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leti innovation for industry

Hardware integrity : from design to characterisation

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Fake/cloned/counterfeit products…

Buying a fake branded handbag for your loved one?

Finding horse meet in your beef lasagna?

Fake portable hard drive?

Having easy access to counterfeit medicines?

Counterfeiting accounts for 2% of the world trade!
Expected to exceed $1.7 trillion by 2015!

Hardware integrity: …

- The corrupted, the counterfeit & the cloned IC
- Context
- Existing solutions
- PUFs used for IC authentication
- Detection of corrupted hardware by physical means

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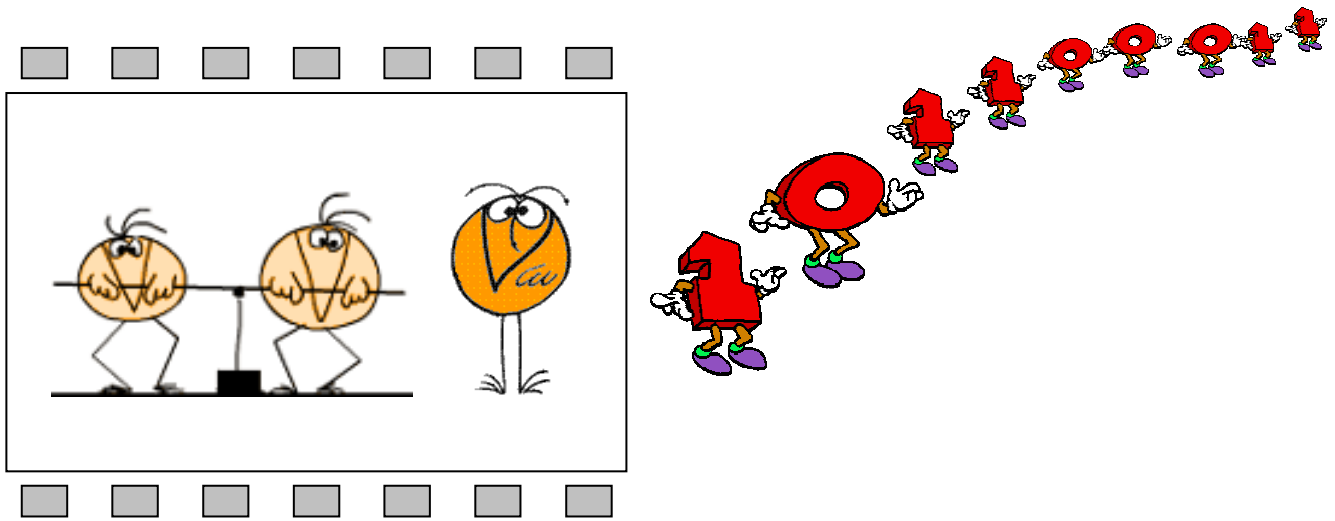
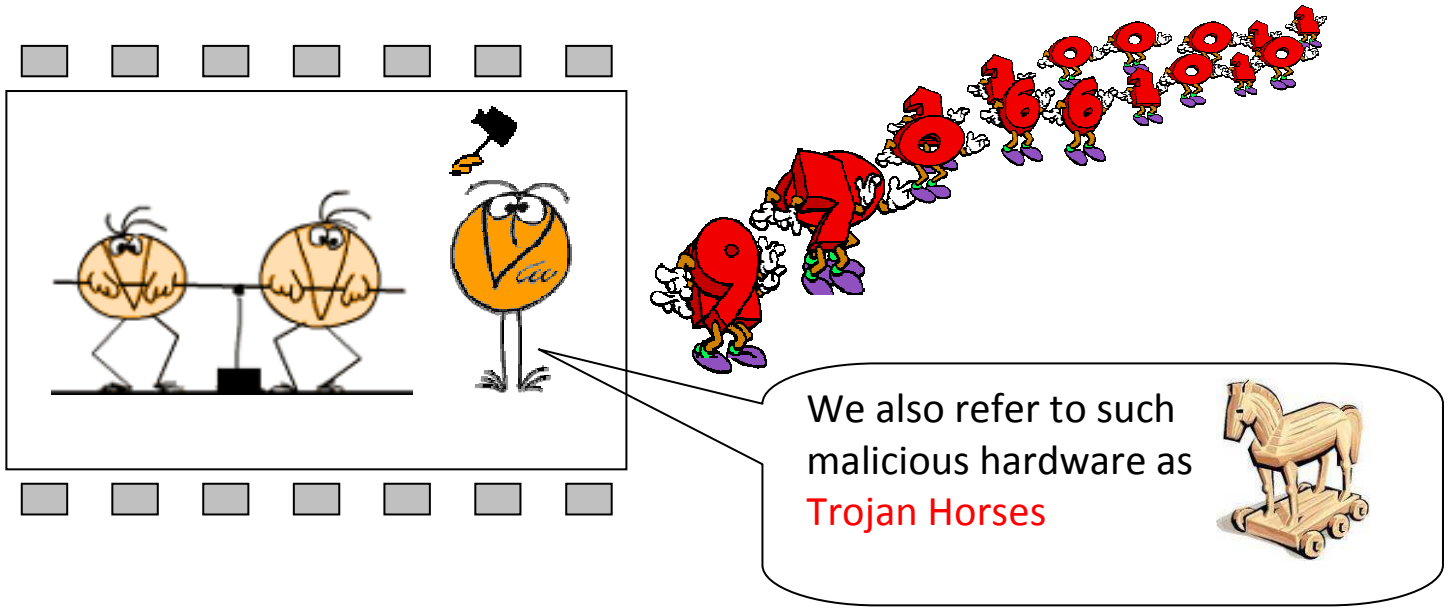
The corrupted, the counterfeit & the cloned IC

