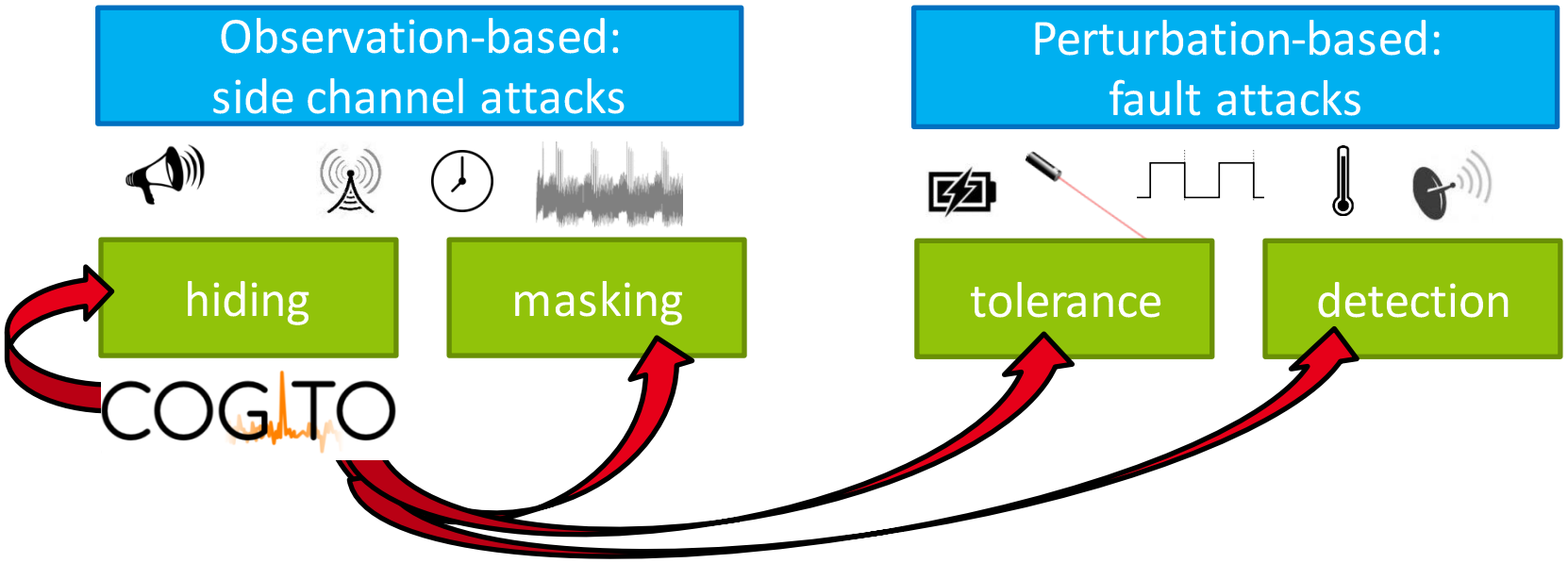
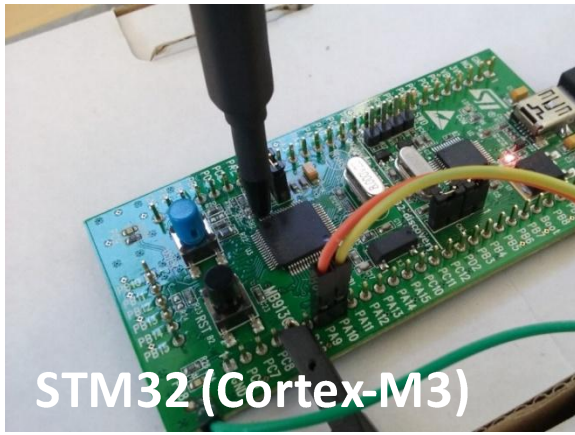


PROJECT CHALLENGES

- **Demonstrate applicability to constrained embedded systems (IoT, SmartCard…)**
  - Experiment target: ARM Cortex-M3 (32-bits), 8 kB RAM
  - Current dynamic compilation frameworks incur a too large overhead.
  - Solution: generate ad hoc runtime code generators



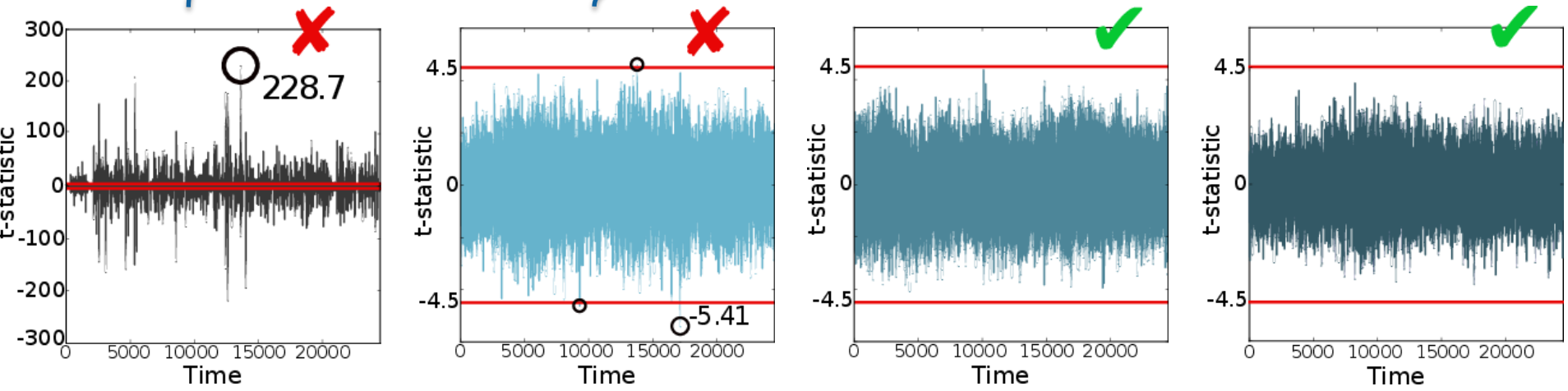
- **Automated application from C source code**
- **Small performance overhead**
- **Certification**
  - Polymorphism can be used in certified components (Collaboration with ANSSI)
- **Effectiveness against side-channel attacks**

ASSESSMENT OF SIDE-CHANNEL INFORMATION LEAKAGE

- **Polymorphism is a hiding countermeasure against side-channel attacks** – does not *remove* information leakage; *reduces* SNR only
- **However, information leakage is sufficiently blurred such that it is *not found* in observation traces, with a confidence level of 99.999%**
- **Configurable level of polymorphism**

CPA attack requires less than 50 traces

CPA attack requires more than 10^6 traces



Unprotected reference

Low polymorphic variability

Medium polymorphic variability

High polymorphic variability

t-tests results (2x 10000 observations)

TAKE AWAY MESSAGES

- Proof-of-concept implementation of code polymorphism
  - A practical solution, even on constrained embedded systems, to diversify the runtime behaviour of a software component.
  - Increases the resistance against side channel attacks
  - Application of polymorphism can be fully automated
- Code polymorphism is compatible with certification standards
- On-going work
  - Combination of polymorphism with other countermeasures
  - Validation of a polymorphic component

COGITO – Runtime Code Generation to Secure Devices

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