IoT Sensor Layer

Internet of Things

UTEC UNIVERSIDAD DE INGENIERÍA Y TECNOLOGÍA

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HANES, CISCO BOOK IOT FUNDAMENTALS

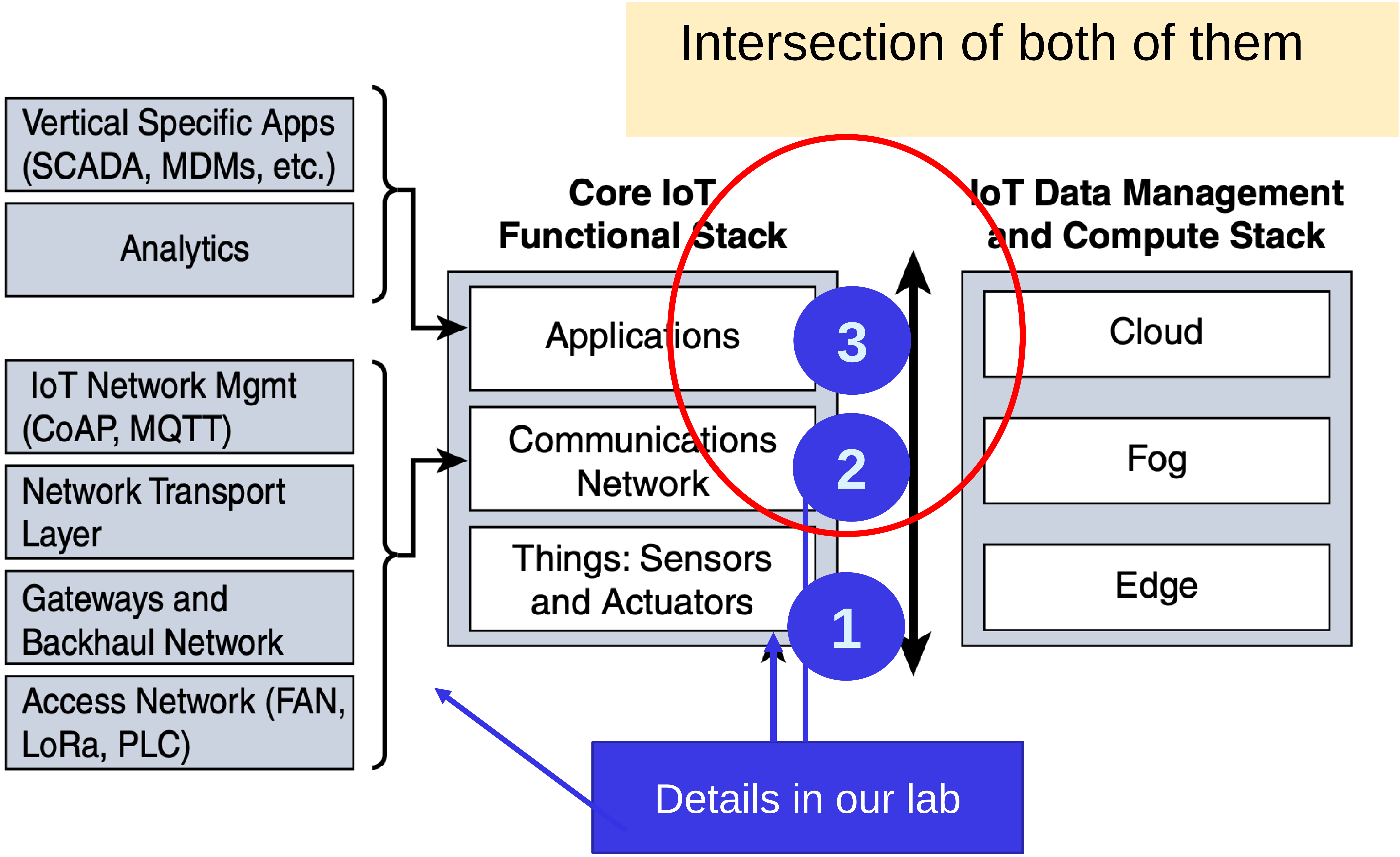
Executive Summary

- **Motivation:** IoT emerges as a solution to define smart devices as “things”.
- **Problem:** We need to define the general requirements of the IoT platform and the associated things.
- **Overview:**

  - IoT Architecture review and introduction of the design perspective.
  - Fundamentals in sensors and actuators.
  - Basic concepts of MEMS.
- **Conclusion:** IoT emerges as an integral platform to propose next-gen designs for providing services using networking and “things”.

