Internet of Things (IoT)

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Année universitaire 2023-2024

Internet of Things (IoT)

Teacher Biography

- An Associate Professor in electronics and signal processing at **ESILV** since 2021.
- She held the same position from 2010 at Aeronautical Engineering School (**IPSA**).
- From 2014 to 2018, she was an Associate Researcher at **Sorbonne University** in System On Chip (SOC) department working on the design of a reconfigurable RF transceiver for the 5G wireless communication systems.
- Dr. Benabid received her Ph.D from the **University Paris Saclay** in 2005, on the design of ADC converters for the 5G wireless communication systems, at the department of signal and electronic systems at **CentraleSupélec**.
- She obtained an Engineer degree in Electronics engineering from **Setif University, Algeria**, in 1995.
- Research interests: Embedded Systems, Information Processing, AI Algorithms, IoT, Wireless Communication Systems, Electronics IC Design.

Internet of Things (IoT)

Learning Contexte & Objectives

- This course introduce the concept of the Internet of Things (IoT),
- The current vision of IoT is to ensure that everything from everywhere is connected to the Internet at all times,
- This idea has potential for making home, cities, electrical grid ..etc, more safer, more efficient and easier to manage.
- This course learn how IoT is applied in manufacturing and what manufacturers should consider when deciding to implement this technology.

Internet of Things (IoT)

Learning Contexte & Objectives

- This course cover: IoT definition, IoT application domains and IoT architecture and implementation,

- In this course, we will design IoT example in practice (i.e Smart city, Smart home ..etc):

Pre-requisited & Targeted skills

- Pre-requisited skills : design a basic electronic circuits,

- Targeted skills:
  - Identify the sensors and other devices (processing unit) needed for IoT solution
  - Understand, design and implement an embedded system incorporating specific devices for IoT solution

Summary

- Lessons: IoT definition,
  IoT applications,
  IoT market evolution,
  IoT architecture,
  Hardware solutions for IoT,
  Heltec LoRa ESP32 board and sensors,
  Useful informations to succeed project

- Project: Design and implement IoT architecture
  - Describe Hardware and software tools (Heltec LoRa ESP32 board, Arduino editor),
  - Sensors: temperature, air pressure, humidity, light sensor, Heartbeat sensor…etc
  - Each group an IoT architecture for a proposed application (smart home, smart city, smart hospital, smart grid ..etc)

Evaluation: Present the project results at the last session of the course according your schedule

Lesson 1

- IoT definition, applications and architecture,
- Hardware solutions for IoT,

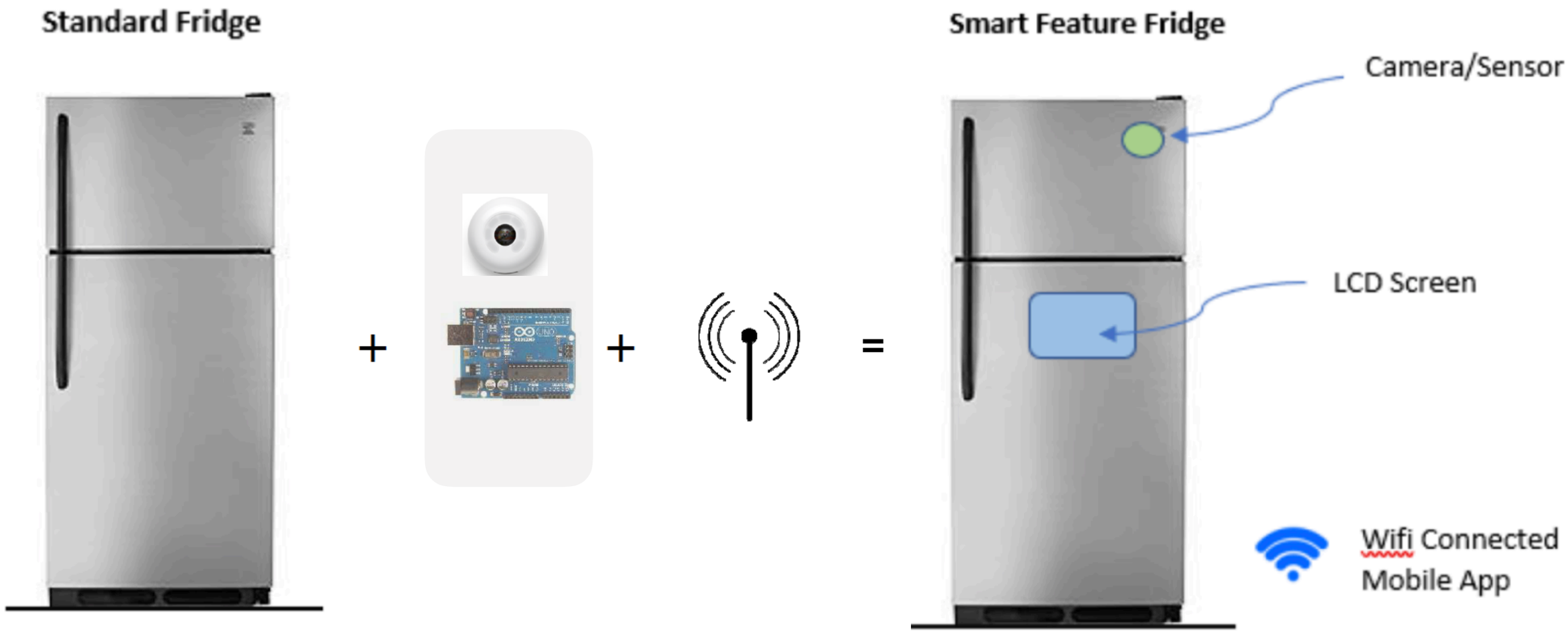
IoT definition

- IoT term is coined by the british engineer Kevin Ashton, a technology pioneer during a presentation in 1999,

- Kevin Ashton used the expression “Internet of Things“ to describe a system in which the Internet network is connected to the physical world through ubiquitous sensors.

IoT definition

In short, the IoT refers to the connected objects that are able to collect and exchange data in real time using embedded sensors and processing unit.
Objects: cars, thermostats, lights, refrigerators, TV, ….etc