- This is your original chip… running your critical, sensitive operation…



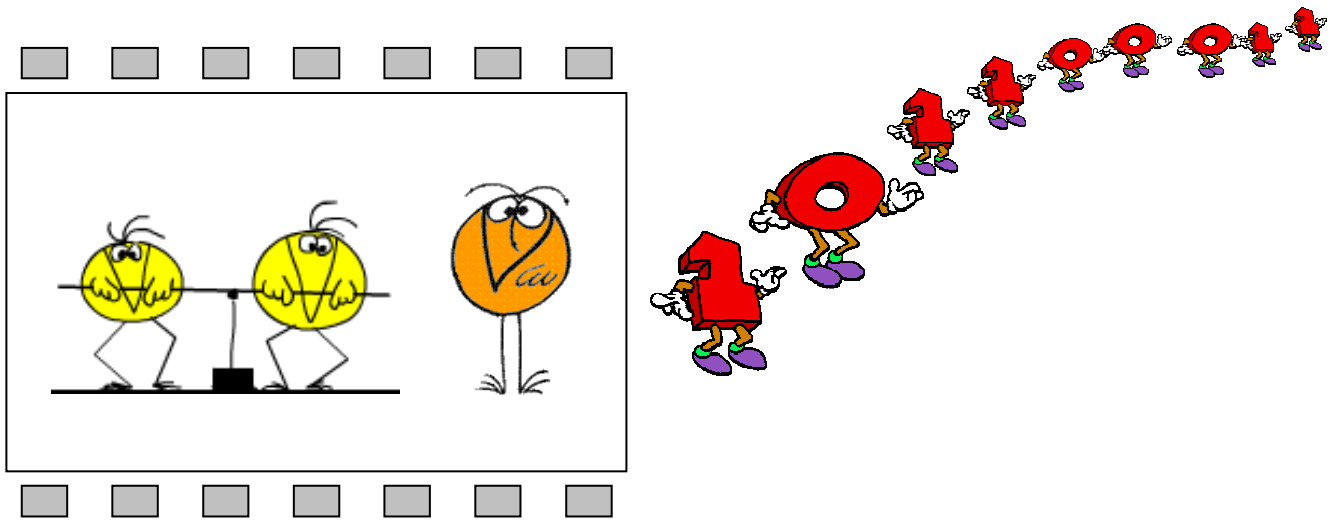
The corrupted, the counterfeit & the cloned IC

