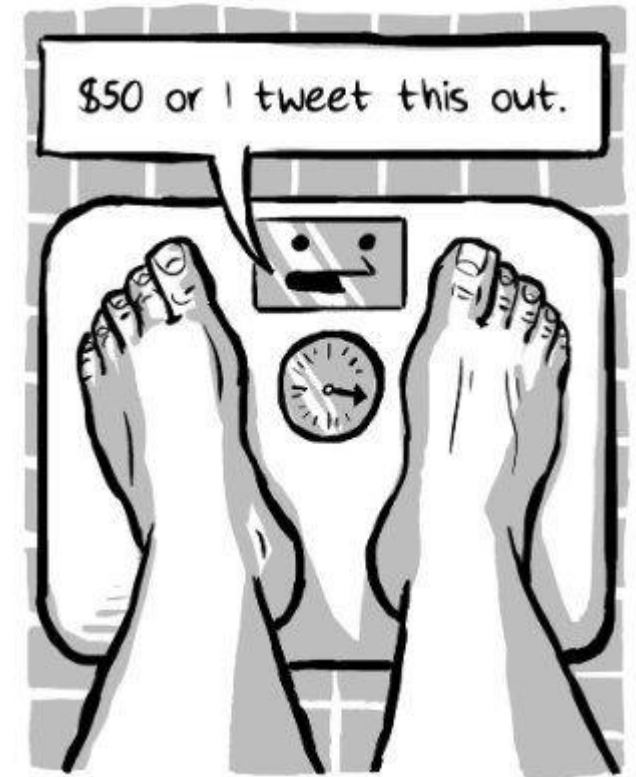# Cybersecurity Management
GCS 2.2 – IoT/ICS

2022-2023
Prof. Marc Ruiz

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Introduction to Internet of Things (IoT)

Basic definition

- The Internet of Things (IoT) describes the network of physical objects—"things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet.
- These devices range from ordinary household objects to sophisticated industrial tools.
- With more than 7 billion connected IoT devices today, experts are expecting this number to grow to 10 billion by 2020 and **22 billion by 2025**.

source: **ORACLE**

IoT use cases

Top IoT Applications

- Smart City
- Smart Home
- Self-Driving Cars
- Smart Farming
- Fitness Trackers
- Smart Factories
- Hospitality & Tourism
- Retail IoT
- Smart Grid
- Health Monitoring

>hackr.io

IoT device classification

- Sensors/actuators (constrained IoT devices)
  - They do not communicate with the server
  - Data from these IoT devices can be transmitted to server using gateway
  - Typically they use zigbee, NFC, Bluetooth and RFID standards for communication
  - Battery operated
  - They take care of single sensors, with low data volume
- Intermediate/gateway nodes
  - Directly communicate to central servers for data storage
  - It supports IP protocol and various comm ports: DSL, FTTH, WiFi
  - Powerful processors, not constrained by battery power
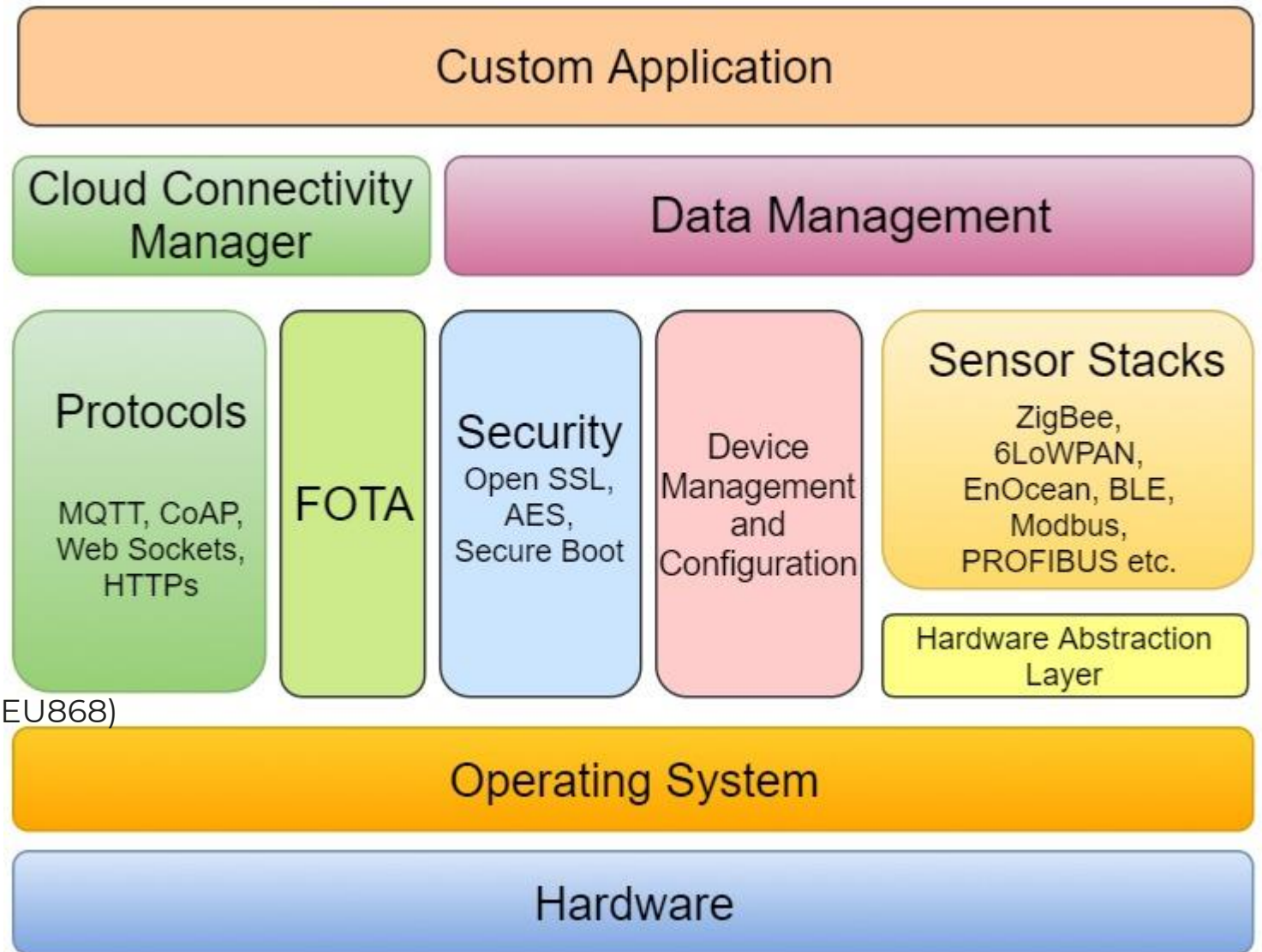
Constrained IoT devices