IoT definition

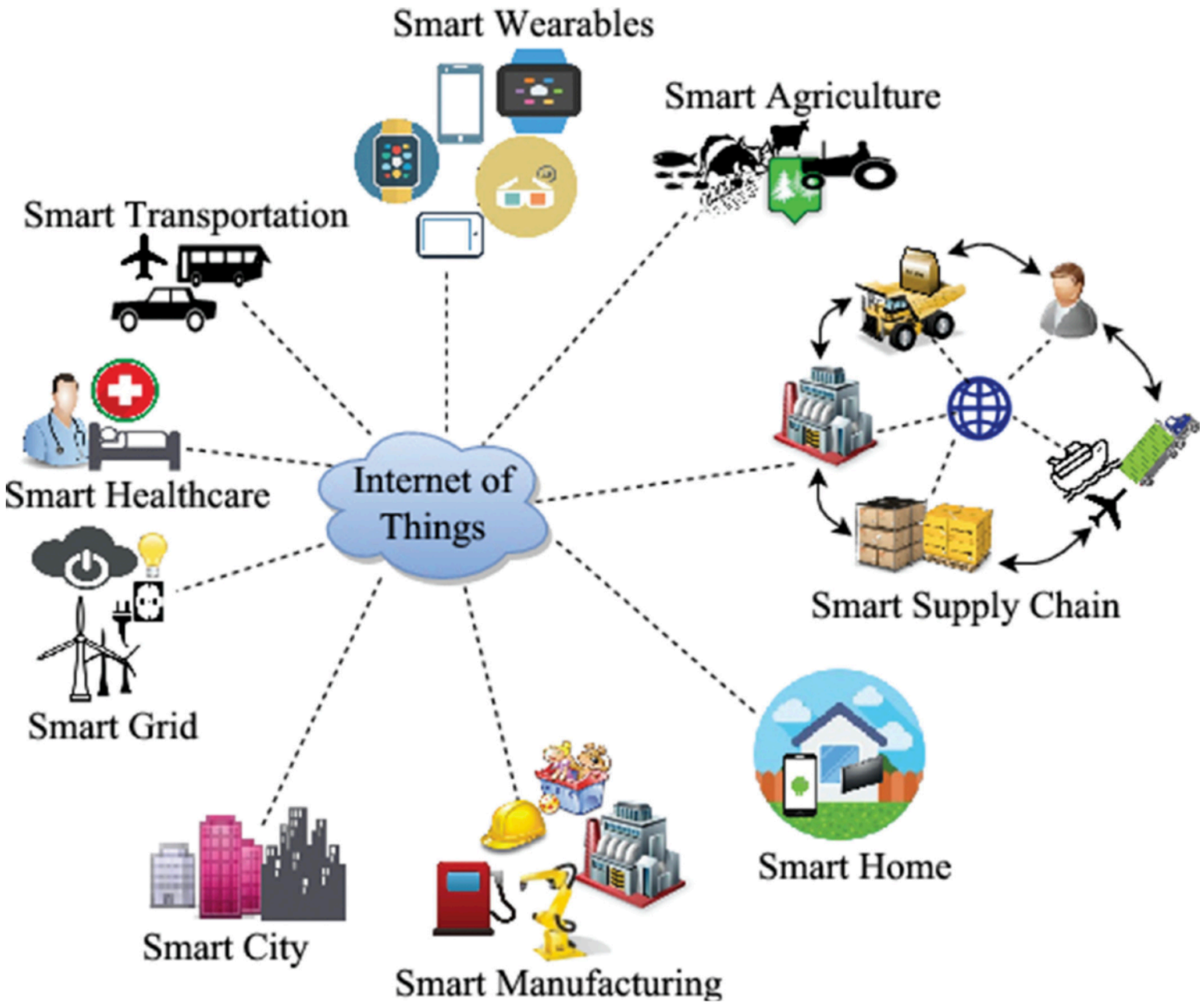
Standard Fridge: keeps food cold

Smart Fridge:

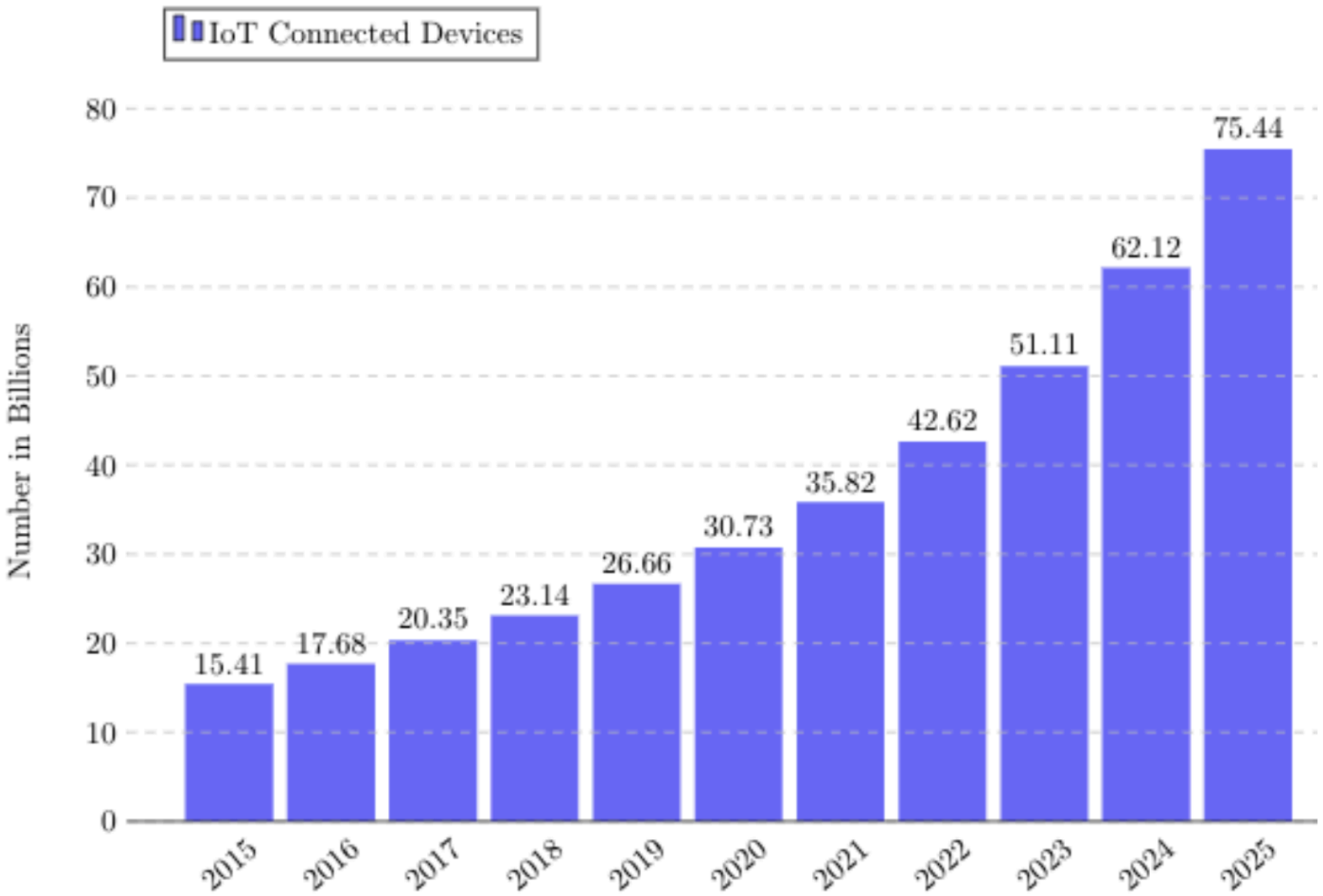
- keeps food cold
- indicates if the door is ajar (bip)
- indicates if the water filter needs to be changed (bip)
- detects the food it has
- if food is missing
- warns on smartphone to buy food
- order a water filter and find the best price
- compares its consumption with other fridges
- suggests certain repairs to be made to the user's smartphone
- …etc

IoT applications

- IoT application domains that have emerged in recent years:



