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Covert Communications in Heterogeneous SoCs

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► **To cite this version:**

Carlos Andres Lara-Nino, Lilian Bossuet. Covert Communications in Heterogeneous SoCs. École d'hiver Francophone sur les Technologies de Conception des Systèmes Embarqués Hétérogènes (FETCH), Université Libre de Bruxelles, Feb 2024, Maillen, Belgium. hal-04467933

HAL Id: hal-04467933

<https://hal.science/hal-04467933>

Submitted on 20 Feb 2024

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fεtCh 2024

Communications cachées dans des SoC hétérogènes

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École d'hiver Francophone sur les Technologies de Conception des Systèmes Embarqués Hétérogènes (FETCH)

Maillen, Belgique

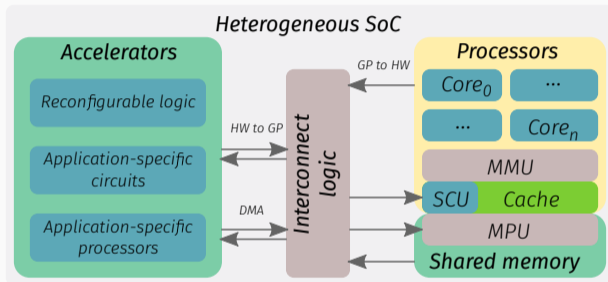
Février 7-9, 2024

Université Jean Monnet Saint-Etienne, CNRS, Laboratoire Hubert Curien

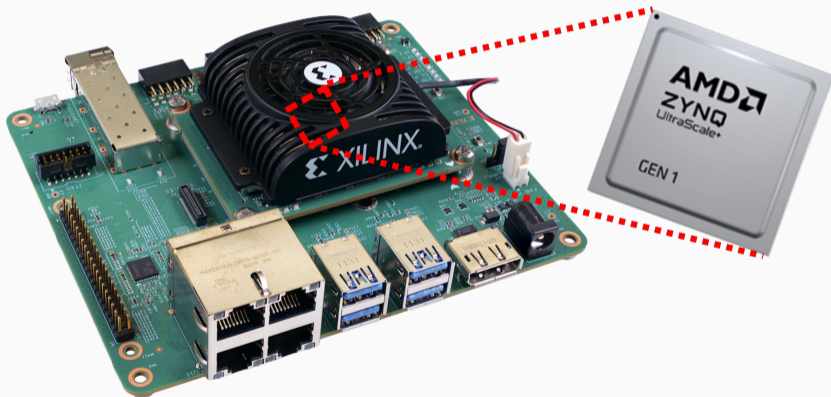
UMR 5516, F-42023, SAINT-ETIENNE, France

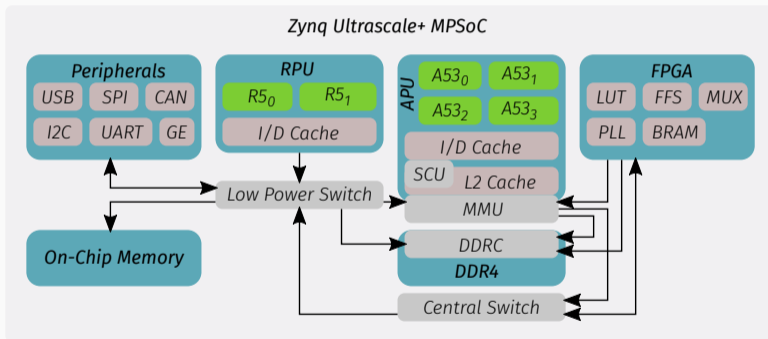


System(s)-on-a-Chip



A **system-on-a-chip (SoC)** is a device which integrates multiple processing elements in the same die. An **heterogeneous SoC** may feature different processors, hardware accelerators, and even an FPGA.





Intrinsic channels

The shared resources of the SoC may be leveraged to covertly transfer information.

Attack goals

- Bypass isolation policies
- Change the nature of the channel¹
- Enable more complex attacks²

¹Benhani, E.M. & Bossuet, L. (2018). DVFS as a security failure of TrustZone-enabled heterogeneous SoC. In *25th IEEE International Conference on Electronics, Circuits and Systems (ICECS)* (pp. 489-492). IEEE.

²Fellah-Touta, A., Bossuet, L., & Lara-Nino, C. A. (2023). Combined Internal Attacks on SoC-FPGAs. In *2023 IEEE European Symposium on Security and Privacy Workshops (EuroS&PW)* (pp. 281-286). IEEE.

