Smart (health) systems need smart security

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ESAT COSIC

KU Leuven - iMinds

Smart Systems Industry Summit
October 14, 2014

Outline of the talk

- Who are we?
- Smart medical devices: security risks
- Cryptographic solutions
- Key generation
- Privacy
- Conclusion

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North Sea
BELGIUM
DENMARK
Kattegat
Copenhagen
Malmö
Bornholm
Hamburg
Bremen
Berlin
Poznań
Oder
Amsterdam
NETH.
Rotterdam
Essen
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Elbe
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Lille
Bonn
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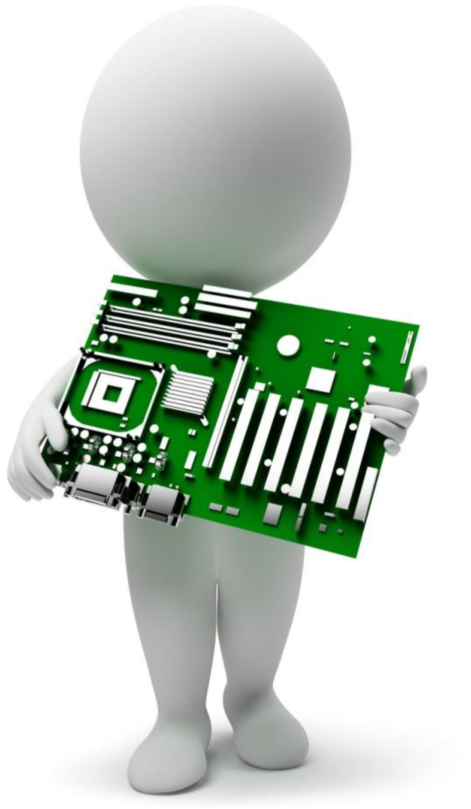
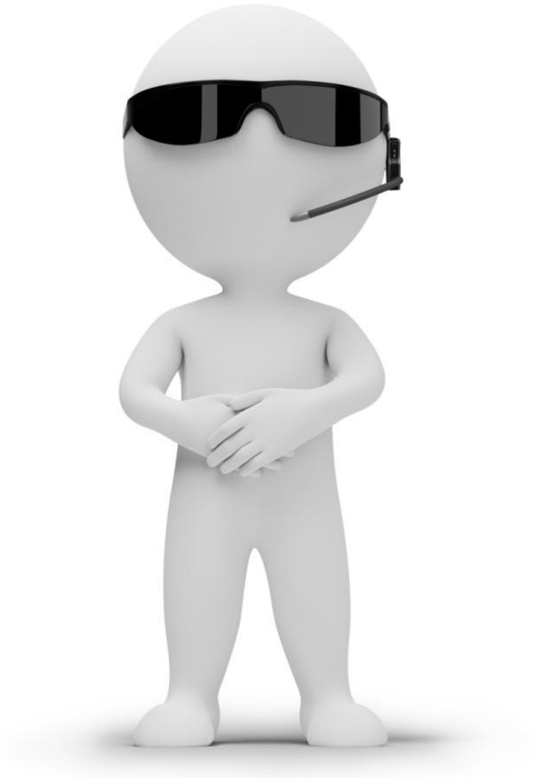
iMinds security department

ICRI
Legal
Engineering



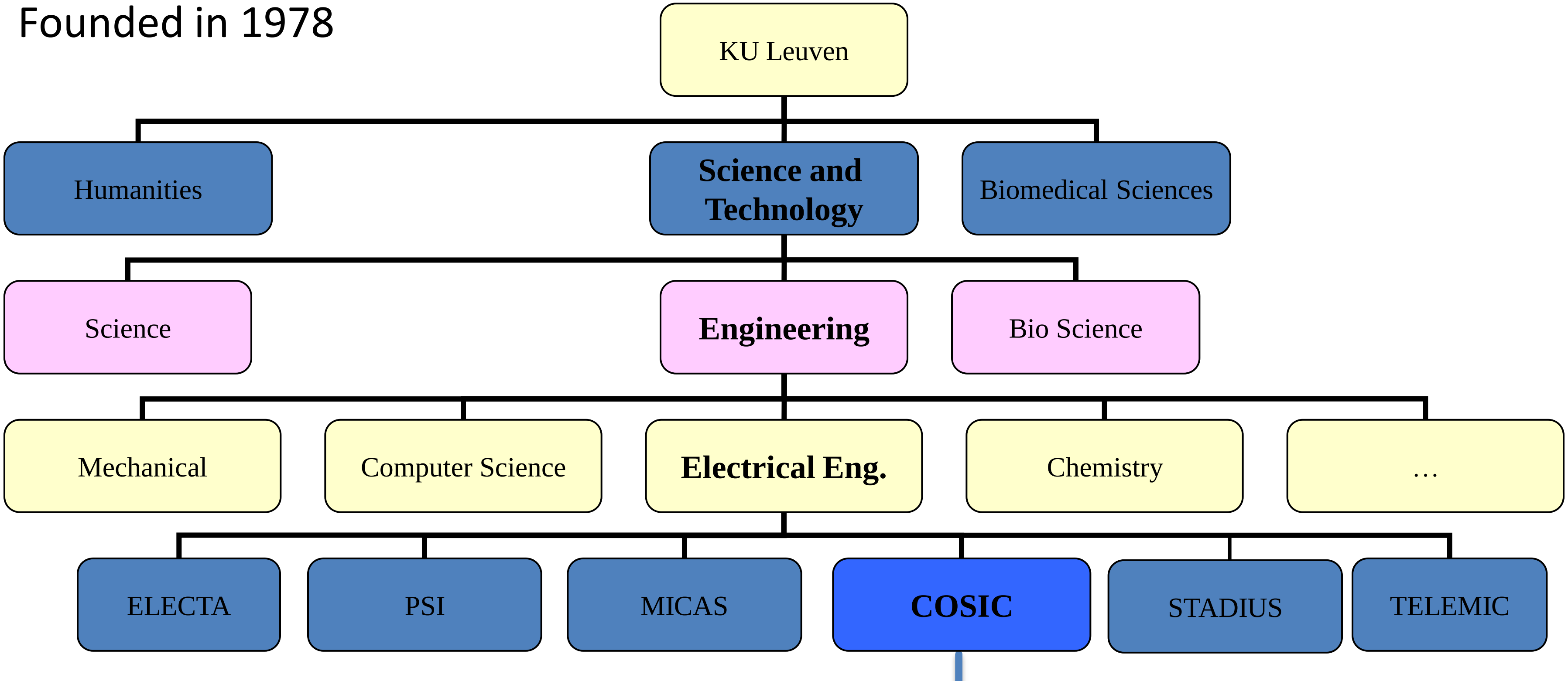
COSIC
Cryptographic
Engineering



DistriNet
Secure Software
Engineering

COSIC: COmputer Security and Industrial Cryptography

Founded in 1978



KU Leuven

Humanities

Science and Technology

Biomedical Sciences

Science

Engineering

Bio Science

Mechanical

Computer Science

Electrical Eng.