Outline

Recall: General IoT Architecture

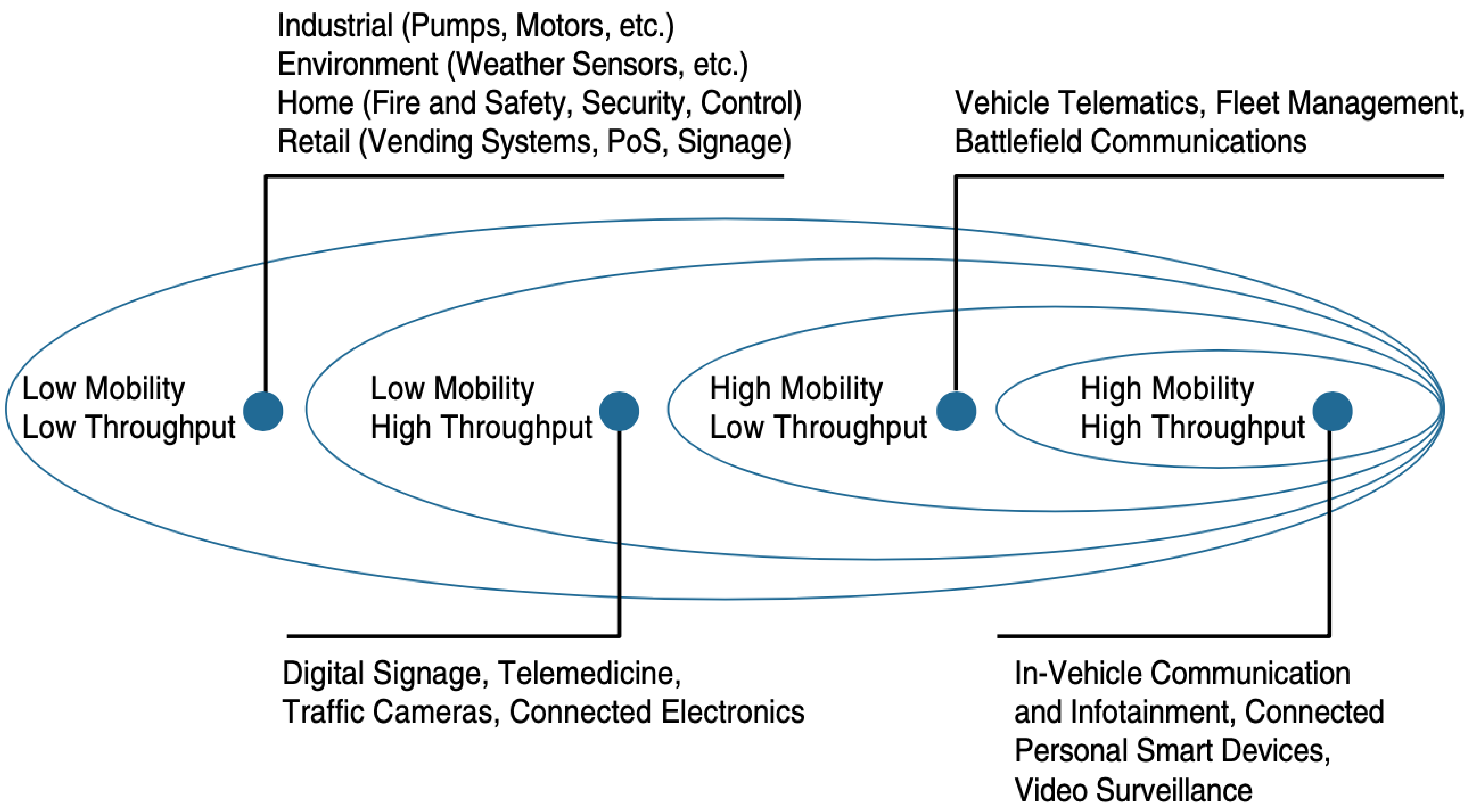


- **Layered architecture (abstraction to implementation)**
  - **Current IoT target** has a very important component of analytics.
- Hardware sensing platforms are not envisioned for **computing intensive tasks.**
- **Offload computing:** defines the Compute Stack.

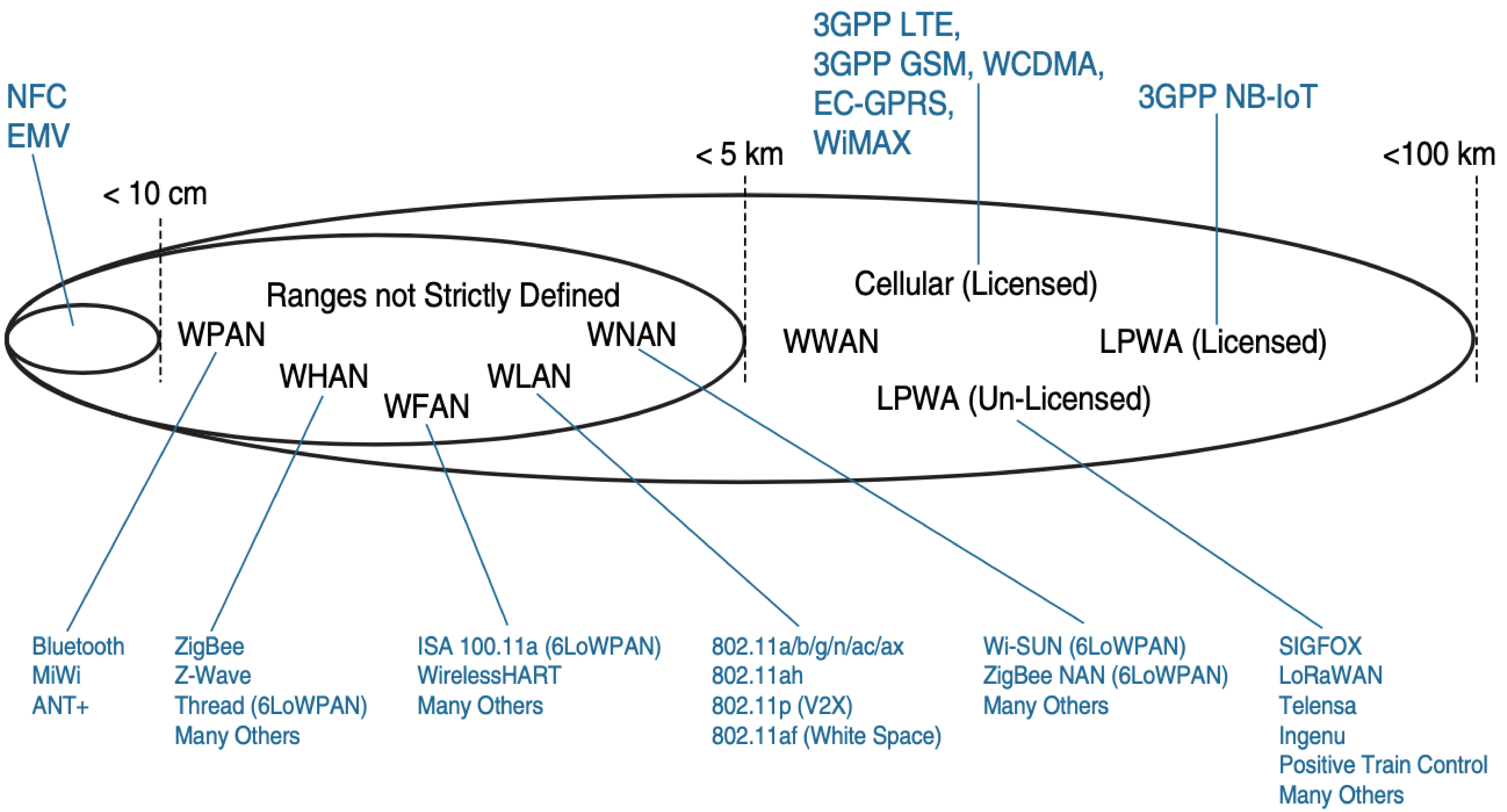
Outline

Sensor Applications

- Mobility required by the sensor:



