Fault attacks on System On Chip

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Context

Smartcard

Mobile device

Same services, different securities

Context

Based on a Secure Element

- Simple SoC
- Designed for security
- Evaluated

Based on a Computer on Chip

- Complex SoC
- Designed for performance
- Adding TEE[1] for software security

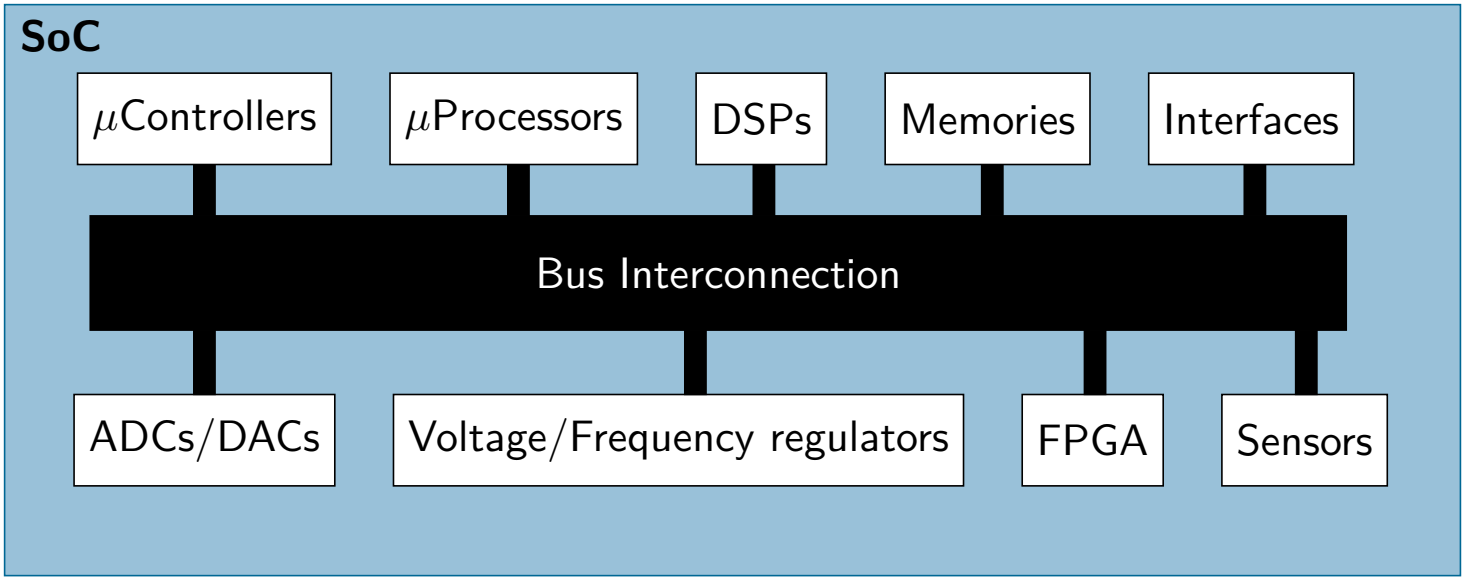
[1] **Trusted Environment Execution**

Hardware attacks ?

