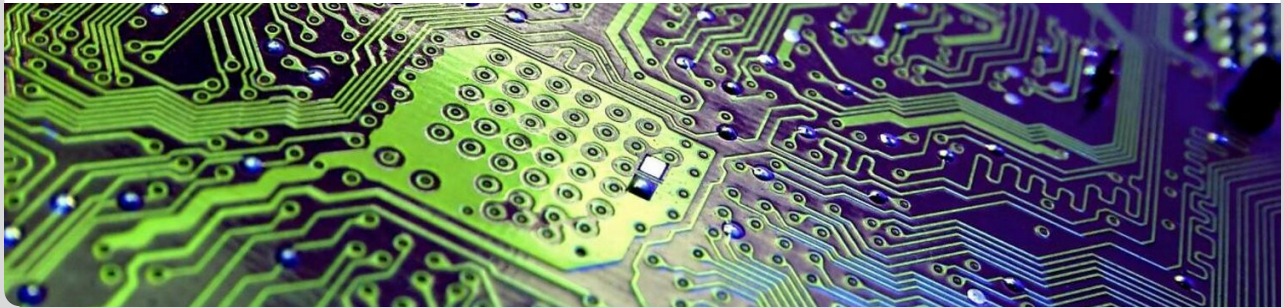
Karlsruhe Institute of Technology

Secure sharing of FPGAs in the Cloud: New Challenges at the Technology Level

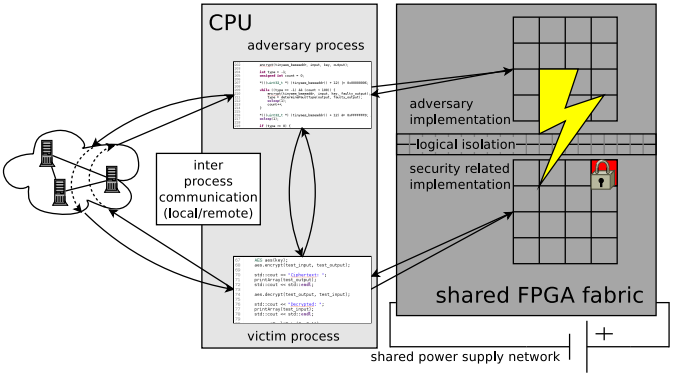
Fall School on Nano-Electronics for Secure Systems 2021

Jonas Krautter, Dennis R. E. Gnad, Mehdi B. Tahoori | 10.11.2021

ITEC – CHAIR OF DEPENDABLE NANO COMPUTING (CDNC)



Threat Model



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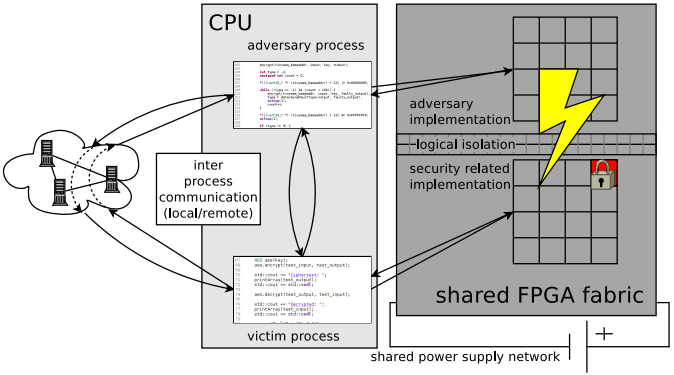

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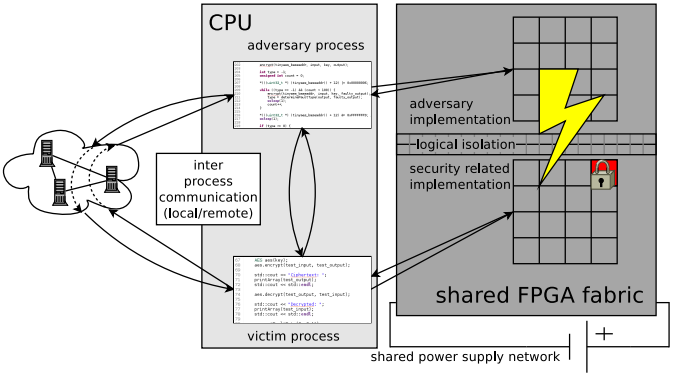

- Attacker and victim design **logically isolated**
- Shared FPGA fabric ⇒ **Shared Power Supply Network**
- ⇒ **Fault attacks** from one design to the other