Chemistry

…

ELECTA

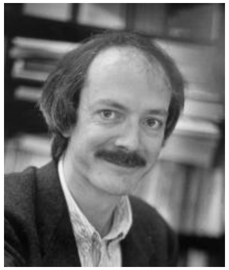
PSI

MICAS

COSIC

STADIUS

TELEMIC



Bart Preneel

Ingrid Verbauwhede

Vincent Rijmen

Claudia Diaz

COSIC - Research

Efficient and secure implementations

- software: block ciphers, point counting algorithms
- hardware: FPGA and ASIC
- side-channel attacks: power, timing, and electromagnetic analysis, fault attacks

Cryptographic protocols: design and cryptanalysis

entity authentication, credentials, oblivious transfer,

Cryptographic algorithms: design and cryptanalysis

block ciphers, stream ciphers, hash functions, MAC algorithms, (hyper)-elliptic curve cryptography
e.g.: AES, RIPEMD-160, HAMSI

Fundamental research in discrete mathematics

number theoretic algorithms, Boolean functions, secure multi-party computation, secret sharing

COSIC - Applications

Creating electronic equivalent of the real world:

confidentiality, digital signature, anonymity, payments, digital right managements, elections

- **Technologies:**
  - key management: ad hoc networks
  - anonymous communications and services
  - software tamper resistance and obfuscation
  - trusted platforms
  - multimedia security
- **Applications:**
  - electronic payments and commerce
  - e-government: electronic ID card, e-voting
  - car-to-car communications
  - **ehealth**

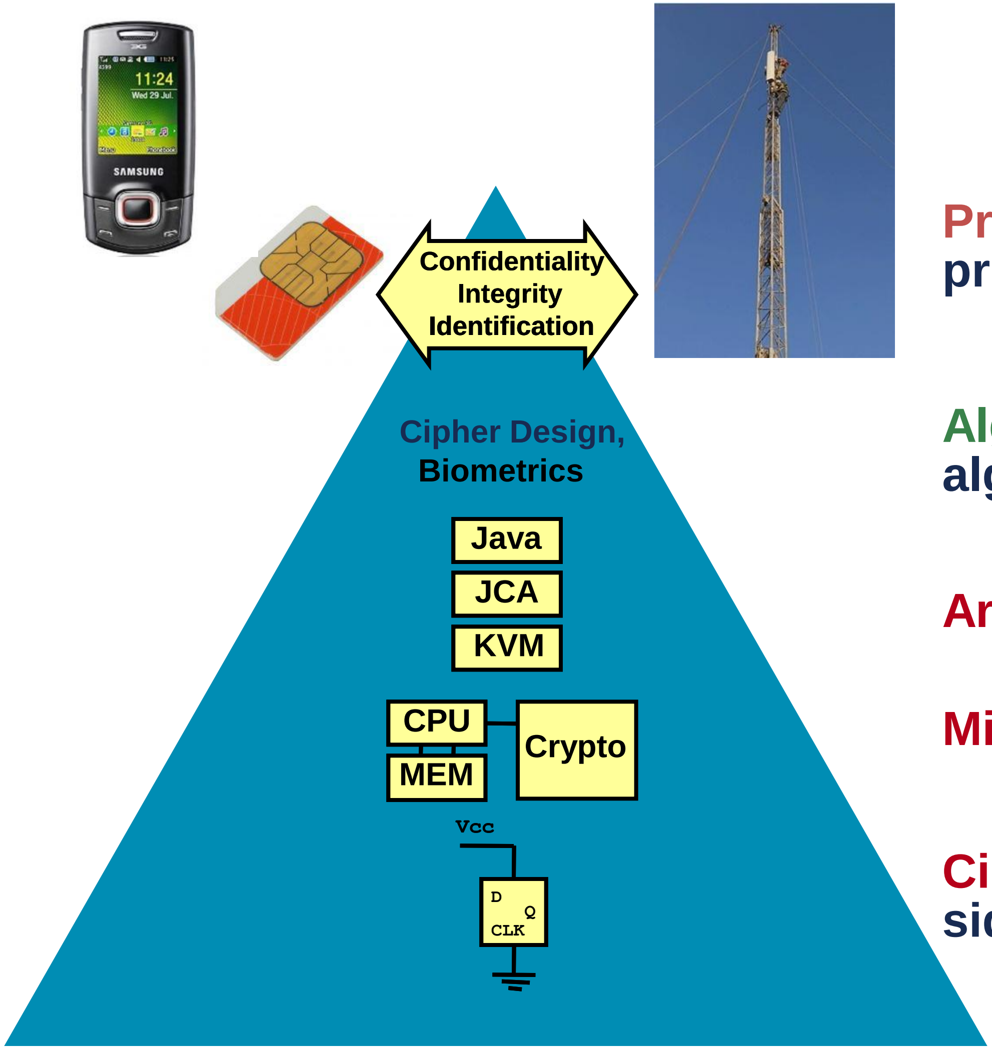
BELGIË IDENTITEITSKAART | BELGIQUE CARTE D'IDENTITE | BELGIEN PERSONALAUSWEIS | BELGIUM IDENTITY CARD

Naam / *Name* Dupont
Voornamen / *Given names* Sophie

Geboorteplaats en -datum / *Place and date of birth* Namen 01 MEI 1960
Geslacht / *Sex* V
Nationaliteit *Nationality* Belg
Kaartnr. / *Card No* 000-0001000-00

Geldig van - tot / *Valid from - until* 02.04.2003 - 02.04.2008
Handtekening van de houder / *Holder's signature*

Implementations in embedded systems



Protocol: low power authentication protocol design

Algorithm: public key, secret key, hash algorithms

Architecture: Co-design, HW/SW, SOC

Micro-Architecture: co-processor design

Circuit: Circuit techniques to combat side channel analysis

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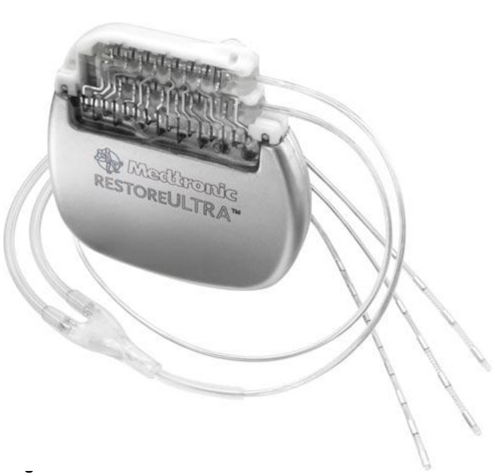
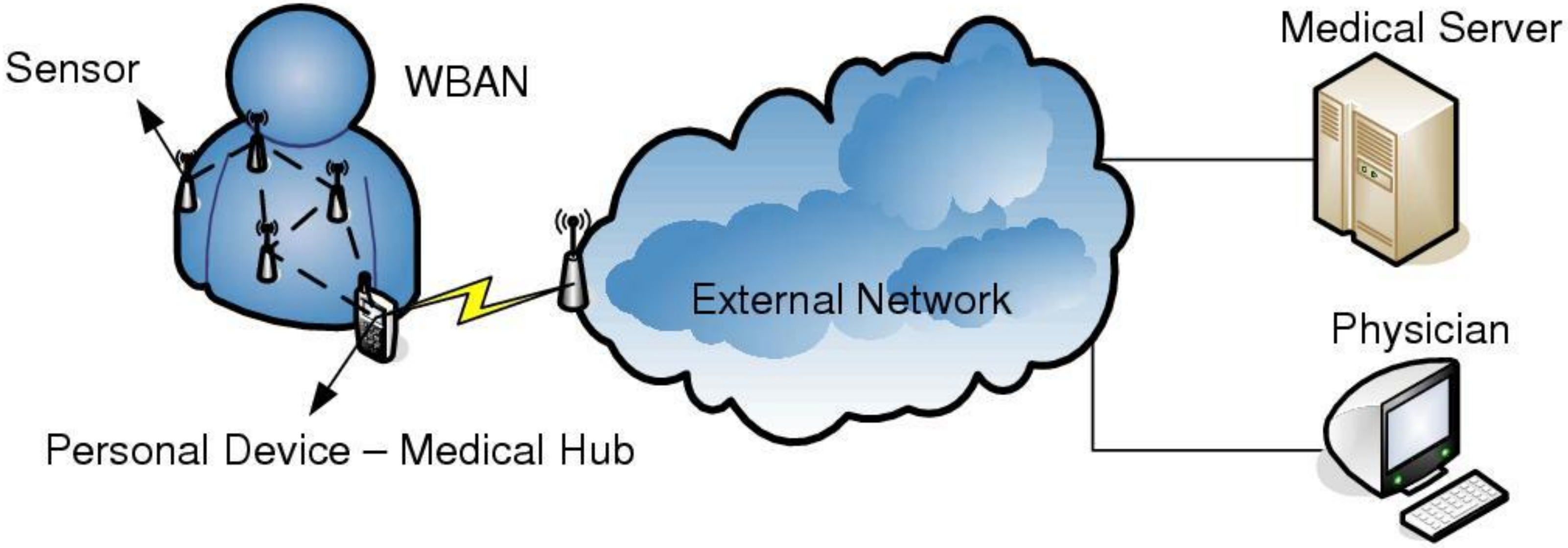
Implantable medical devices