Distance: communication standards

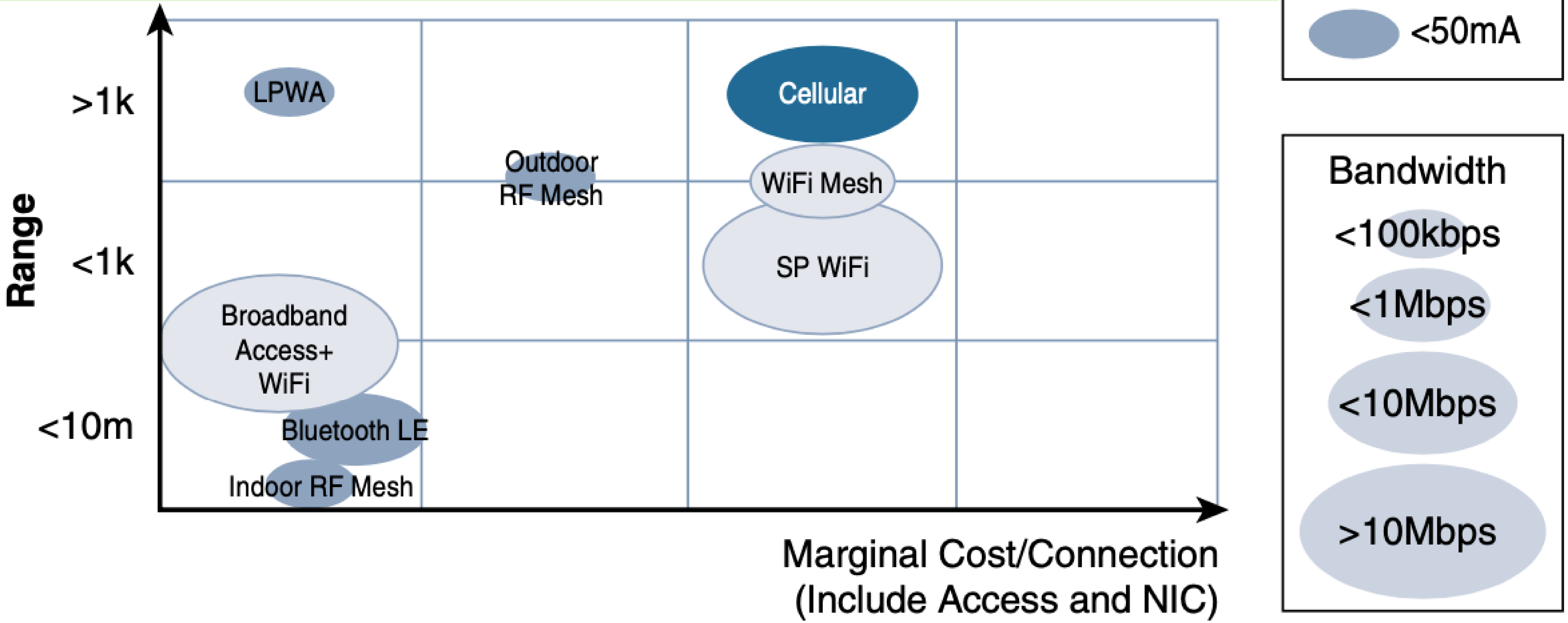


WPAN: Wireless Personal Area Network
WHAN: Wireless Home Area Network
WFAN: Wireless Field (or Factory) Area Network
WLAN: Wireless Local Area Network

WNAN: Wireless Neighborhood Area Network
WWAN: Wireless Wide Area Network
LPWA: Low Power Wide Area

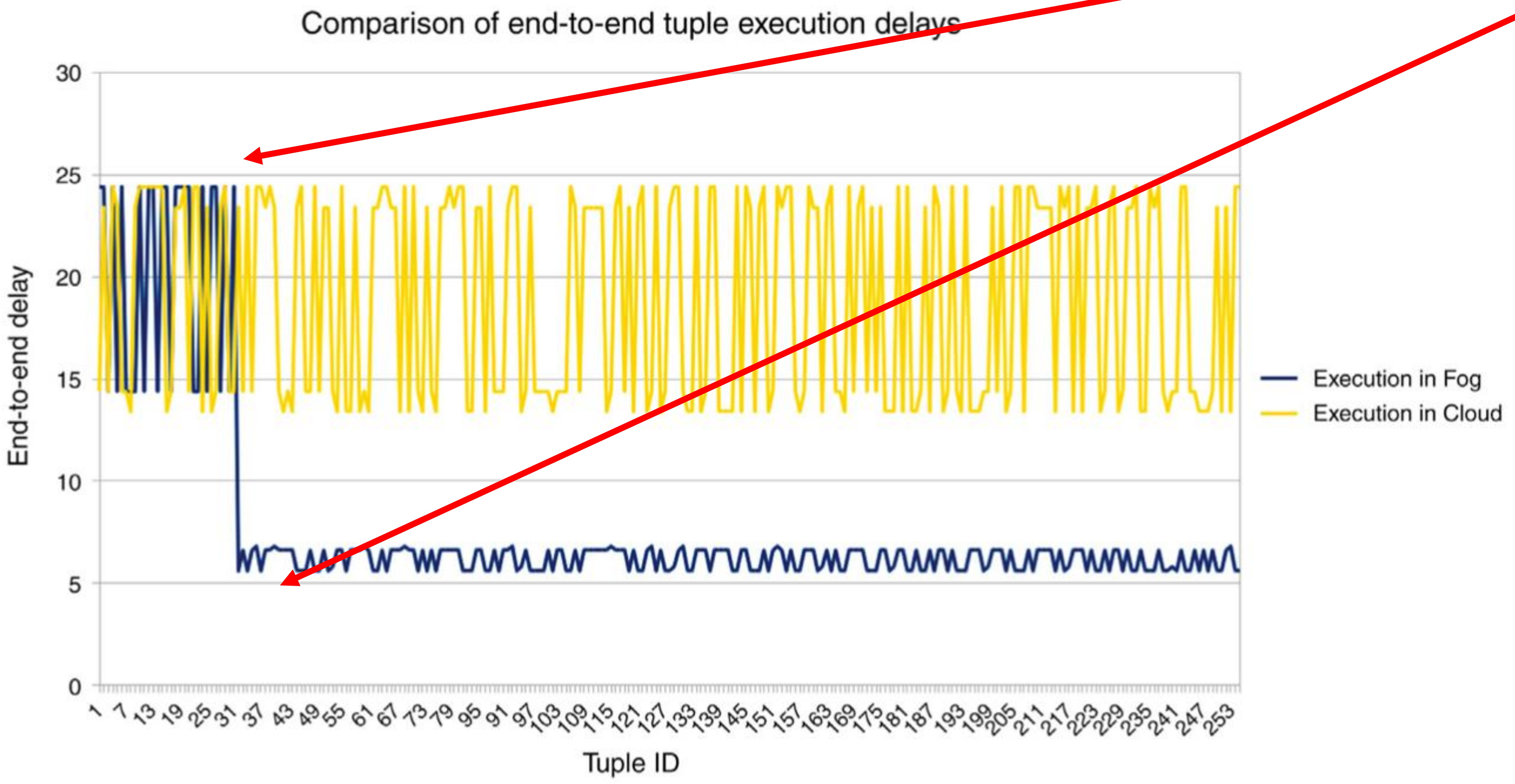
Dinstance: Power and bandwidth

- **More is more?**
- **Desirable: High performance with low power operation**



Performance in the computing stack

Assume a tuple as pair of data from the IoT domain



What is desirable?
Fog vs Cloud
Higher delay or lower delay? Why?

