Security by Design for Sustainable CPS

VAIBHAV 2020

Vertical: V6 - Data Sciences – Session V6H3S1 Data Privacy and Security

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My background

- My research is on Smart Electronic Systems, the backbone of which is a combination of AI/ML, Data Analytics, Security at the Edge of IoT in the Cyber-Physical Systems (CPS) that make the smart cities.

- My Smart Electronic Systems research can be grouped into the following inter-related thrusts:

    - Security and Energy Aware Cyber-Physical Systems (CPS)
    - IoMT Based Approaches for Smart Healthcare
    - IoT-Enabled Consumer Electronics for Smart Cities

- Existing collaboration with Indian researchers at:

    - IIT Kanpur
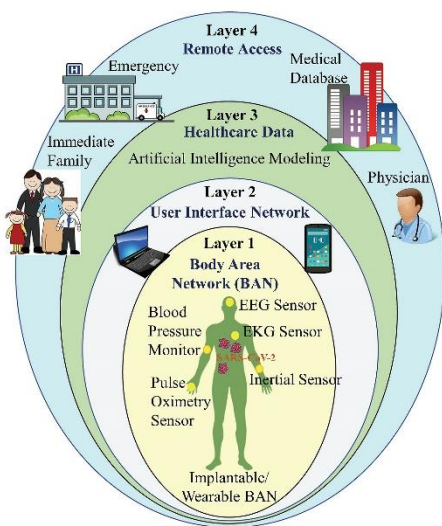   - MNIT Jaipur
    - NIT Rourkela
    - IIIT Naya Raipur

Smart Healthcare - Security and Privacy Issue

Healthcare Cyber-Physical System (H-CPS)

https://ctsoc.ieee.org

Selected Smart Healthcare Security/Privacy Challenges

- Data Eavesdropping
- Data Confidentiality
- Data Privacy
- Location Privacy
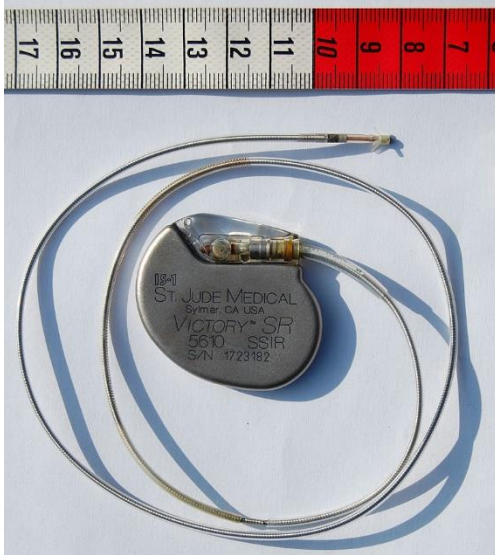- Identity Threats
- Access Control
- Unique Identification
- Data Integrity
- Device Security

