Internet of Things

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Internet of Things - Introduction

- What is the Internet of Things (IoT)?
- Which are the enabling technologies?
- Which are the opportunities, applications and research challenges brought by the IoT?

What is the Internet of Things

- It is a new paradigm of the Internet, i.e. a communication network, where objects, referred to as “things”, play a key role

- What are the things?

What are the *things* in the IoT?

Any sort of thing,

equipped with a communicating device,

can be a thing of the IoT

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Things in the IoT

Objects, tools, home devices
that we use on a daily basis
are often
connected to the Internet

They are often called
smart-things:
smart-phones, smart-TV,
smart-watch, smart-car, connected cars,
wearable electronics

Traditionally, these objects were **NOT considered as part of the Internet**

Smart-devices in smart-environments

From the smartness of the things,
derives a new paradigm
also for the environments where
they are employed:
smart-cities, smart-agriculture,
smart-grid, smart-homes

Smart-environments: smart-agriculture

Devices are heterogeneous in computation and communication capabilities

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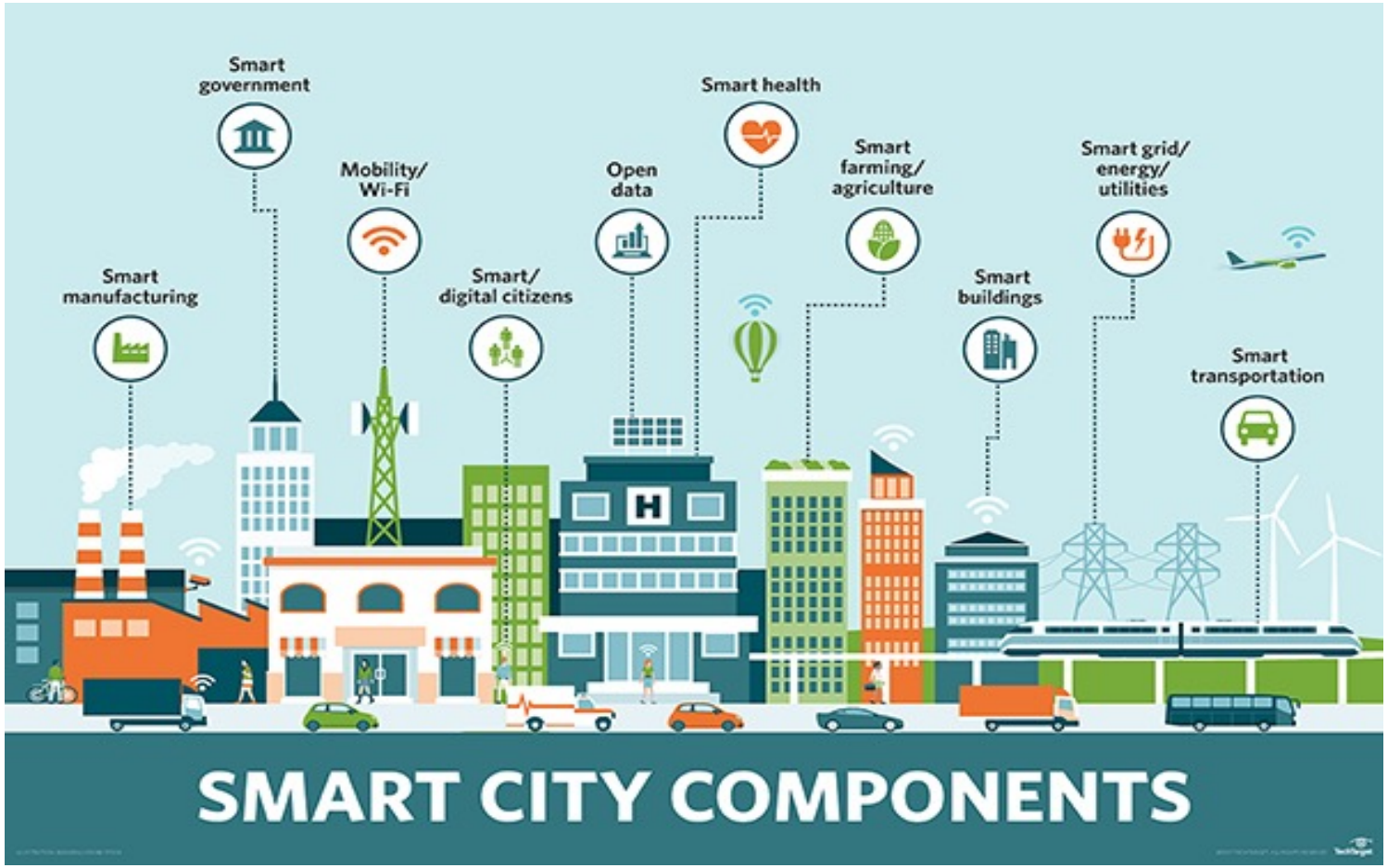
Smart-environments: smart-farming

Utilize wireless IoT applications to collect data regarding the location, well-being, and health of their livestock

Monitor pregnant cows:

- Sensor powered by battery is expelled when her water breaks.
- This sends an information via the Internet to the rancher.