Fault attacks

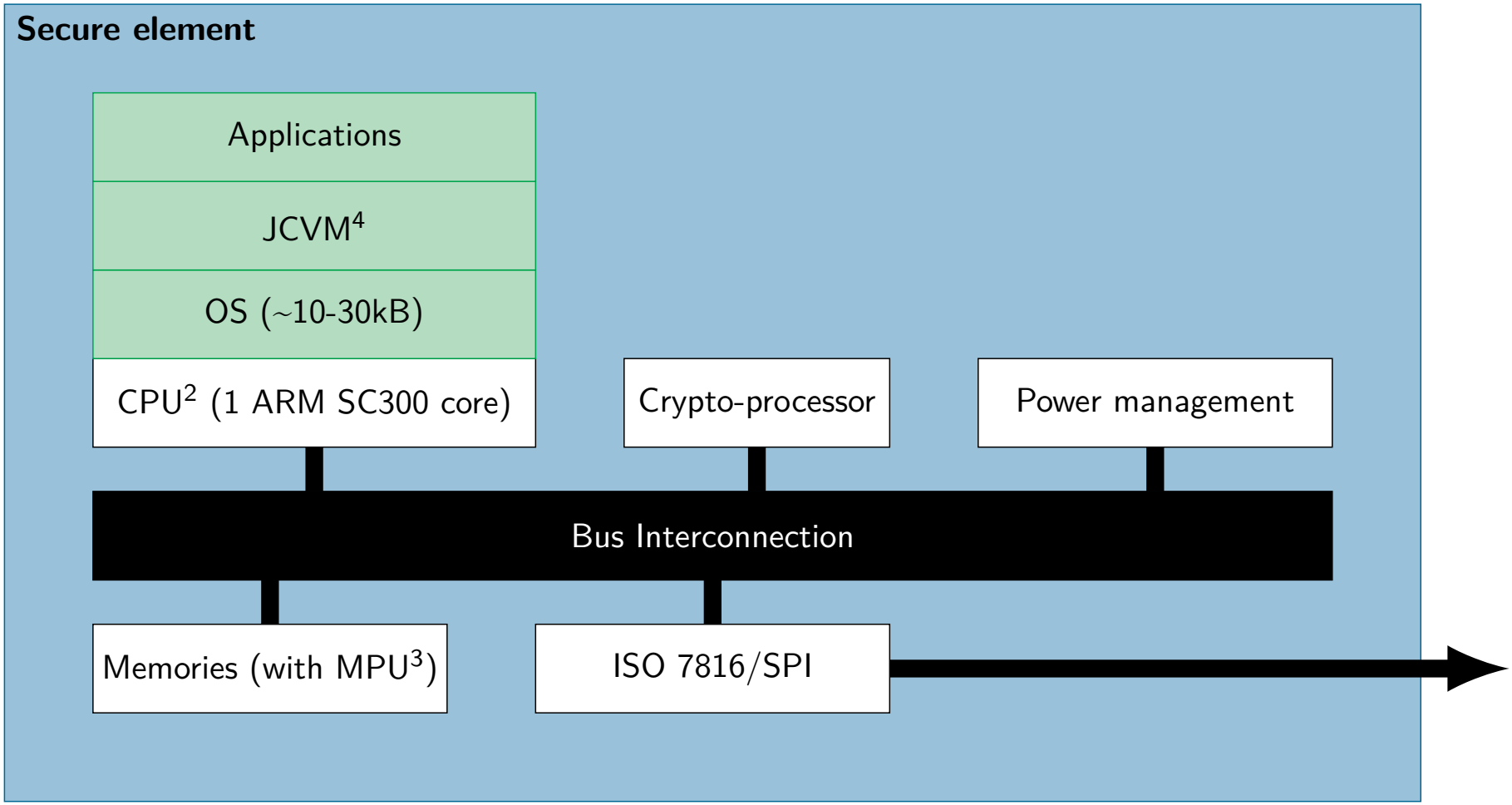
- Laser/EM injection
- Clock glitch
- Voltage glitch
- Rowhammer
- Heating
- Body biasing

What is a System on Chip ?



