Security and Trustworthiness of Modern Cyber-physical Systems

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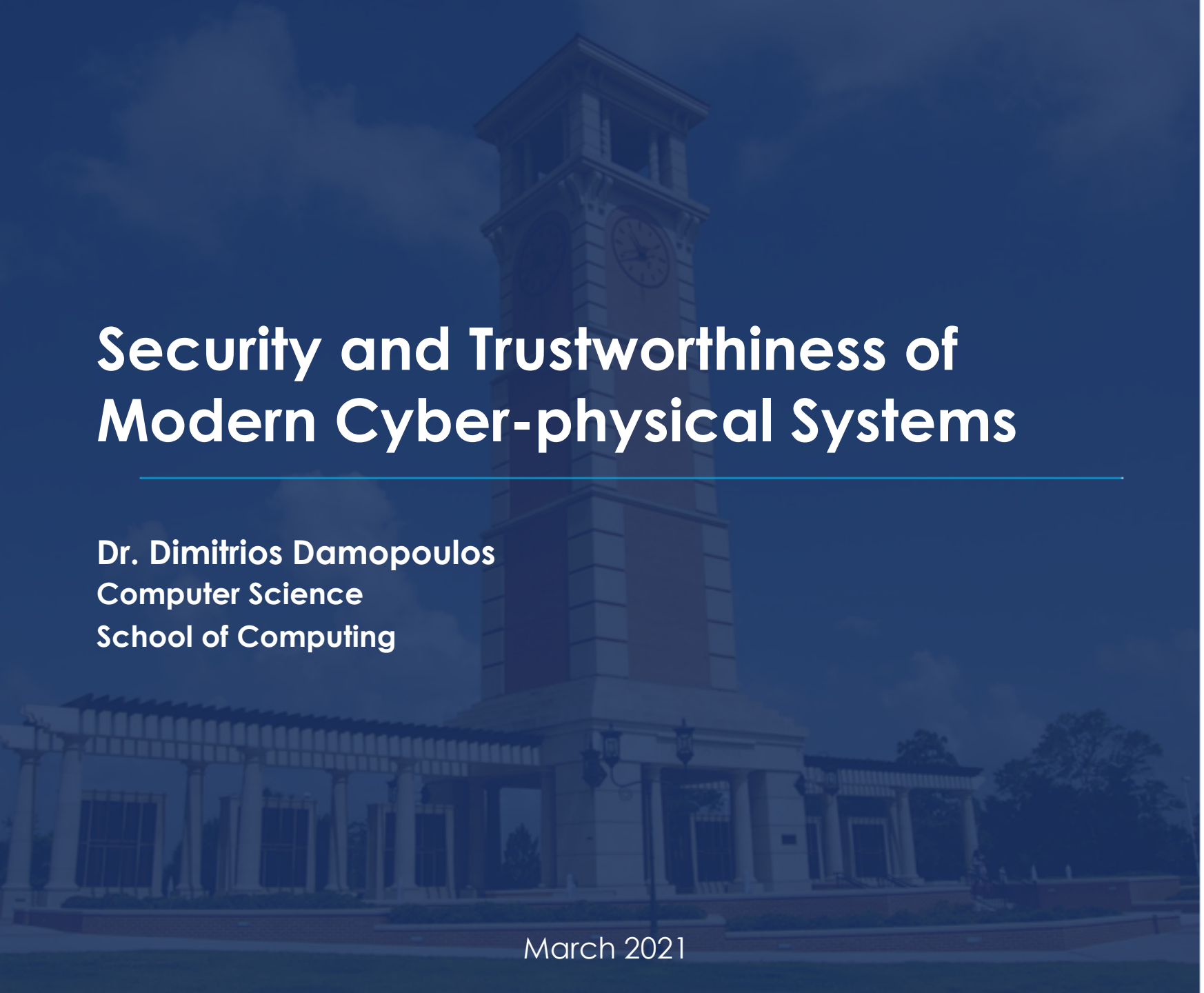

UNIVERSITY OF SOUTH ALABAMA

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About me

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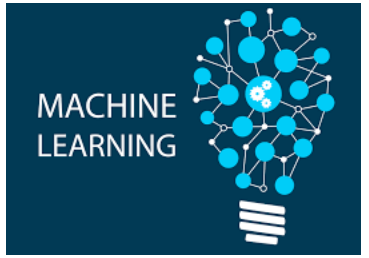

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Cybersecurity Education needs to start very early…

Last 15 years

Cybersecurity

Cyber-Physical Systems

Intrusion Detection

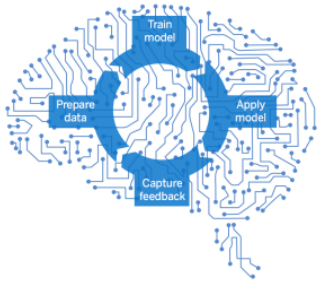
Smartphones
IoT
CPS

Education

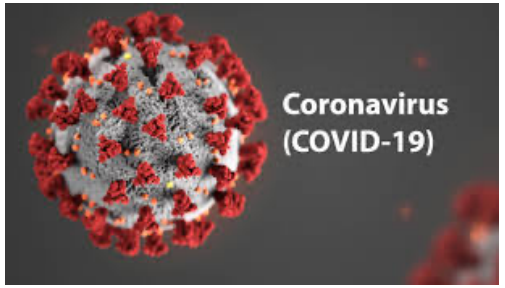
Trustworthiness
Ethics
Privacy
Law

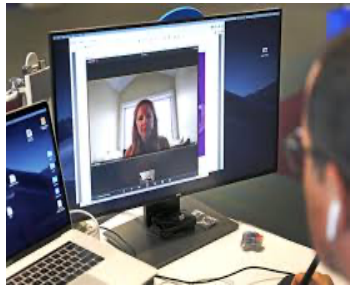
AI
Deep Learning
Machine Learning

Machine Learning



Today: Inter-connected world





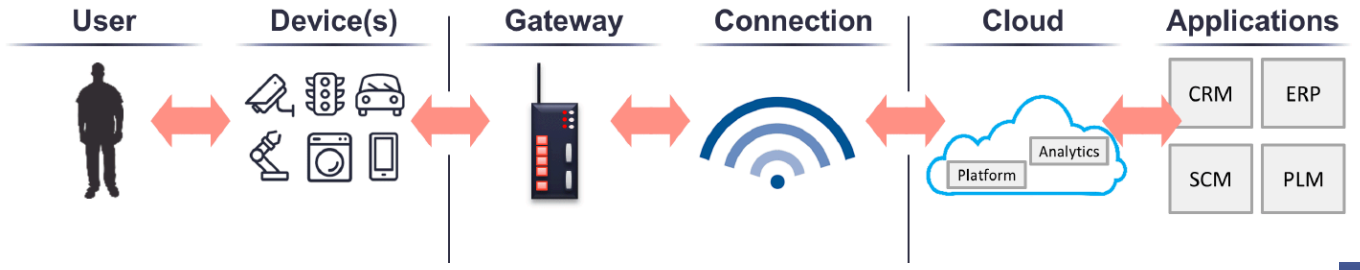
In **2017** was predicted that **20.4 billion** IoT devices will be online **by 2020**