Smart-environments: smart-city



Devices are heterogeneous in computation and communication capabilities

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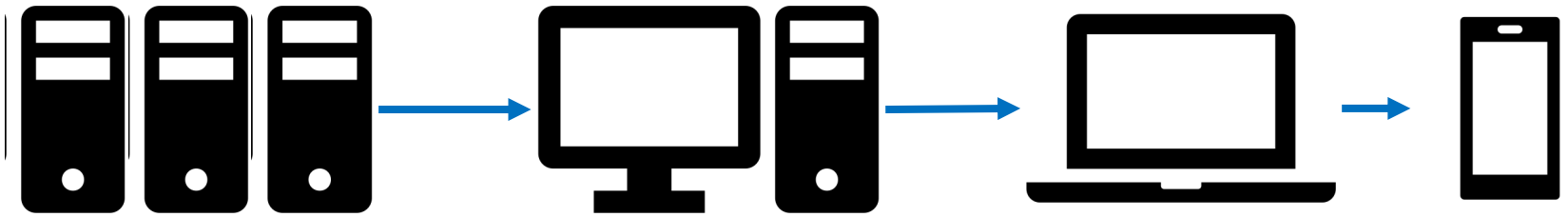
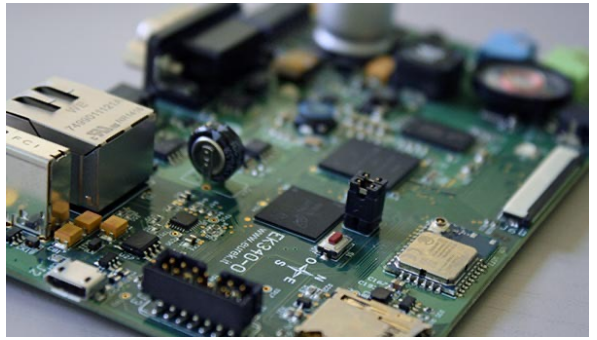
Smart-environment: smart-home

IoT seen as an evolution of the Internet

IoT revolutionized the concept of **Internet host:**

from computers, laptops, mobile phones to the things, i.e. smart devices





Enabling technologies of the IoT paradigm

Derives from the concurrent progresses of diverse **enabling technologies**:

- Embedded systems,
- Cloud computing,
- Communication protocols,
- Big data analytics,
- Mobile internet,
- Web services,
- Wireless sensor networks.

What is an embedded system?

- An embedded system is a computer system designed to perform specific tasks or functions, often with real-time constraints, in a dedicated environment. It is a combination of hardware and software designed to control, monitor, or interact with the physical world.
- Embedded systems are found in various products and devices, including consumer electronics, automotive systems, medical equipment, industrial control systems, and aerospace and defense systems. They are typically designed to be low-power, low-cost, and reliable and often have limited resources, such as memory, processing power, and storage capacity.
- The software in embedded systems is usually written in low-level programming languages, such as assembly or C, and is tailored to the specific hardware platform. The hardware may also be customized to suit the particular application's needs. Overall, embedded systems are specialized computer systems built to meet the unique requirements of the application they serve.

… said chatGPT ☺

IoT is the joint work of diverse technologies

The enabling technologies of IoT meet together to create a smart system that is able to:

1. monitor a certain phenomenon,
2. collect data that describes it,
3. analyze this data locally or via a resourceful cloud server,
4. determine actions,
5. perform actions through an actuator.