Temperature sensor
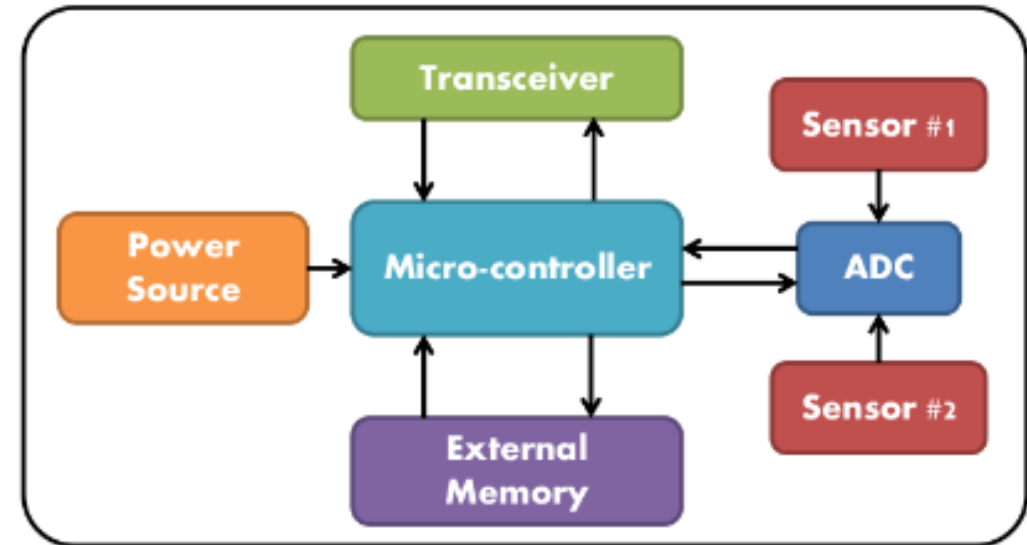
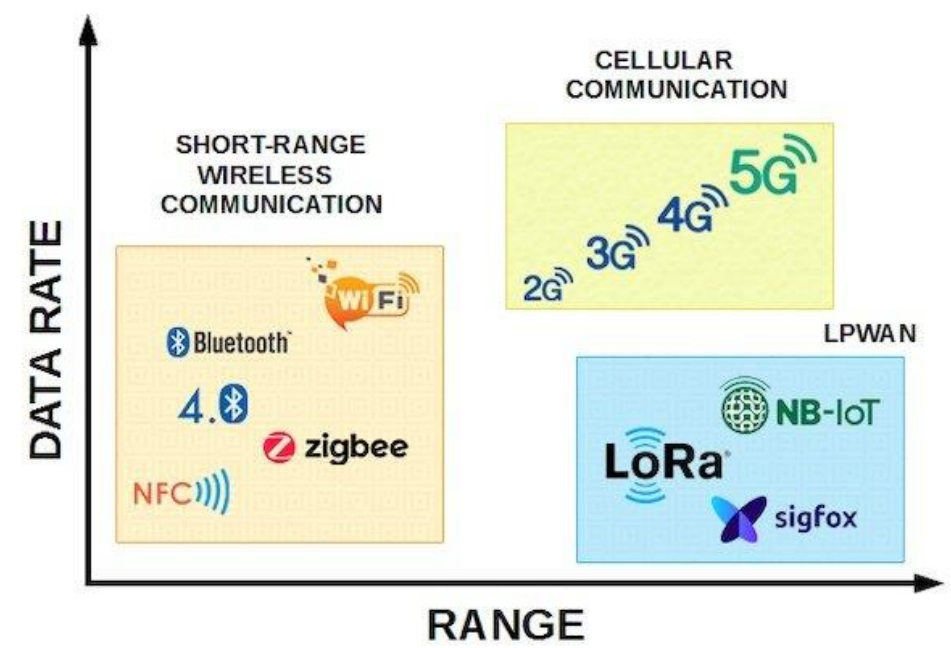| Name	data size (e.g., RAM)	code size (e.g., Flash)
Class 0, C0	<< 10 KiB	<< 100 KiB
Class 1, C1	~ 10 KiB	~ 100 KiB
Class 2, C2	~ 50 KiB	~ 250 KiB