2020: A significant year for many reasons

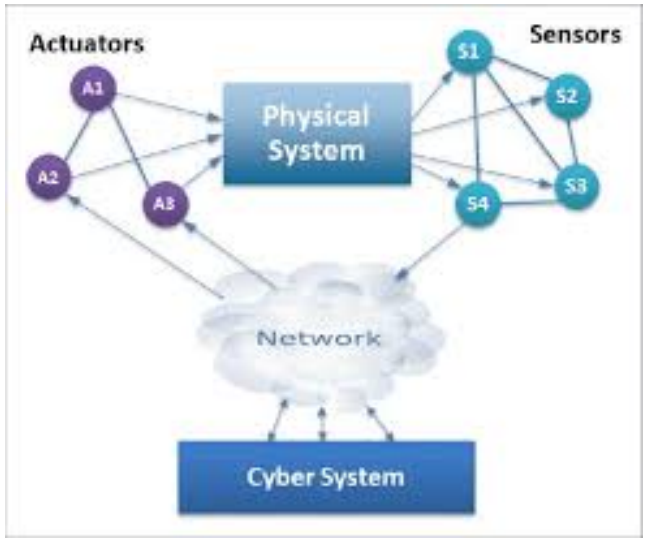
- Remote work
- Blockchain and AI
- Apple and Google COVID-19 contact tracing system
- Cyber Attacks
- IoT Cybersecurity Improvement Act of 2020

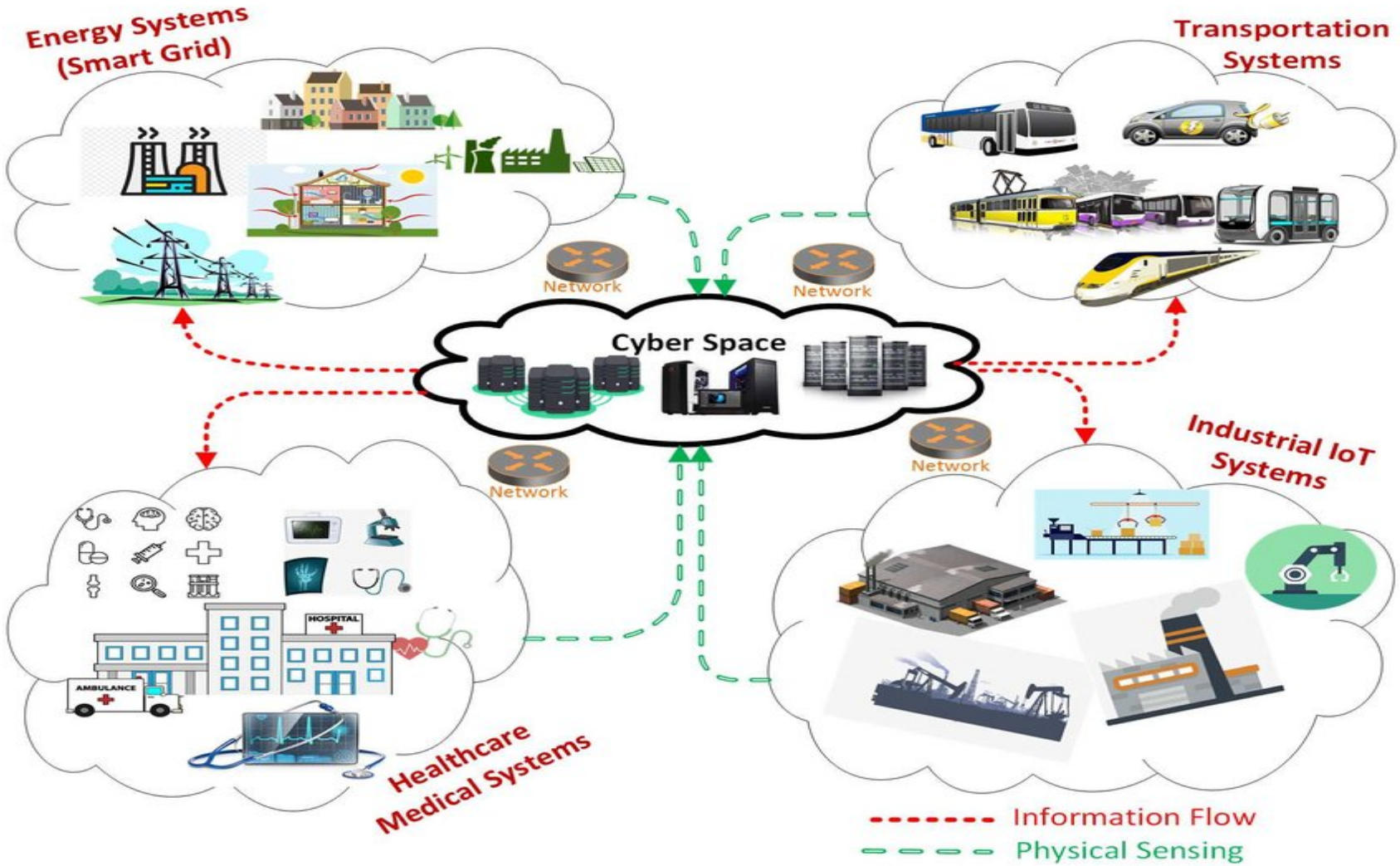
Cyber-physical Era

- A **cyber-physical system** refers to any network-connected instrumentation that also interacts with the physical world.