Related work

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- BRAM collisions[4] or AES modules[5] can induce faults in simple logic
- Seemingly benign logic can be used to precisely inject faults into AES[6]

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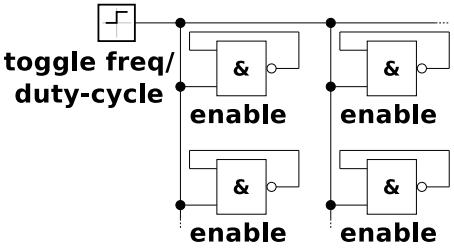
Voltage Virus Logic



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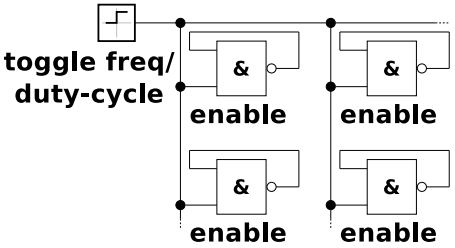

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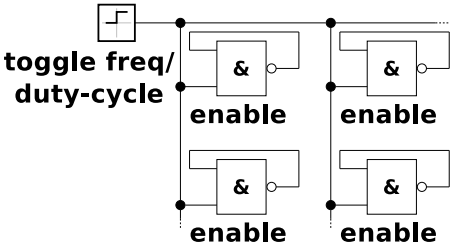

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- Gate switching ⇒ Current variation ⇒ Voltage fluctuations
- RO grid additionally toggled in a very specific way

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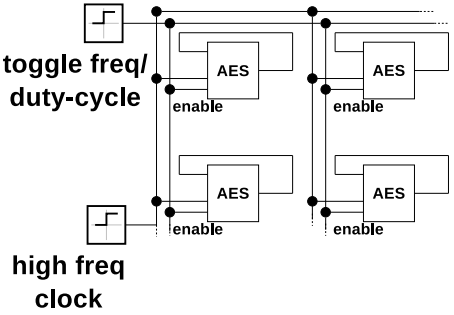

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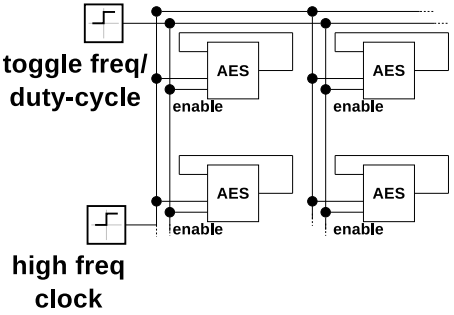

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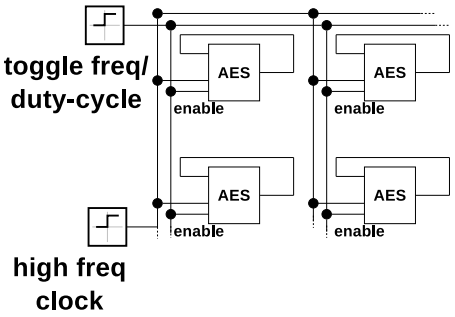

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- Again: Common enable signal for synchronized toggling

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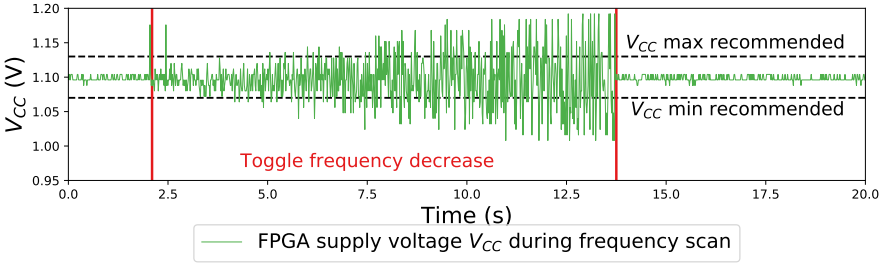

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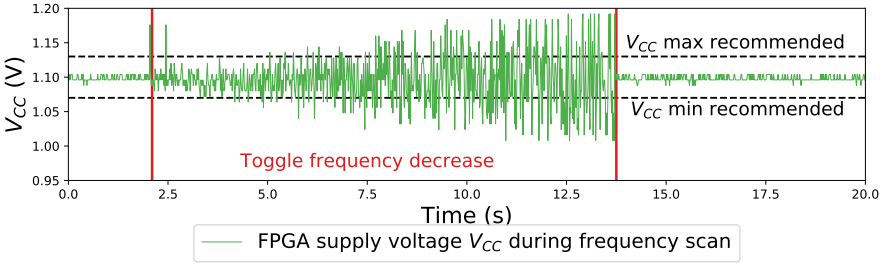