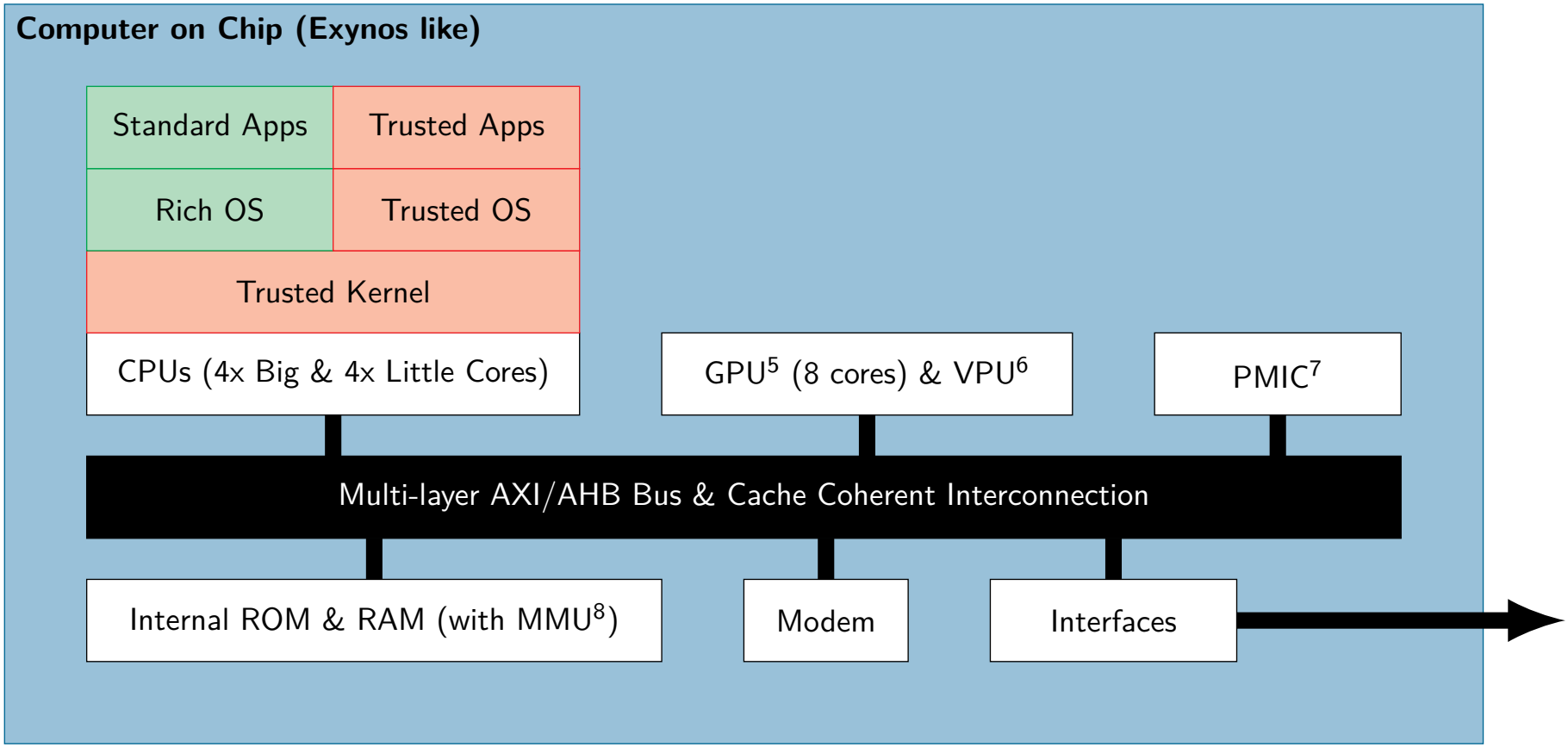
- Integrate all components on the same chips
- Reduce power consumption
- Reduce chip size

What is a Secure Element ?



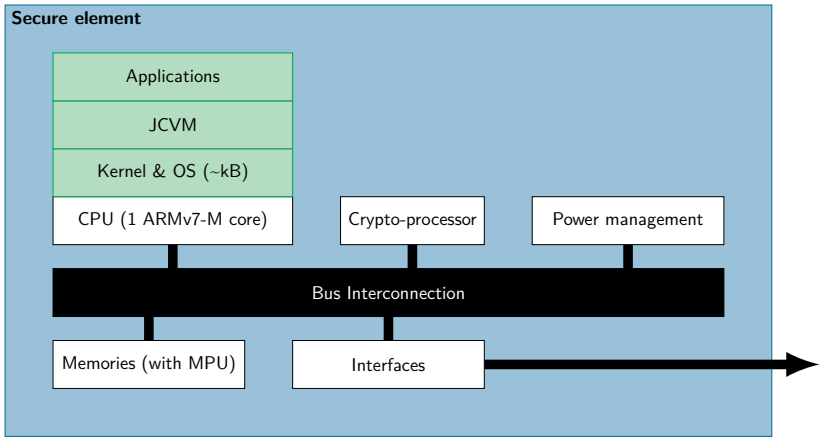
[2] **Central Processing Unit**
[3] **Memory Protection Unit**
[4] **Java Card Virtual Machine**