# H-CPS Security Measures is Hard - Energy Constrained

Pacemaker Battery Life - 10 years

Neurostimulator Battery Life - 8 years

> Implantable Medical Devices (IMDs) have integrated battery to provide energy to all their functions → Limited Battery Life depending on functions
>
> Higher battery/energy usage → Lower IMD lifetime
>
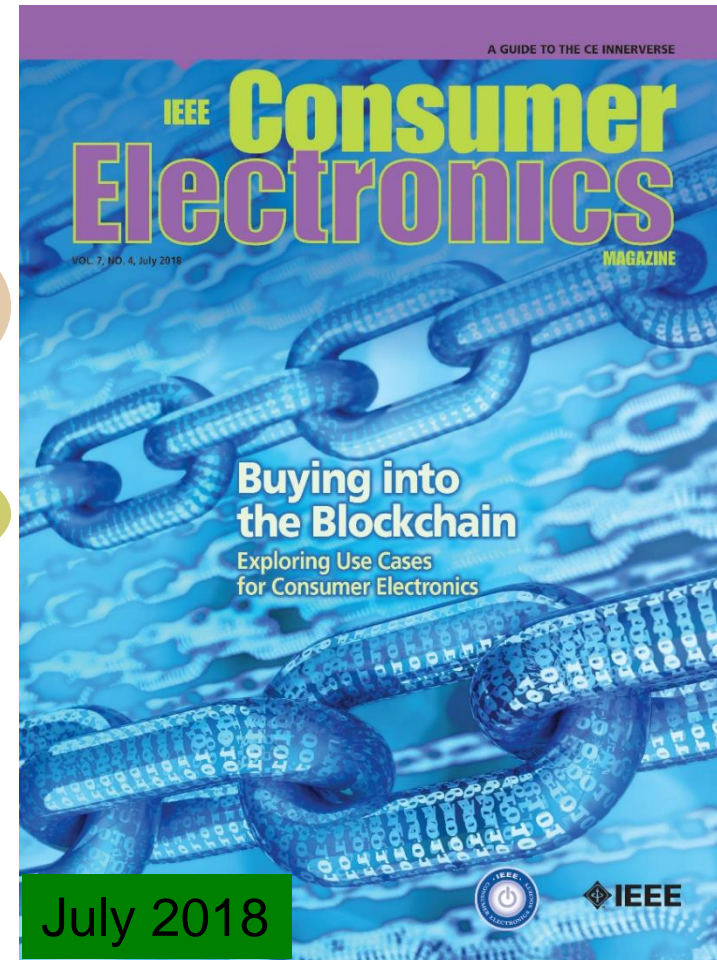> Battery/IMD replacement → Needs surgical risky procedures

SbD for CPS - Prof./Dr. Saraju P. Mohanty

Smart Electronic Systems Laboratory (SESL)

Our Secure by Design Approach for Robust Security in Healthcare CPS
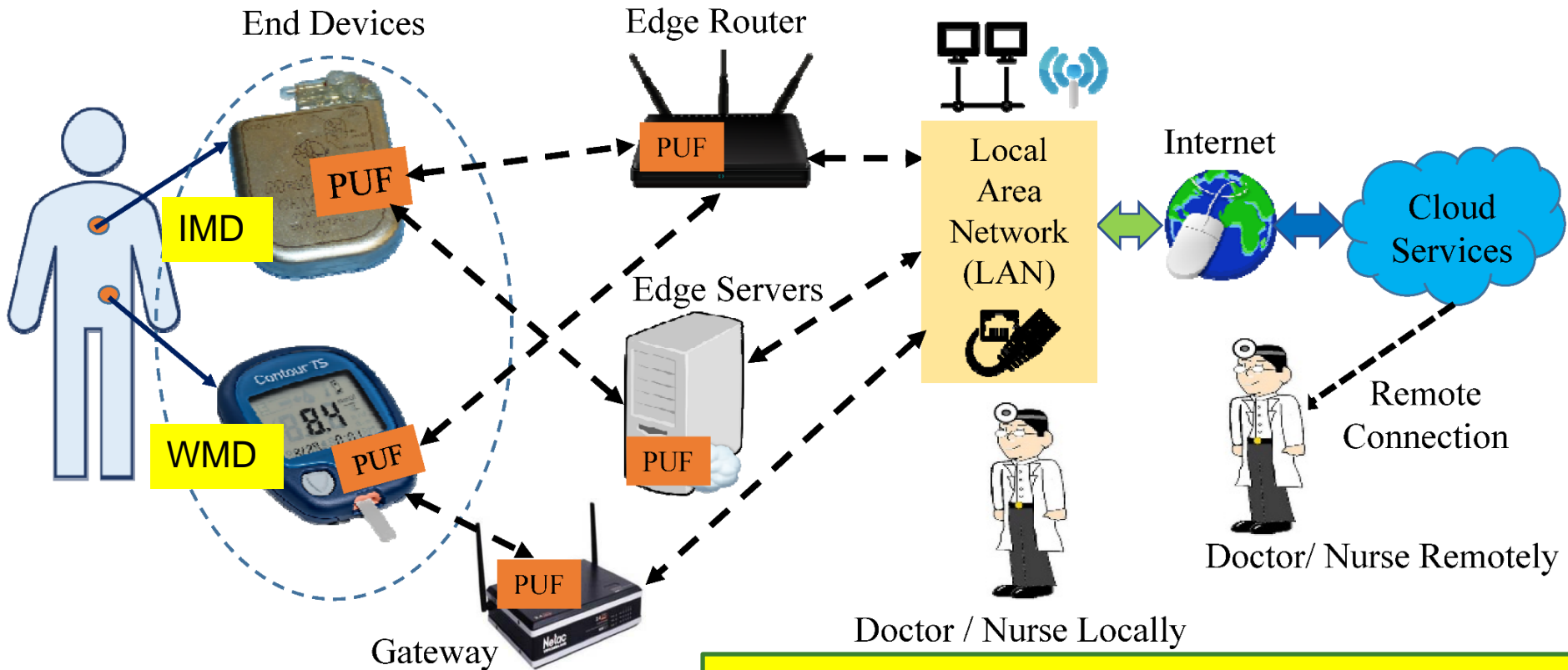
Authentication: Time – 1 sec, Power - 200 μW