Cyber-physical Ecosystem





Issues & Challenges

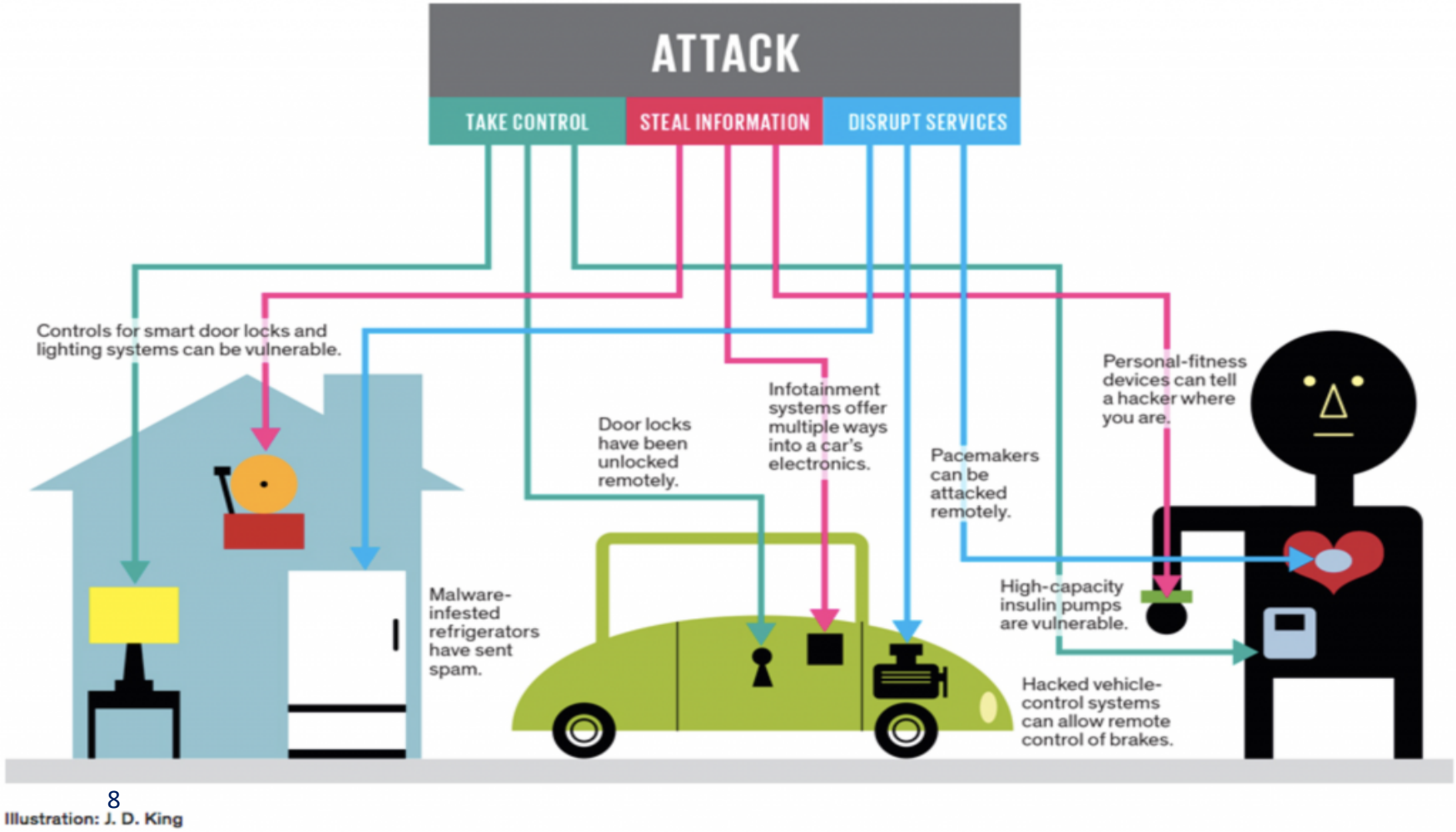


Illustration: J. D. King

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Are we prepared for the

Cyber-Physical Era ?

Today's Goal: Raise Awareness

- How Security & Trustworthiness in an essential part of:
  - Cyber-physical systems security
  - AI / ML Trustworthiness

What is Machine Learning ?

- **Machine Learning** is a branch of **Artificial Intelligence** based on the idea that systems can:
  - learn from data
  - identify patterns
  - make decisions with minimal human intervention