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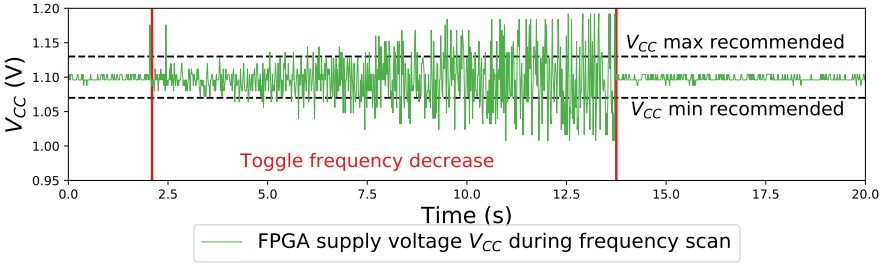

- Toggle signal controls the timing and intensity of the voltage drop
- Both frequency and duty-cycle have an impact
- $\Rightarrow$ **Calibration** of fault injection parameters required

Fault Attack on AES

- Differential Fault Analysis on AES[3]
- Differential $\Rightarrow$ **Pairs** (c, c') of correct and incorrect ciphertexts

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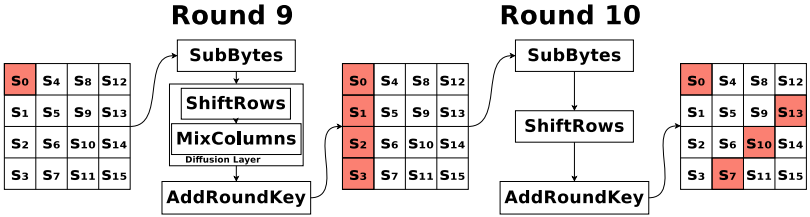

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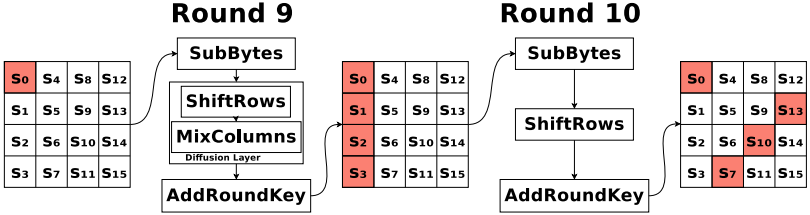

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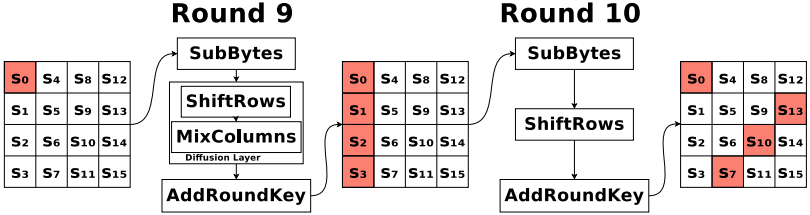

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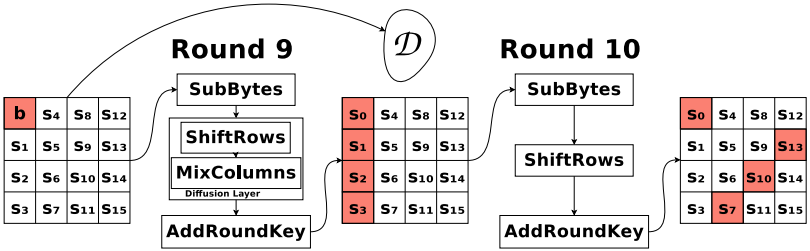

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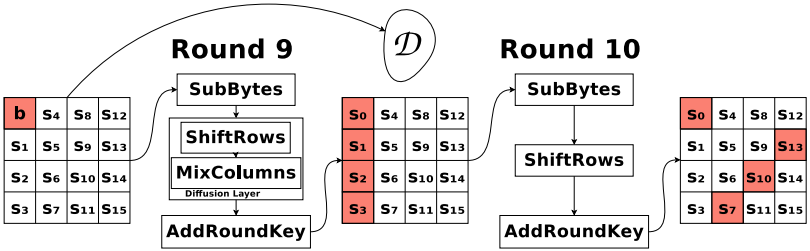