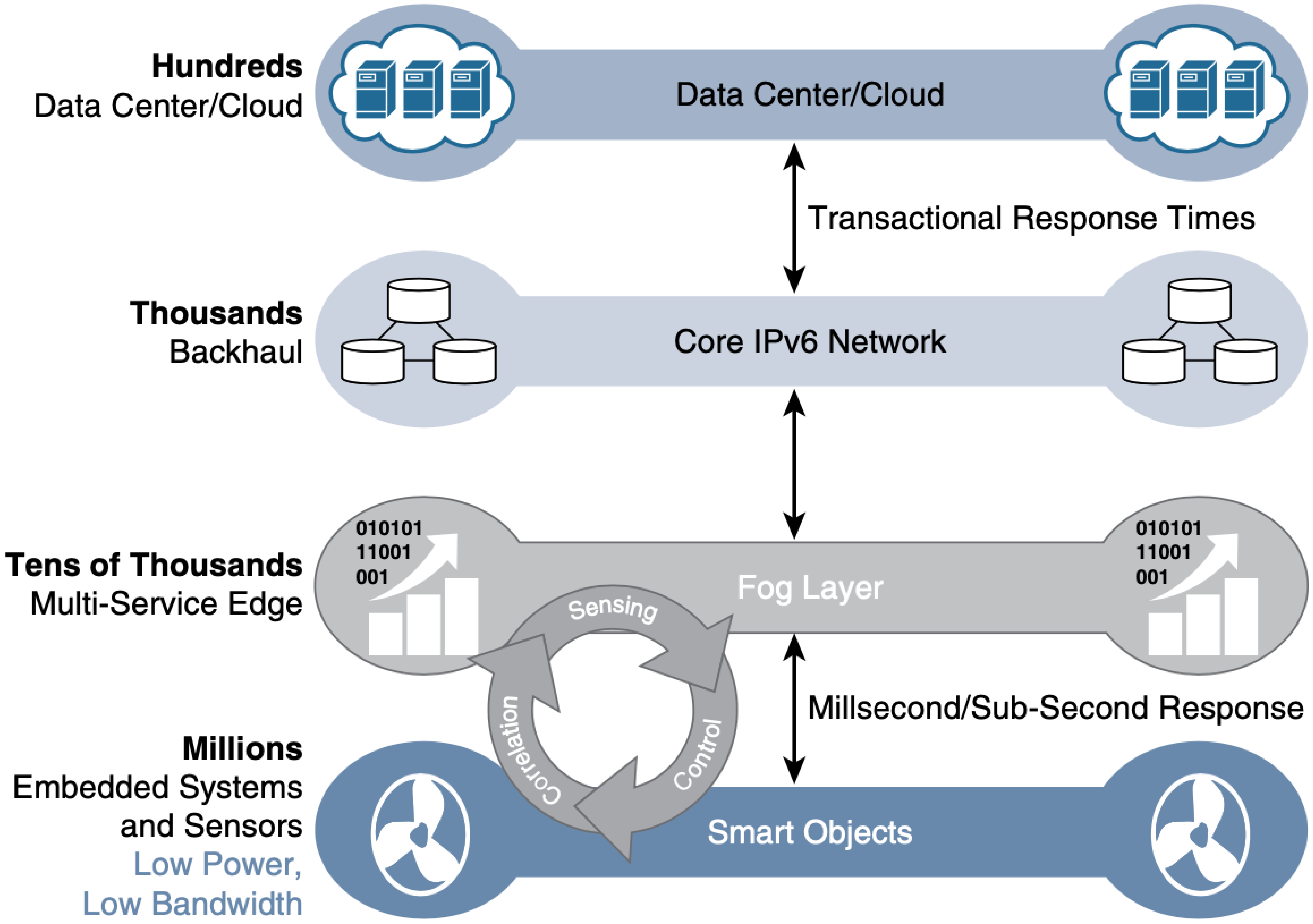
Reasons to have a higher delay:

- Location (distance) for data availability
- Communication infrastructure
- Protocols (intermediate)

So… what is the limit of Fog?