- The corrupted chip is your original chip to which some malicious hardware has been added for, say,
  - Denial of service
  - Outputting sensitive data



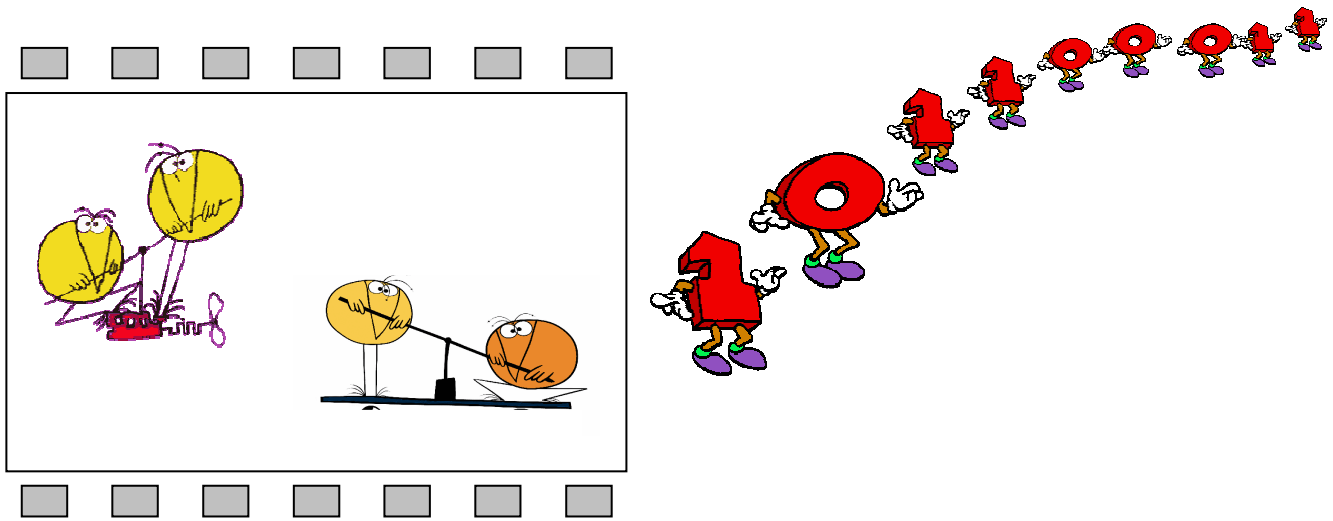
The corrupted, the counterfeit & the cloned IC

- The counterfeit is an exact copy of your original chip… doing the same operations…
  - … sometimes from the same manufacturer



The corrupted, the counterfeit & the cloned IC

- The ‘functional’ clone is another chip doing the same critical & sensitive operations as your original chip…
  - May be the same chip as your original one but with downgraded features.



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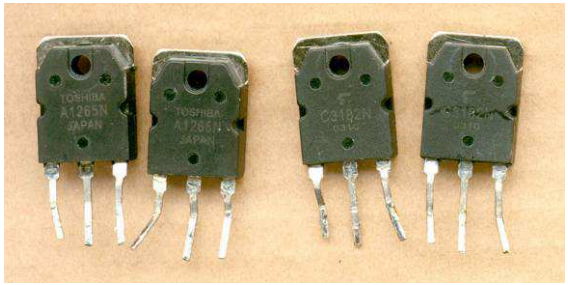
Context… some examples