Require: k , an encryption key

Require: p , a plaintext to be encrypted

covert_bit_set()

AES(p, k)

covert_bit_clear()

{Pull trigger}

{Release trigger}

Require: k , an encryption key

Require: p , a plaintext to be encrypted

Require: f, f' , two core frequencies

$\text{cpu_freq} \leftarrow f'$

$\text{AES}(p, k)$

$\text{cpu_freq} \leftarrow f$

{Pull trigger}

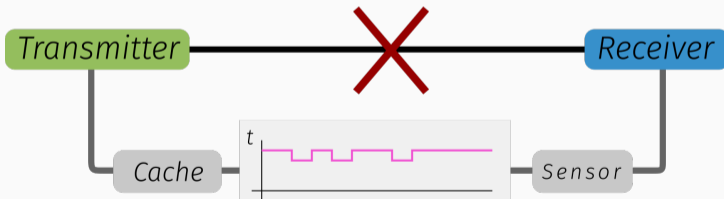
{Release trigger}















Challenges

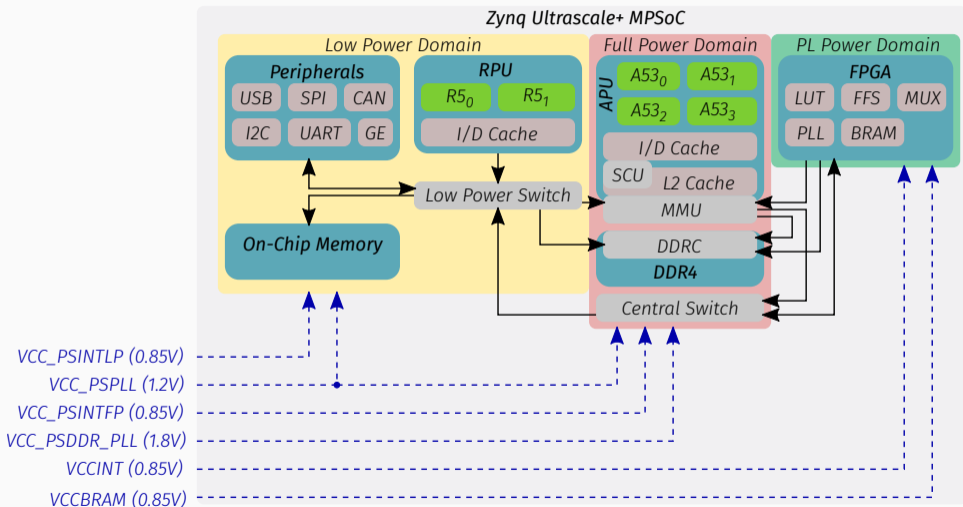
- Many intrinsic channels available
- Implementation strategies change from one platform to another
- Mitigating the attack, once discovered, is complicated

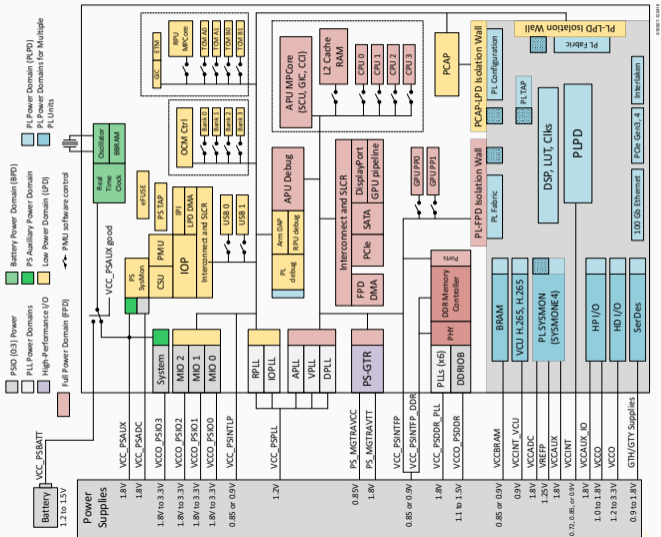


Potential approaches

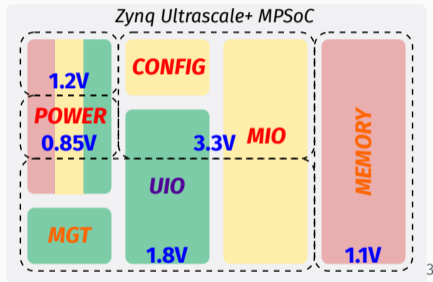
- Conventional study of architectural vulnerabilities
- Implementation of stricter isolation rules
- Use of pre-silicon tooling for the study of intrinsic channels