Cyber-physical Systems Security

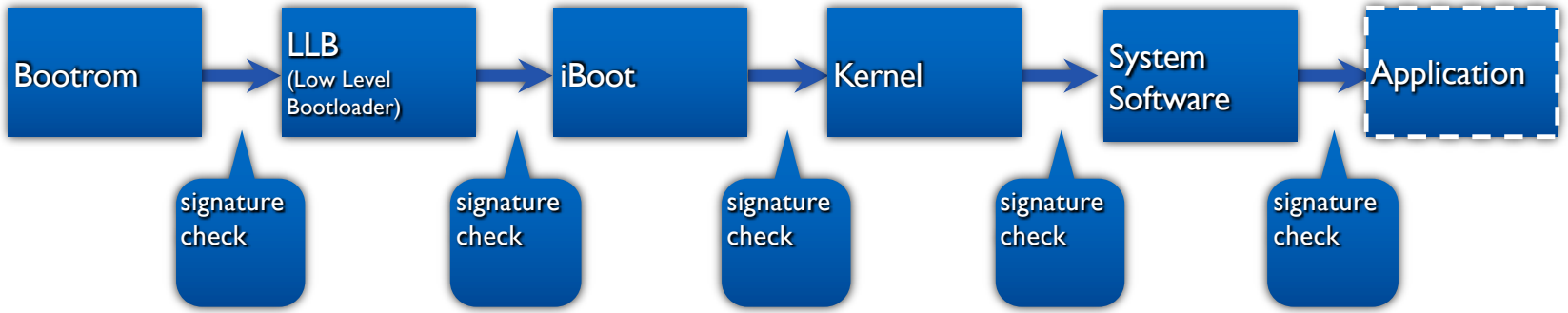
Trustworthy Cyber-physical System

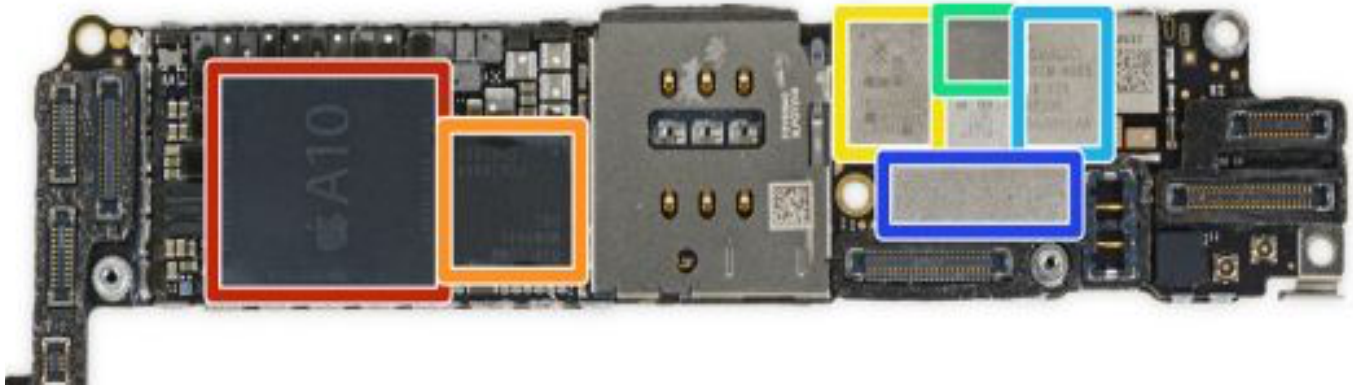
- Systems must be **trustworthy** to ensure that the technology is used to benefit humanity

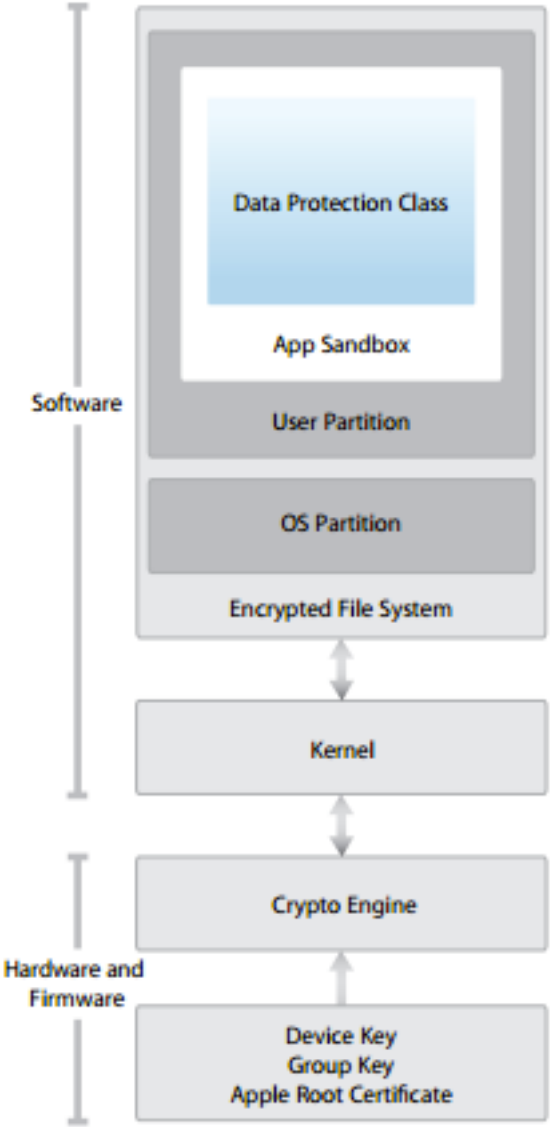
- Software Security
- Hardware Security
- Network Security
- Cloud Security
- Smartphone / IoT Security / CPS
- Digital Forensics

- AI / ML trustworthiness
- Standards & Frameworks
- Compatibility – Legacy system
- Privacy – Law - Ethics
- Management
- Education

Smartphone Security







Built-in Security Mechanisms

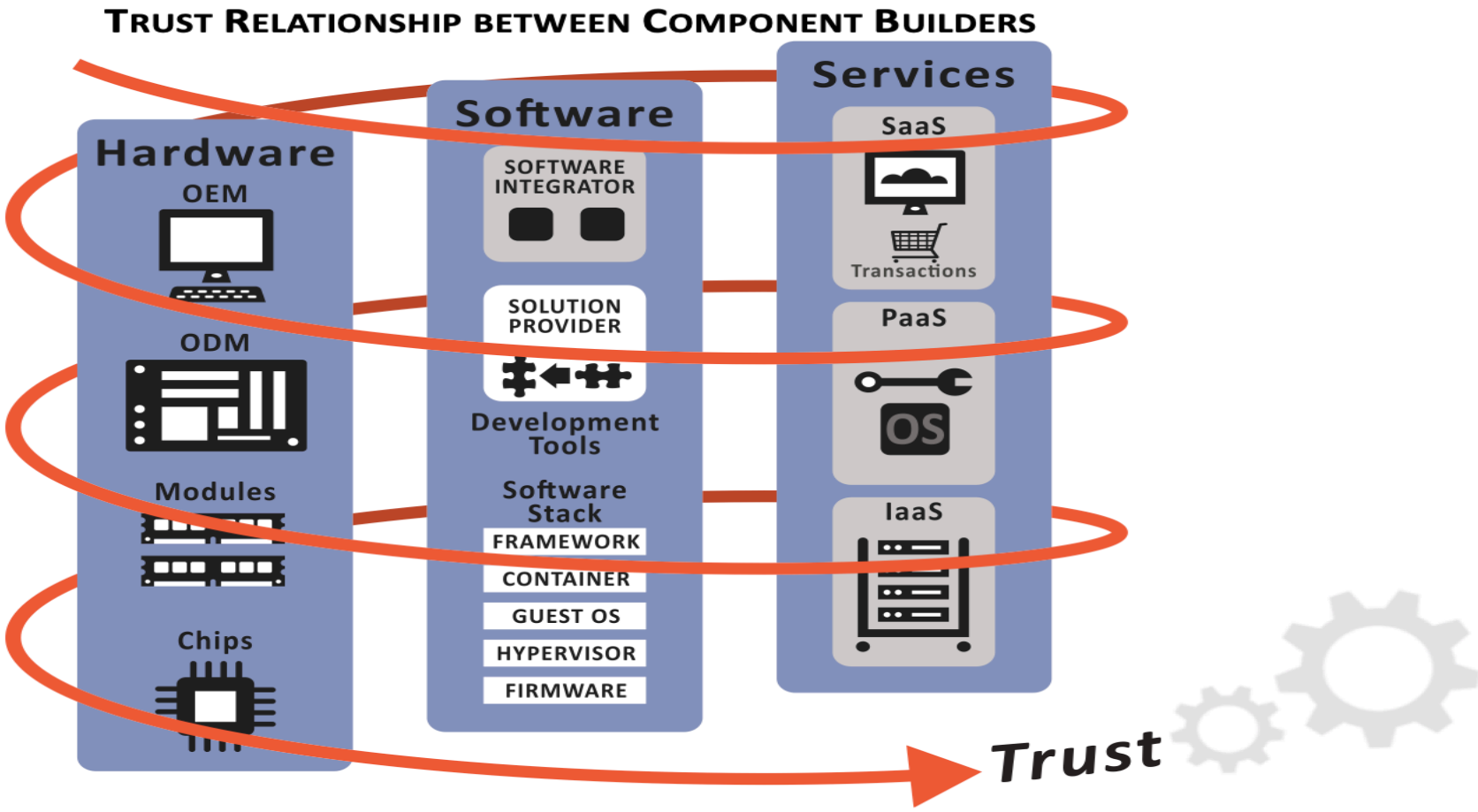
- Secure Boot Chain
- Data Execution Prevention
- Address Space Layout Randomization
- Sandbox
- Code Signing Enforcement
- Runtime Process Security