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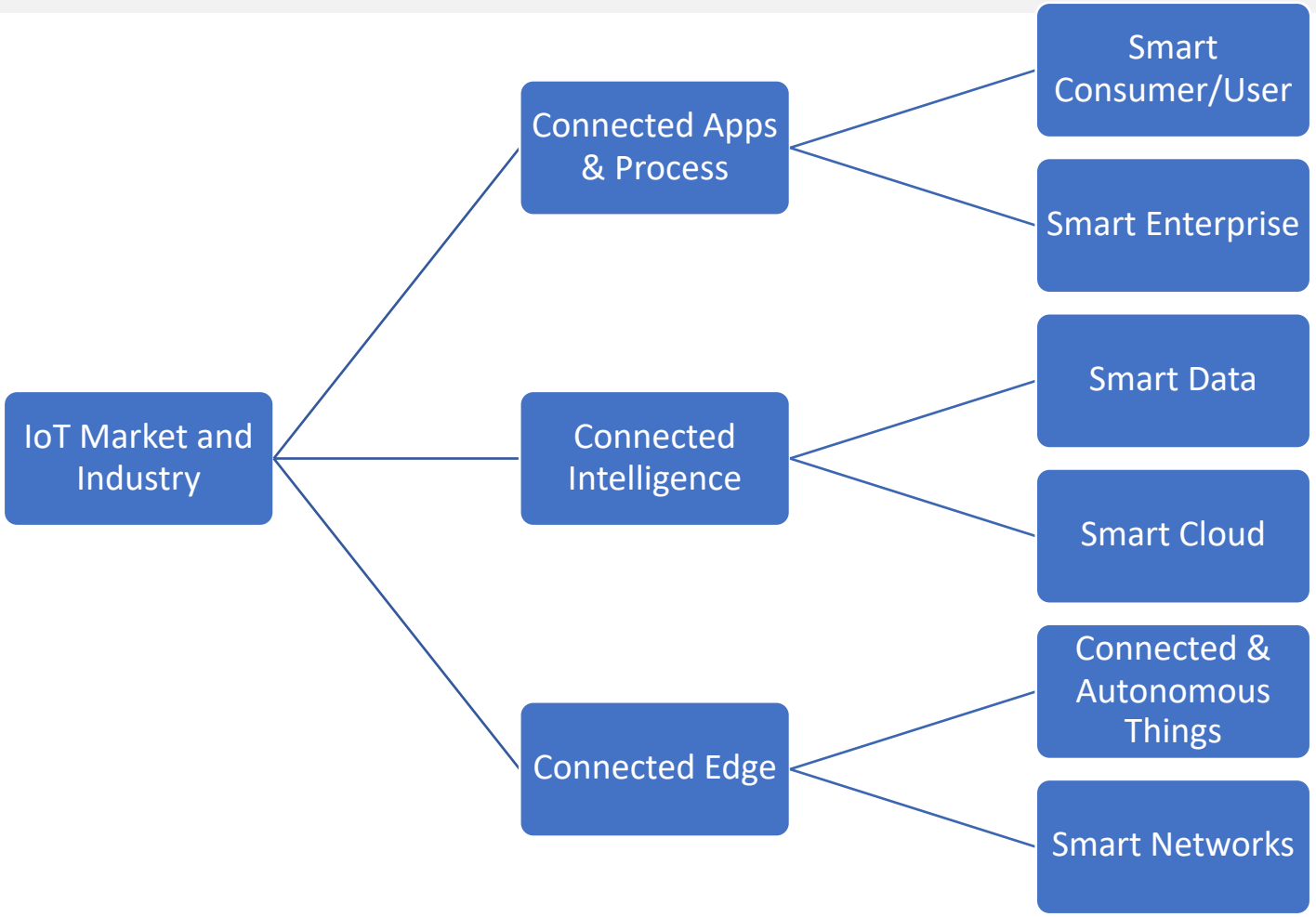