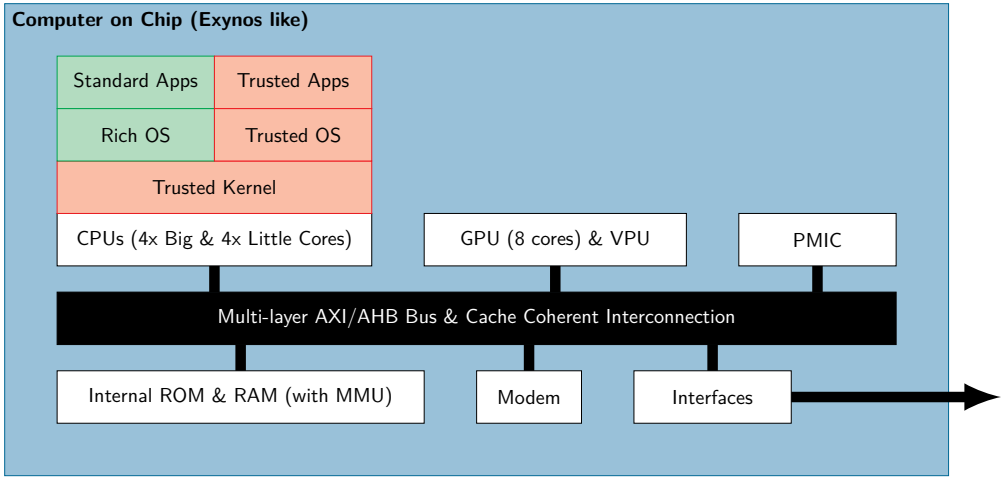
What is a Computer on Chip ?



[5] **Graphical Processing Unit**
[6] **Video Processing Unit**
[7] **Power Management Integrated Circuit**
[8] **Memory Management Unit**

Secure element vs Computer on Chip



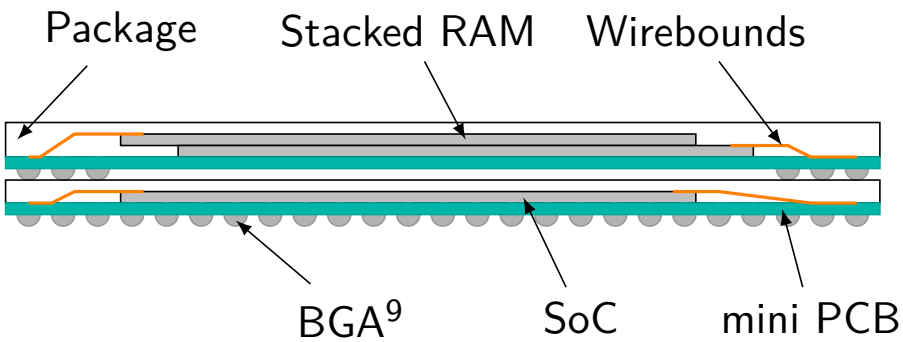


- Run at 4 to 60MHz
- Not multithreaded
- Fine engraving $>$ 40 nm
- Constant Voltage & Frequency
- Trusted hardware & Trusted apps only
- Hardware mitigations