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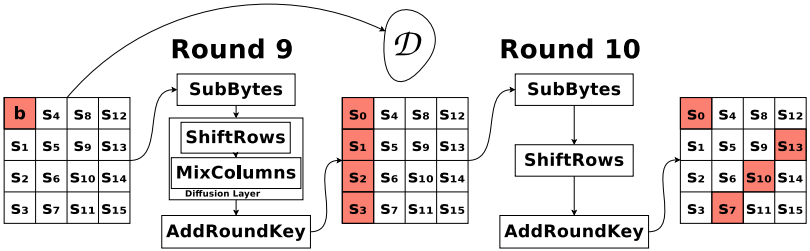

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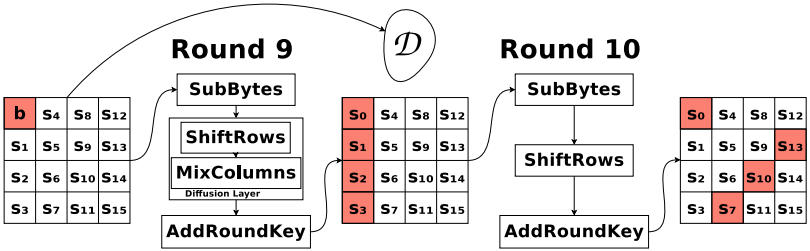

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- Compute these differences into a set $\mathcal{D}$

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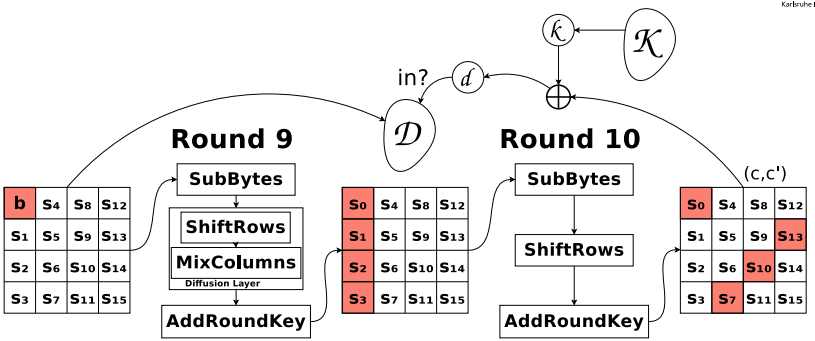

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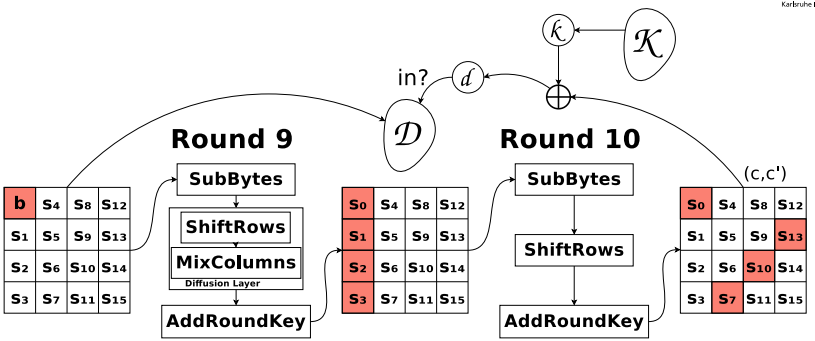

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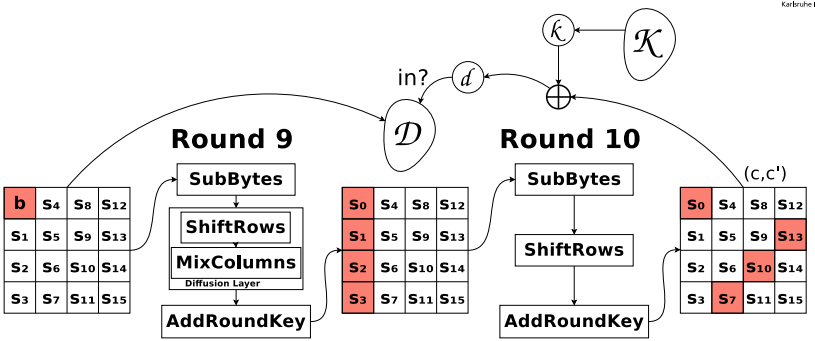