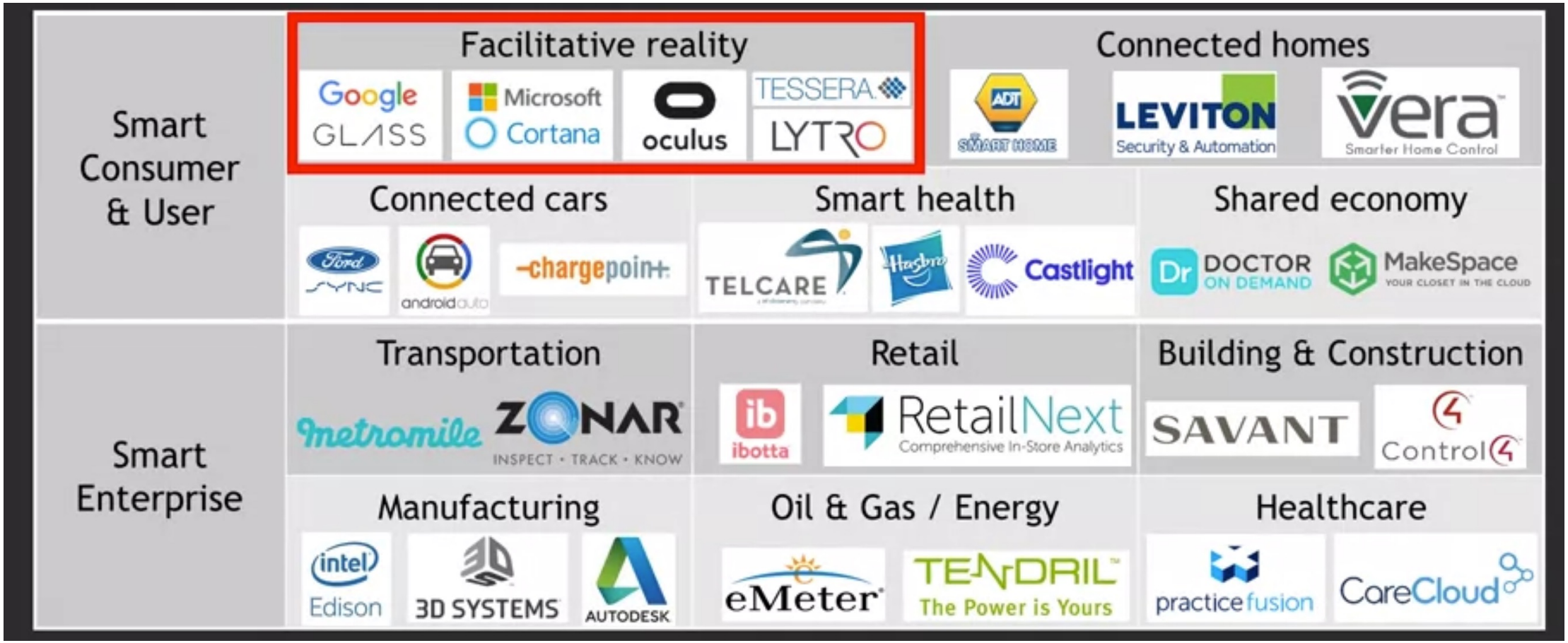
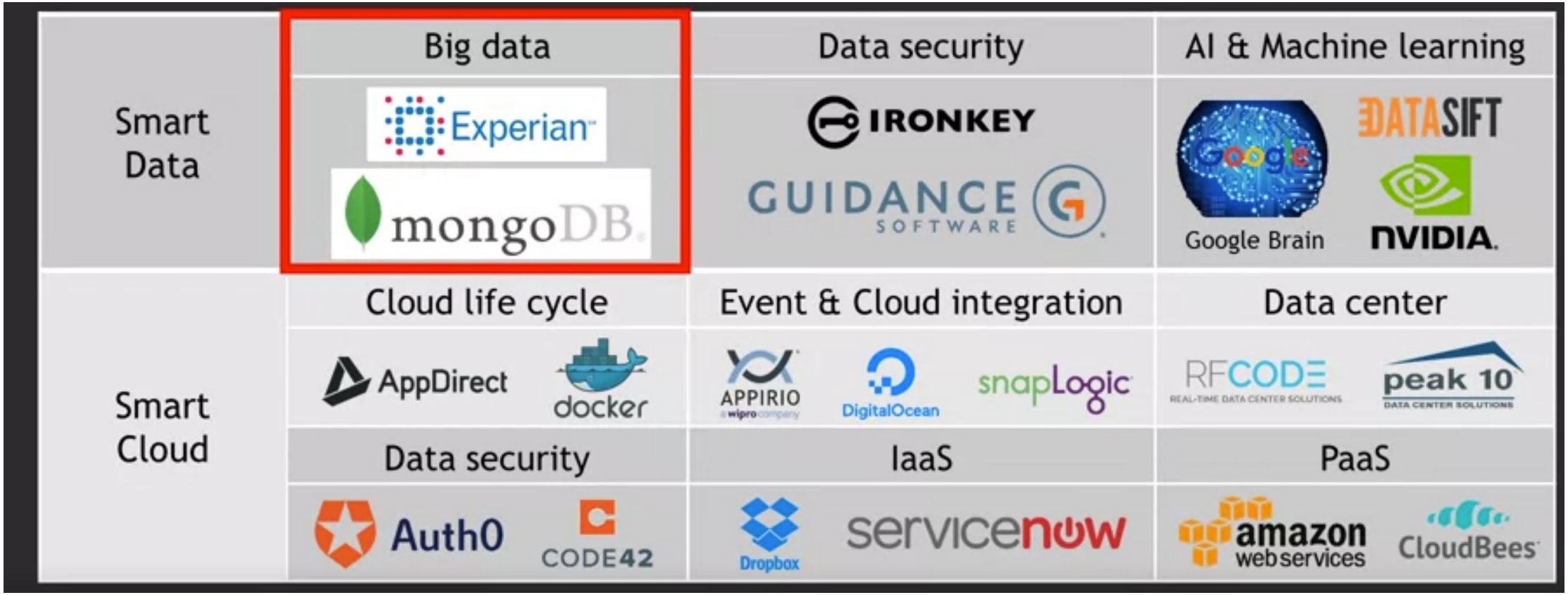
IoT Market and Industry