IoT market

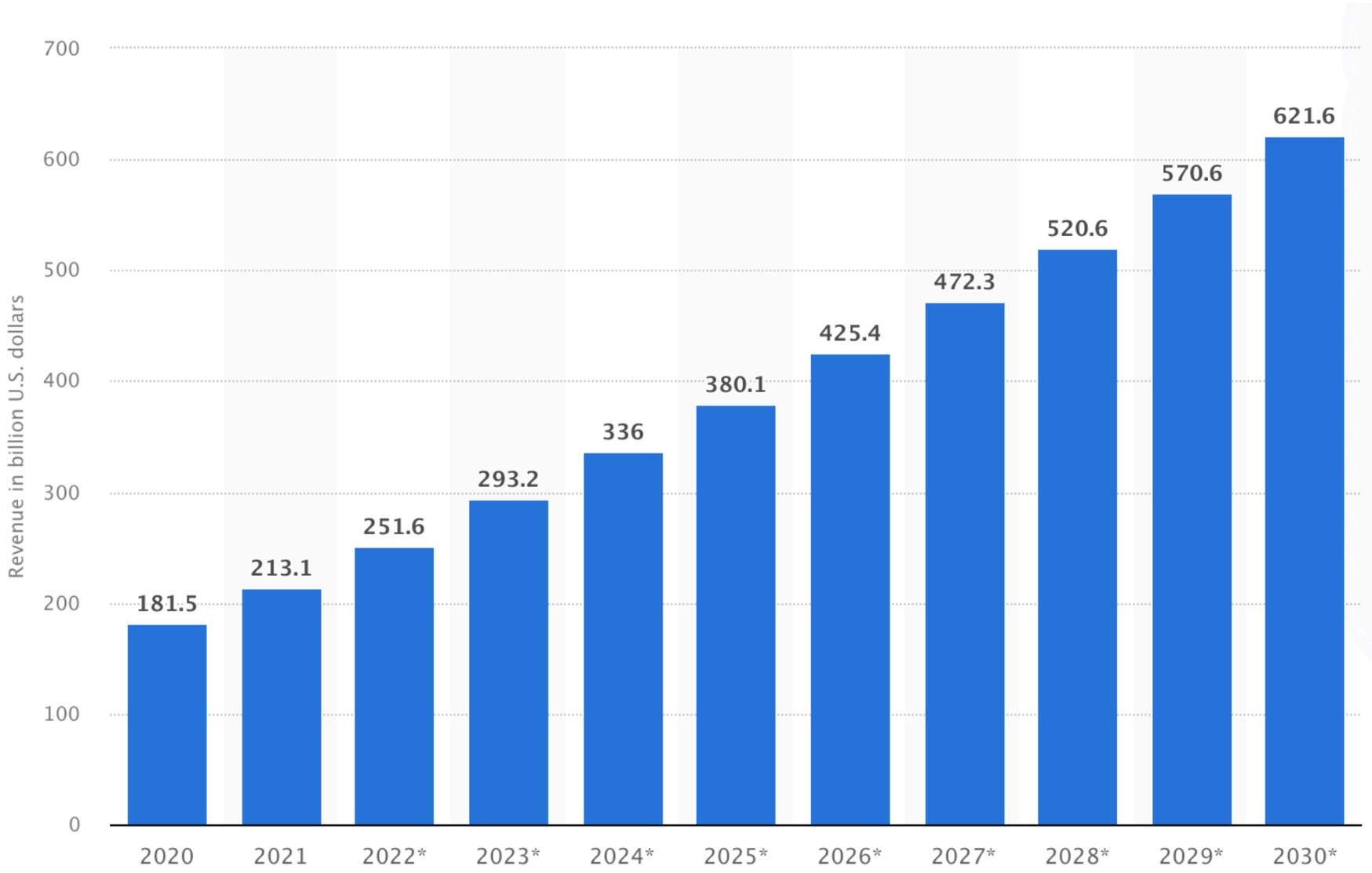


Source: https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/

1 billion = 1000 Million

IoT market

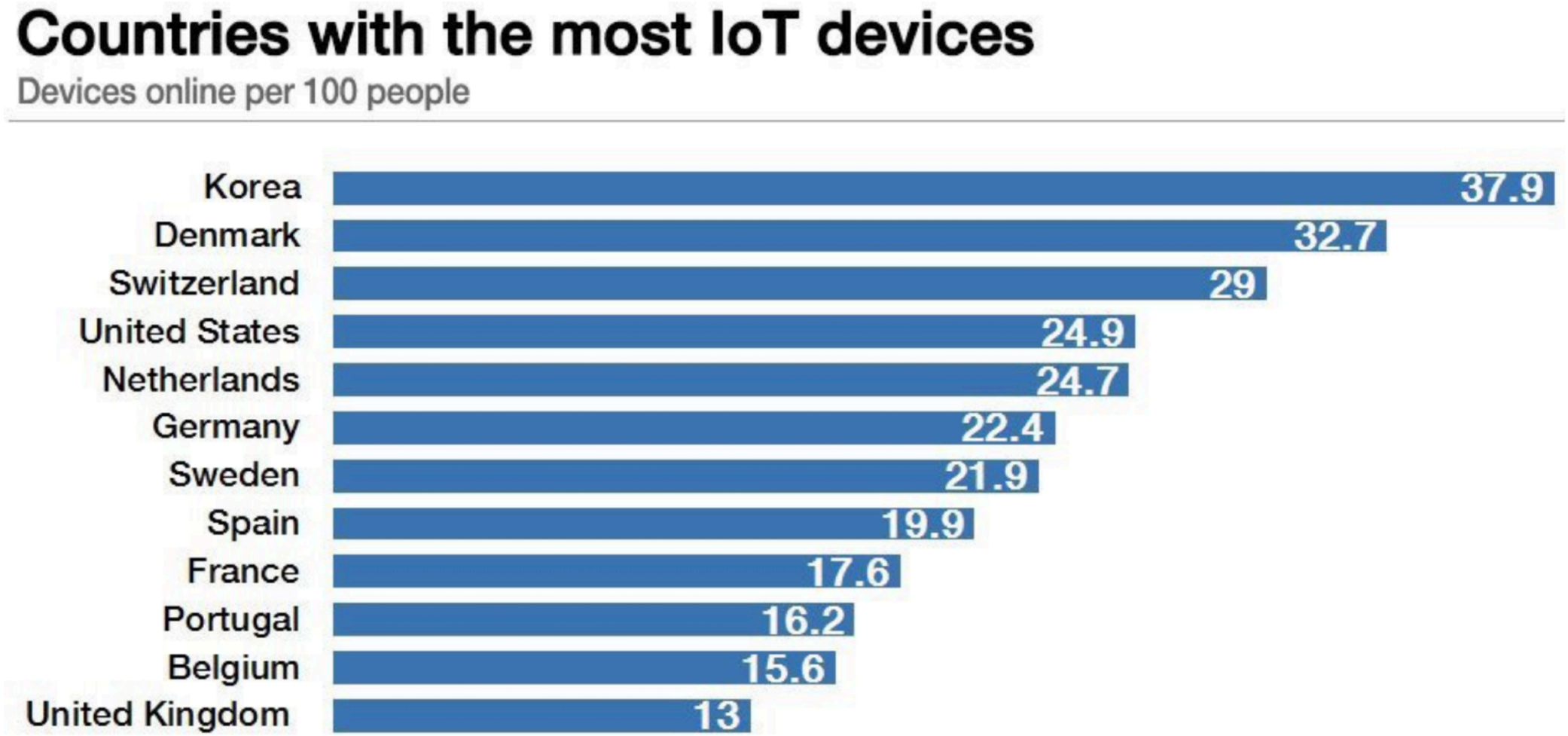
IoT total annual revenue worldwide from 2020 to 2030