# IoT gateway

Dragino LPS8 Indoor LoRaWAN Gateway (EU868)

Custom Application

Cloud Connectivity Manager

Data Management

Protocols

MQTT, CoAP, Web Sockets, HTTPs

FOTA

Security
Open SSL, AES, Secure Boot

Device Management and Configuration

Sensor Stacks

ZigBee, 6LoWPAN, EnOcean, BLE, Modbus, PROFIBUS etc.

Hardware Abstraction Layer

Operating System

Hardware

IoT comms

| Protocol	Frequency	Range	Data Rates
Bluetooth	2.4 GHz	100 m	125 Kbps–Mbps
Wi-Fi	2.4 GHz, 5 GHz	50 m	150–600 Mbps
NFC	13.56 MHz	4 cm	100–420 Kbps
LoraWAN	867–869 MHz (Europe) 902–928 MHz (North America)	15 Km	0.3–50 Kbps
Cellular	900/1800/1900/2100 MHz	30 m (Between node and base station)	21 Mbps (3G+) 600 Mbps (4G)
Z-wave	865–926 MHz (ISM)	100 m	100 Kbps
Zigbee	2.4 GHz (ISM)	100 m	20 Kbps–250 Kbps
Sigfox	900 MHz	3–50 Km	10–1000 bps