Connected apps and process

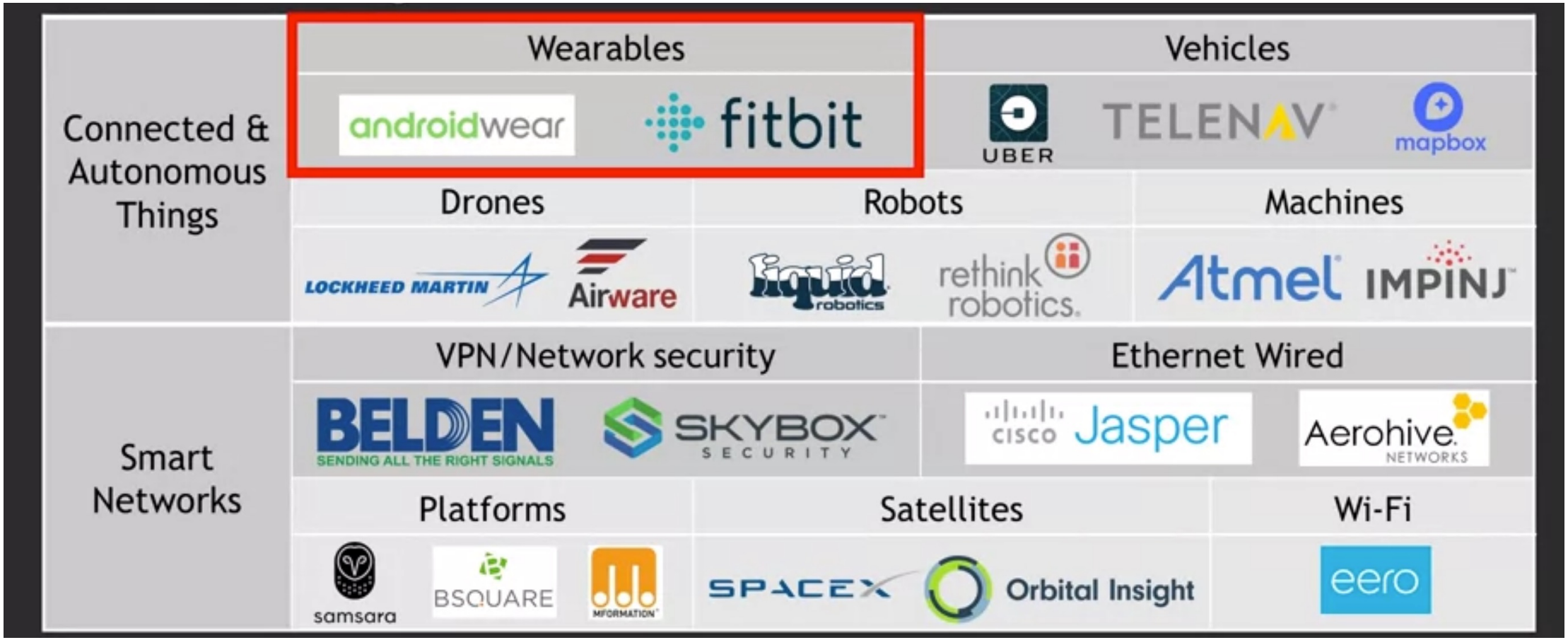


Connected intelligence



IaaS = infrastructure as a service
PaaS= platform as a service

Connected edge



Functional blocks of the IoT

1. **IoT devices**: the things that handle phenomenon monitoring, data collection, and actuation.
2. **Servers**: these are usually remote cloud servers that are resourceful and capable of handling intensive data analysis and storage.
3. **Database**: needed to store the data (that is usually massive) that is collected by the IoT system.
4. **Application**: a software interface that enables users of the IoT system to visualize system status and control its activities and actions.
5. **Communication**: the critical block that handles the communication between the different entities in the IoT system (IoT devices, databases, application, and cloud servers).

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Additional features

+ Security
+ Management
+ Service organization

implementing applications based on IoT systems requires mastery of various tools and technologies.