Smart Homes & IoT Security

Chip	OS& Service	Hardware Root of Trust	Defense in Depth	Small TCB	Dynamic Compartments	Certificate-based Auth.	Failure Reporting	Renewable Security
MT3620	Azure Sphere							
Espressif ESP32	RTOS & ?							
Marvell 88MW300/2	RTOS & ?							
Qualcomm QCA4010	RTOS & ?							
Broadcom BCM43907	RTOS & ?							
TI CC3220x	RTOS & ?							

= Full, Partial, or No Silicon support = Full, Partial, or No OS support = Full, Partial, or No Cloud Security Service support

Trust Cyber-physical Systems

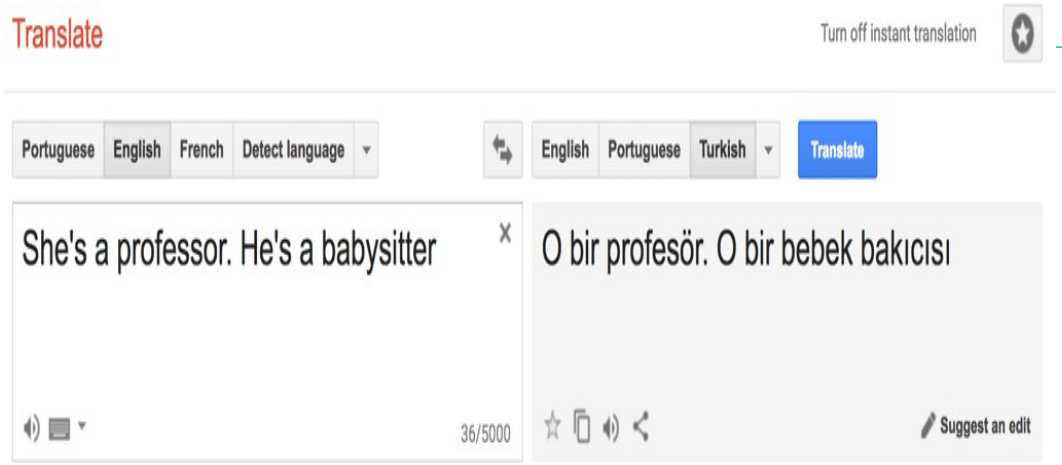


AI Trustworthiness

AI Trustworthiness

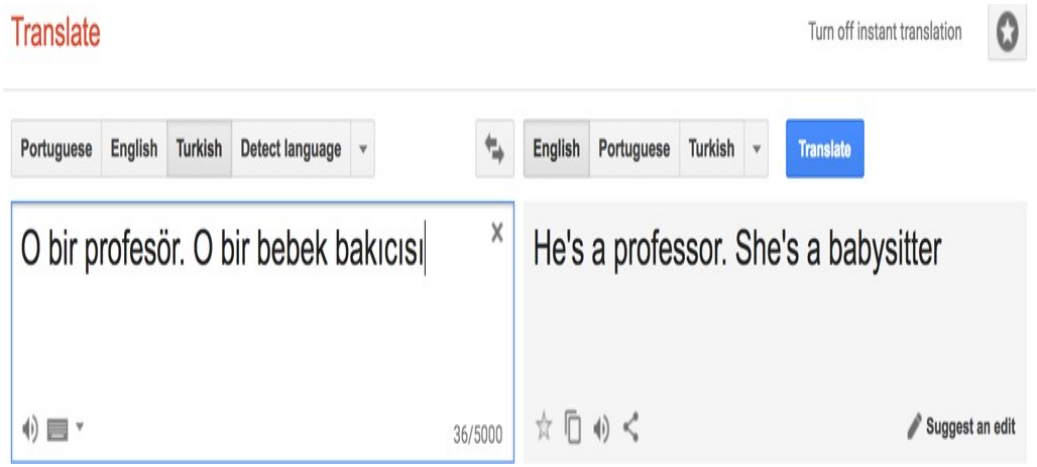
- People will not be willing to engage and trust **AI systems** without:
  - Accuracy & Performance
  - Privacy - Ethics - Ownership
  - Data & Model Validation
  - ML Fairness
  - Adversarial Machine Learning
  - Explainable AI
  - Digital Forensics