End-to-end IoT architecture
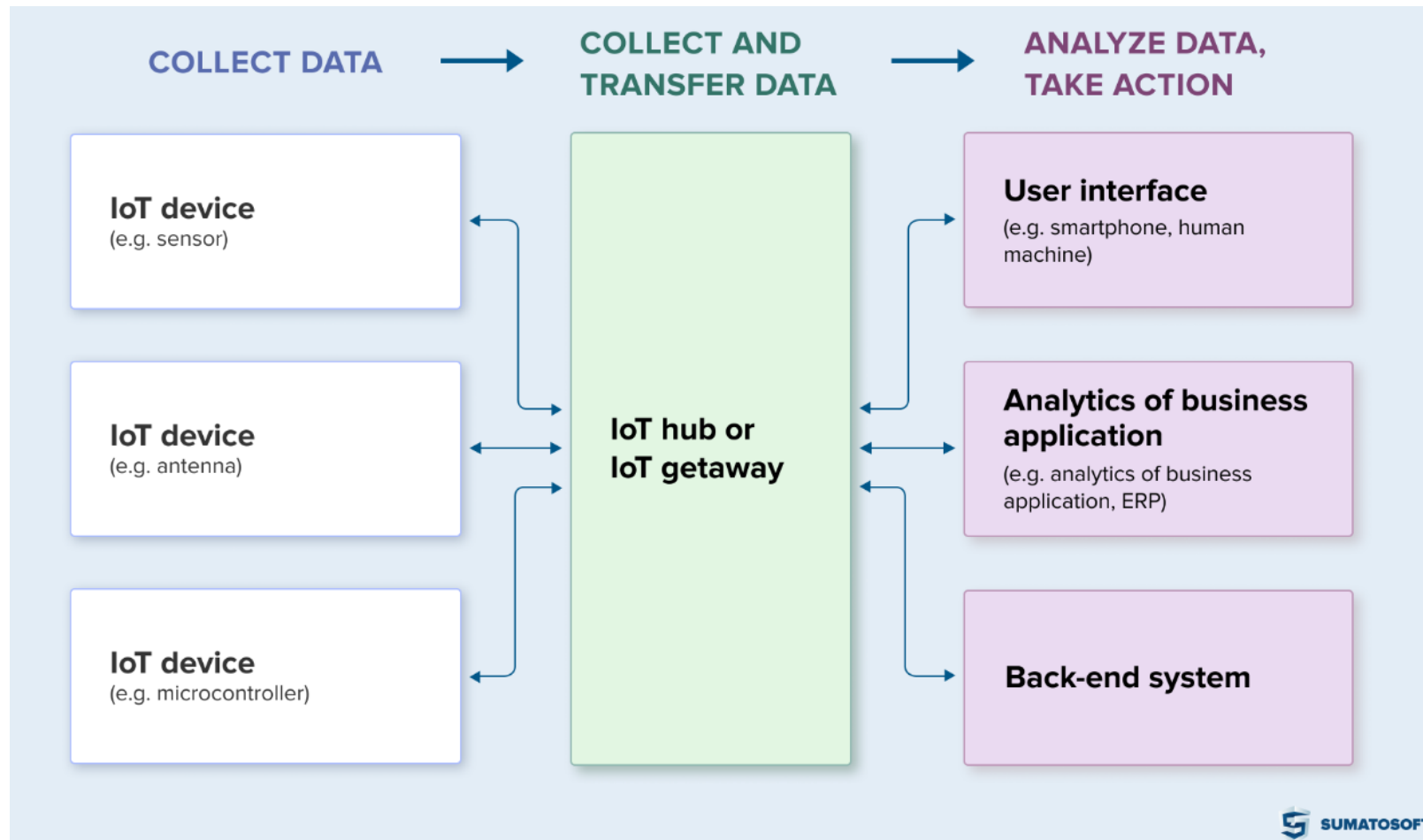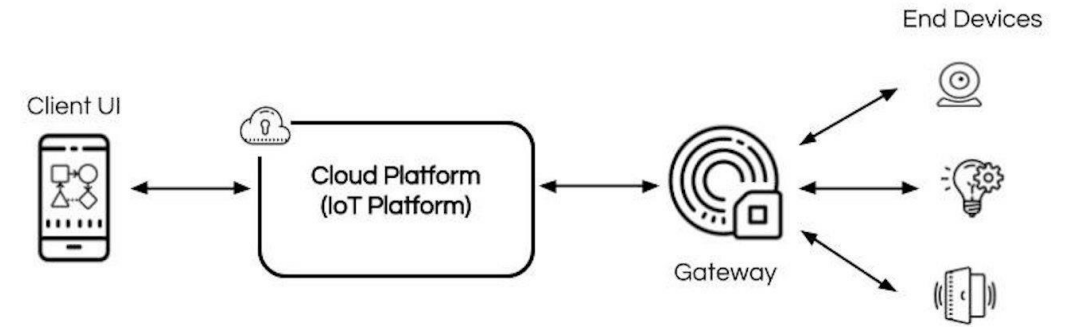
IoT control loops
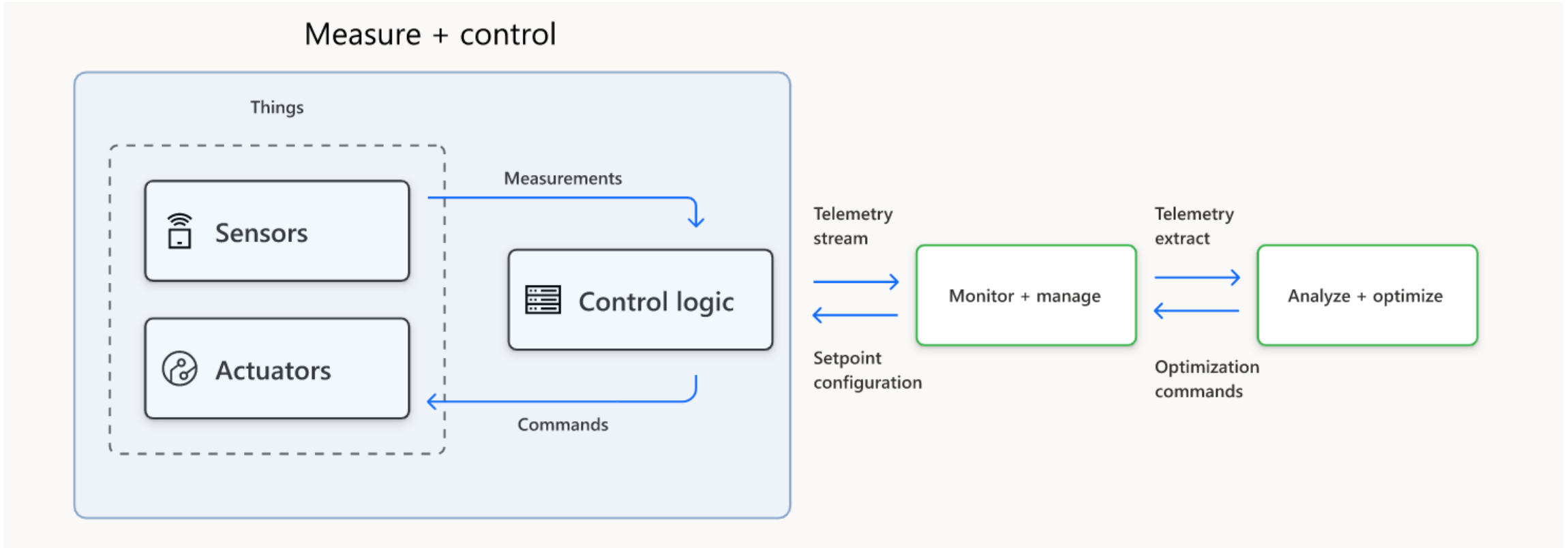
IoT platforms

- Node-RED
  - Low-code programming for event-driven applications
  - https://nodered.org/
- OpenRemote
  - 100% Open Source IoT Platform for OEMs
  - https://openremote.io/
- ThingsBoard
  - Device management, data collection, processing and visualization
  - https://thingsboard.io/

IoT Congress Barcelona

TECHNOLOGY STAGES

This is it! **The new era of industry has arrived. IOT and disruptive technologies are changing the game**, with new business models emerging and technological innovation rapidly changing our world. The content of the **IOT Solutions World Congress** is divided into **6 technology stages:**

| INDUSTRY IOT | AI | DIGITAL TWIN | EDGE COMPUTING | AUGMENTED REALITY | 5G |

IoT Congress Barcelona

IOT SOLUTIONS WORLD CONGRESS

31 JANUARY - 2 FEBRUARY 2023
BARCELONA - GRAN VIA VENUE HALL 4

INDUSTRY JOURNEYS

For targeted audience groups across multiple industry sectors and markets. Learn how these technologies are transforming industries and how they can be foundational to your business.