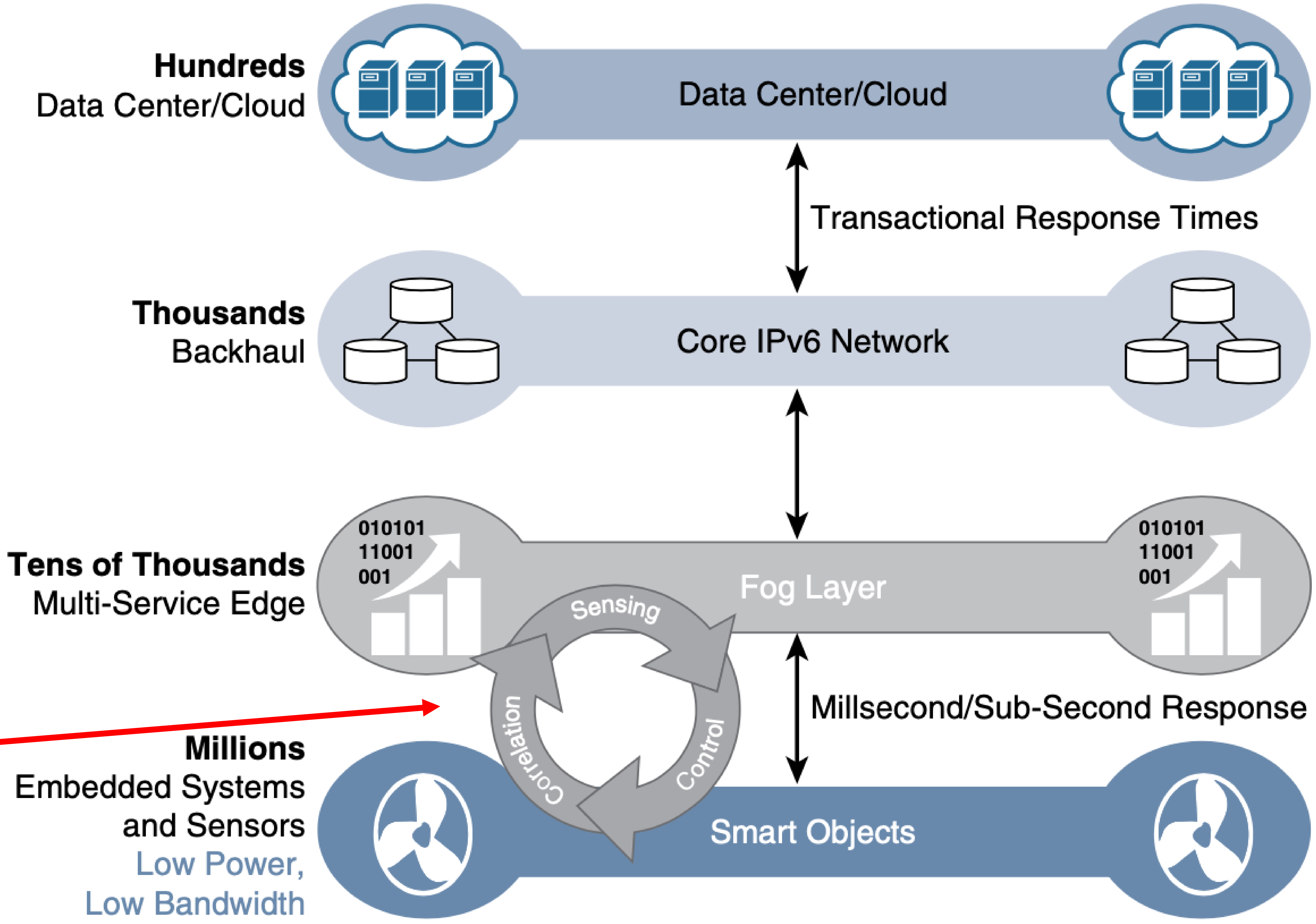
Design perspective

- **Design Principles:**
  1. **Minimizing latency**
  2. Conserving network bandwidth
  3. Increasing local efficiency



Relevance of smart objects or things

- To reduce computing in the higher layer.
  - Lower layer provides “smart” data.
- Things are required to be smart.
  - Simplify data analysis, if possible: preprocessed data.



Ready Data

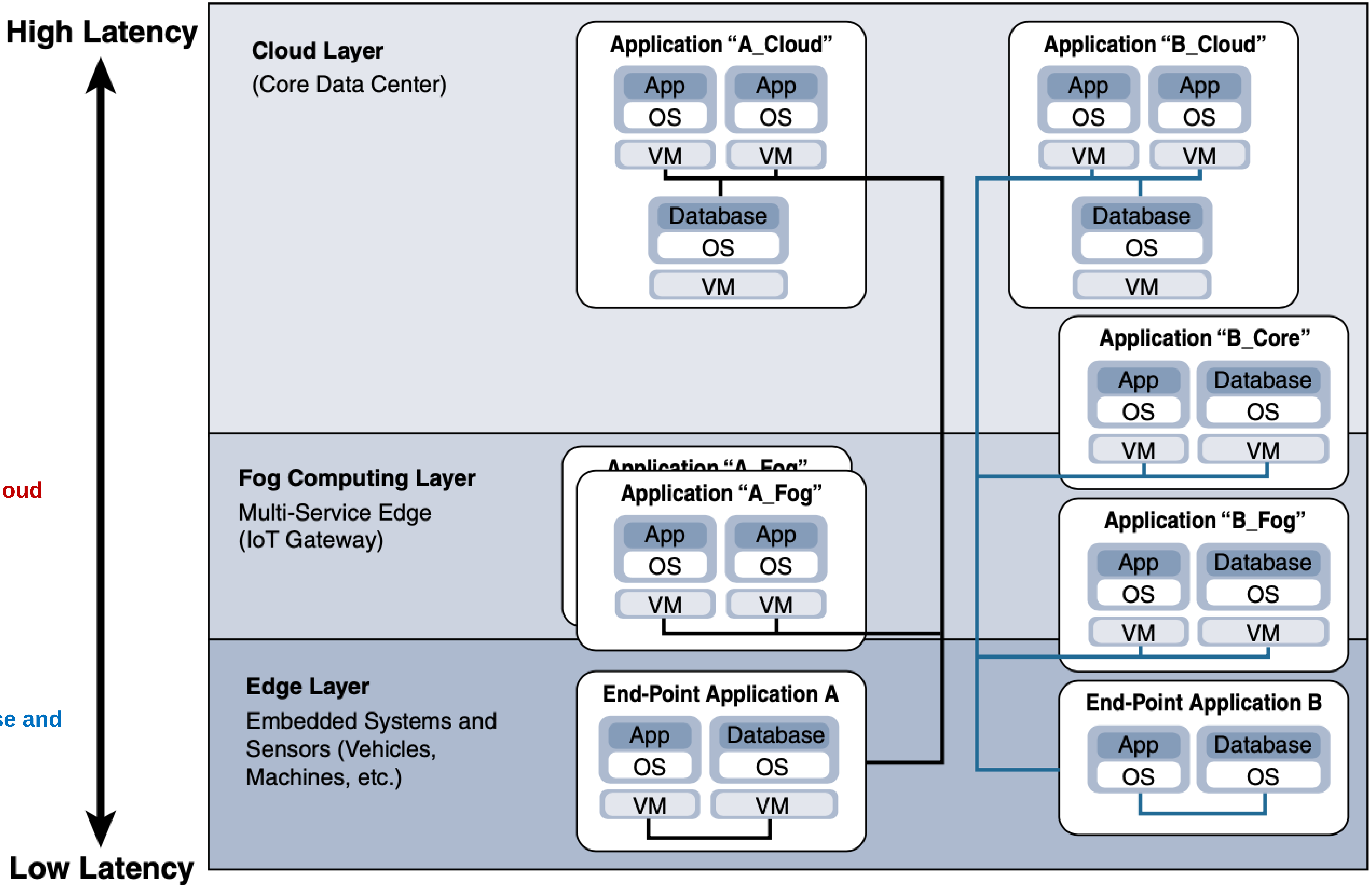
1. Only essential data to be processed in higher layers.
2. Smaller chunks of data in the network domain, reduce communication latency.

- **Idea:**
  - Maintain a lower layer of smart objects with limited networking an processing (functionality) characteristics.
  - Lower layer data, does not require extreme security as higher layers.
    - Security is one the main concerns for modern IoT services (open problem). Because the limited functionality is not focused on security.