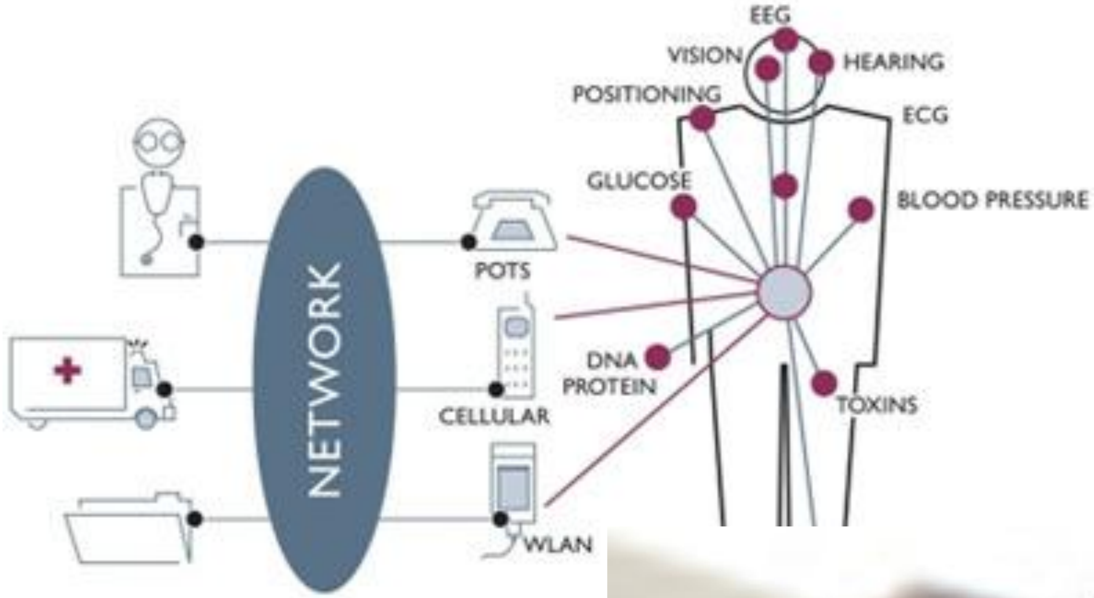
- Remote reprogramming / monitoring
- Software updates

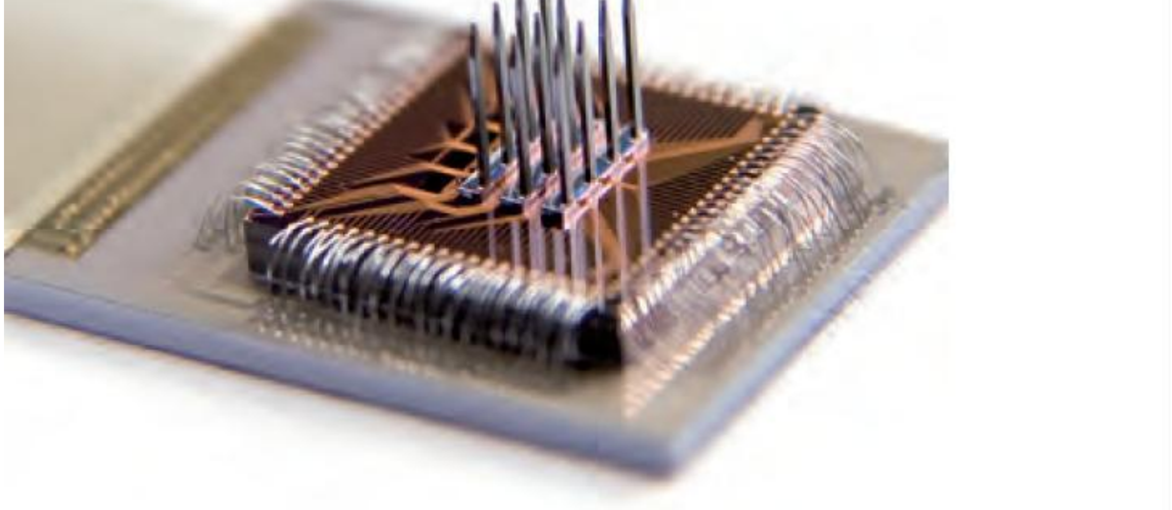
Wireless Body Area Networks



- WBAN: Sensor network on/in the patient
- Remote monitoring / reprogramming

(Ultra) low power medical devices



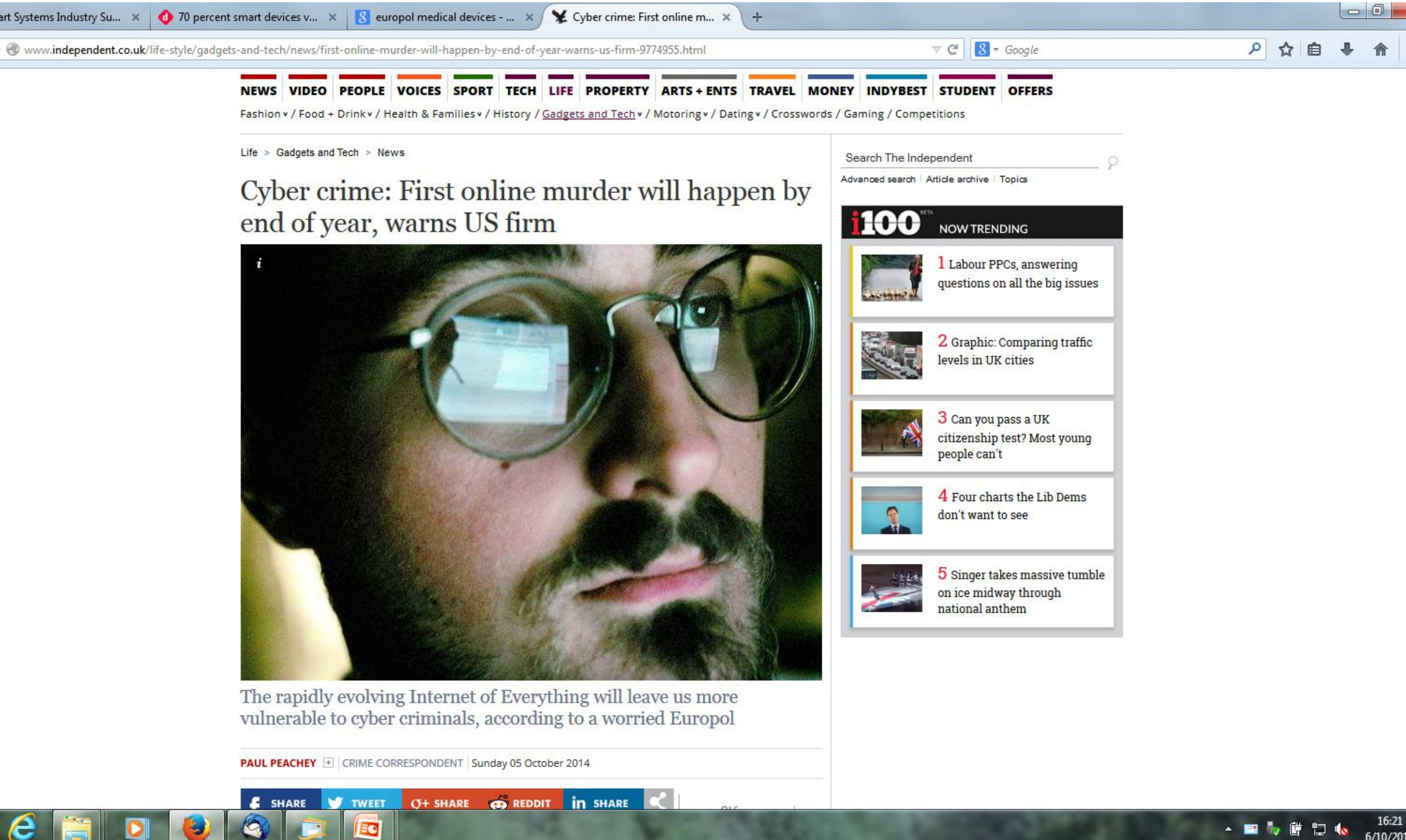


Wireless communication link

- **Wireless communication** omnipresent
  - MICS band / Bluetooth / ZigBee / …
  - More convenient
  - Extract medical telemetry
  - Remote commands
  - (Re)configuring device

