Enhanced Processor Defence Against Physical and Software Threats by Securing DIFT Against Fault Injection Attacks

PhD Dissertation Defense

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Outline

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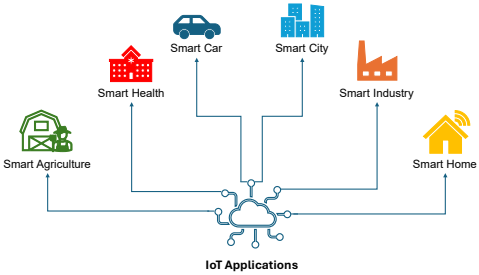
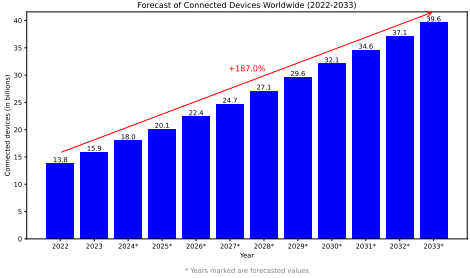
Context: Embedded Systems and IoT

Internet of Things (IoT)

- Wide range of application
- Fast growing market with exponential usage
- Rely on sensors depending on their use
- Collect and share data
- Manipulation of critical data
- Increasingly vulnerable to multiple threats





Motivations: IoT Under Threats

Threats

- Software threats: malwares, memory overflow attacks, SQL injection, etc
- Network threats: DDoS, Man-In-The-Middle, jamming, etc
- Hardware threats: physical attacks such as reverse engineering, Side-Channel Attacks (SCA), Fault Injection Attacks (FIA)

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Software threats: Information Flow Tracking

- Security mechanism
- Protection against software attacks (e.g.: *buffer overflow*, *format string*, *SQL injections*, ...) [1, 2]
- Static or Dynamic
- Software, Hardware or Hybrid
- Hardware DIFT: off-core, off-loading core, in-core

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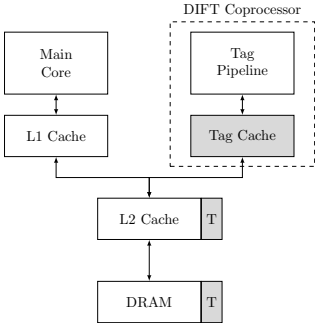

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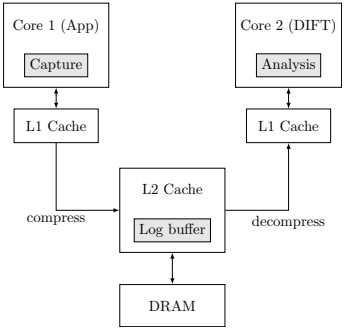

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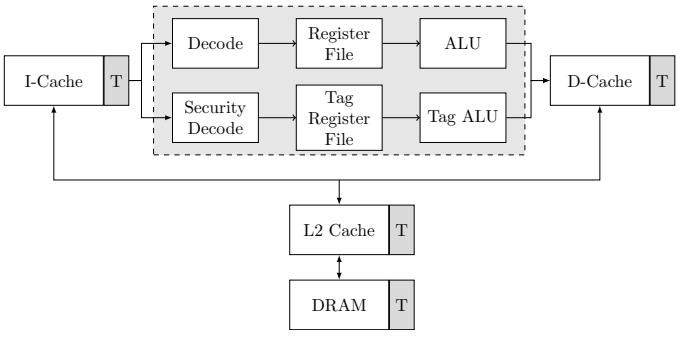
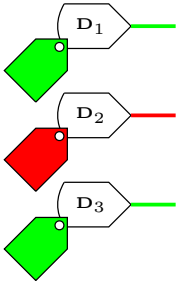


Dynamic Information Flow Tracking

Three steps

- Tag initialisation
- Tag propagation
- Tag check



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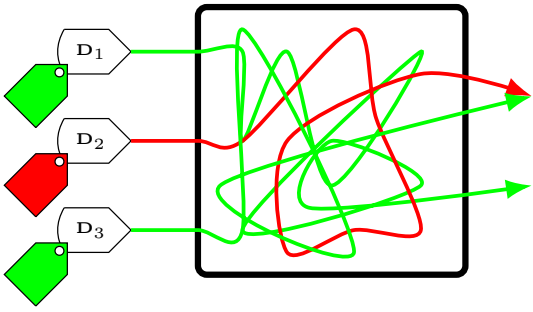

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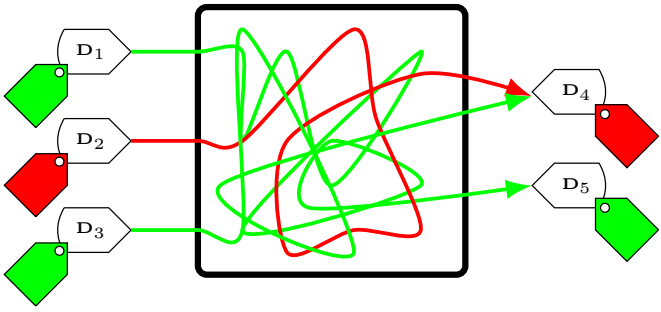

Hardware threats: Physical Attacks

- Reverse Engineering: process of information retrieval from a product by analysing and understanding the design, functionality, and operation of existing hardware
- Side-Channel Attacks: exploit information leakages on the circuit behaviour
- Fault Injection Attacks: involve deliberately introducing one or more fault(s) into the system to observe its behaviour and identify potential vulnerabilities.