For analytics

To access the Cloud

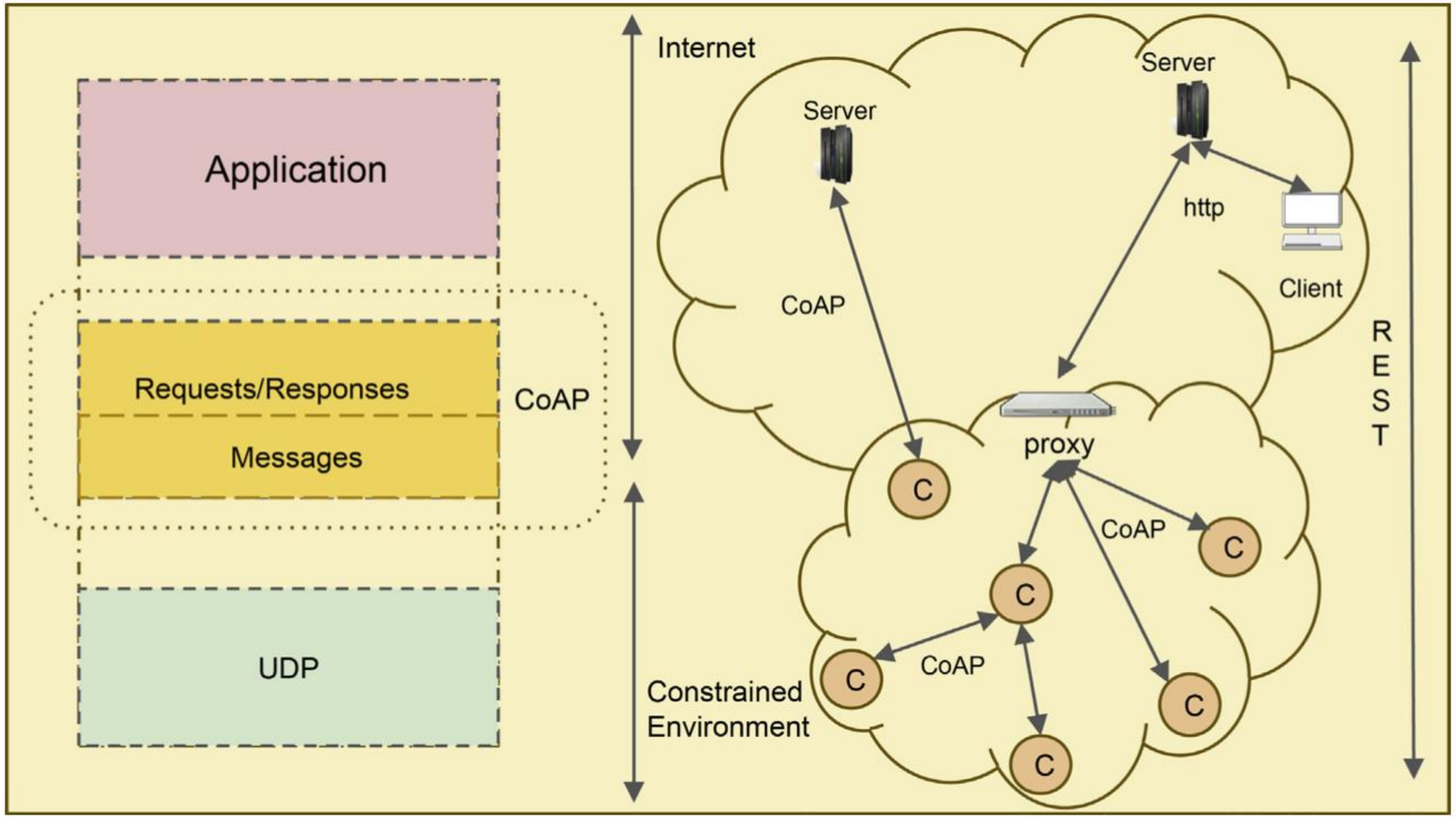
With limited functionality: sense and collect.



OS:operating systems

VM: virtual machines

How to implement the computing stack?



- **Recall:** Plataformas and Cloud Course – with Prof. Jesus Bellido ;)

- **IoT trend:**

- Based on constrained REST applications.

- Constrained Application Protocol (CoAP)

- Request/response model.

- Relaxed security.
- CoAP has four types of messages: *Acknowledgement, Reset, Confirmable (CON),* and *Non- Confirmable (NON, less reliable)*

Outline

Sensors

- **Definition:** Measures some physical quantity and converts that measurement reading into a digital representation.

- **That digital representation is typically passed to another device for transformation into useful data that can be consumed by intelligent devices or humans.**
  - **Recall:** last lab session digitization and sampling.

Sensor Classification

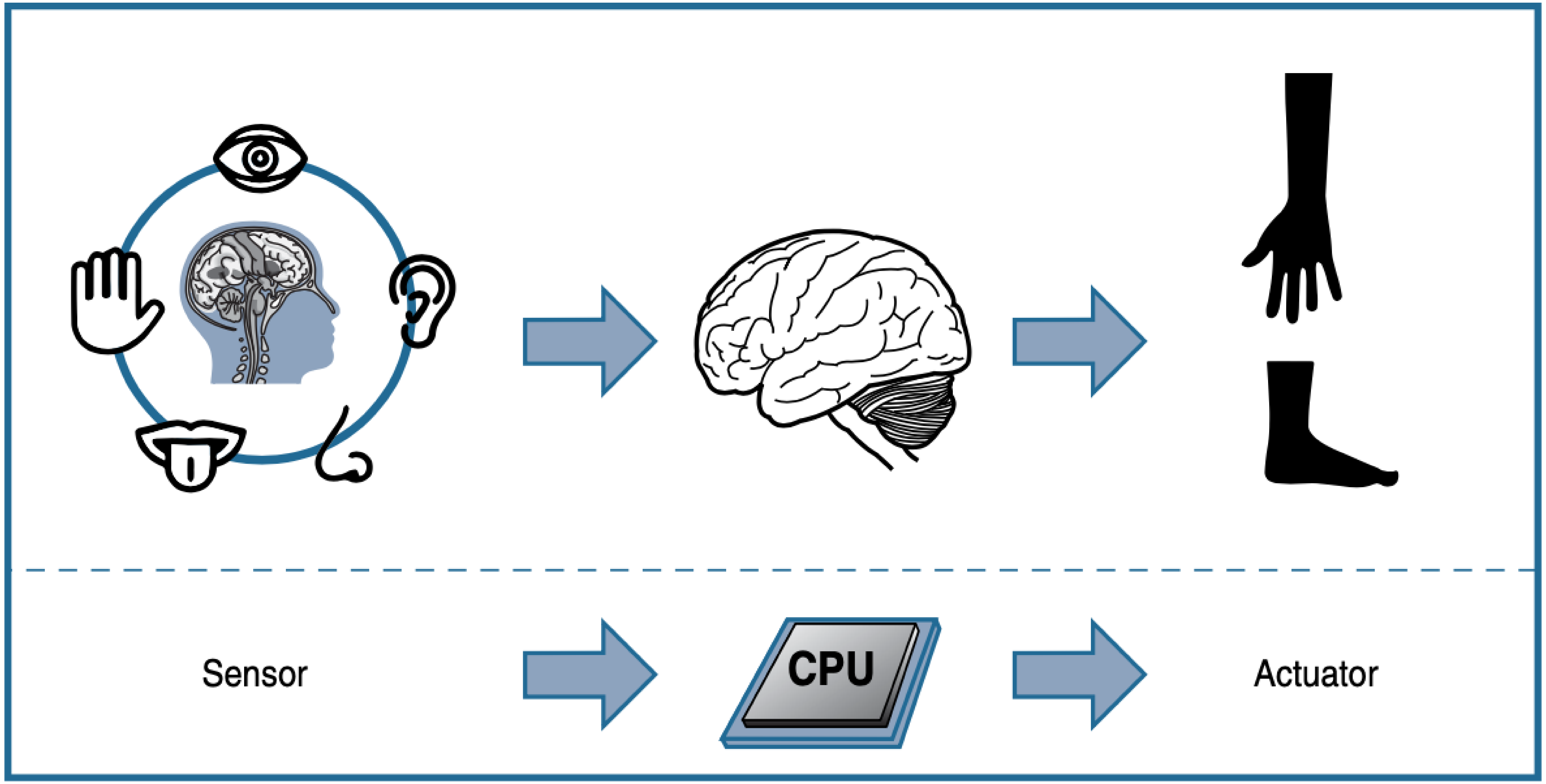
Active or passive	based on whether they produce an energy output and typically require an external power supply (active) or whether they simply receive energy and typically require no external power supply (passive).
Invasive or non-invasive	based on whether a sensor is part of the environment it is measuring (invasive) or external to it (non-invasive).
Contact or no-contact	based on whether they require physical contact with what they are measuring (contact) or not (no-contact).
Absolute or relative	based on whether they measure on an absolute scale (absolute) or based on a difference with a fixed or variable refer- ence value (relative).
Area of application	based on the specific industry or vertical where they are being used.
How sensors measure	based on the physical mechanism used to measure sensory input (for example, thermoelectric, electrochemical, piezo- resistive, optic, electric, fluid mechanic, photoelastic).
What sensors measure	based on their applications or what physical variables they measure.