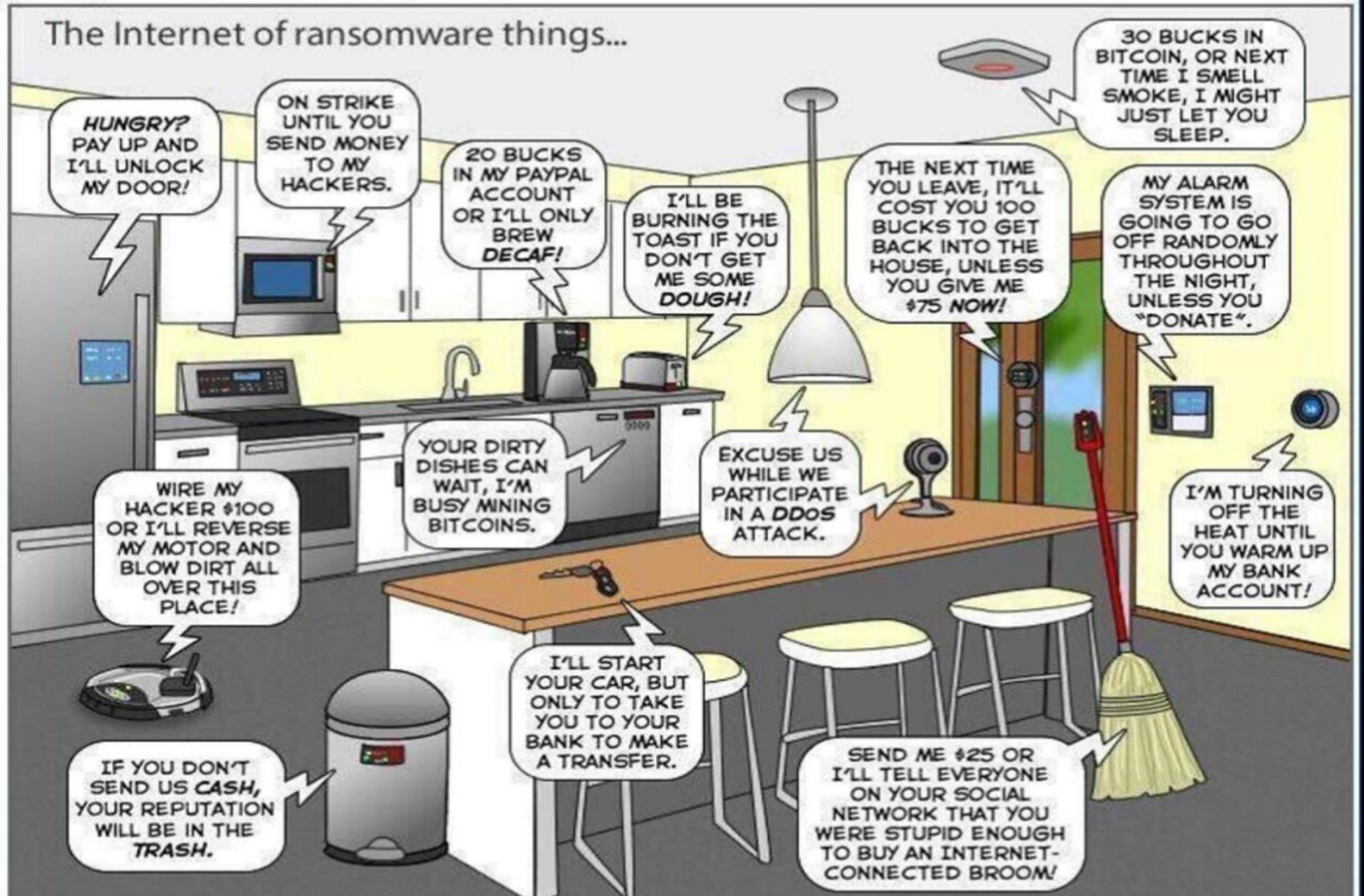| MANUFACTURING / SUPPLY CHAIN | HEALTHCARE | ENERGY / UTILITIES | SMART BUILDINGS / CITIES | CONNECTED TRANSPORTATION |

IoT Security

The joke…

Concept

- Methods of protection used to secure internet-connected or network-based devices.
- Not only internet-based devices e.g., Bluetooth technology also count as IoT
- Family of techniques, strategies and tools used to protect these devices from becoming compromised.
- The more ways for devices to be able to connect to each other, the more ways threat actors can intercept them.