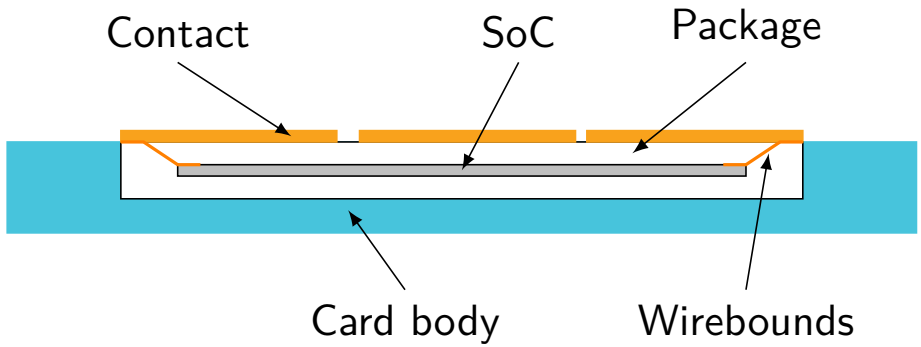
- Run at 300MHz to 3Ghz
- Multithreaded
- Fine engraving $<$ 20 nm
- Dynamic Voltage & Frequency management
- Trusted Environment Execution
- No hardware mitigations

The packaging

Computer on Chip package on package



Secure element package



[9] **Ball Grid Array**

Assets to protect

- Cryptographic secrets and operations
- Secure boot
- Memory partitioning
- Execution flow integrity
- Trusted part isolation

Unknowns

- Repeatability ?
- Design impact ?
- Technology impact ?
- New attack paths ?

Soooo let's start !

- Computer on Chip $\rightarrow$ software security only
- Hardware quite similar with Secure Elements
- Some attacks already exist:
  1. Evaluate their difficulty
  2. Push some uncompleted attacks
  3. Find new paths

Known attacks

Injection medium	Physical target	Software target	Software security
Software	RAM	Virtual to physical translation table	Memory partitioning
Glitch voltage	Clock	Key	Cryptography
Laser	Register	Instruction	Secure boot
EM	Bus	Return value	Execution flow integry
	Cache	Program counter	
	MMU	User rights	
	Pipeline		

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Project Zero attack/Drammer (2015 - 2016) [Vee+16]

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Project Zero NaCl/Rowhammer on TrustZone (2015) [Car17]