Case studies

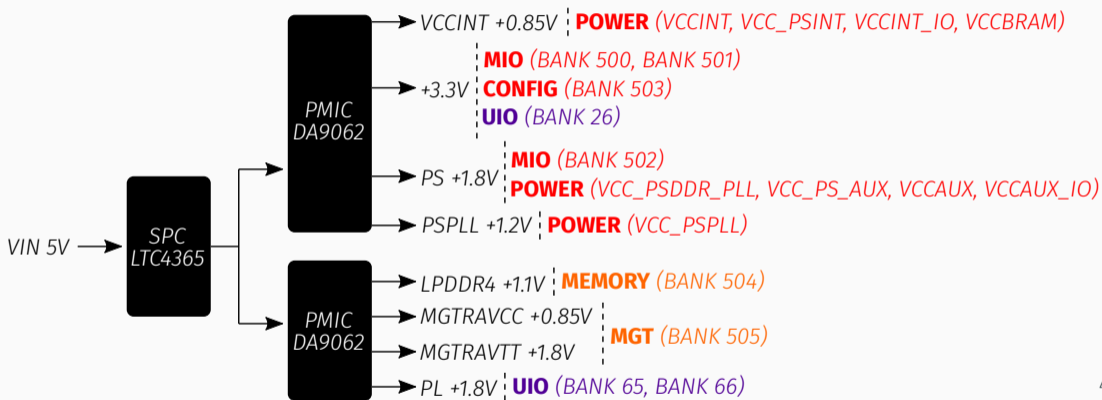




ARM 9001



³ https://shop.trenz-electronic.de/Download/?path=Trenz_Electronic/Development_Boards/TE0802/REV02/Documents



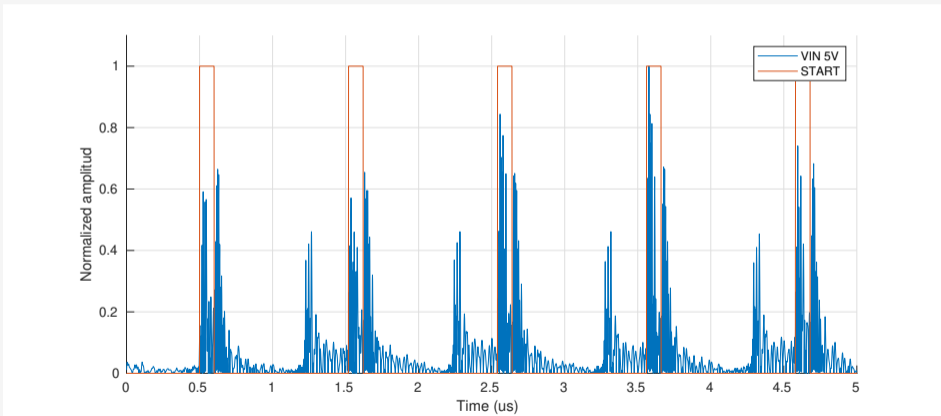
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⁴ https://shop.trenz-electronic.de/Download/?path=Trenz_Electronic/Development_Boards/TE0802/REV02/Documents