- Wireless sensors
- Medical implants
- Internet of Things

Wireless communication link vulnerable to attacks



art Systems Industry Su...
70 percent smart devices v...
europol medical devices - ...
Cyber crime: First online m...
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Cyber crime: First online murder will happen by end of year, warns US firm

The rapidly evolving Internet of Everything will leave us more vulnerable to cyber criminals, according to a worried Europol

PAUL PEACHEY | CRIME CORRESPONDENT | Sunday 05 October 2014

1 Labour PPCs, answering questions on all the big issues

2 Graphic: Comparing traffic levels in UK cities

3 Can you pass a UK citizenship test? Most young people can't

4 Four charts the Lib Dems don't want to see

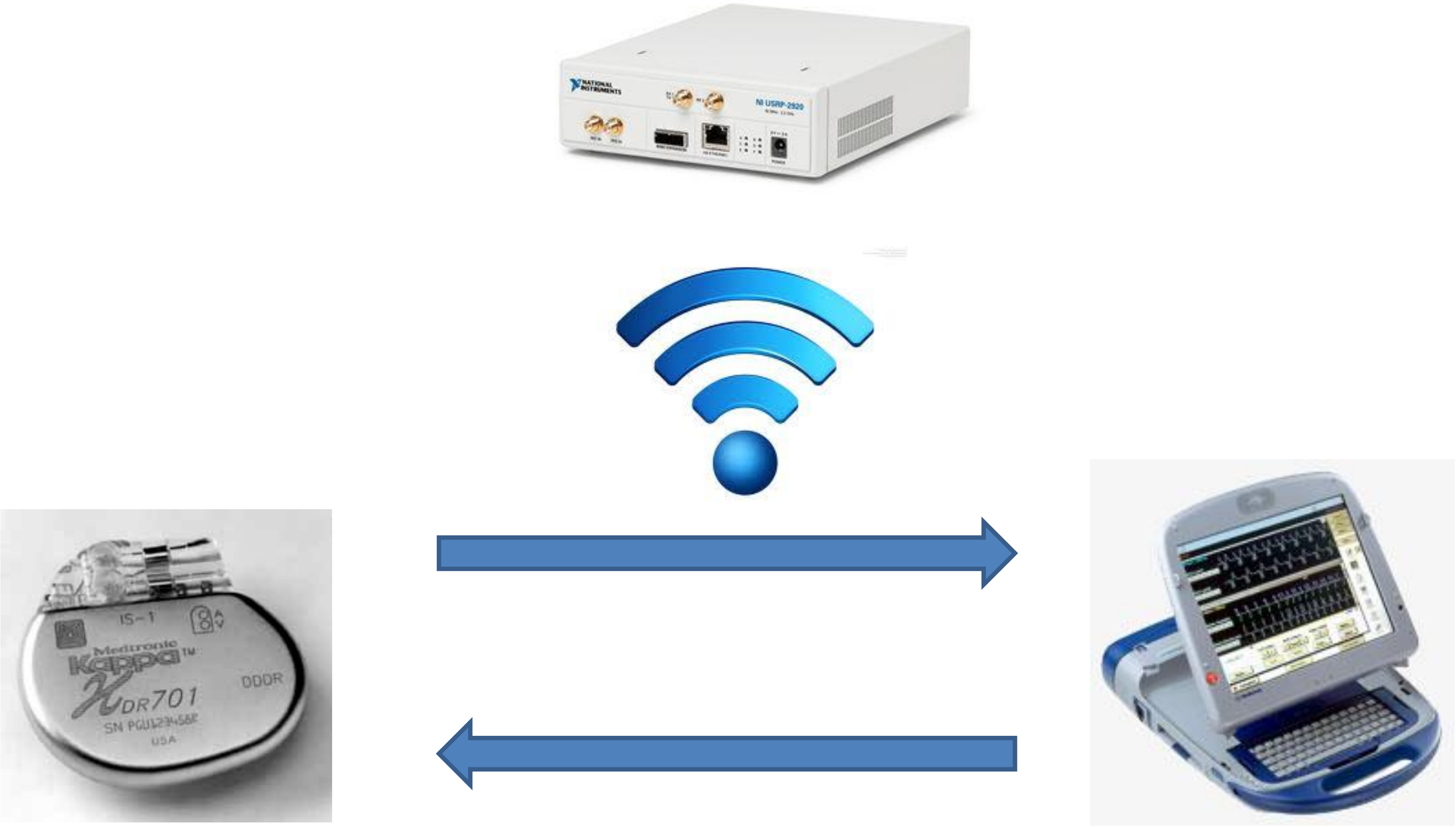
5 Singer takes massive tumble on ice midway through national anthem

Security and privacy risks

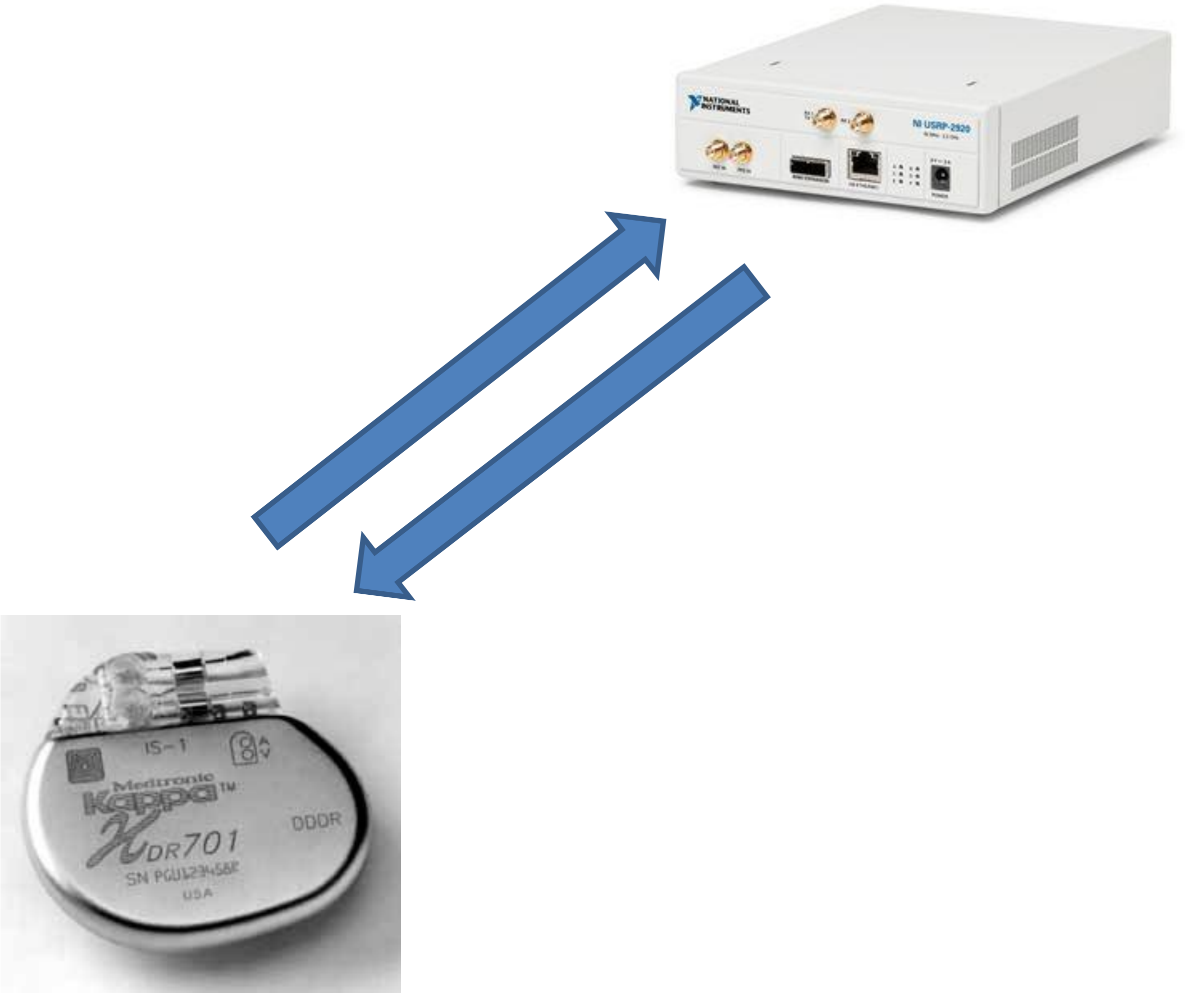
- Passive attacks
  - Eavesdropping
- Active attacks
  - Man-in-the-middle attacks
  - Replay attacks
  - Unauthorized commands
  - Denial-of-Service attacks
  - ….