Fake & genuine Atmel chips

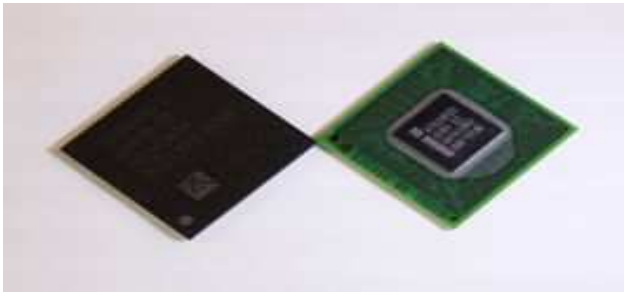
fake card genuine card

http://martybugs.net

FAKE REAL



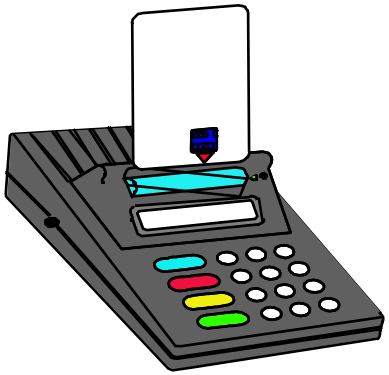
Genuine & Fake Toshiba transistors



Fake chips sold to US military in 2010 (VisionTech scandal)

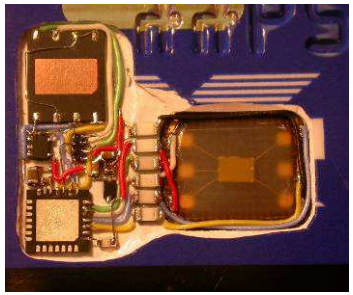
Context… another example

…it is a genuine card?



When a bank terminal or ATM machine is presented with a car, how can it know that…

…it is a functional clone?



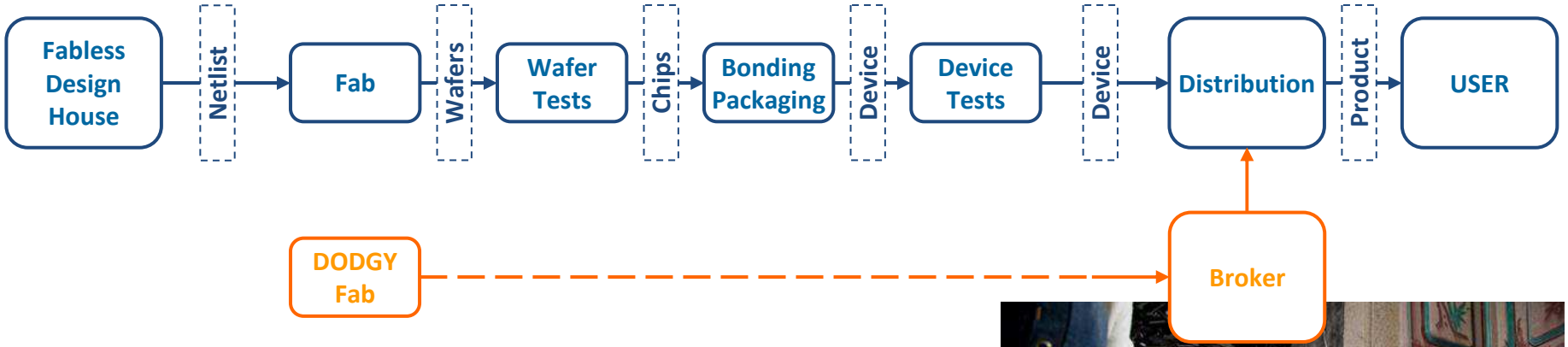
…it is a compromised card?

http://www.lightbluetouchpaper.org/2012/09/10/chip-and-skim-cloning-emv-cards-with-the-pre-play-attack/

Context… the supply chain

- *A simplified version of the story…*

How far is everything under control? Who can you trust?



Some ‘accelerating’ factors:

- Delocalisation of production sites to foreign countries
- Increasing number of ‘design houses’
- More & more value-added chips
- More and more complexe systems
- ‘Throw old & buy new’ of modern electronic devices

Context… some figures

- Counterfeit products (in general) represent **10%** of the goods sold worldwide
  - Costs around $200b in the US each year…
  - …which represents 250K job losses!

- It was estimated that the cost of counterfeiting and piracy for G20 nations was between **$450 and $650 billion in 2008 and** will grow to **$1.2 to1.7 trillion in 2015**

- For the semiconductor industry, the counterfeit market is estimated at **7%** of the whole market, representing approx. **$10b of loss** for the industry each year.