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IoT – a network of intelligent objects

IoT: key concepts

The IoT paradigm grounds upon three fundamental pillars defining the capabilities of the **smart-things**:

- **Identification**
- **Communication**
- **Interaction**
  - with each other, building a network of interconnected objects
  - with the end users or other network entities

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Smart thing: definition

Entity that:

- Has its own physical characteristics such as size, shape, and so on.
- Has at least basic communication functionalities including **the capability of being located, and to accept and respond to incoming messages.**
- Has a name and an address.
- Has at least basic computational capabilities, including **recognizing a message based on its recipient or execute network management functions.**
- Is able to detect or measure physical phenomena, e.g. temperature, light, movement (sensors) or can make actions with consequences on the surrounding (actuators).

We note that the last point is the fundamental difference between hosts in the traditional Internet (computers, routers) and things in IoT.

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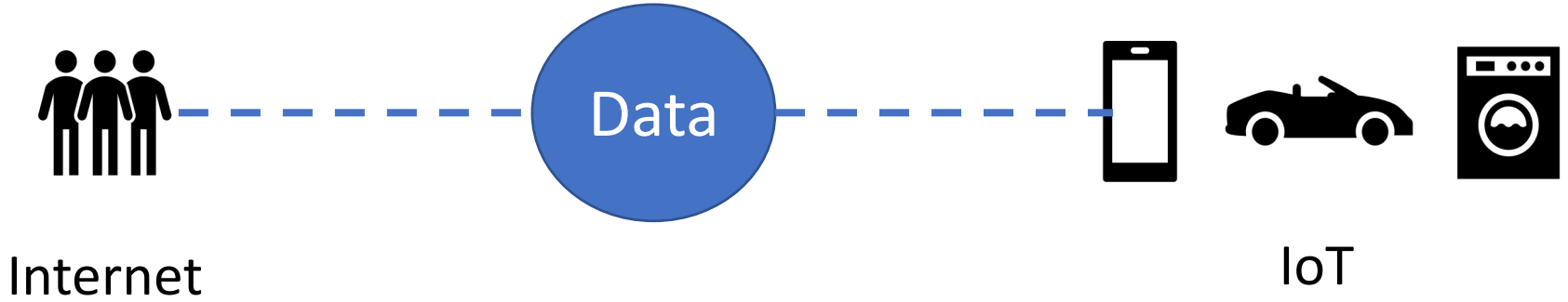
IoT: data related to the physical environment

IoT is related to entities that interact with the network as producers or consumers of data related to the surrounding physical environment



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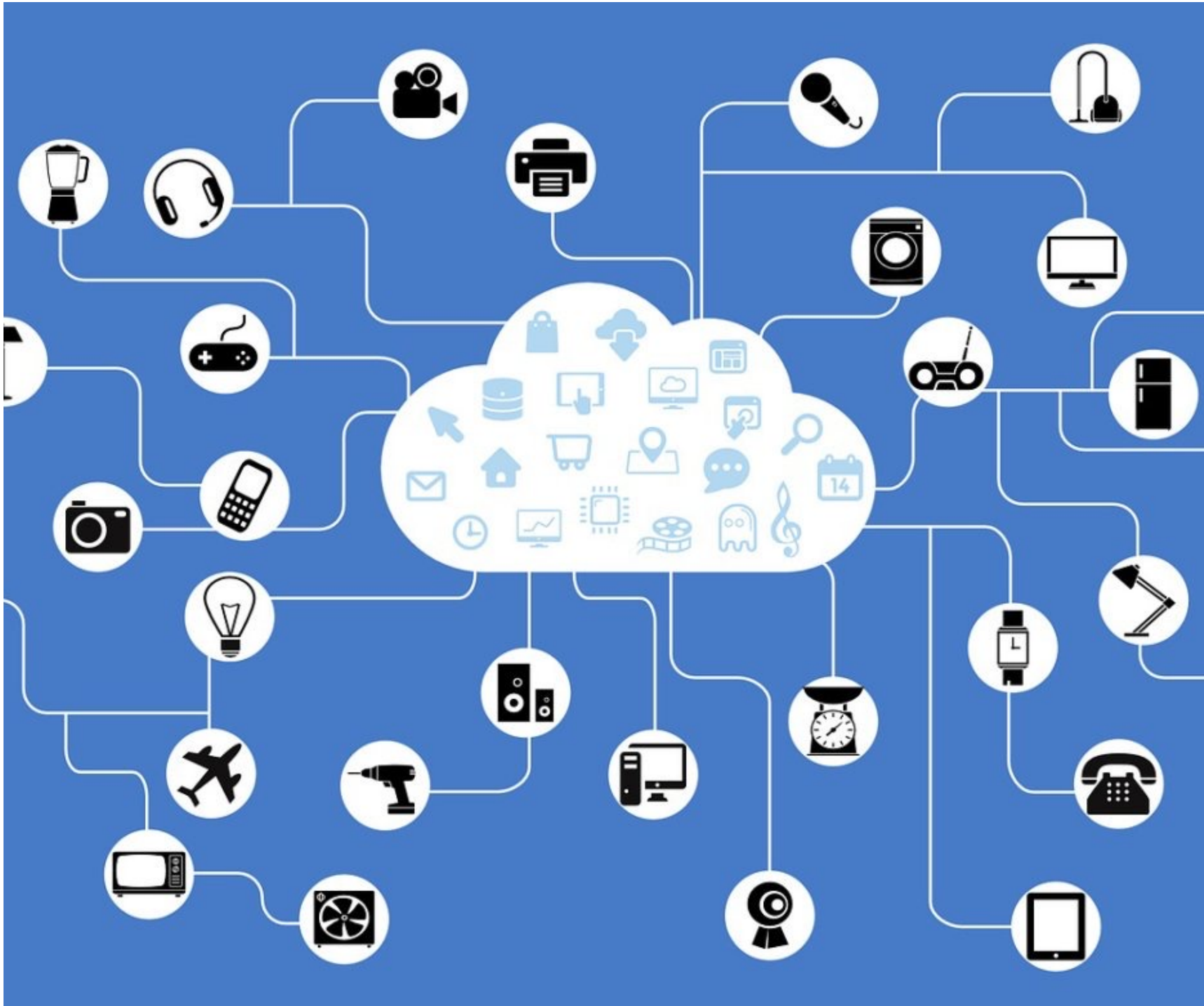
IoT global network