Intercepting wireless communication

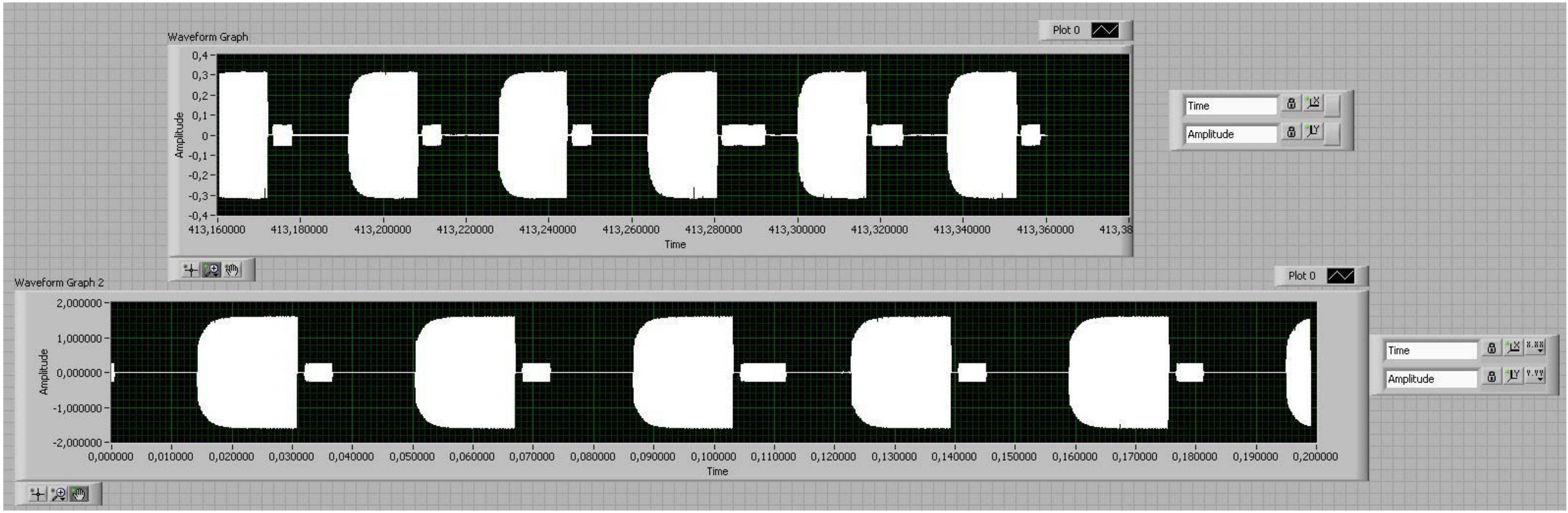
Software Defined Radio: setup



Software Defined Radio: setup



Software Defined Radio attacks



Software Defined Radio attacks

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Secure wireless communication

- End-to-end security
- Cryptographic algorithms needed
- Technological challenges
  - Low-cost hardware resources
  - Ultra low-power budget
  - Limited memory
  - Long lifetime
  - …
- **Lightweight cryptography**

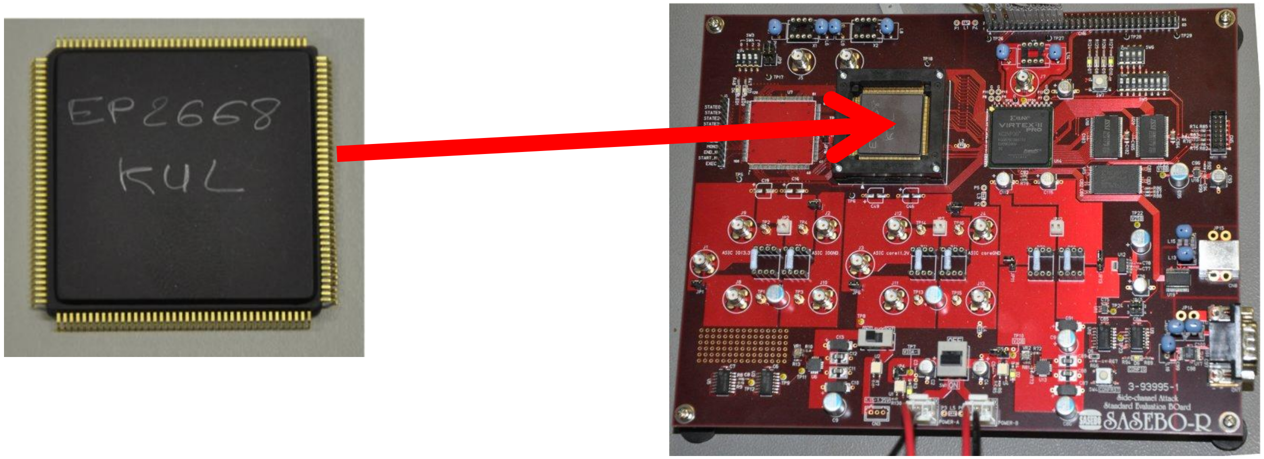
Lightweight cryptographic primitives

- Lightweight, compact cryptographic algorithms
  - KATAN (802 GE)
  - Present (1075 GE)
  - Trivium (2599 GE)

- Lightweight cryptographic protocols
  - Wireless authentication protocols
  - Broadcast authentication
  - Key agreement protocols

Embedded crypto implementations

- Efficient lightweight implementations
  - Within power, area, speed, … budgets
  - E.g., ECC processor (0.13μm - 14,566 GE - 7.3μW)



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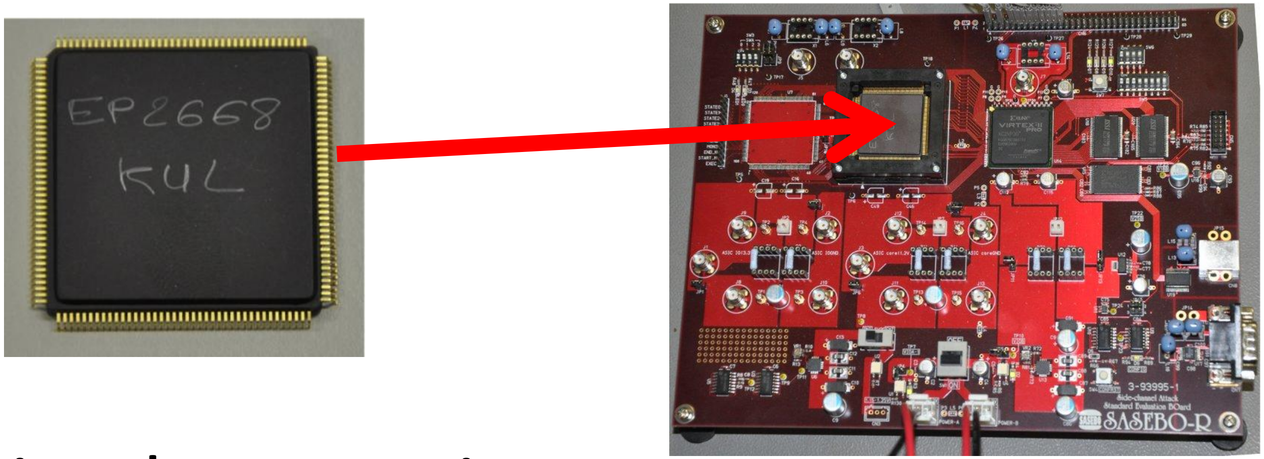