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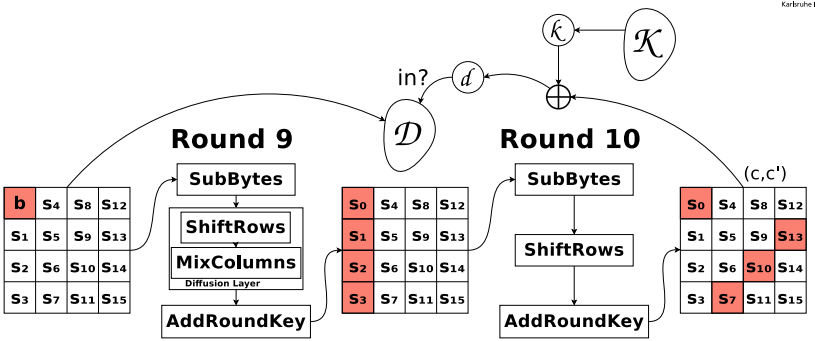

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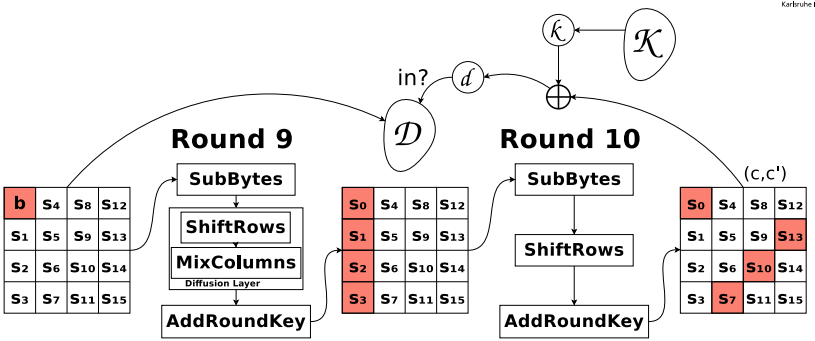

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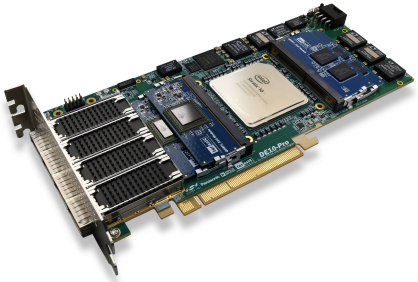
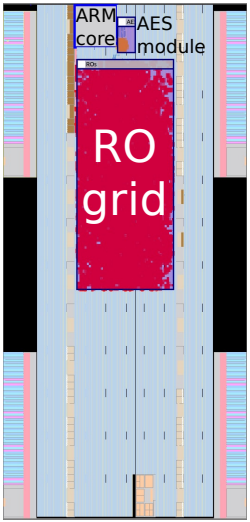
- Repeat with a fresh pair until one key candidate remains

Edge and Cloud Devices

Terasic DE10-Pro – Intel Stratix 10 (2.8M LUTs):





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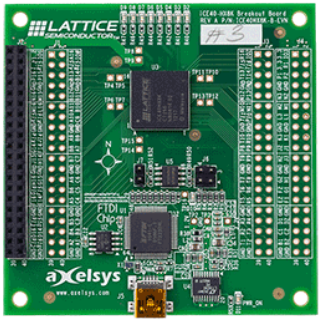
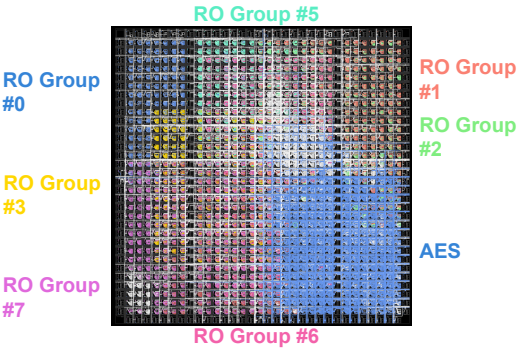
Lattice iCE40-HX8K Breakout Board (8K LUTs):





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- $\Rightarrow$ We need to adapt injection parameters to achieve precise injection
- $\Rightarrow$ Live-Demo on Intel Stratix 10

Thank you for your attention!

Questions? Write us an email!

{jonas.krautter,dennis.gnad,mehdi.tahoori}@kit.edu