Some Examples



Hotel A gets average **3.2**

with a mix of mostly 3 and 4

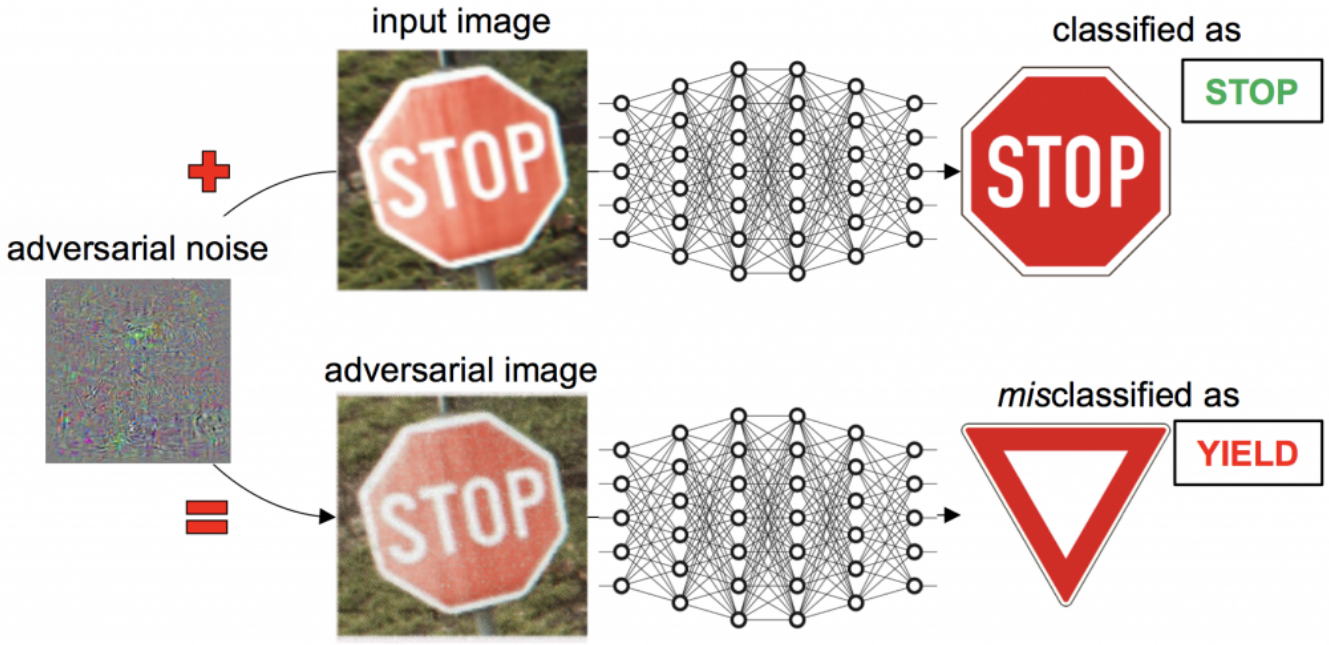


Hotel B gets average **3.2**

with a mix of mostly 1 and 5

Adversarial Machine Learning

- Adversarial examples are malicious inputs designed to fool Machine Learning models



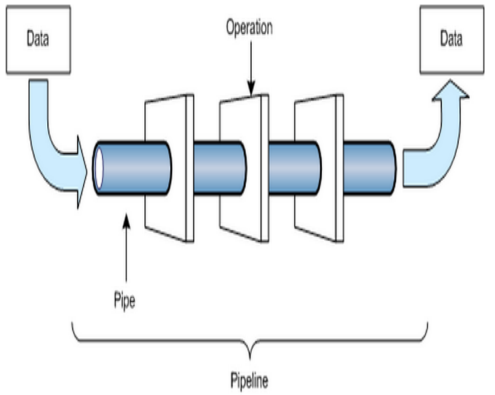
Security & Trust in CPS

Holistic Security & Trust

Intrusion Detection

Hardware Security

AI/ML Trustworthiness



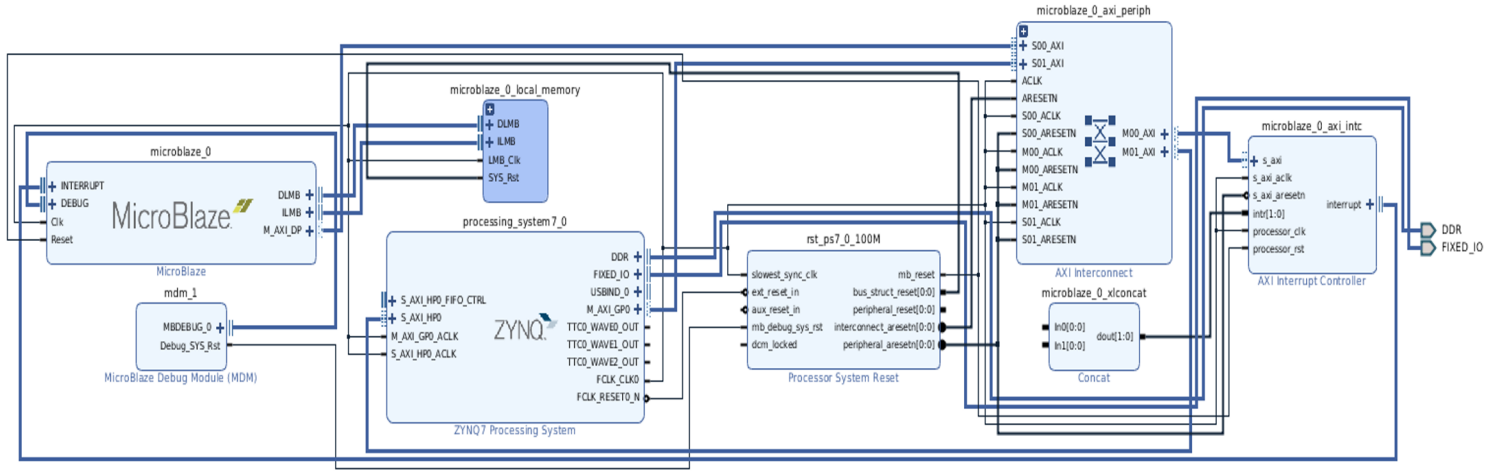
Data Pipeline Security

Currently

- An AI Updatable Hardware-based IDS
- Chain of Trust in Data Pipelines for Digital Investigation
  - Quantum-resistant Encryption Scheme (PKI) for CPS
- AI Trustworthiness
  - Bias evaluation
  - Adversarial attacks
  - Transfer Learning

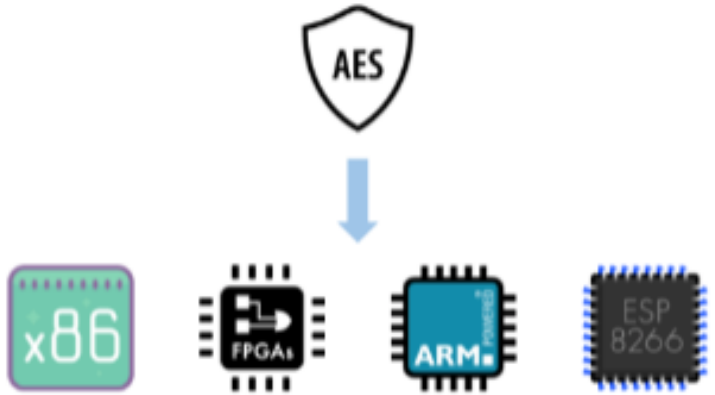
An AI Updatable Hardware-based IDS

- Simulated Buffer Overflow (Arm)
- Canary Detection (FPGA)
- Currently:
  - IoT Malware detection system
  - Transfer Learning
  - Side-Channels