Context… a few stories

- In 2006 **fake NEC company** unveiled in China.
  - Over 50 counterfeit products were produced there!
- In 2007, **hacked payment terminals** found in the UK.
  - Extra hardware had been inserted to store card data and PIN and send them to Pakistanis servers
- Between 2006 & 2010, **VisionTech Components** knowingly sold counterfeit ICs to approx. 1,101 customers WW.
  - including counterfeit ICs for military applications.
- In 2011, the Chinese company **Huawei** was excluded from the public safety broadband network projects.
  - Risk of hidden functions to disrupt or intercept (American) communications.
- In 2011, a virus infected the cockpits of America's **Predator and Reaper drones**.
  - logging pilots' every keystroke during fly missions over Afghanistan and other warzones.
- A few on going initiatives:
  - The **Trusted Foundry Program**: www.trustedfoundryprogram.org
  - **The Trust in IC** program: started by the DARPA in 2007 to develop efficient methods for Hardware Trojan detection.
  - The **ENISA** (European Networks and Information Security Agency) initiated in 2011 an action towards securing the Supply Chains of electronics security devices.

Context… the consequences

- **Market loss… with the potential impact on the job market!**
- **Damaging brand image & customer satisfaction**
- **Downgraded security**
- **Dowgraded reliability**
- **Potential impact on the environment**
  - ‘Out-of-regulation’ production, disposal etc

Hardware integrity: …

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- **Existing solutions**
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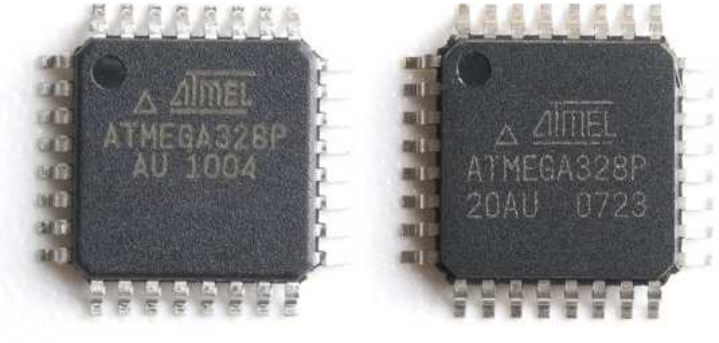
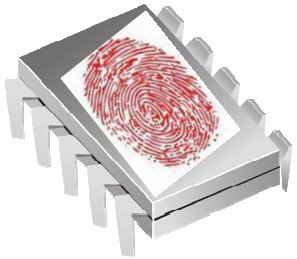
Existing solutions

- Visual inspection!



- PUF-based authentication
  - Retrieving a digital « fingerprint » of a circuit (*we'll come back to that later*)



- Obfuscation
  - 'Obfuscation' of the HDL code
  - Hardware 'random' Place & Route.

- Watermarking
  - Similar to watermarking of a software, a picture, a movie…
  - Objective is to add a « hidden » characteristic within the circuit

Existing solutions (cont'd)

- 'Cryptographic' activation of the chip…
- … or restricting access to some parts of the chip
- Obfuscation of finite state machines
- Dynamique encryption of bit streams (for FPGAs)

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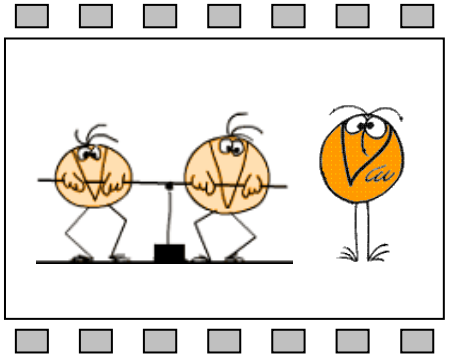
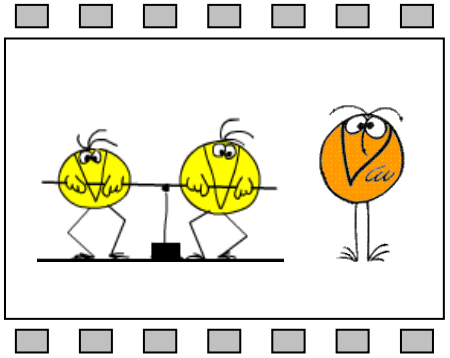
PUFs used for IC authentication