IoT attacks examples

- Disable the brakes of a connected car
- Hack a connected health device (insulin pump) to administer too much medication to a patient
- Disconnect a refrigeration system housing medicine
- Disable (or unlock) smart door locks
- Etc, etc, etc

IoT attacks examples

- **Botnets**
    - large collection of devices that has fallen under the control of a centralized attacker
    - DDoS attacks or introduce malware to new victims
    - Many of the security breaches that find their way into the news are the results of botnets!!!
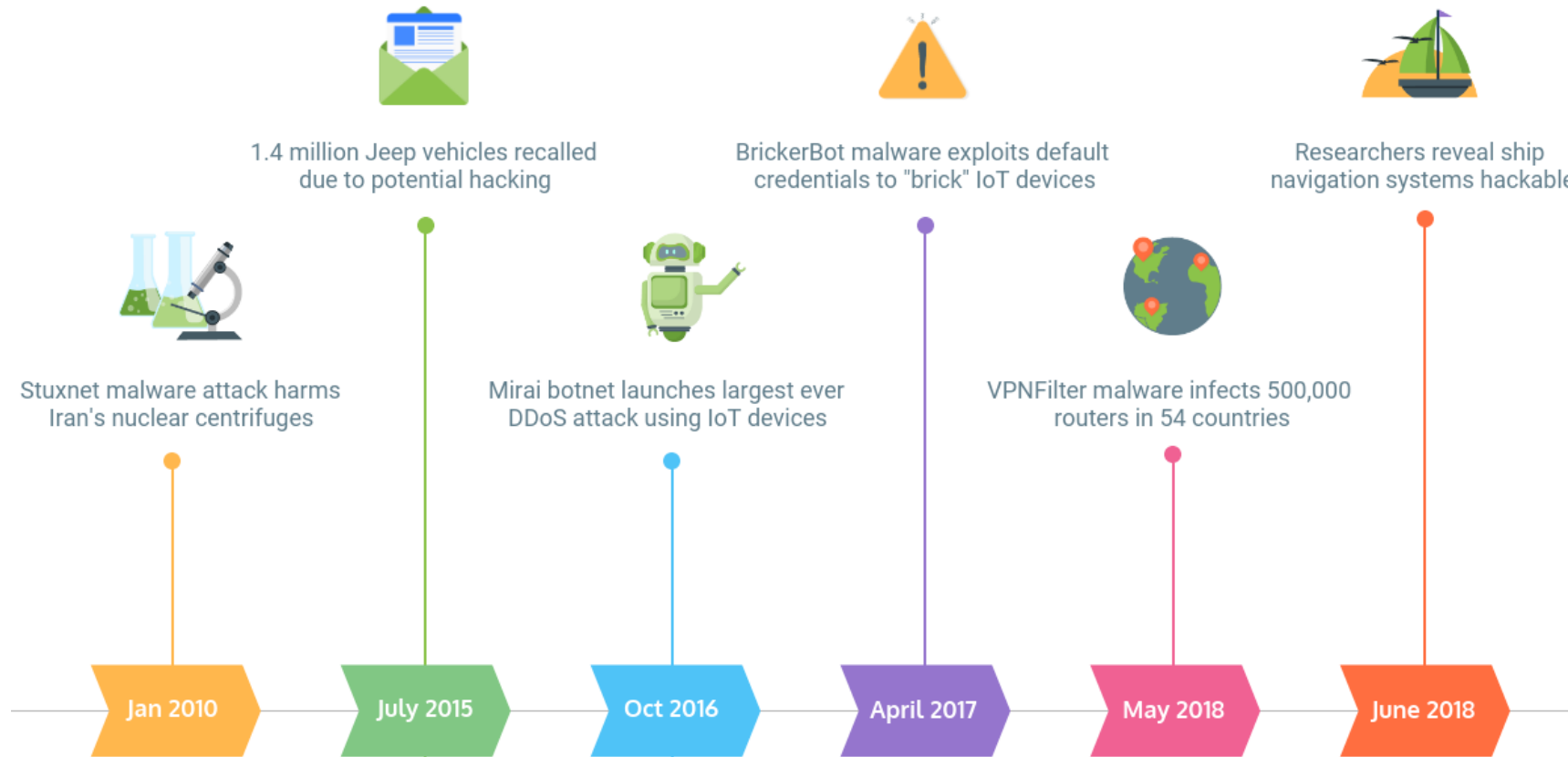
IoT Security targets

Famous IoT attacks

1.4 million Jeep vehicles recalled
due to potential hacking

BrickerBot malware exploits default
credentials to "brick" IoT devices

Researchers reveal ship
navigation systems hackable

Stuxnet malware attack harms
Iran's nuclear centrifuges

Mirai botnet launches largest ever
DDoS attack using IoT devices

VPNFilter malware infects 500,000
routers in 54 countries

| Jan 2010 | July 2015 | Oct 2016 | April 2017 | May 2018 | June 2018 |

Source: GetApp

Exercise 2: Lightreading of famous attacks and lessons learned: https://www.getapp.com/resources/internet-of-things-security/

Exercise 3: Watch Video **Hacking TESLA car**: https://www.youtube.com/watch?v=5mdU4ksOc2w

Cybersecurity threats

- **Service disruption**
  - Manipulating IoT devices to make an essential service (e.g., a power generating dam, the water system, a database) completely unavailable

- **Data theft**
  - Gaining improper access to personally identifiable information (PII), such as names, user accounts, social security, national health ID numbers, telephone numbers and residence addresses

- **Data or service manipulation**
  - Where the attacker can make arbitrary changes to the settings of a device, which can cause loss of life, loss of service, damage to the device itself or damage to other devices.
  - Include manipulation of actuators for malicious purposes

Major flaws

- **Inadequate default settings**
  - Default passwords

- **Non-existent upgrade paths**
  - Sometimes, it is impossible to update the firmware or other information itself, making the device permanently toxic to healthy IoT networks.