Source: https://www.statista.com/statistics/1194709/iot-revenue-worldwide/

1 billion $ = 1000 Million $

IoT market

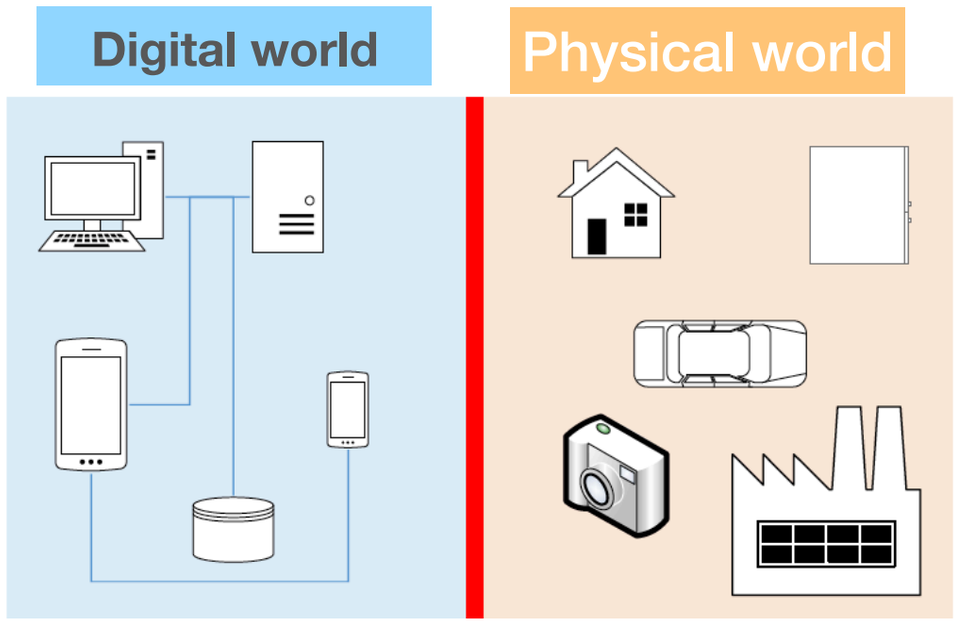


published in 2016

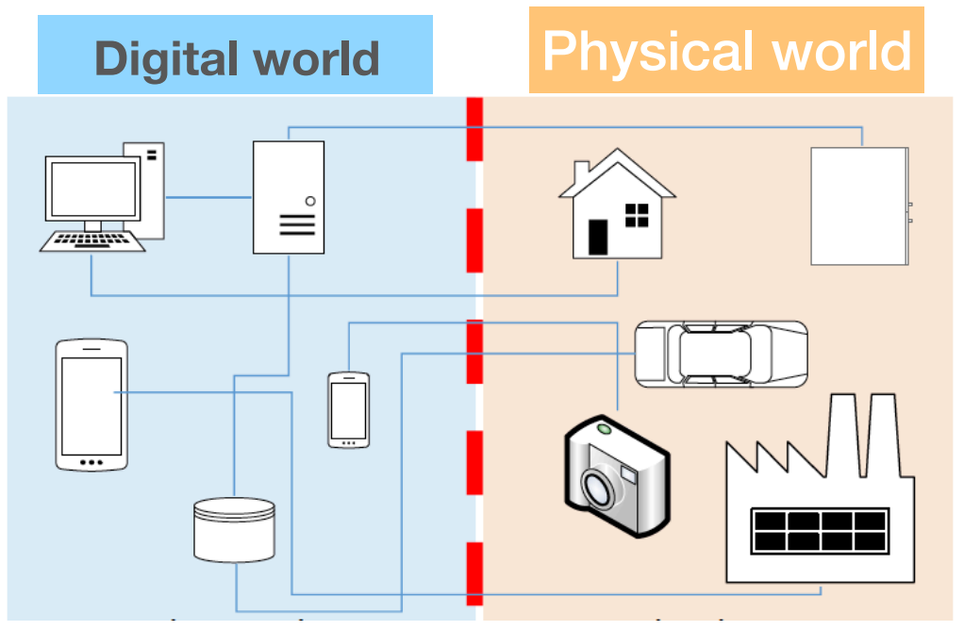
IoT architecture

Junction between the physical world and digital world

Before IoT



Today



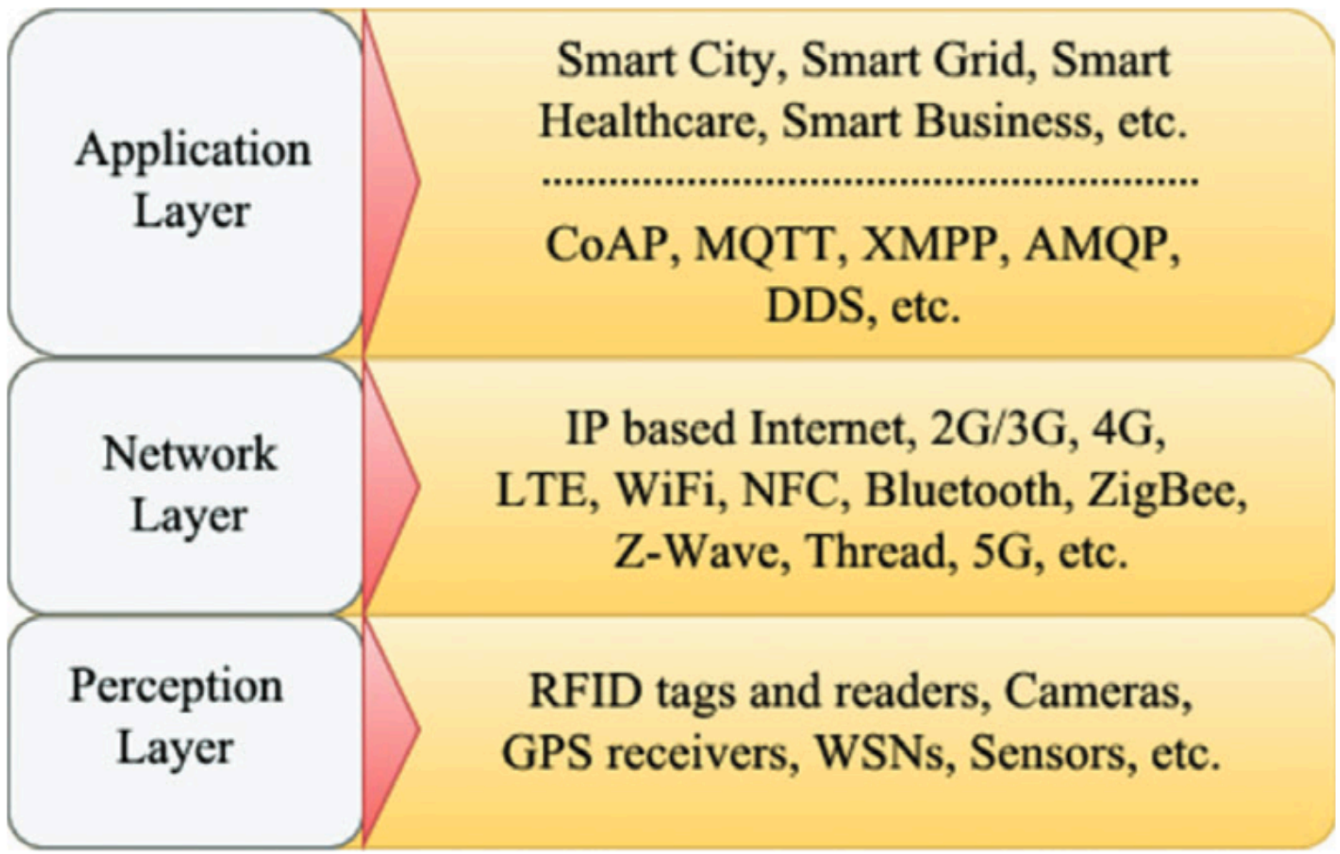
IoT architecture

- IoT structure can generally be divided into 3 distinct layers,

1. Provides support for business services and different kinds of personalized services to individual users.

2. Consists for different kinds of communication protocols, which serve as access networks. Responsible for for initial processing and transmission of data.