Source: V. P. Yanambaka, S. P. Mohanty, E. Kougianos, and D. Puthal, "PMsec: Physical Unclonable Function-Based Robust and Lightweight Authentication in the Internet of Medical Things", *IEEE Transactions on Consumer Electronics (TCE)*, Volume 65, Issue 3, August 2019, pp. 388--397.

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Blockchain has Many Challenges

Fake Block Generation

High Energy Consumption

Lack of Scalability

Blockchain Challenges

51% Attack

High Latency

Limited Onchain Storage Capability

Lack of Privacy
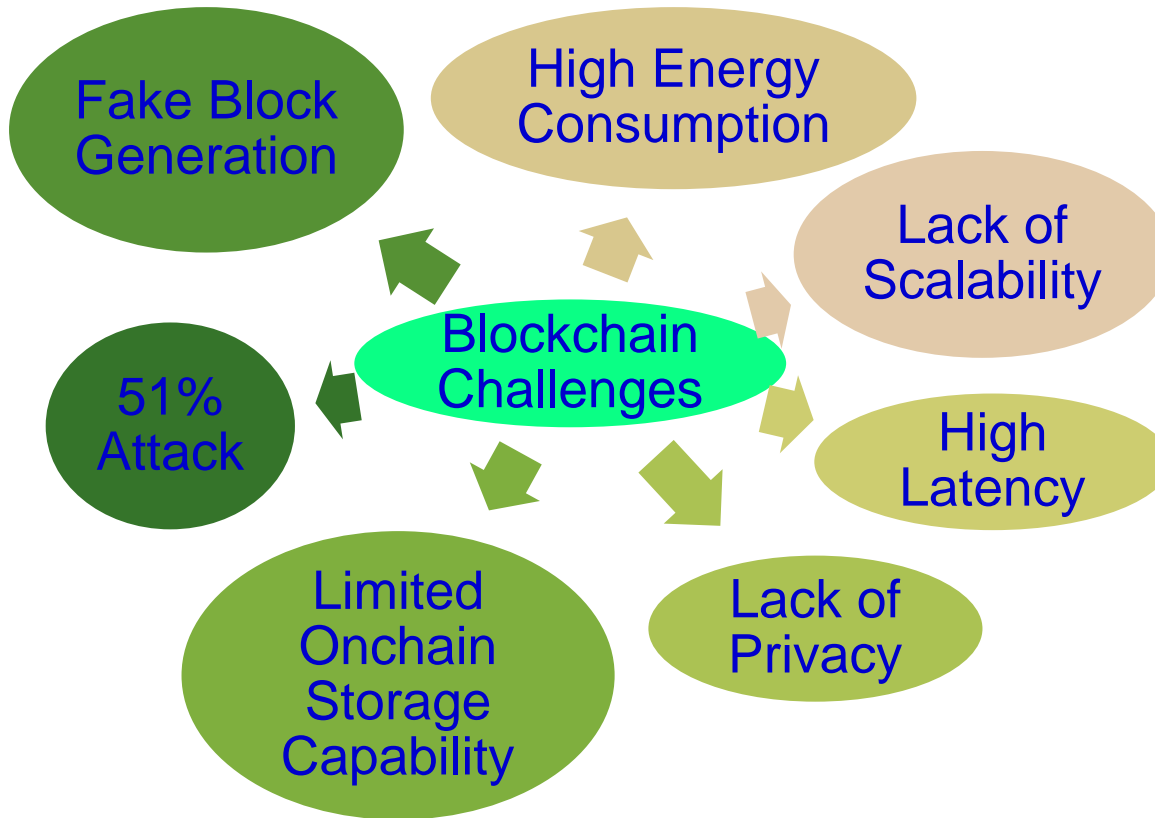
July 2018

Source: D. Puthal, N. Malik, S. P. Mohanty, E. Kougianos, and G. Das, "Everything you Wanted to Know about the Blockchain", *IEEE Consumer Electronics Magazine (CEM)*, Volume 7, Issue 4, July 2018, pp. 06--14.

Blockchain Energy Need is Huge

Energy for mining of 1 bitcoin

=

Energy consumption 2 years of a US household
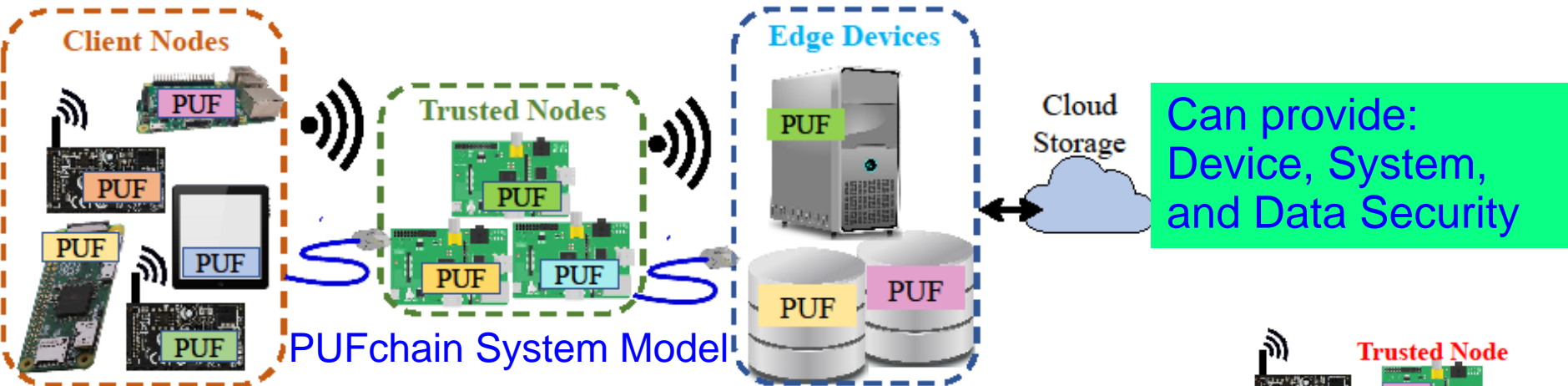

Energy consumption for each bitcoin transaction

= 80,000X

Energy consumption of a credit card processing

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PUFchain: The Hardware-Assisted Scalable Blockchain