Enabling technologies

Enabling technologies

The things of the IoT interact with the environment through

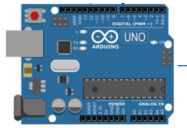
- **Sensors**: Devices capable of sensing physical phenomena and translating them into a stream of informative data
- **Actuators**: Devices capable of triggering actions that have an impact on the physical realm

Sensors and actuators

A sensor measures a physical feature and transforms it in an electrical signal (voltage, current).

An actuator, receives an electrical signal and translates it into a physical interaction with the environment, e.g. movement, led activation, sound, heat, and so on.

Movement sensor



Light switch actuator

Sensors and actuators are distinct components. They may co-exist onboard the same device (thing).

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Microcontroller

It manages sensors and actuators of a device (thing)

- Processor: 8-bit, 8MHz
- RAM: 8-10KB
- Flash memory (for code): 48-128KB
- Flash memory (for storage): 1MB
- Wireless: 2.4GHz, 802.15.4, 250Kbps
- Battery powered
- Activity led
- Enables connectivity and management of multiple sensors and actuators

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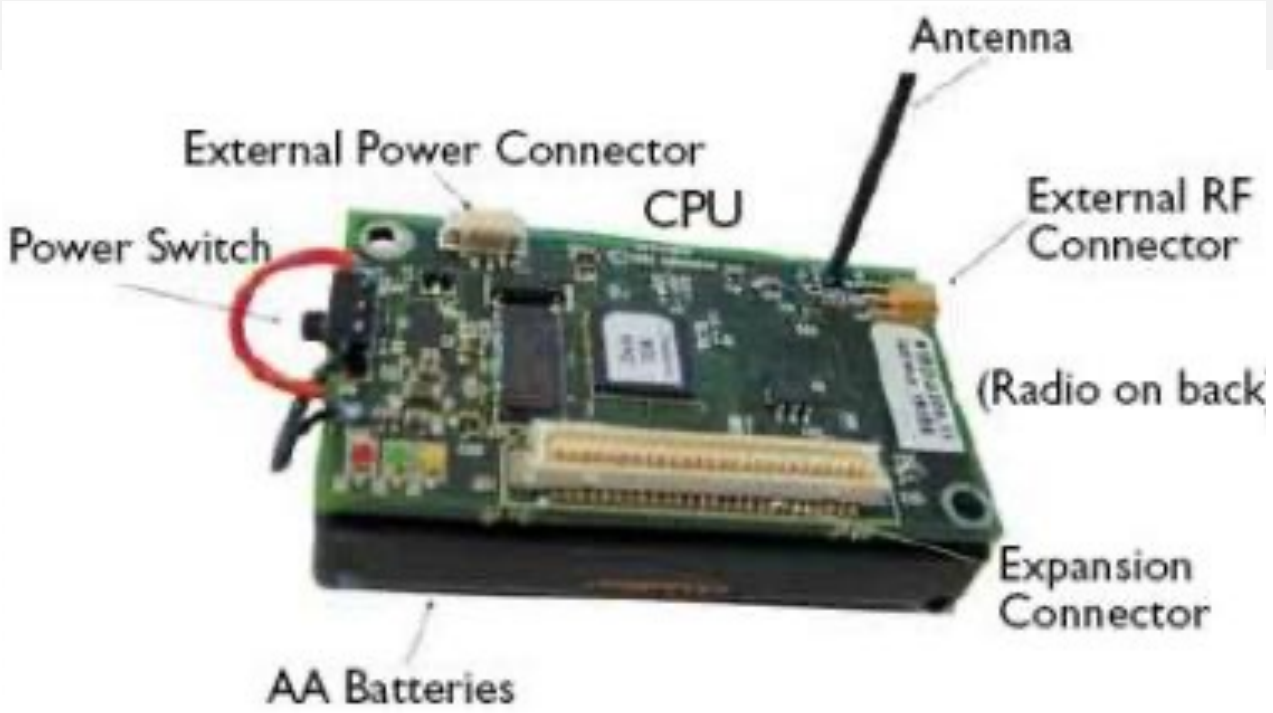
Sensor