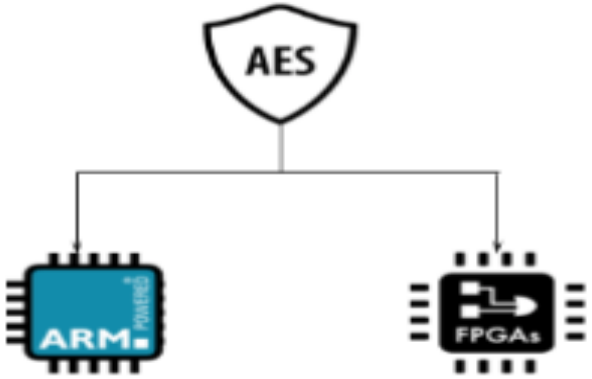


Quantum-resistant Encryption Scheme for PKI

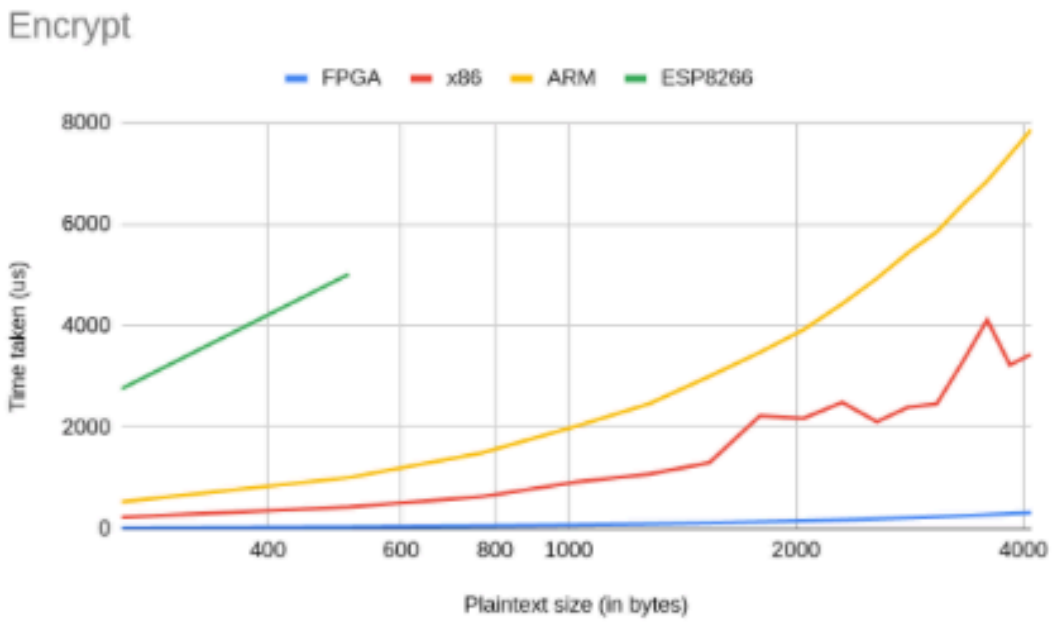
- A hardware/software implementation of a quantum resistant encryption algorithm
  - 3DES
  - AES

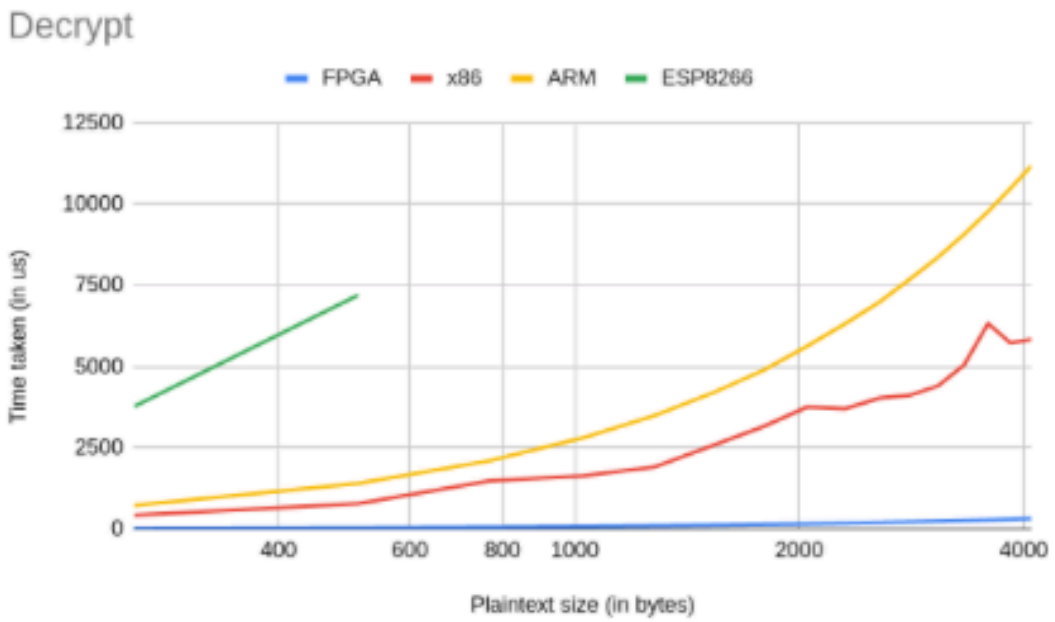


- A hardware/software implementation of a Blockchain in zero trust
  - SHA, Elliptic Curve