- Say we have 2 ‘identical’ circuits from the same manufacturer…

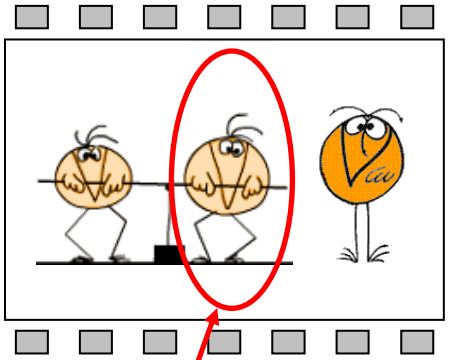


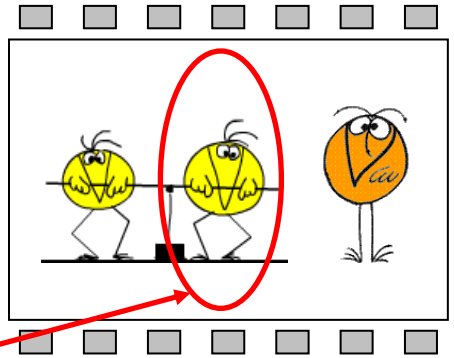


- Those two circuits have subtle differences due to technological & fabrication processes

PUFs used for IC authentication

- A ‘Physically Unclonable Function’ (PUF) is a function which should allow to measure a characteristic « biometric data » of the circuit…



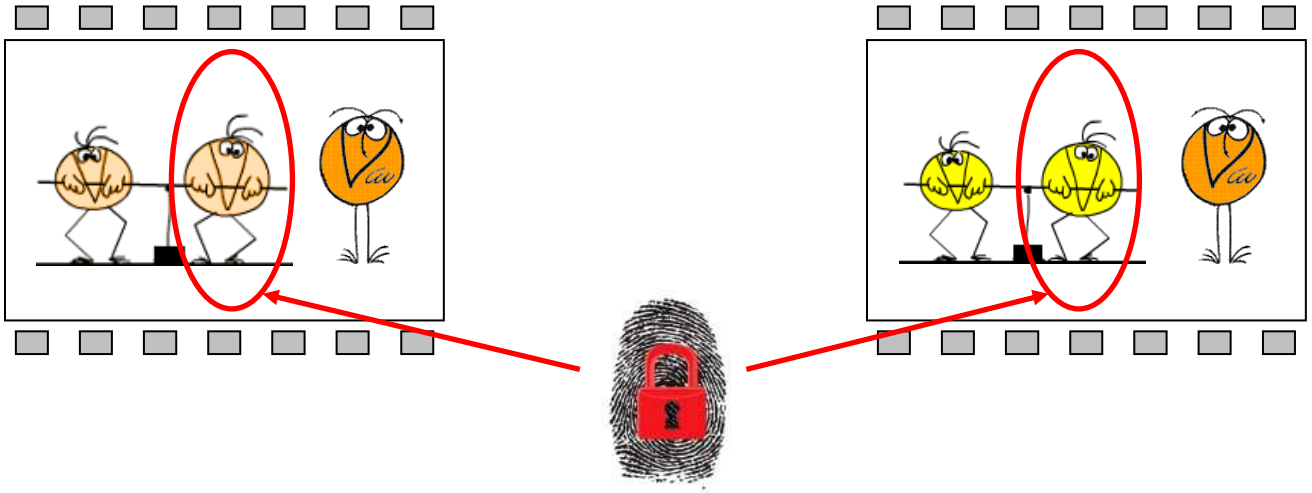


Those two have (different colours ☺) but also different « **fingerprints** »

Main Properties
- Unique
- Non predictable
- Stable wrt environmental conditions
- *…tamper evident*

Some examples
- Non predictable SRAM state upon power on
- Subtle differences in the frequency of two ring oscillators
- Arbiter based race conditions of two paths
- …