Sensor Types

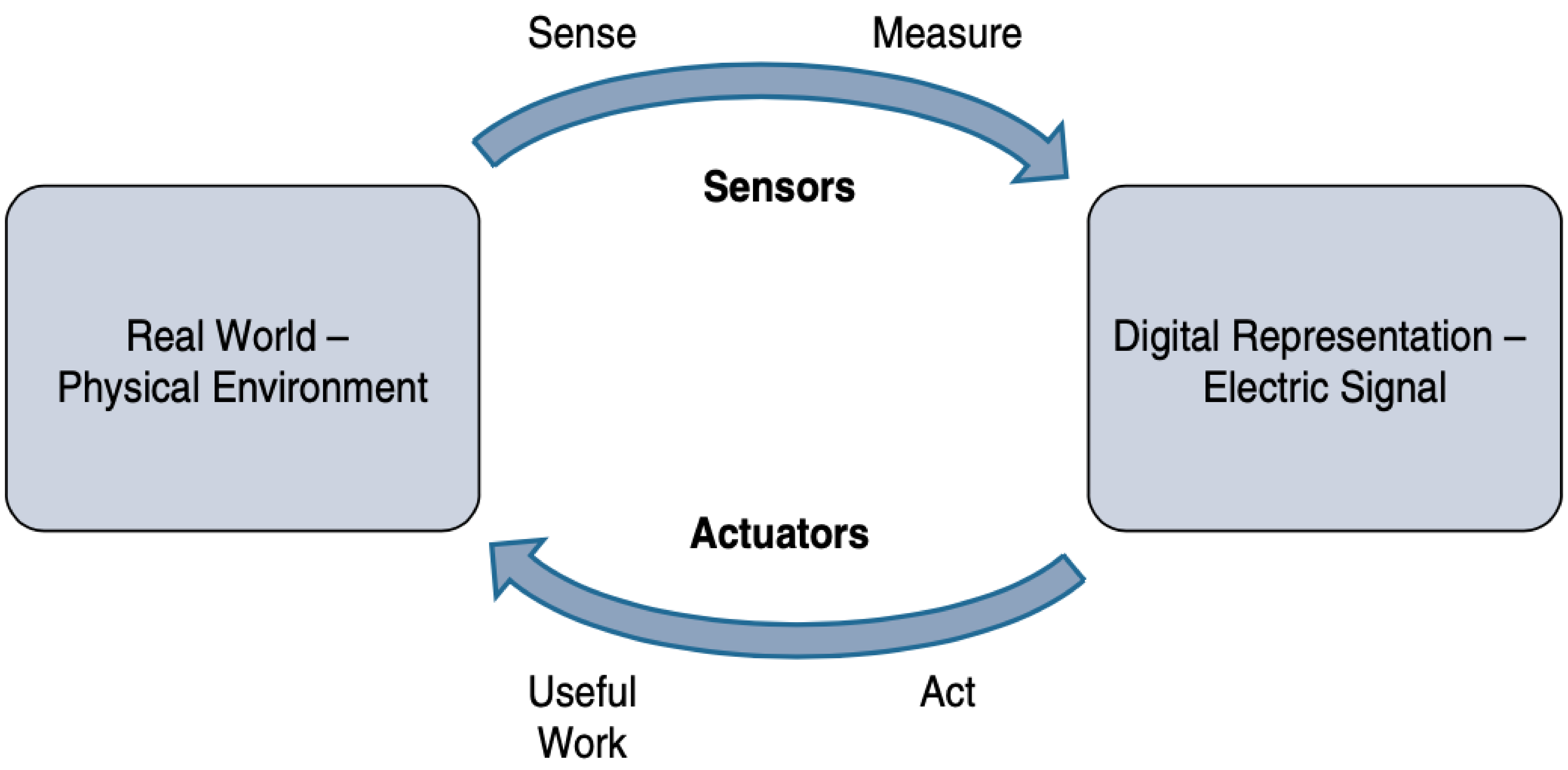
Sensor Types	Description	Examples
Position	A position sensor measures the position of an object; the position measurement can be either in absolute terms (absolute position sensor) or in relative terms (displacement sensor). Position sensors can be linear, angular, or multi-axis.	Potentiometer, inclinometer, proximity sensor
Occupancy and motion	Occupancy sensors detect the presence of people and animals in a surveillance area, while motion sensors detect movement of people and objects. The difference between the two is that occupancy sensors generate a signal even when a person is stationary, whereas motion sensors do not.	Electric eye, radar
Velocity and acceleration	Velocity (speed of motion) sensors may be linear or angular, indicating how fast an object moves along a straight line or how fast it rotates. Acceleration sensors measure changes in velocity.	Accelerometer, gyroscope
Force	Force sensors detect whether a physical force is applied and whether the magnitude of force is beyond a threshold.	Force gauge, viscometer, tactile sensor (touch sensor)
Pressure	Pressure sensors are related to force sensors, measuring force applied by liquids or gases. Pressure is measured in terms of force per unit area.	Barometer, Bourdon gauge, piezometer
Flow	Flow sensors detect the rate of fluid flow. They measure the volume (mass flow) or rate (flow velocity) of fluid that has passed through a system in a given period of time.	Anemometer, mass flow sensor, water meter