3. Responsible for gathering all kinds of data/information from physical world using physical and devices.

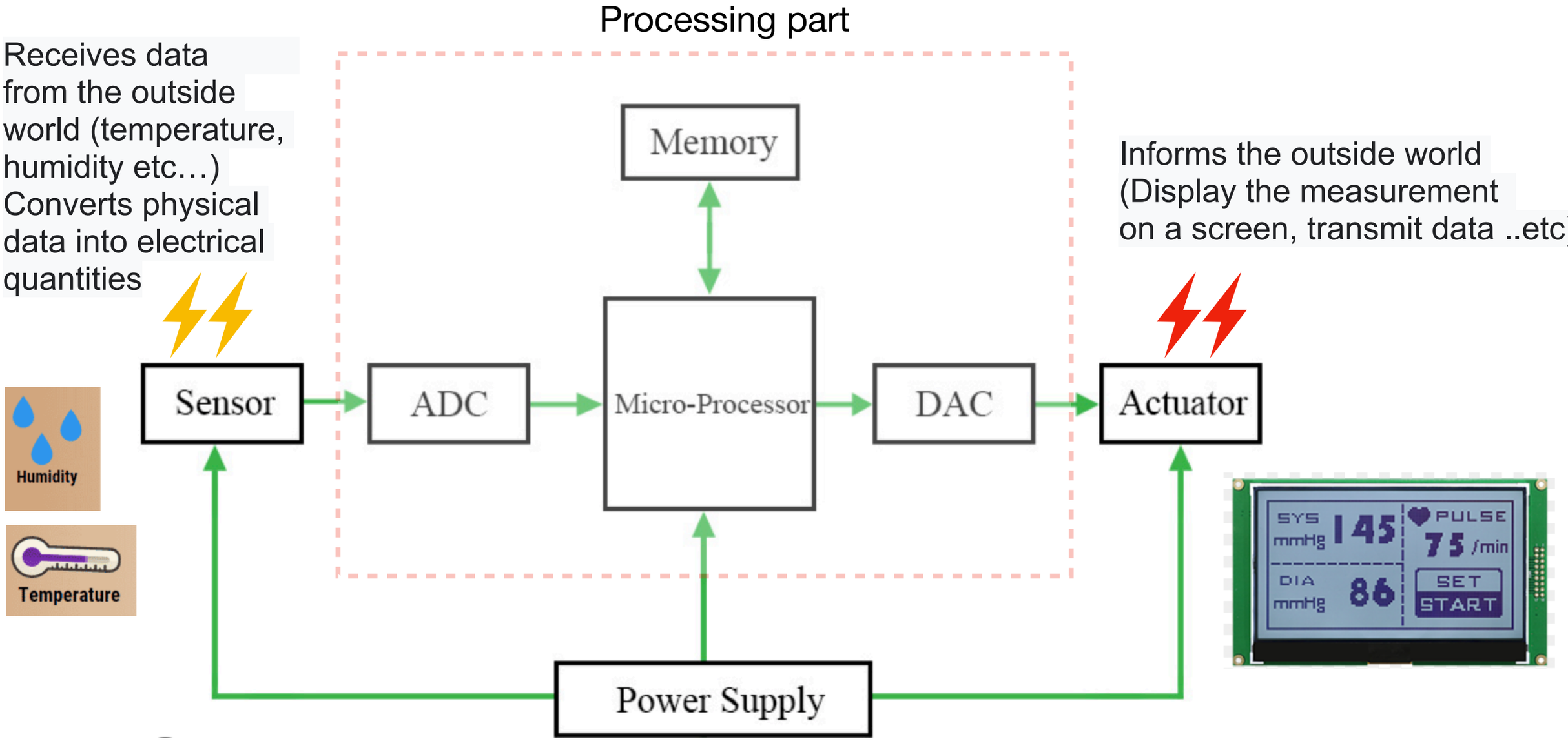


WSN: Wireless Sensor Network

Hardware solutions for IoT

Embedded System Block Diagram

- Receives data from the outside world (temperature, humidity etc…)
- Converts physical data into electrical quantities



Hardware solutions for IoT

Processing part in Embedded Systems	
Traditionnel architectures	**Specific architectures (Hardware accelerator)**
CPU (Central Processing Unit) General purpose applications	GPU (Graphics Processing Unit)
Microcontroller	ASIC (Application-Specific Integrated Circuit)
DSP (Digital Signal Prossecing) Signal processing	FPGA (Field-Programmable Gate Array)
Sequential processing	**Parallel processing**

Hardware solutions for IoT

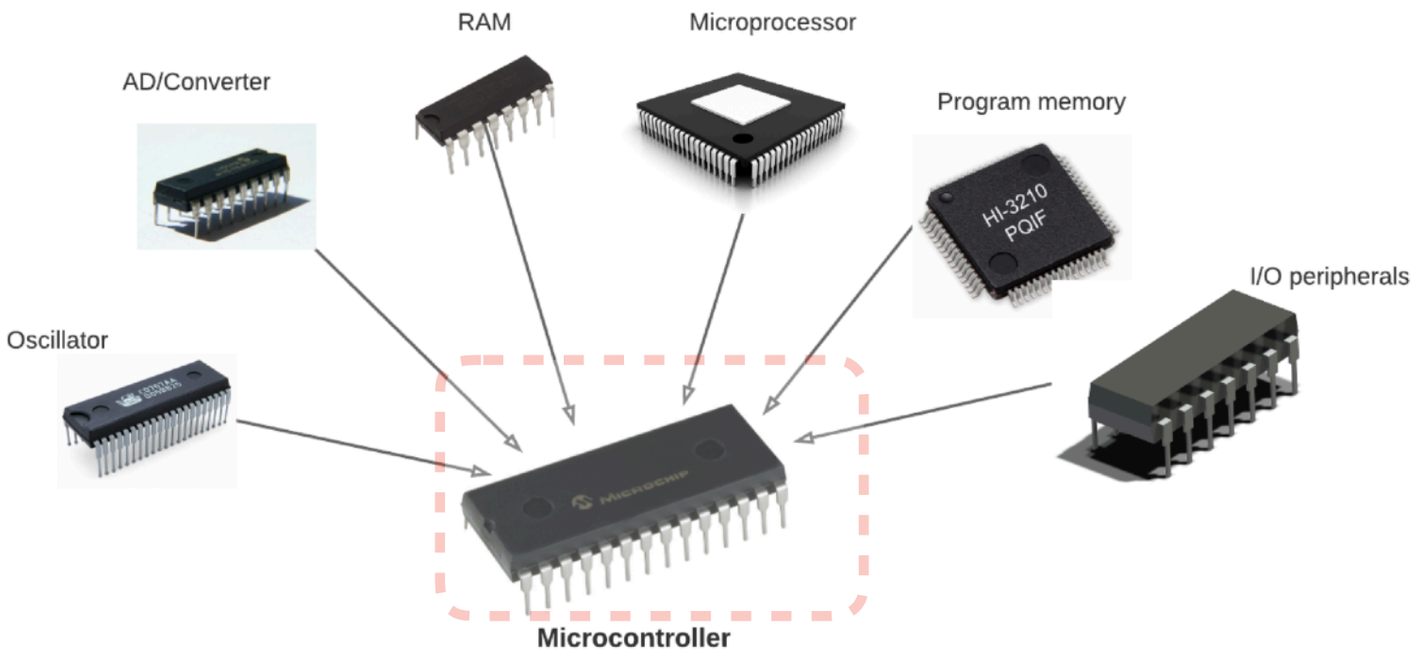
- **Microcontroller (µc or MCU)**

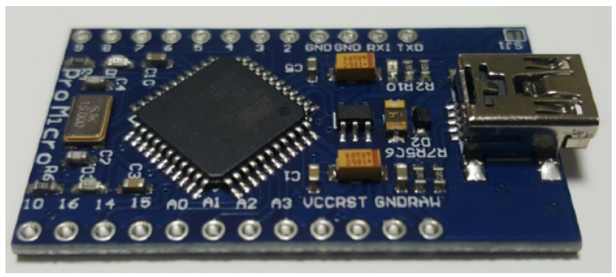
Created in **1970s** by two American companies **Intel** and **Texas Instrument**

µc includes a processor, program memory, RAM, input/output pins, and more on a single chip
µc is designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications.