Can provide: Device, System, and Data Security

PUFchain System Model

PUFChain 2 Modes:
(1) PUF Mode and
(2) PUFChain Mode

PUFchain Working Model
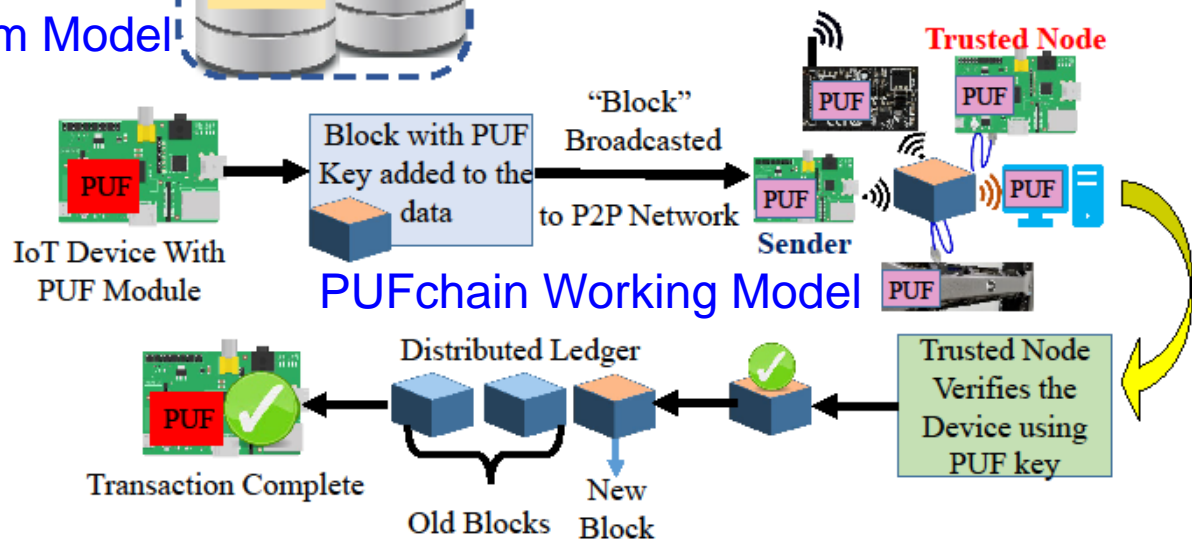
Source: S. P. Mohanty, V. P. Yanambaka, E. Kougianos, and D. Puthal, "PUFchain: Hardware-Assisted Blockchain for Sustainable Simultaneous Device and Data Security in Internet of Everything (IoE)", *IEEE Consumer Electronics Magazine (MCE)*, Vol. 9, No. 2, March 2020, pp. in Press.