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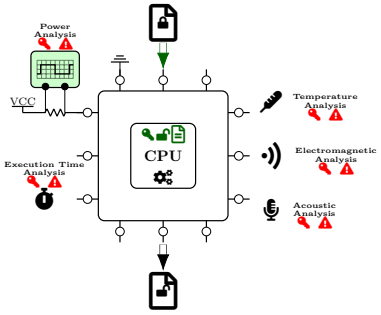

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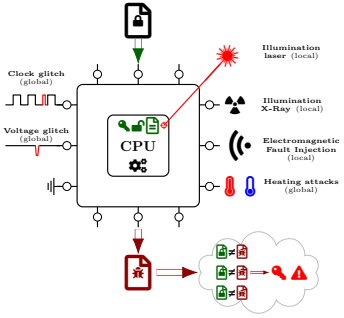

Issue

How can we maintain maximum protection against software attacks in the presence of physical attacks?

Objectives of this PhD Thesis

Contributions

- Provide a robust security mechanism against software and hardware threats.
- Take into account Fault Injection Attacks
- Propose lightweight countermeasures against FIA
- Take into account constraints, such as area and performance overhead

Outline

D-RI5CY

Vulnerability Assessment

Outline

Introduction

Parity codes

Simple Parity

Hamming Code

SECDED

Outline

Experimental setup

Outline

Conclusion

Perspectives

Publications

Publications

International peer-reviewed conferences

1. **William Pensec**, Vianney Lapôtre, and Guy Gogniat. 2023. Another Break in the Wall: Harnessing Fault Injection Attacks to Penetrate Software Fortresses. In Proceedings of the First International Workshop on Security and Privacy of Sensing Systems (SensorsS&P), 2023. [3]
2. **William Pensec**, Francesco Regazzoni, Vianney Lapôtre, and Guy Gogniat. Defending the Citadel: Fault Injection Attacks Against Dynamic Information Flow Tracking and Related Countermeasures. 2024 IEEE Computer Society Annual Symposium on VLSI (ISVLSI), 2024, pp. 180-185. [4]
3. **William Pensec**, Vianney Lapôtre, and Guy Gogniat. Scripting the Unpredictable: Automate Fault Injection in RTL Simulation for Vulnerability Assessment. 2024 27th Euromicro Conference on Digital System Design (DSD), 2024. [5]

Enhanced Processor Defence Against Physical and Software Threats by Securing DIFT Against Fault Injection Attacks

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Thank you for your attention.

References

References

[1] Christopher Brant et al. “Challenges and Opportunities for Practical and Effective Dynamic Information Flow Tracking”. In: *ACM Computing Surveys* 55.1 (Nov. 2021). ISSN: 0360-0300. DOI: 10.1145/3483790.

[2] Wei Hu, Armaiti Ardeshiricham, and Ryan Kastner. “Hardware Information Flow Tracking”. In: *ACM Computing Surveys* (2021). DOI: 10.1145/3447867.

[3] William Pensec, Vianney Lapôtre, and Guy Gogniat. “Another Break in the Wall: Harnessing Fault Injection Attacks to Penetrate Software Fortresses”. In: *Proceedings of the First International Workshop on Security and Privacy of Sensing Systems*. SensorsS&P. Istanbul, Turkiye: Association for Computing Machinery, 2023, pp. 8–14. DOI: 10.1145/3628356.3630116.

[4] William PENSEC et al. “Defending the Citadel: Fault Injection Attacks Against Dynamic Information Flow Tracking and Related Countermeasures”. In: *2024 IEEE Computer Society Annual Symposium on VLSI (ISVLSI)*. Knoxville, United States, July 2024, pp. 180–185. DOI: 10.1109/ISVLSI61997.2024.00042.

[5] William Pensec, Vianney Lapotre, and Gogniat Guy. “Scripting the Unpredictable: Automate Fault Injection in RTL Simulation for Vulnerability Assessment”. In: *27th Euromicro Conference Series on Digital System Design (DSD)*. Sorbonne University. Paris, France, Aug. 2024. URL: https://hal.science/hal-04683084.

[6] Transforma Insights; Exploding Topics. *Number of Internet of Things (IoT) connections worldwide from 2022 to 2023, with forecasts from 2024 to 2033*. Online. Accessed 13 August 2024. 2024. URL: https://www.statista.com/statistics/1183457/iot-connected-devices-worldwide/.