The most popular development boards on the market are the **Raspberry Pi** and the **Arduino Uno**.
Programming language (assembly code, C/C++, Python),

µc can handle a wide range of complex circuit designs, but they still may not be sufficient for some complex projects



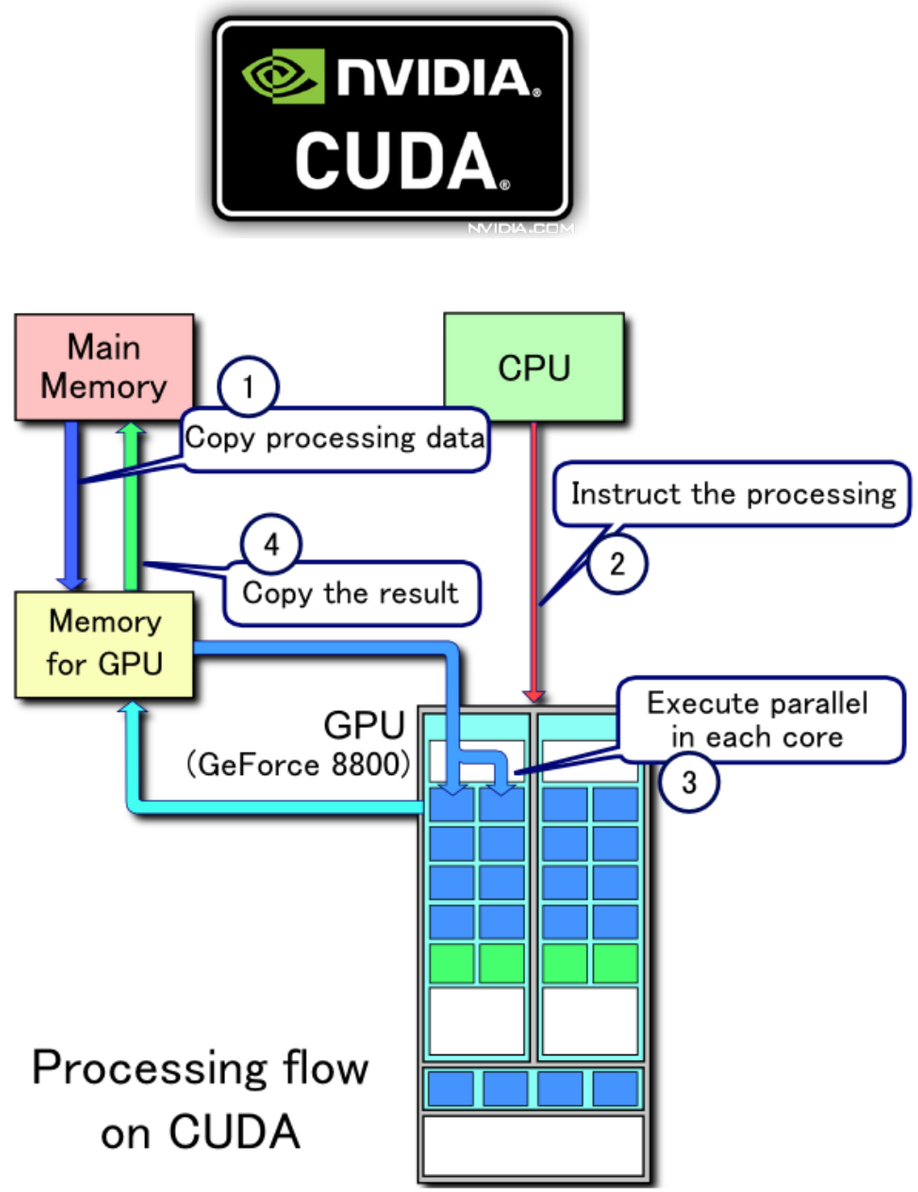


Hardware solutions for IoT

- ## Graphics Processing Unit (GPU)

GPU is a specialized chip that can do rapid processing, for **computer graphics and image processing .**

In 1999, **NVIDIA** popularized the term **GPU**, which contains chips that have what are known as **CUDA (Compute Unified Device Architecture) Cores**, and each one of these cores is a tiny processor that can execute some code. CUDA allows **programming** of GPUs **in C**



Hardware solutions for IoT

- **Field-Programmable Gate Array (FPGA)**

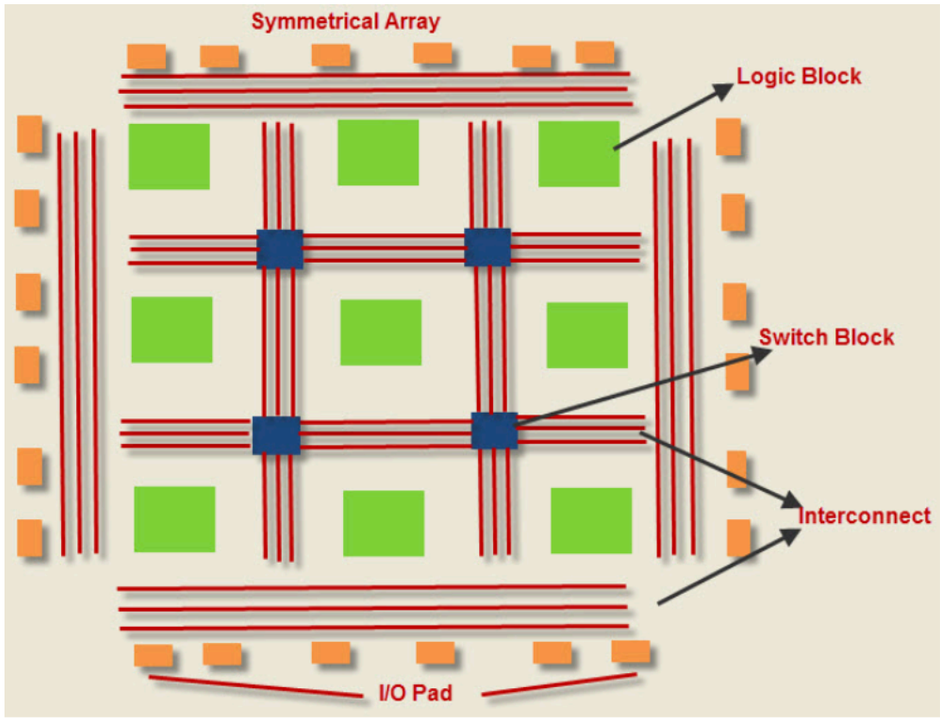
  Created in the late **1980s.**
  Is an integrated circuit (IC) made **to be configured and reprogrammed to the wanted application** by a designer **after manufacturing.**

  Include a range of **programmable logic blocks** and a hierarchy of "**reconfigurable interconnects**" that enable the blocks to be connected together.

  They can be beneficial over GPUs in terms of **interface flexibility** and enhanced by the integration of programmable logic with CPUs and standard peripherals

  A **hardware description language** such as Verilog or VHDL, to describe their functionality.

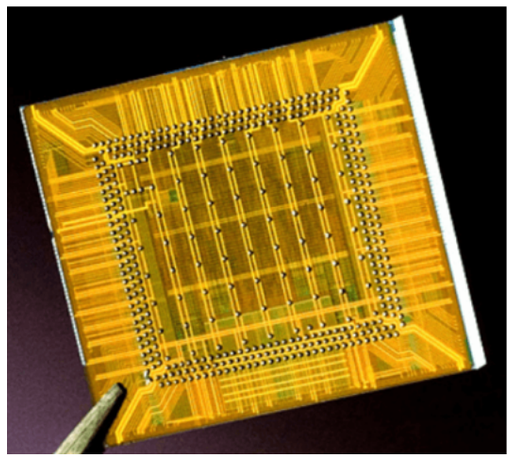
  Companies like **Xilinx** or **Altera** have launched their FPGA products as latest datacenter accelerator cards as satisfying increasing business demand for heterogeneous architectures.



FPGA Architecture

Hardware solutions for IoT

- **Application-Specific Integrated Circuit (ASIC)**



In contrast to FPGA, ASIC is an integrated circuit (IC) or **a silicon chip** designed for one **specific logic function** or **a particular use**

ASIC can only perform the task it was built to perform. **It cannot be changed**.