- Trustworthy implementations
  - Resistant to side-channel and fault injection attacks

=> BOTH are needed

Crypto: long lifetime

- Large key size
- Key updates -> cryptographic protocols needed
- Post-quantum cryptography
  - Multivariate Quadratic (MQ)
  - Lattice-based cryptography

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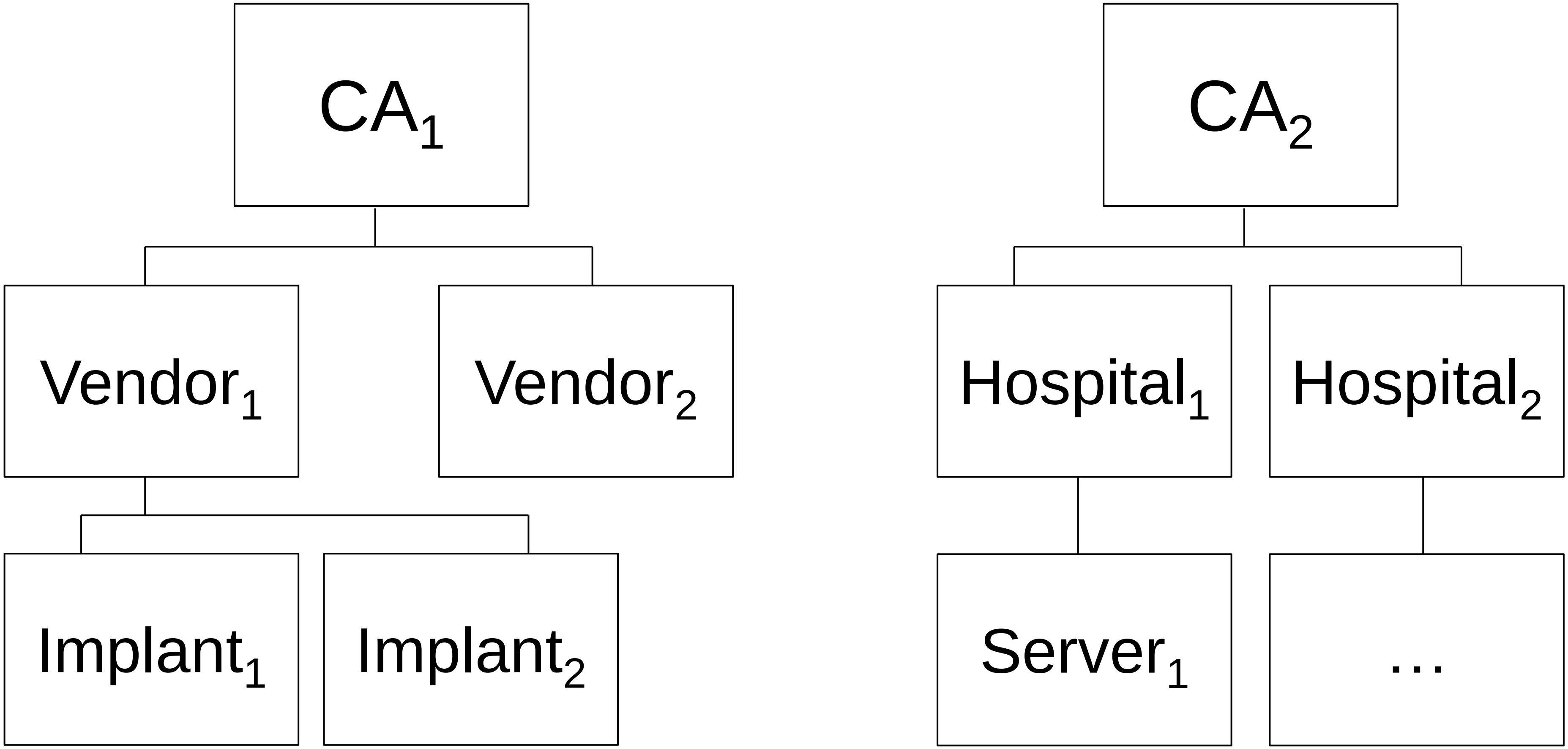
Key management

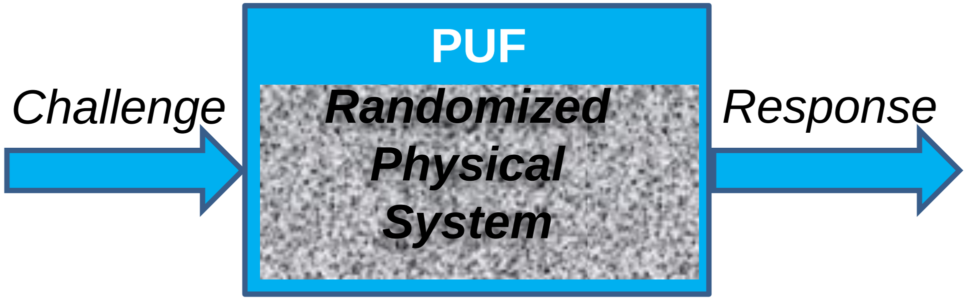
- Pre-installed
- Using out-of-band channel
  - Location-based
  - Physical contact
  - User input
  - Biometrics
  - …
- Physical Unclonable Functions (PUFs)
- Key distribution schemes
- PKI infrastructure

PKI Infrastructure



PUF: concept (I)

- **P**hysically
  Unclonable
  Functions



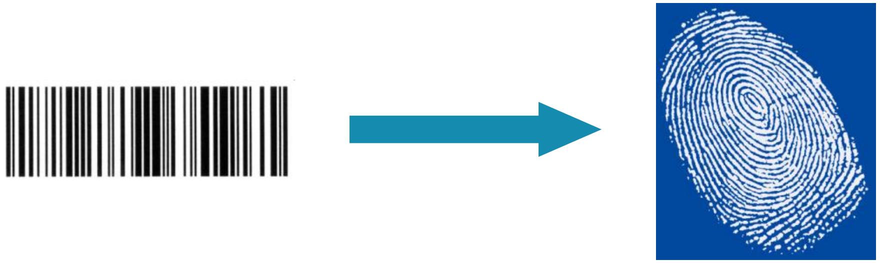
Challenge

PUF

Randomized Physical System

Response

- PUFs represent a paradigm shift in physical security:
  1. Explicitly programmed digital identity → Intrinsic physical identity