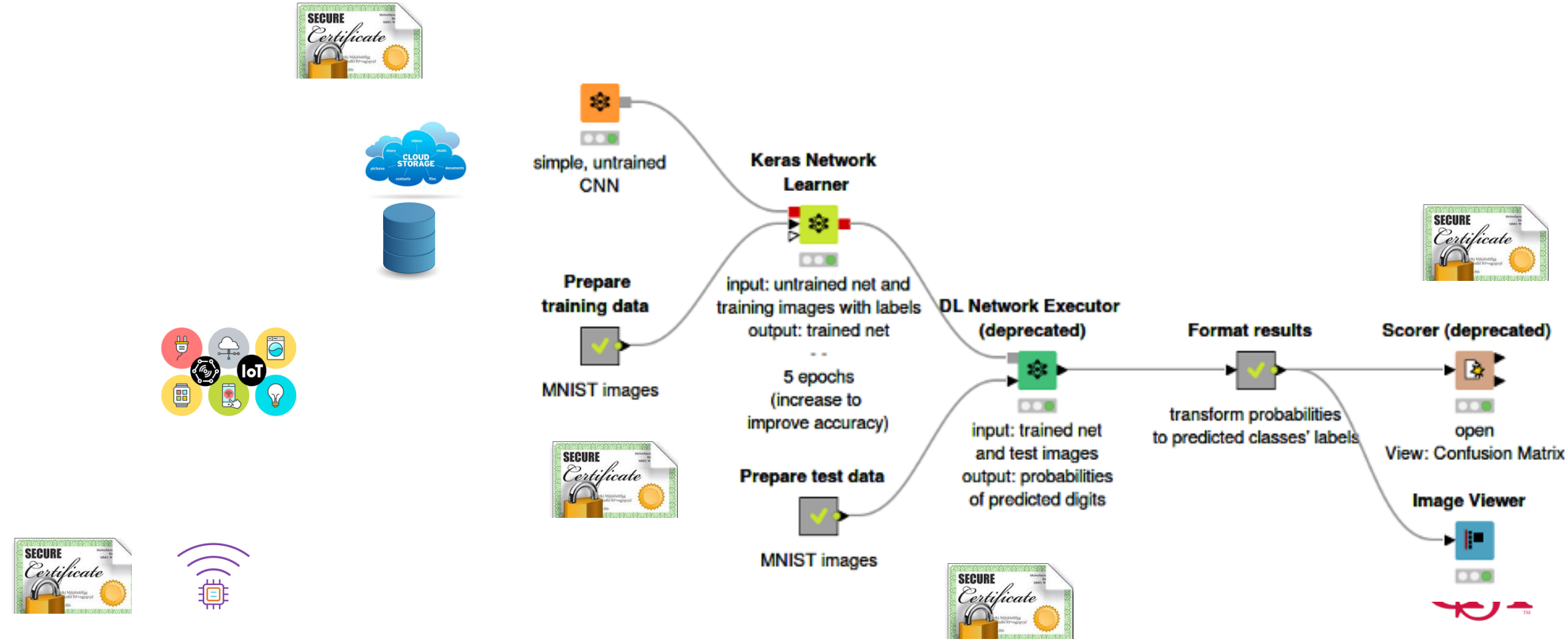


AES Performance Analysis





Chain of Trust in Data Pipelines for Digital Investigation



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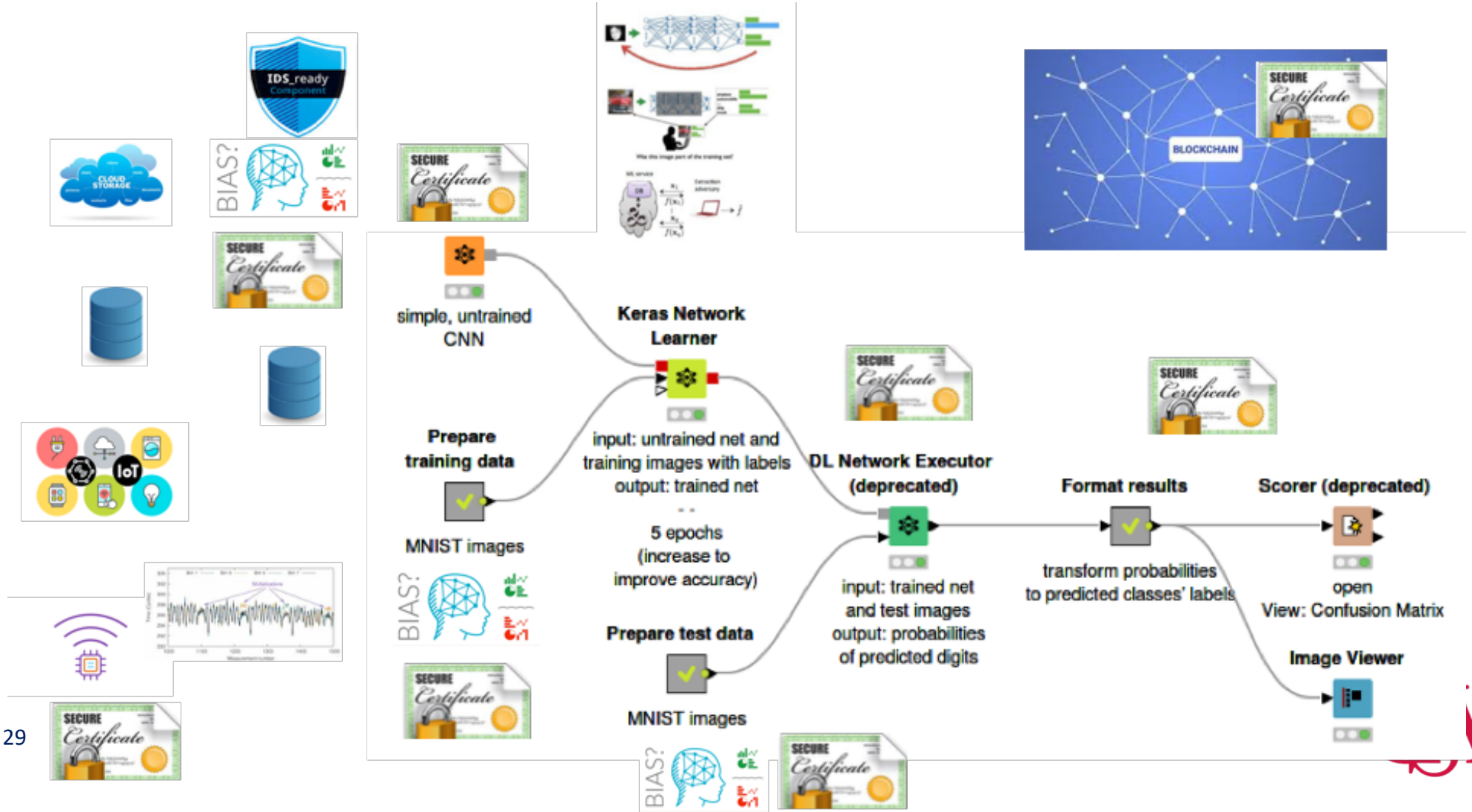

AI Trustworthiness

- Transfer & Reinforcement Learning
  - Bias evaluation
  - Adversarial attacks

- Models based on:
  - Random Forest
  - Neuron Networks

Open Research Directions

- So many ☺
  - Multilayer issue
    - ✓Explore hardware and software vulnerabilities
    - ✓Side-channels
    - ✓Updatable and transferable security
  - Trust in AI / DL Learning
  - Holistic Intrusion Detection

Final Remarks

- Trustworthiness, Cybersecurity, Education
  - Develop **processes and tools** for the **Cyber-physical ecosystem** capable to evaluate the **trustworthiness** of a system
    - Cybersecurity
    - AI
  - Cybersecurity & AI Trustworthiness in **Education**

Thank You!

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