ASICs are typically **used in a product** that will run in very high volumes.

The ASIC **consume less power** for the computing capability when compared to the aforementioned chips, and have a much **smaller size**.

ASICs have **time-consuming to design** and **more expensive** than other options

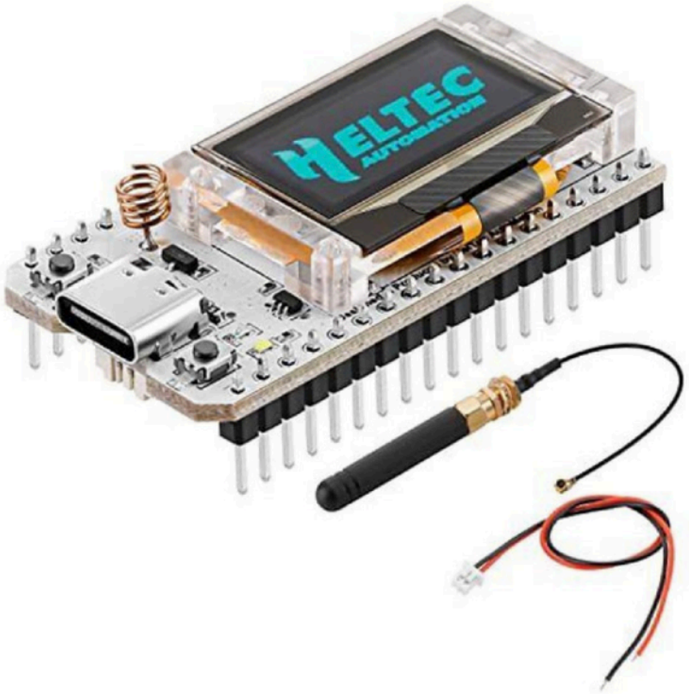
Hardware solutions for IoT

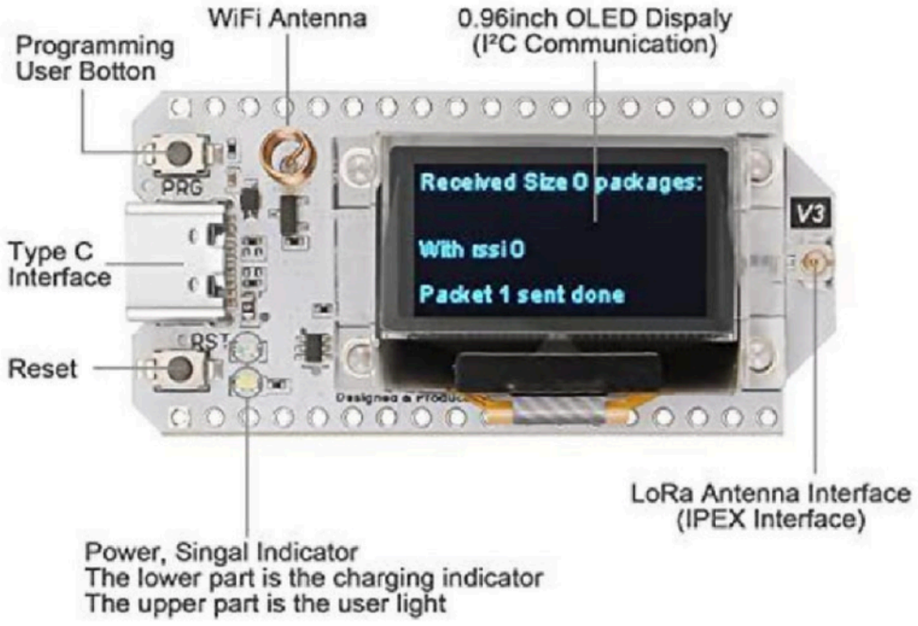
- **Comparison between the different hardware solutions**

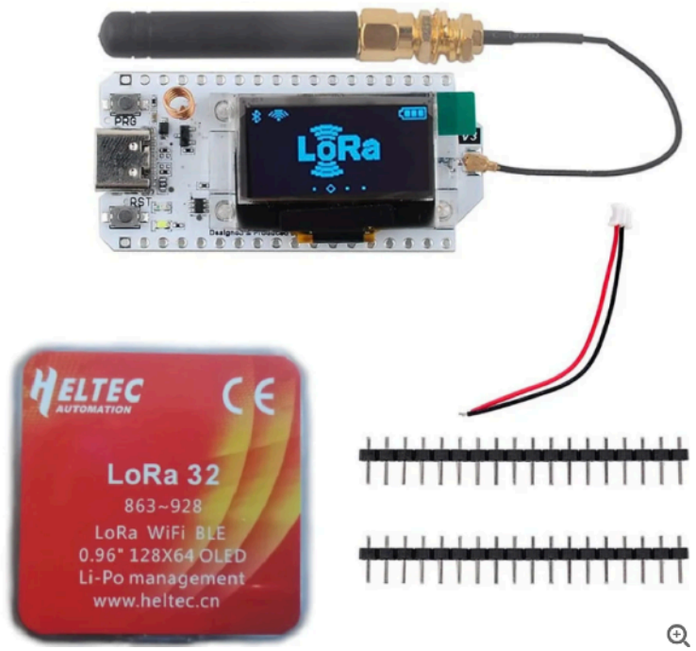
Core type	Typical Power Consumption	Description	Strengths	Constraints
CPU µc	High	Flexible, general purpose processing units	• Complex instructions and tasks • System management	• Possible memory access bottlenecks • Few cores (4-16)
GPU	High	Parallel cores for high quality graphics rendering	• High performance AI processing • Highly parallel core with 100's or 1,000's of cores	• High power consumption • Large footprint
FPGA	Medium	Configurable logic gates	• Flexible • In-field reprogrammability	• High power consumption • Programming complexity
ASIC	Low	Custom logic designed with libraries	• Fast and low power consumption • Small footprint	• Fixed function • Expensive custom design

Hardware development board

- **Heltec WiFi LoRa 32 V3 Board:**
  - A classic IoT dev-board designed & produced by **Heltec Automation** in **2017**,
  - Based on **ESP32 S3 *µc***
  - Integrated 03 network connections: **WiFi (Wireless Fidelity)**, **LoRa (Long Range)**, **Bluetooth**,
  - **OLED display**,
  - It is the best option for smart cities, farms, homes, industrial control, and IoT developers.