- Connected to a microcontroller
- Sensor unit (i.e. measures temperature, humidity, light, gas)
- **Typically powered by a battery**
- The operative system in use is TinyOS*.



A sensor prototype

*Initially developed at Berkeley, TiniOS is designed to work on limited power and limited memory boards. It is based on the C programming language and utilizes a custom compiler called NesC.

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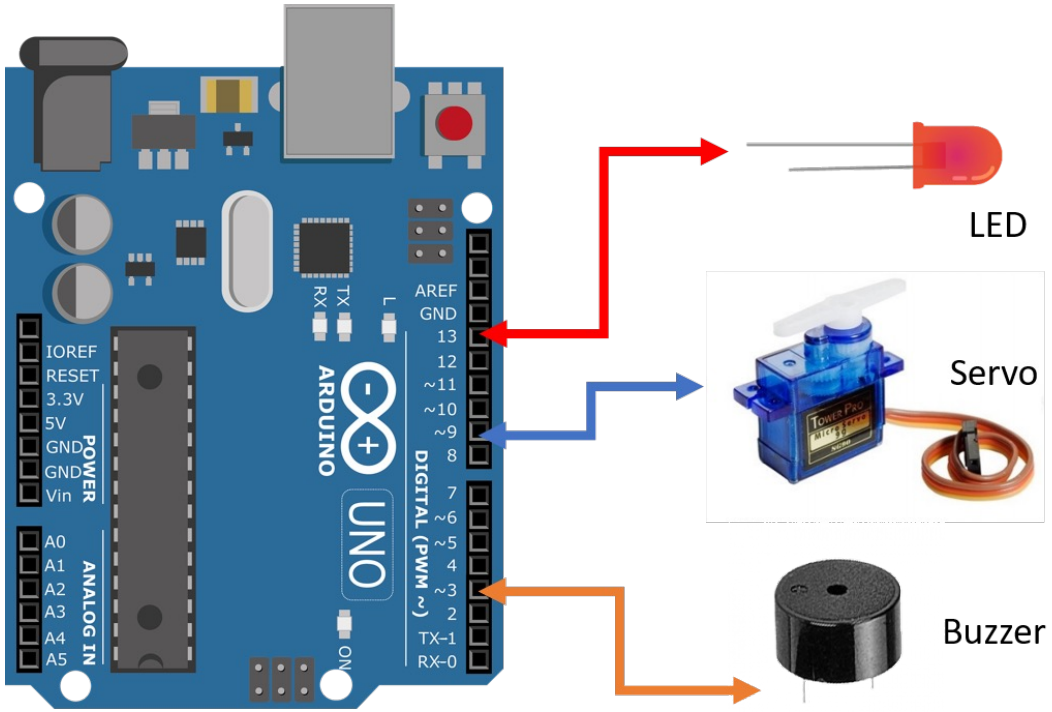
Actuator

It comprises:

- a board endowed with a microcontroller (e.g. Arduino)
- the actuator unit (e.g., led, servo, buzzer)
- a power supply (battery or power grid, depending on the energy requirement, for instance battery for a buzzer, power grid for a gate)



Actuator examples

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