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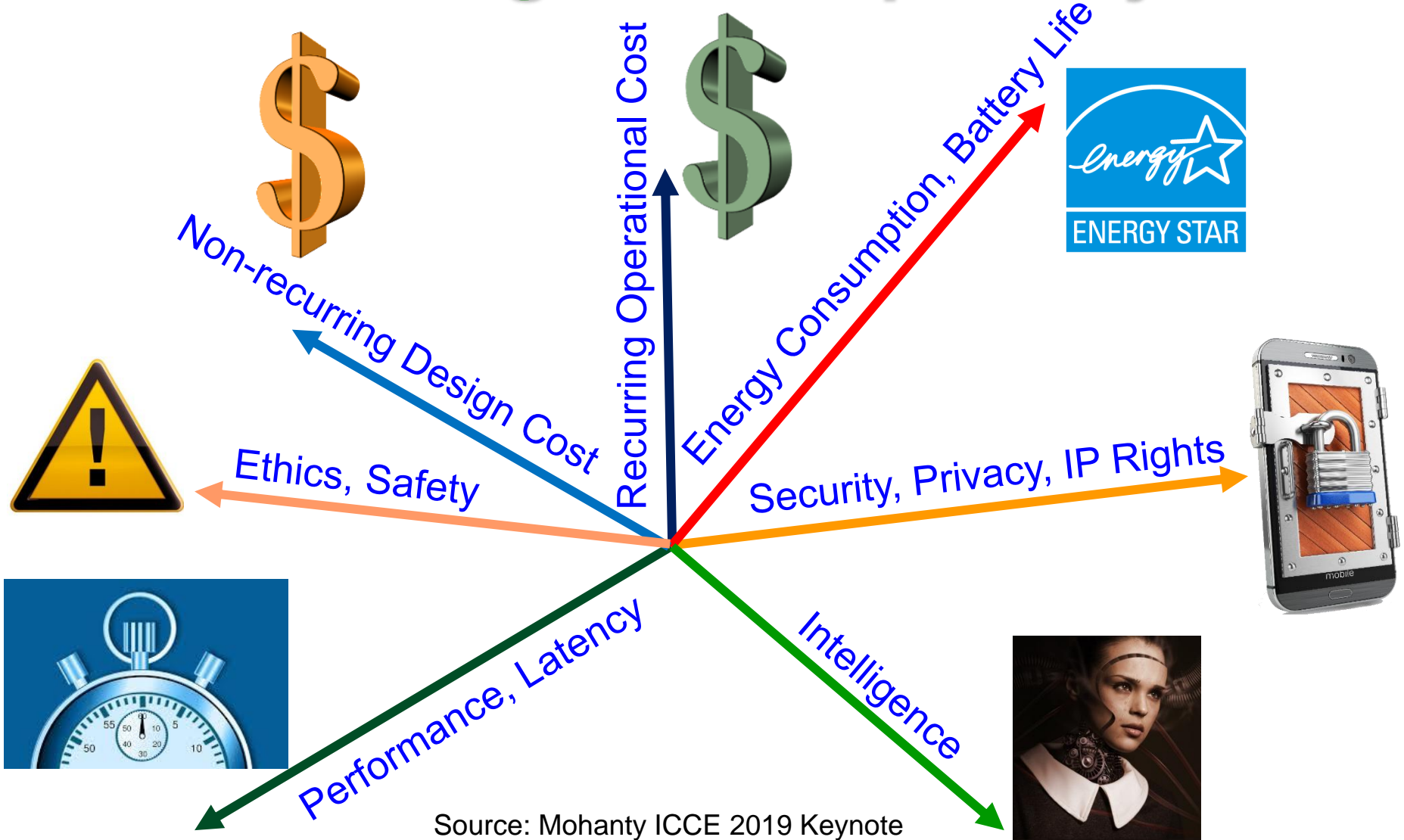# IoT/CPS Design – Multiple Objectives