- **The use of inappropriate technology**
  - Placing powerful software onto an IoT device, even though such computing power is not necessary.
  - Complete Linux operating system makes an IoT device a powerful weapon in the hands of an attacker.
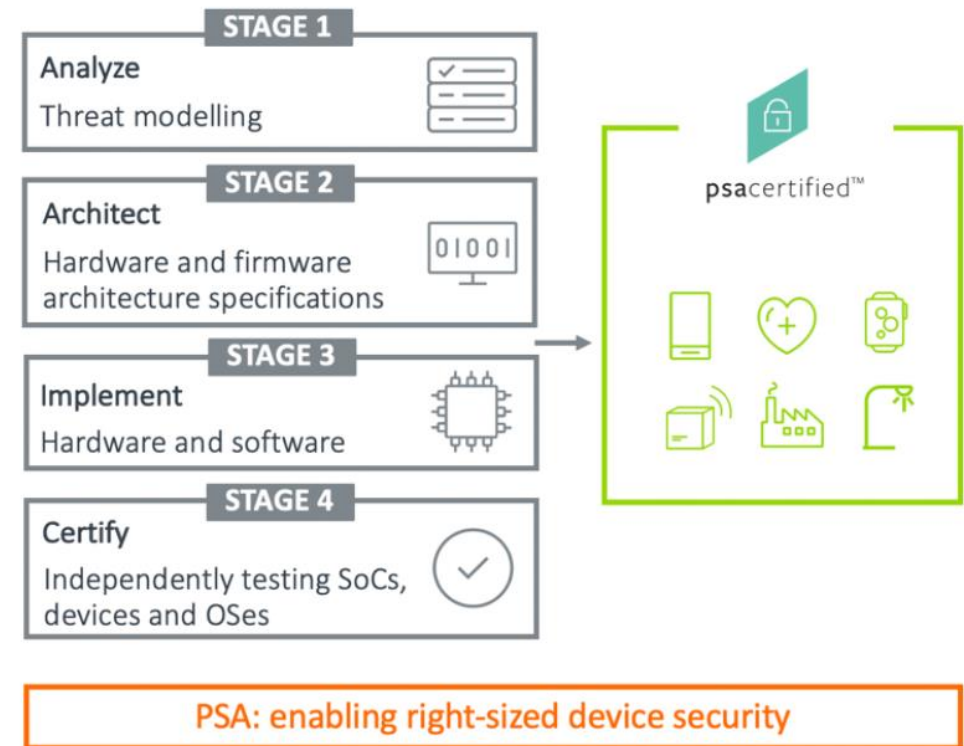
Issues and challenges

- **Remote exposure is…good…and also bad**
  - accessibility is extremely valuable <-> grants hackers the opportunity to interact with devices remotely
  - IoT security has to account for a large number of entry points!!

- **Maybe digital revolution is going too fast…**
  - More IoT devices -> cost-efficient production ☺
  - More IoT devices -> more vulnerability ☹
  - Lack of investment in securing IoT devices.

- **Resource constraints**
  - Not all IoT devices have the computing power to integrate sophisticated firewalls or antivirus software.
  - Energy can be scarce in those devices with batteries e.g., field sensors

Measures

- Introduce IoT security awareness during the design phase

Platform Security Architecture (PSA)

The open device security framework, with independent testing

STAGE 1
Analyze
Threat modelling

STAGE 2
Architect
Hardware and firmware architecture specifications

STAGE 3
Implement
Hardware and software

STAGE 4
Certify
Independently testing SoCs, devices and OSes

psacertified™

PSA: enabling right-sized device security

Measures

- PKI and digital certificates to protect messages and interactions
- Secure connectivity by implementing network security
- API security