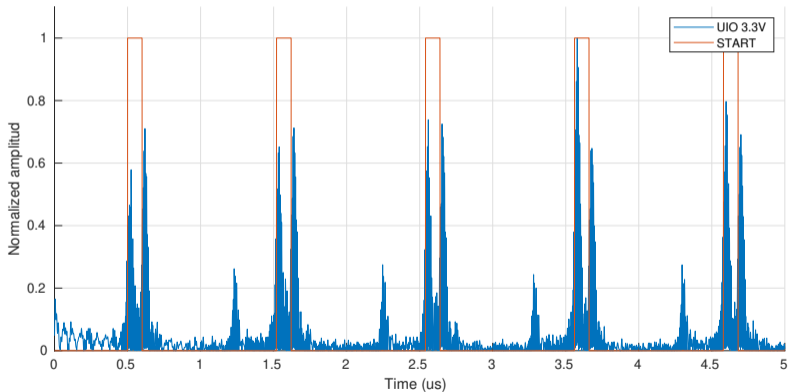
Considerations

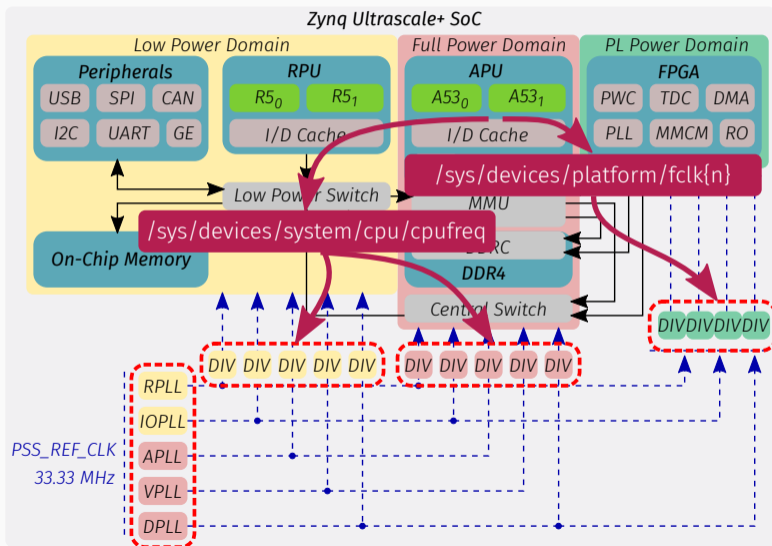
- Transmitter: Hardware accelerator in the FPGA
- Receiver: External
- Shared resource: **V_PL**

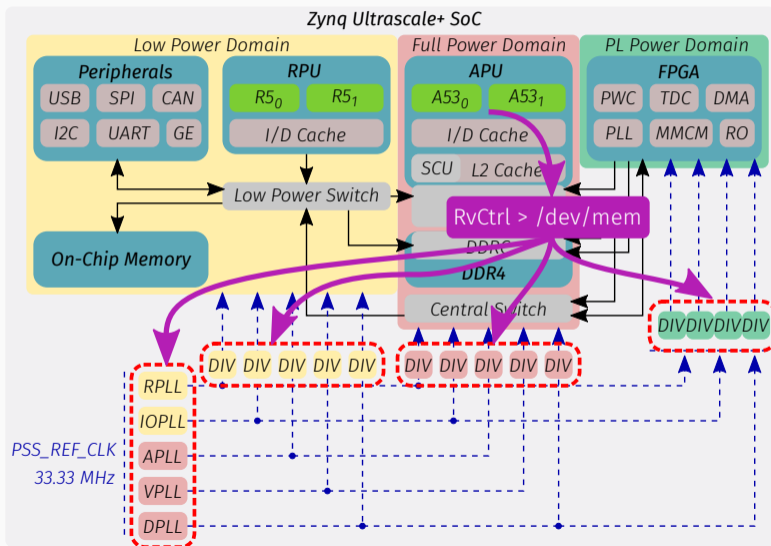
PDN intrinsic channel



PDN intrinsic channel



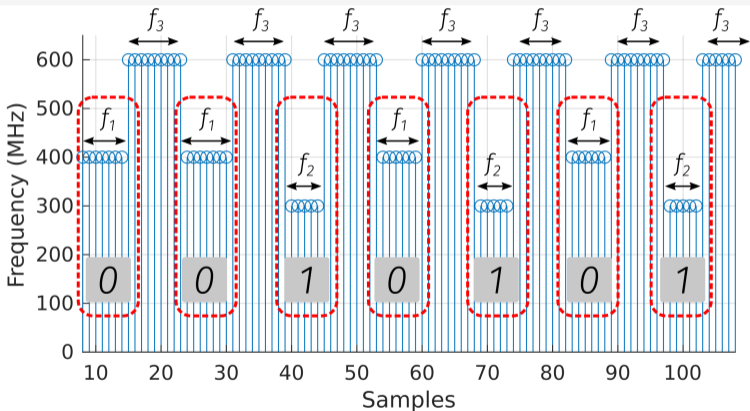




Considerations

- Transmitter: User application coded in C
- Receiver: User application coded in C
- Shared resource: **cpufreq driver**

DVFS intrinsic channel



Final remarks

- Intrinsic channels have niche applications but are difficult to mitigate
- Their transmission rate is low, but the volume of information required is not high
- We need to rethink the design of SoC platforms to introduce more effective isolation strategies



This work has been supported by the French government in the framework of the *France 2030* initiative under project ARSENE (ANR-22-PECY-0004).

Thanks !