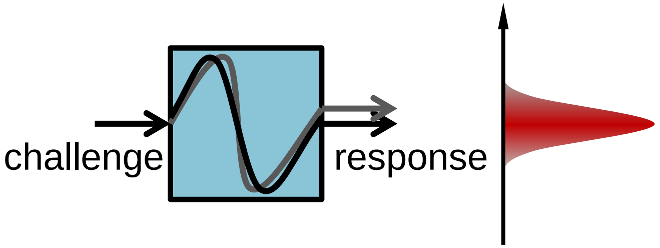


  2. Unclonable because of physical protection of digital data
     → Unclonable because of uncontrollable physics

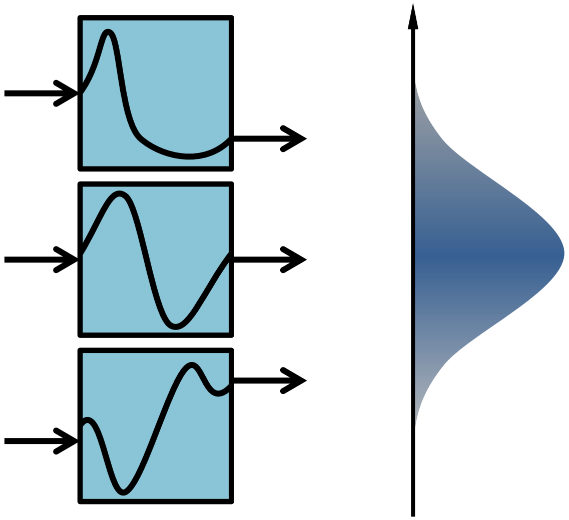
100110…00101

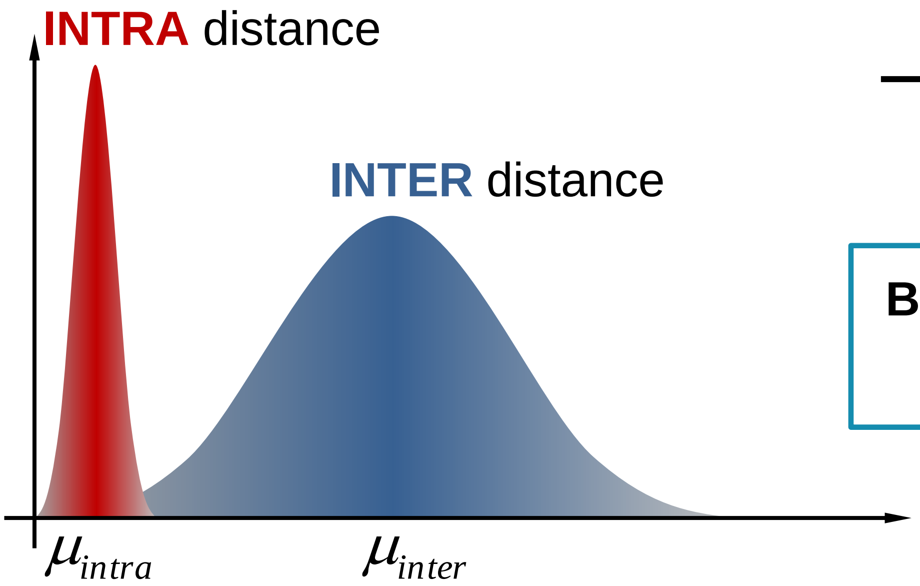
PUF: concept (II)

Single PUF instance



Multiple "identically manufactured" PUF instances



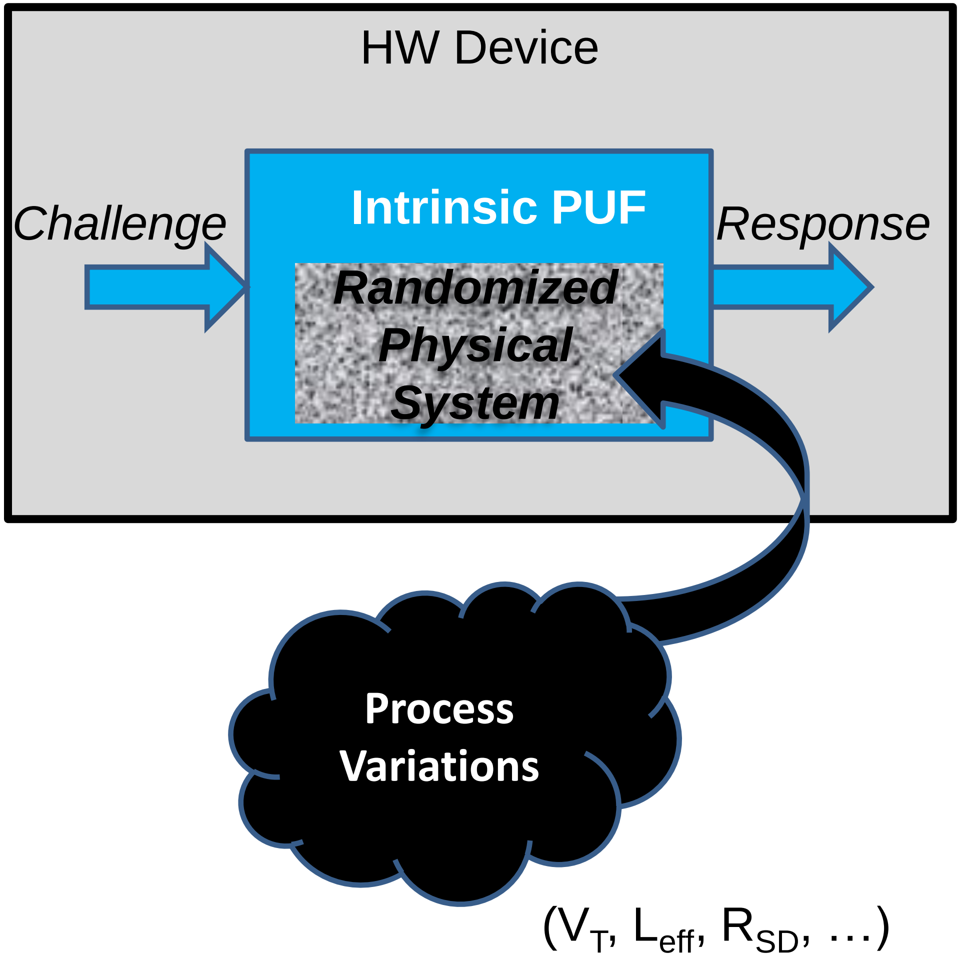


Basic PUF property:

$\mu_{inter} >> \mu_{intra}$

PUF: concept (III)

- Non-silicon
- Silicon
- Intrinsic
  1. Randomness = ***intrinsic*** manufacturing variability
     - no manufacturing overhead
     - i.c. CMOS process variations
  2. Integrated measurement
     - no external equipment
     - i.c. PUF response on-chip



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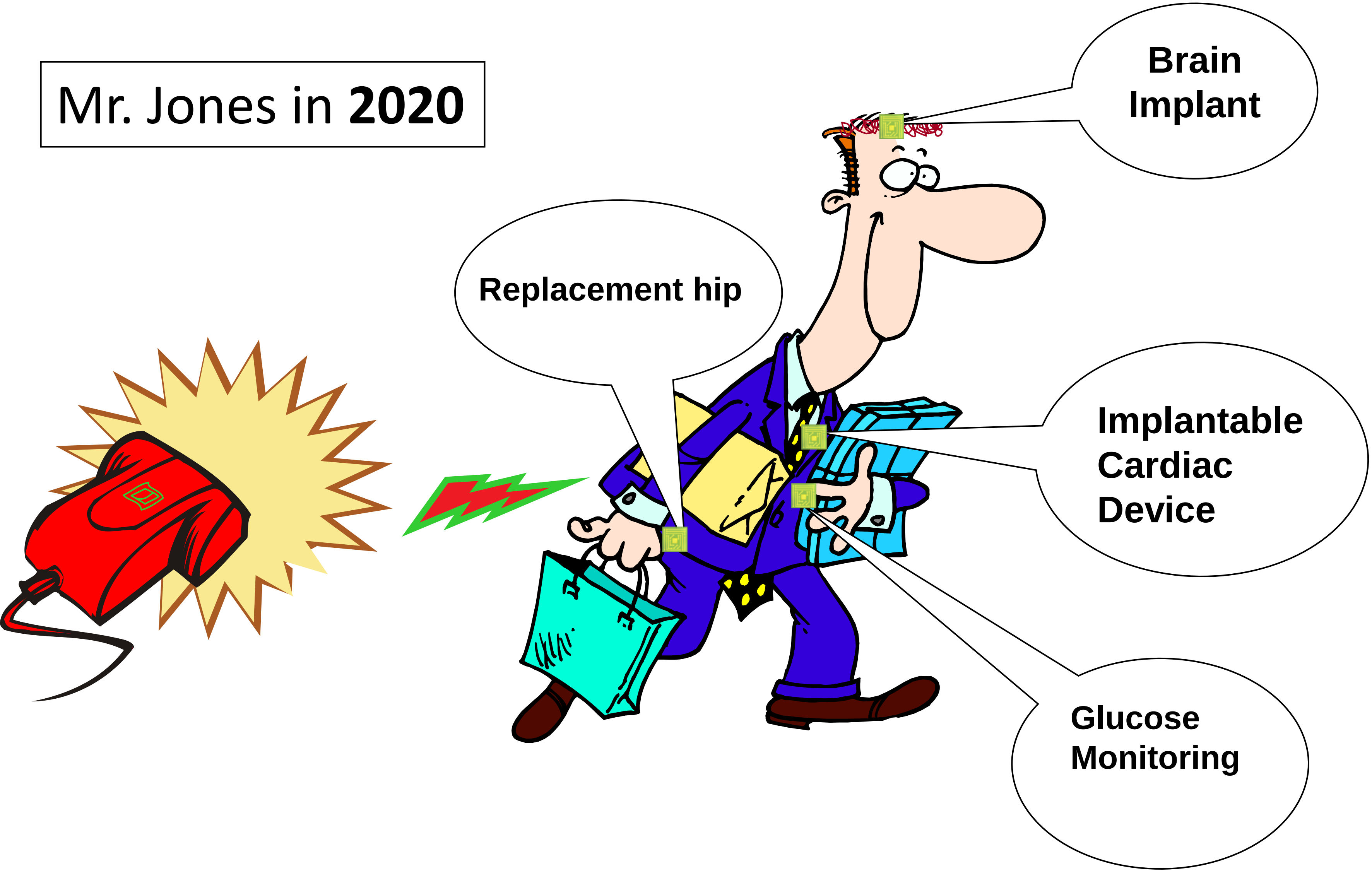
Privacy challenges