Non-recurring Design Cost

Recurring Operational Cost

Energy Consumption, Battery Life

Ethics, Safety

Security, Privacy, IP Rights

Performance, Latency

Intelligence

Source: Mohanty ICCE 2019 Keynote

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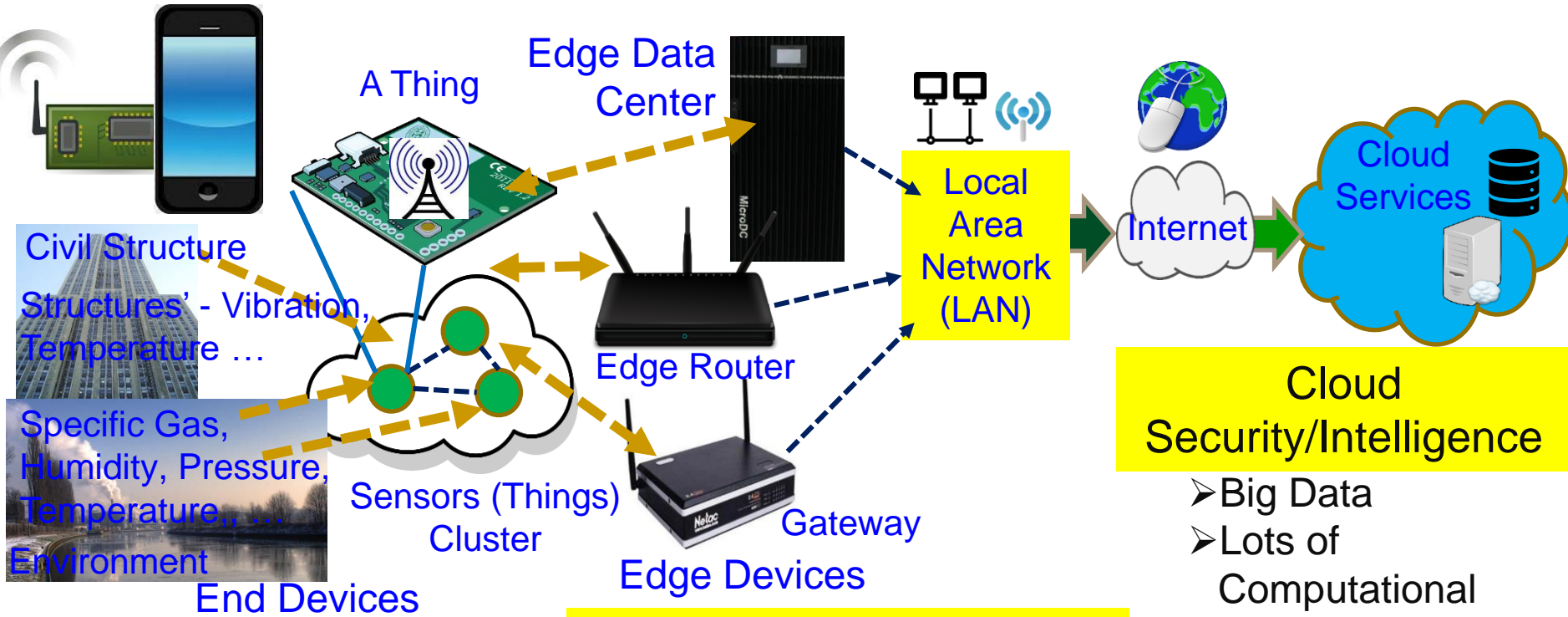# Security by Design (SbD) and/or Privacy by Design (PbD)

Embedding of security/privacy into the architecture (hardware+software) of various products, programs, or services.

Retrofitting: Difficult → Impossible!

Source: https://teachprivacy.com/tag/privacy-by-design/

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End, Edge Vs Cloud - Security, Intelligence

A Thing

Edge Data Center

Civil Structure

Structures' - Vibration, Temperature …

Specific Gas, Humidity, Pressure, Temperature,, … Environment

Local Area Network (LAN)

Internet

Cloud Services

Sensors (Things) Cluster

Edge Router

Gateway

Edge Devices

End Devices

End Security/Intelligence

➢ Minimal Data
➢ Minimal Computational Resource
➢ Least Accurate Data Analytics
➢ Very Rapid Response

Edge Security/Intelligence

➢ Less Data
➢ Less Computational Resource
➢ Less Accurate Data Analytics
➢ Rapid Response

Cloud Security/Intelligence

➢ Big Data
➢ Lots of Computational Resource
➢ Accurate Data Analytics
➢ Latency in Network
➢ Energy overhead in Communications

Source: Mohanty iSES Keynote 2018 and ICCE 2019 Panel

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UNT EST. 1890 DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING College of Engineering

Suggestions for collaboration

- **Potential** collaboration **modes**
  - One to one faculty interactions
  - Serving on Ph.D. students' committee
  - Mentoring junior faculty
  - Indo-USA Science and Technology Forum (IUSSTF)
  - Participating as expert in India Govt. funding
- **From my** experience what works
  - One to one faculty interactions
- **From my** experience what are the challenges
  - Funding to officially compensate USA faculty time

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