PUFs used for IC authentication



TWO APPROACHES

Design issues with (Silicon) PUF implementations

- *Most existing research work rely on* **simulations** *or* **FPGA implementations**.
- *Very few existing ASIC implementations (UNIQUE project).*
- *But extremely difficult to do in industry (full custom design, careful layout etc).*

We are working on the design of Arbiter PUFs and studying the **compromise between the level at which design has to be done 'by hand' and reaching the security properties of PUFs.**

Resistance of proposed PUFs to physical attacks

- *Proposed PUFs satisfy the properties of uniqueness, stability & non reprocdubility* **in theory**.
- *Use physical attacks (power, EM, temperature, Vcc glitches) to corrupt those PUFs*

Use Vcc variations to ***make one PUF behave just like another one***

Use power analysis to infer ***the value of the supposedly secret outputs of the PUF***

Use temperature variations to ***biais the output of the PUF***

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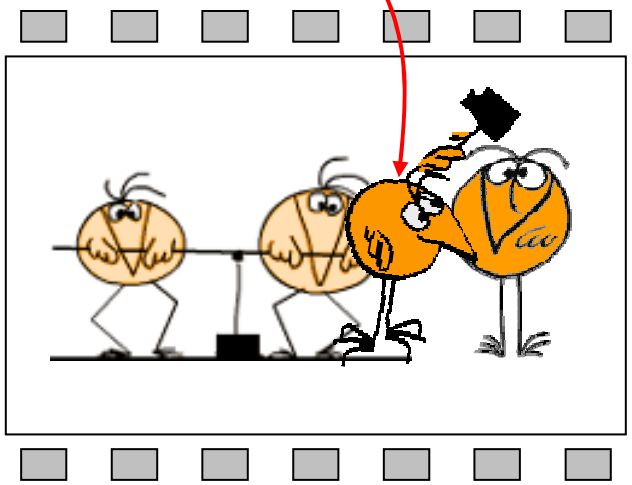
Detection of corrupted hw by physical means

- Our approach is to use side channel measurements to detect the hardware Trojan or detect its effect… **before it is too late**



Objective is to use **power** consummed by the chip or the **Electromagnetic emmations** of the chip to detect the presence of the Trojan

Already an extensive literature on the subject, but most approaches detect the 'effect' of the Trojan, i.e. **once your critical data has been leaked!!**

*We are developping a method based on **Fault injections** to detect modifications incurred by the presence of the Trojan on the circuit even **if it is not active***

Detection of corrupted hw by physical means

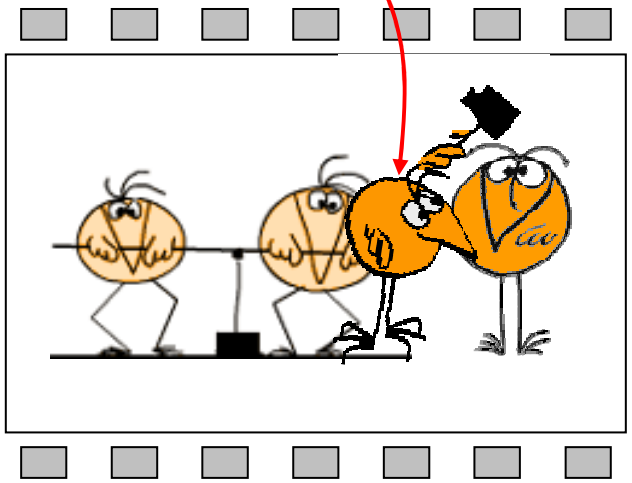
- Our approach is to use side channel measurements to detect the hardware Trojan or detect its effect… **before it is too late**

Fault injections are usually used to corrupt sensitive operations to, say, retrieve cryptographic keys !

But we showed that fault injections can also be used to 'characterize' a circuit, for e.g. measure sensitive data delay paths (w. clock glitches)

"The good & the bad of physical functions"

We measure 'faults generated' for several values of clock glitches' values & define caracteristic s.



Difference between the distribution variation on genuine circuit & that of the same circuit with a hardware Trojan

To conclude…

(Inter)national security issues

Billions of euros at stake for the semiconductor industry

Safety issues

Impact on the environment

It matters for…

Merci de votre attention

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