Mr. Jones in **2020**



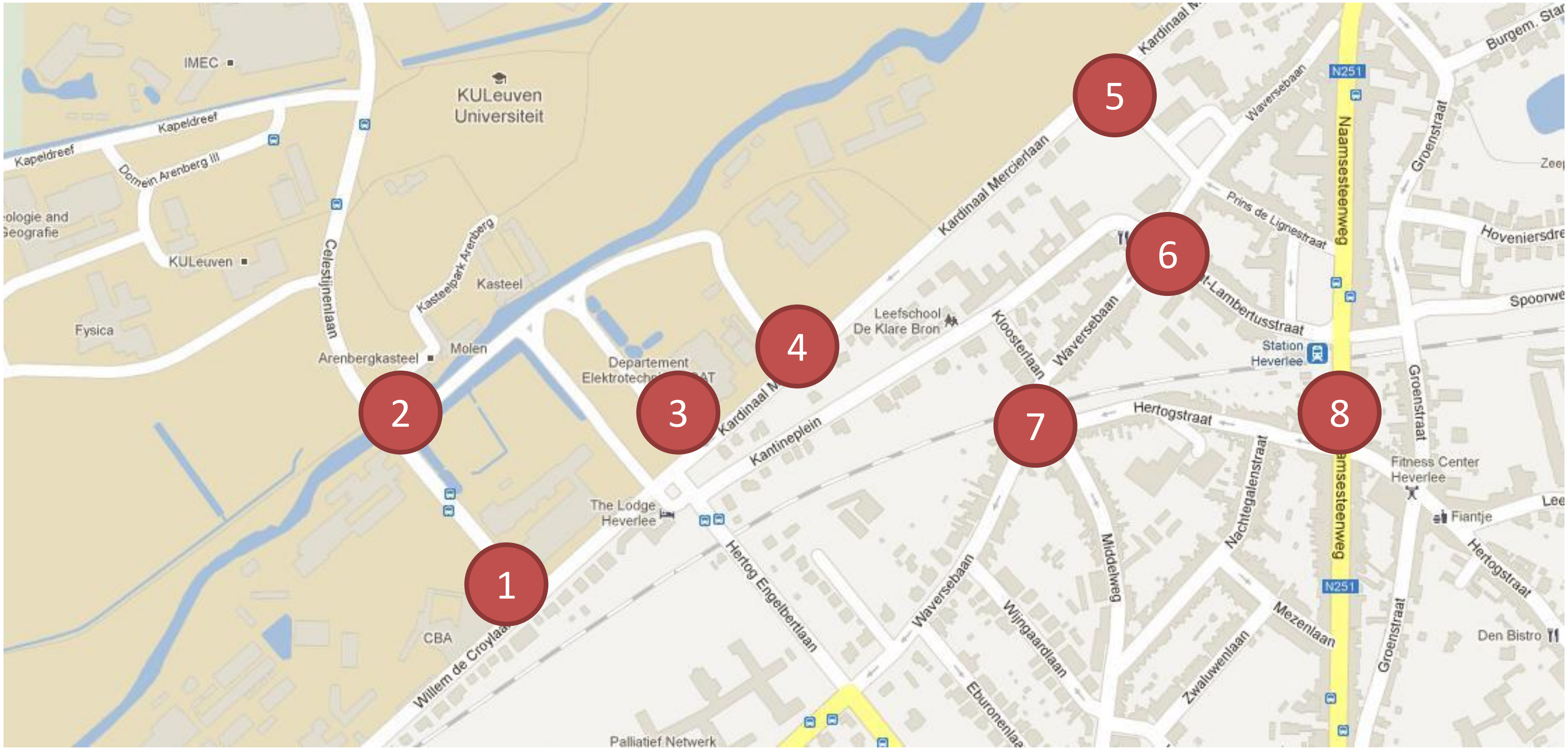
Brain Implant

Replacement hip

Implantable Cardiac Device

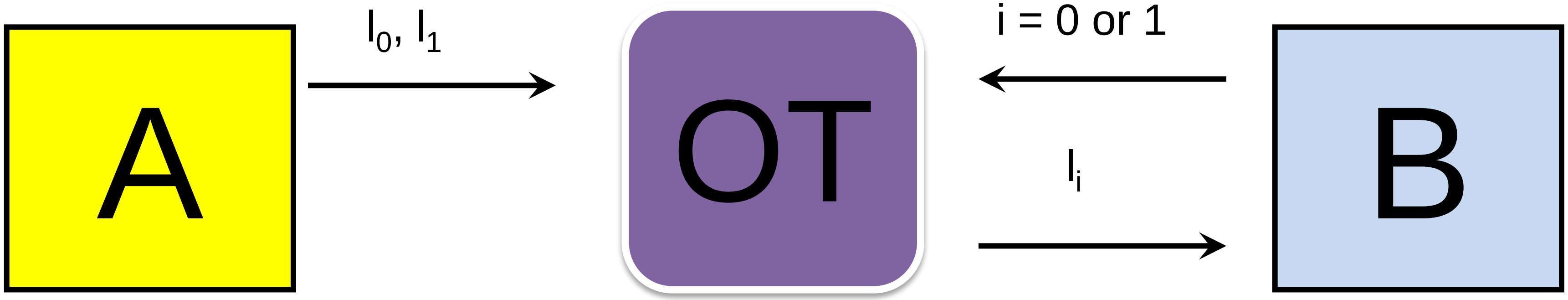
Glucose Monitoring

Location privacy



Data minimization

- **Homomorphic encryption**
- Oblivious transfer



- A does not learn which item B has chosen;
- B does not learn the value of the item that he did not choose

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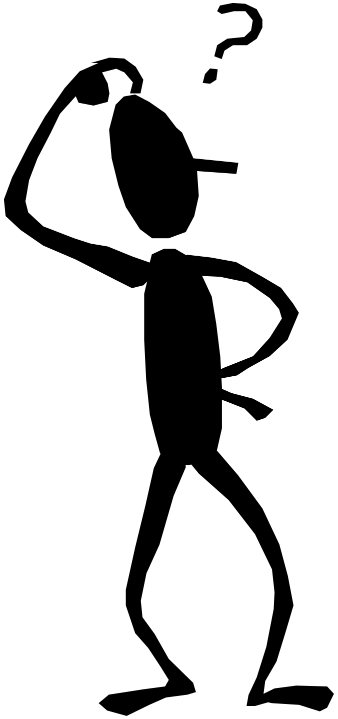
Conclusion

- **Smart security solutions are needed**
- Lightweight cryptography
- Security architecture
  - Key generation / agreement
  - Key update/revocation mechanisms
- Very long lifetime of cryptographic primitives (> 30 years)
- Privacy is also important
- Active area of research

Questions



Contact information

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