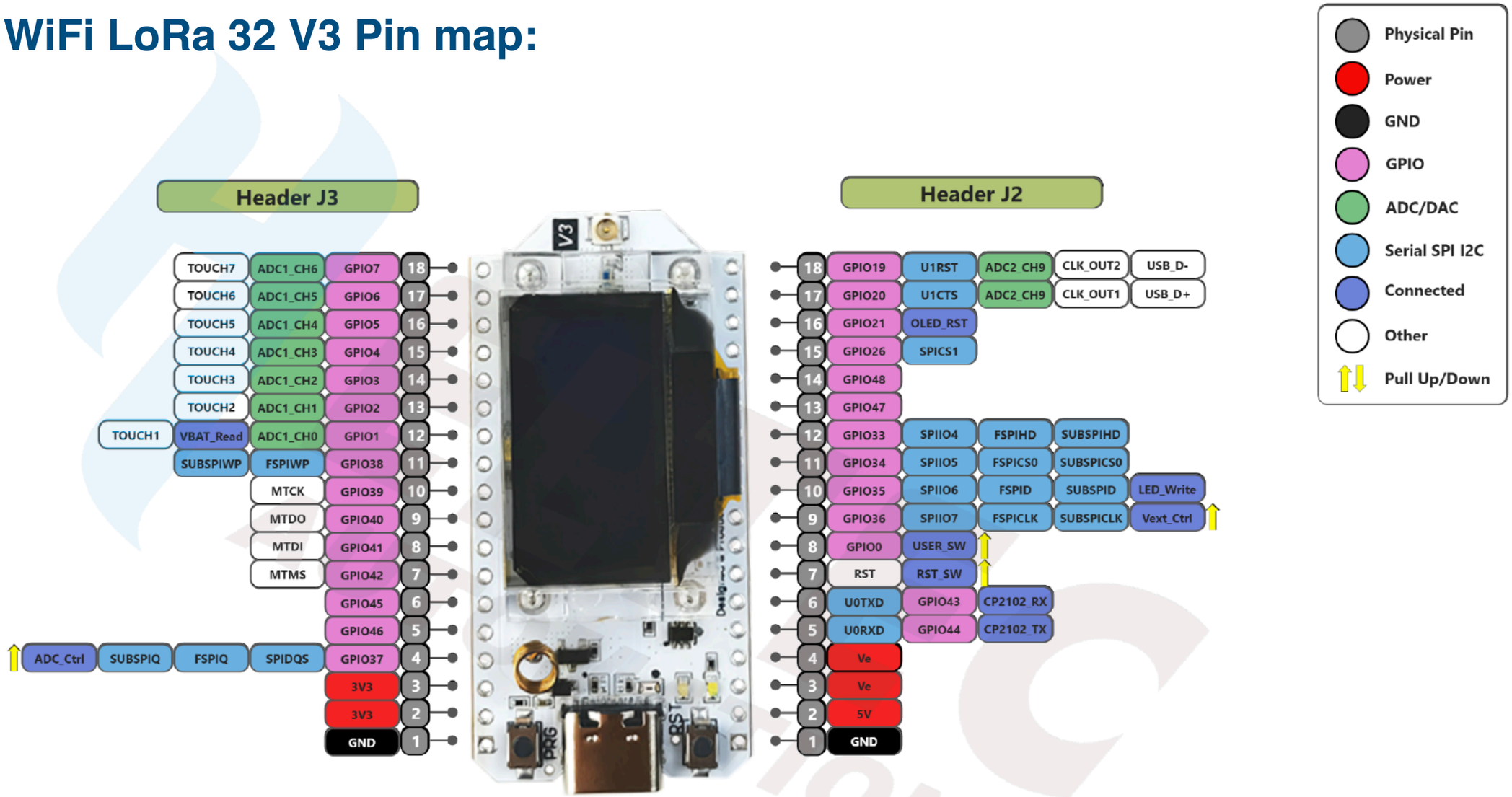
Hardware development board

- **ESP32 S3 *µc*:**
  - ESP32 (Espressif 32) is a series of **low-cost** (6$), **low-power** of chip MCU,
  - Running at **160 or 240 MHz** clock frequency,
  - Programming environment: **Arduino IDE**, Espressif's IoT Development Framework (IDF) or VSCode with PlatformIO
  - Up to 36 GPIOs (General Purpose Inputs Outputs) Pins
  - Operating voltage/Power supply: 3.0 ~ 3.6 V
  - 384 KB ROM & 512 KB SRAM
  - …etc

You can find all the features on this link:
https://www.espressif.com/sites/default/files/documentation/esp32-s3-wroom-1_wroom-1u_datasheet_en.pdf

Hardware development board

- **Heltec WiFi LoRa 32 V3 Pin map:**

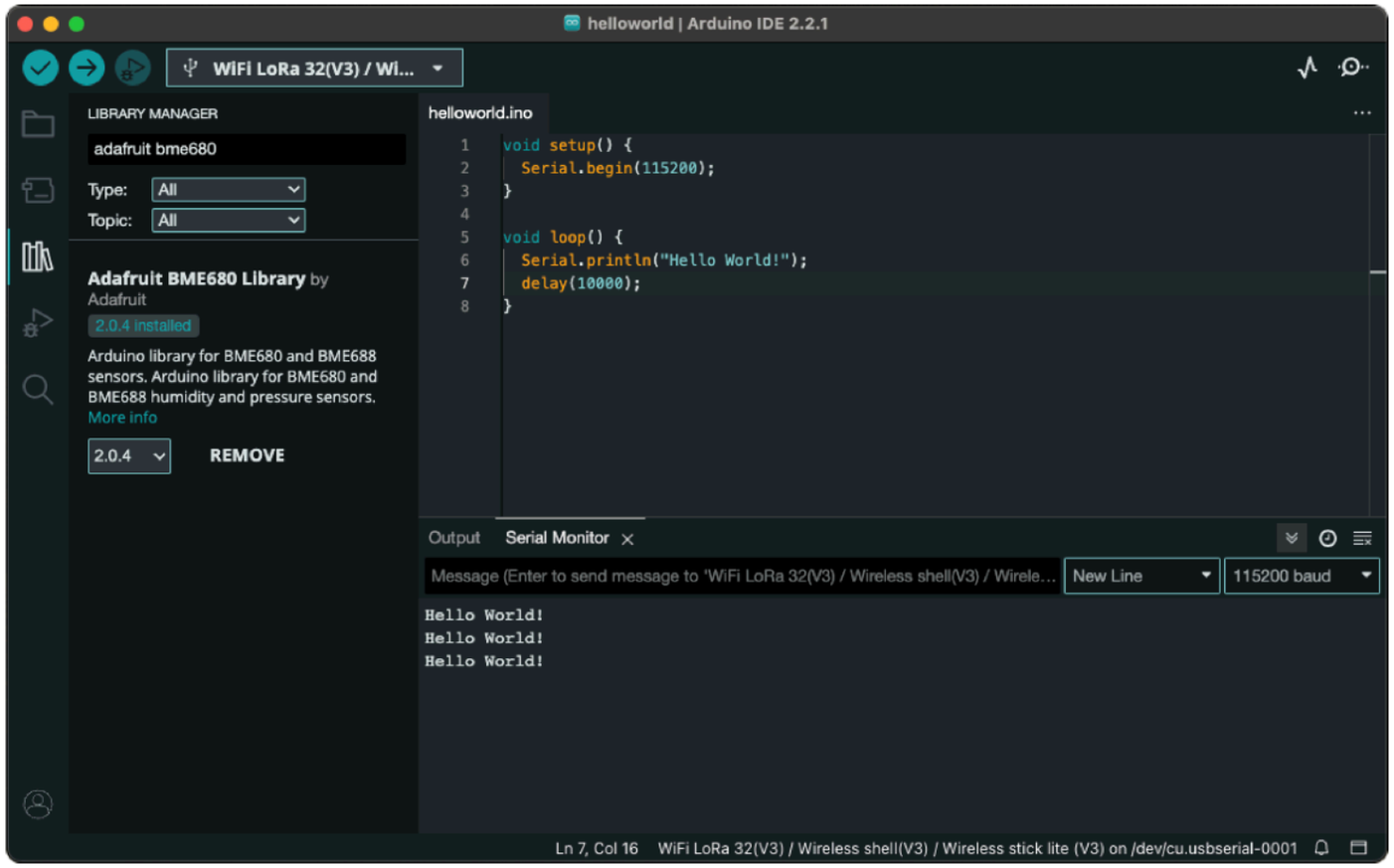


HTIT-WB32LA(F)_V3 Pin map

Hardware development board

- **Development environment for Heltec WiFi LoRa 32 V3 board:**

Arduino IDE (Integrated Development Environment)



Survey

- **In the proposed project in this course, we will control the IoT application with:**

1. ASIC
2. FPGA
3. µc
4. DSP
5. GPU

- **To program Wifi Lora 32 Board, we can use**

1. Java
2. VHDL
3. C
4. C++
5. Verilog

Survey

- **Wifi Lora 32 Board is manufactured by**

    1. Nvidia
    2. Xilinx
    3. Heltec automation
    4. Altera