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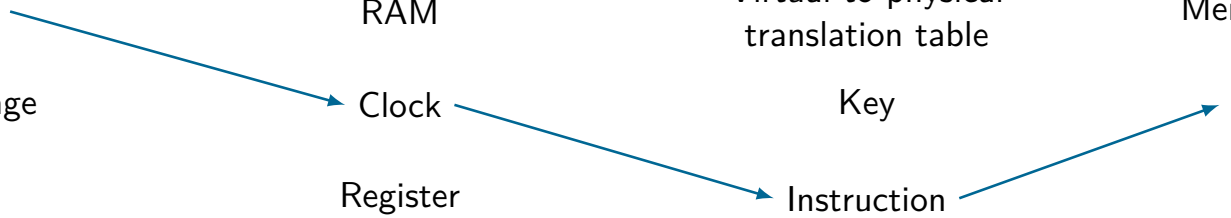
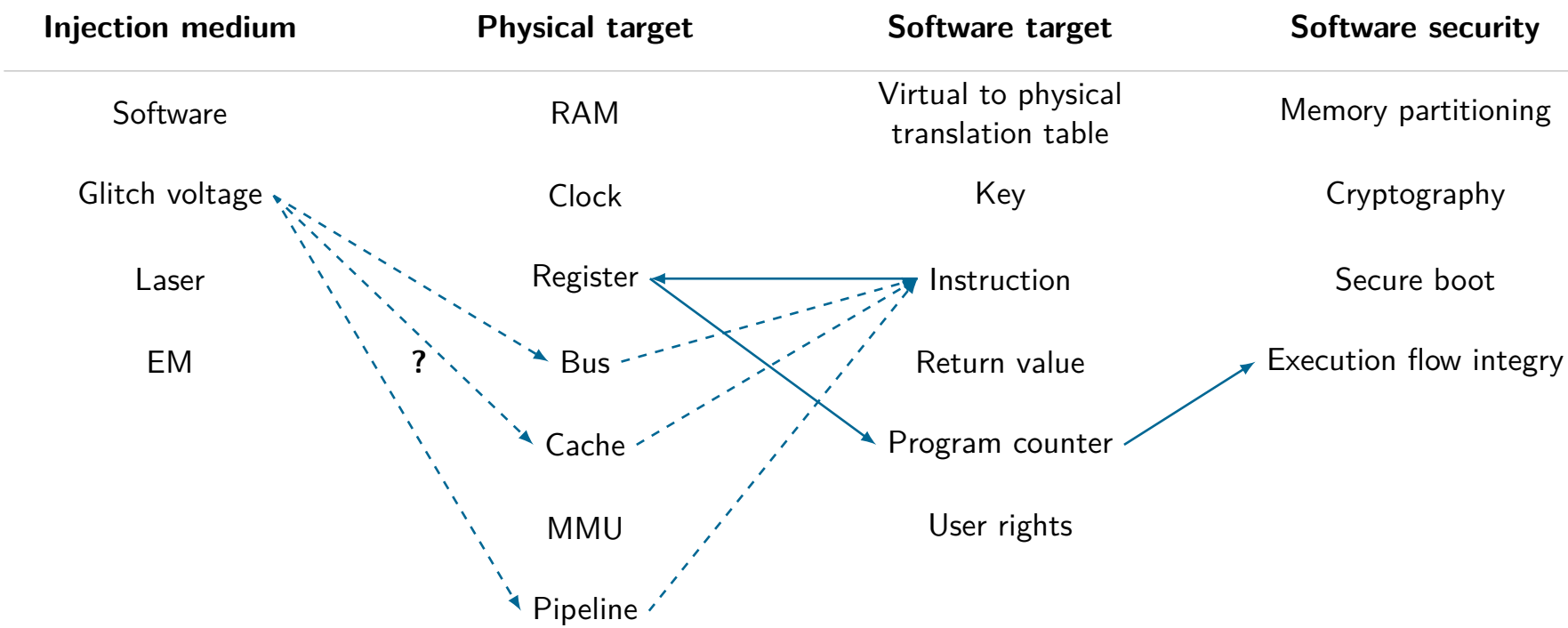


ClkScrew (2017) [AS17]

Known attacks



Controlling PC on ARM (2016) [TSW16]

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Attack on PS3

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Attack on Xbox 360 (2015) [Bla15]

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Laser induced fault on smartphone (2017) [Vas+17]

Conclusion

- Migration of services from Secure Element to Computer on Chip
- Hardware security gap
  - SE is a full trusted environment
  - Computer on chip integrate a software trusted environment
- Invasive/Semi-invasive attacks feel harder on Computer on Chip
- New attack paths

Questions?

References

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[Bla15] BlackHat. "XBOX 360 Glitching on fault attack". Nov. 2015.

[Car17] Pierre Carru. "Attack TrustZone with Rowhammer". In: eshard. 2017.

[TSW16] Niek Timmers, Albert Spruyt, and Marc Witteman. "Controlling PC on ARM Using Fault Injection". In: *2016 Workshop on Fault Diagnosis and Tolerance in Cryptography, FDTC 2016, Santa Barbara, CA, USA, August 16, 2016*. IEEE Computer Society, 2016, pp. 25–35. DOI: 10.1109/FDTC.2016.18.

[Vas+17] Aurélien Vasselle et al. "Laser-induced fault injection on smartphone bypassing the secure boot". In: (Sept. 2017).

[Vee+16] Victor van der Veen et al. "Drammer: Deterministic Rowhammer Attacks on Mobile Platforms". In: *Proceedings of the 2016 ACM SIGSAC Conference on Computer and Communications Security, Vienna, Austria, October 24-28, 2016*. Ed. by Edgar R. Weippl et al. ACM, 2016, pp. 1675–1689. DOI: 10.1145/2976749.2978406.