6 Hot Internet of Things (IoT)
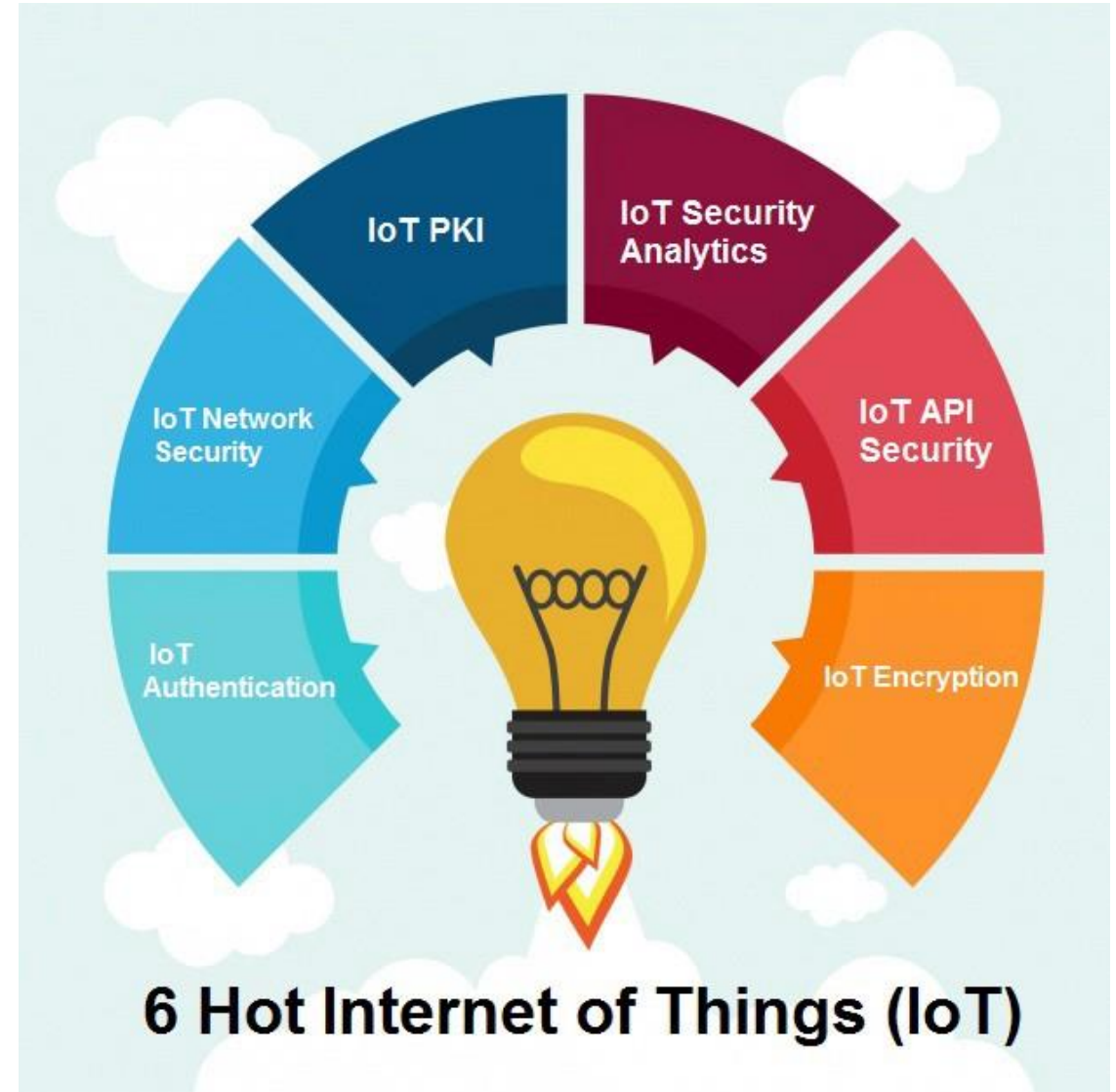
Measures

- Network access control for IoT inventoring

- Network segmentation

- Security gateways acting as intermediary between IoT devices and the network

- Patch management/continuous software updates

- Cybersecurity Training and team integration (devops and cybersec experts)

- Consumer education

Exercice 4: Watch this video: https://www.youtube.com/watch?v=iFsCIVH3eS0

ENISA IoT

Online tool:

https://www.enisa.europa.eu/topics/iot-and-smart-infrastructures/iot/good-practices-for-iot-and-smart-infrastructures-tool

Exercise 5

Find out which good practices ENISA proposes for baseline security IoT in the area of *cryptography*.

enisa
EUROPEAN
UNION AGENCY
FOR CYBERSECURITY

News from the same period

European Rail: Report unveils challenges and stresses the need for investment in cybersecurity

IoT Security: ENISA Publishes Guidelines on Securing the IoT Supply Chain

PRESS RELEASE

IoT Security: ENISA Publishes Guidelines on Securing the IoT Supply Chain

Report addresses the entire lifespan of Internet of Thing (IoT) product development by offering security measures for each step.

Published on November 09, 2020

Industrial Control Systems (ICS)
(Self-learning)

Instructions

- Light-reading documents extracted from the extensive information available at Cybersecurity & Infrastructure Security Agency (CISA) website.
  - *Cybersecurity Practices for Industrial Control Systems (2 pages)*
  - *Cyber Threat Source Descriptions (4 pages)*
  - *Overview of Cyber Vulnerabilities (14 pages)*

  All documents available in RACO!!!!! (ics_docs.zip)

- Read them and make yourself questions to try to better understand the concepts of this lesson, as well as find relations with other lessons of the course:
  - Try to identify the similarities and differences between ICS systems and IoT systems. Feed your ICS knowledge with those lessons learned from IoT systems
  - Which threats/vulnerabilities/attacks described in the document are typically observable in other environments and use cases?
    - For instance, man-in-the-middle attack is identified as a potential attack in ICS LANs. Then, is different to other man-in-the-middle attack typically affecting WANs?
  - Conversely, identify any issue/attack/measure inherent or native to ICS systems that is not present (or infrequent) in other use cases.

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Don't forget the exercises ;)