Sensor Types	Description	Examples
Acoustic	Acoustic sensors measure sound levels and convert that information into digital or analog data signals.	Microphone, geophone, hydrophone
Humidity	Humidity sensors detect humidity (amount of water vapor) in the air or a mass. Humidity levels can be measured in various ways: absolute humidity, relative humidity, mass ratio, and so on.	Hygrometer, humistor, soil moisture sensor
Light	Light sensors detect the presence of light (visible or invisible).	Infrared sensor, photodetector, flame detector
Radiation	Radiation sensors detect radiation in the environment. Radiation can be sensed by scintillating or ionization detection.	Geiger-Müller counter, scintillator, neutron detector
Temperature	Temperature sensors measure the amount of heat or cold that is present in a system. They can be broadly of two types: contact and non-contact. Contact temperature sensors need to be in physical contact with the object being sensed. Non-contact sensors do not need physical contact, as they measure temperature through convection and radiation.	Thermometer, calorimeter, temperature gauge
Chemical	Chemical sensors measure the concentration of chemicals in a system. When subjected to a mix of chemicals, chemical sensors are typically selective for a target type of chemical (for example, a CO_2 sensor senses only carbon dioxide).	Breathalyzer, olfactometer, smoke detector
Biosensors	Biosensors detect various biological elements, such as organisms, tissues, cells, enzymes, antibodies, and nucleic acid.	Blood glucose biosensor, pulse oximetry, electrocardiograph

Human actuators



Actuators


Sense
Measure
Sensors
Real World –
Physical Environment
Digital Representation –
Electric Signal
Actuators
Useful
Work
Act

Actuator classification

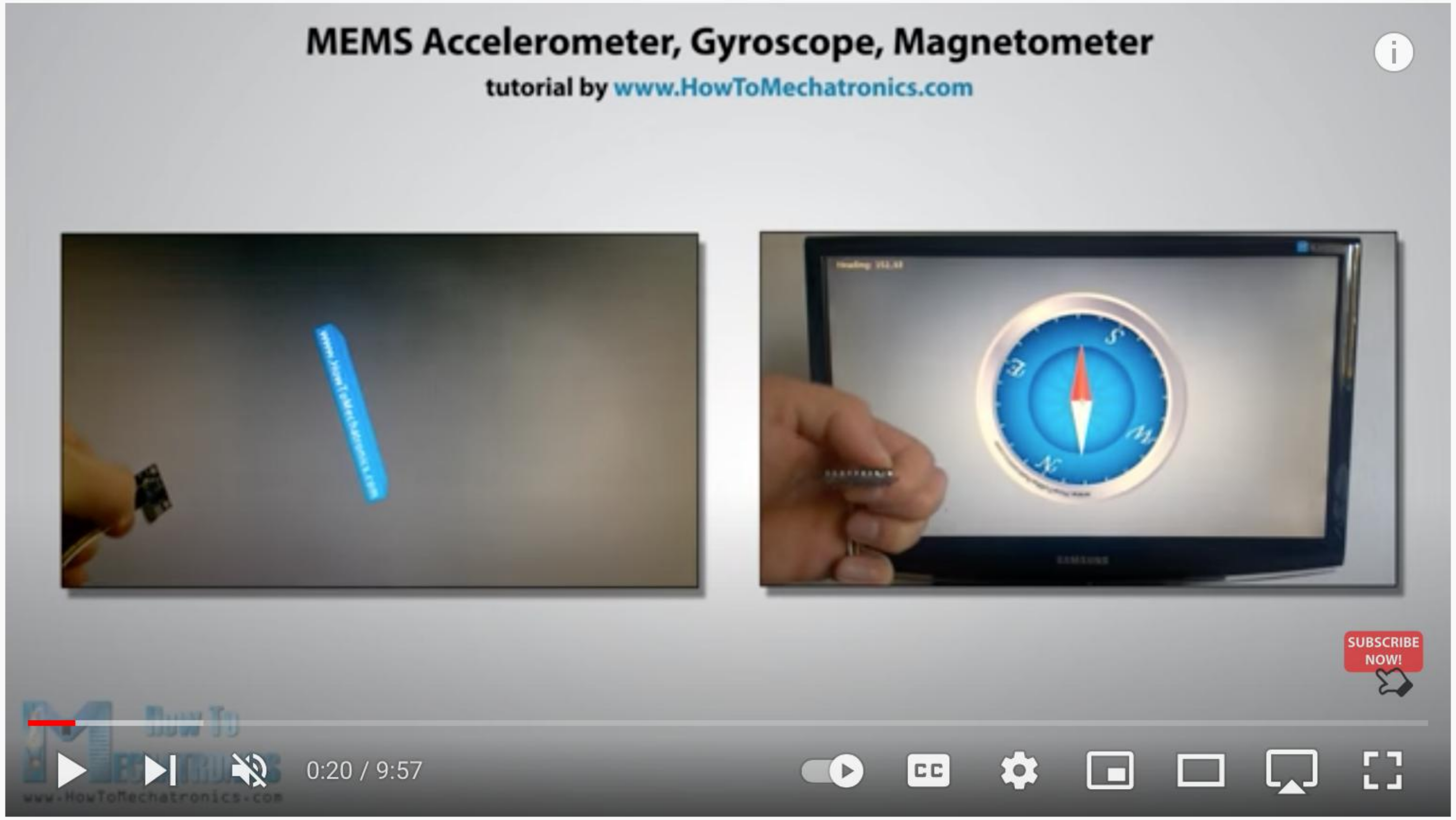
- **Type of motion:** based on the type of motion they produce (for example, linear, rotary, one/two/three-axes).
- **Power:** based on their power output (for example, high power, low power, micro power)
- **Binary or continuous:** based on the number of stable-state outputs.
- **Area of application:** based on the specific industry or vertical where they are used.
- **Type of energy:** Actuators can be classified based on their energy type.

Actuator types

Type	Examples
Mechanical actuators	Lever, screw jack, hand crank
Electrical actuators	Thyristor, biopolar transistor, diode
Electromechanical actuators	AC motor, DC motor, step motor
Electromagnetic actuators	Electromagnet, linear solenoid
Hydraulic and pneumatic actuators	Hydraulic cylinder, pneumatic cylinder, piston, pressure control valves, air motors
Smart material actuators (includes thermal and magnetic actuators)	Shape memory alloy (SMA), ion exchange fluid, magnetorestrictive material, bimetallic strip, piezoelectric bimorph
Micro- and nanoactuators	Electrostatic motor, microvalve, comb drive

Micro-electro-mechanical systems (MEMS)

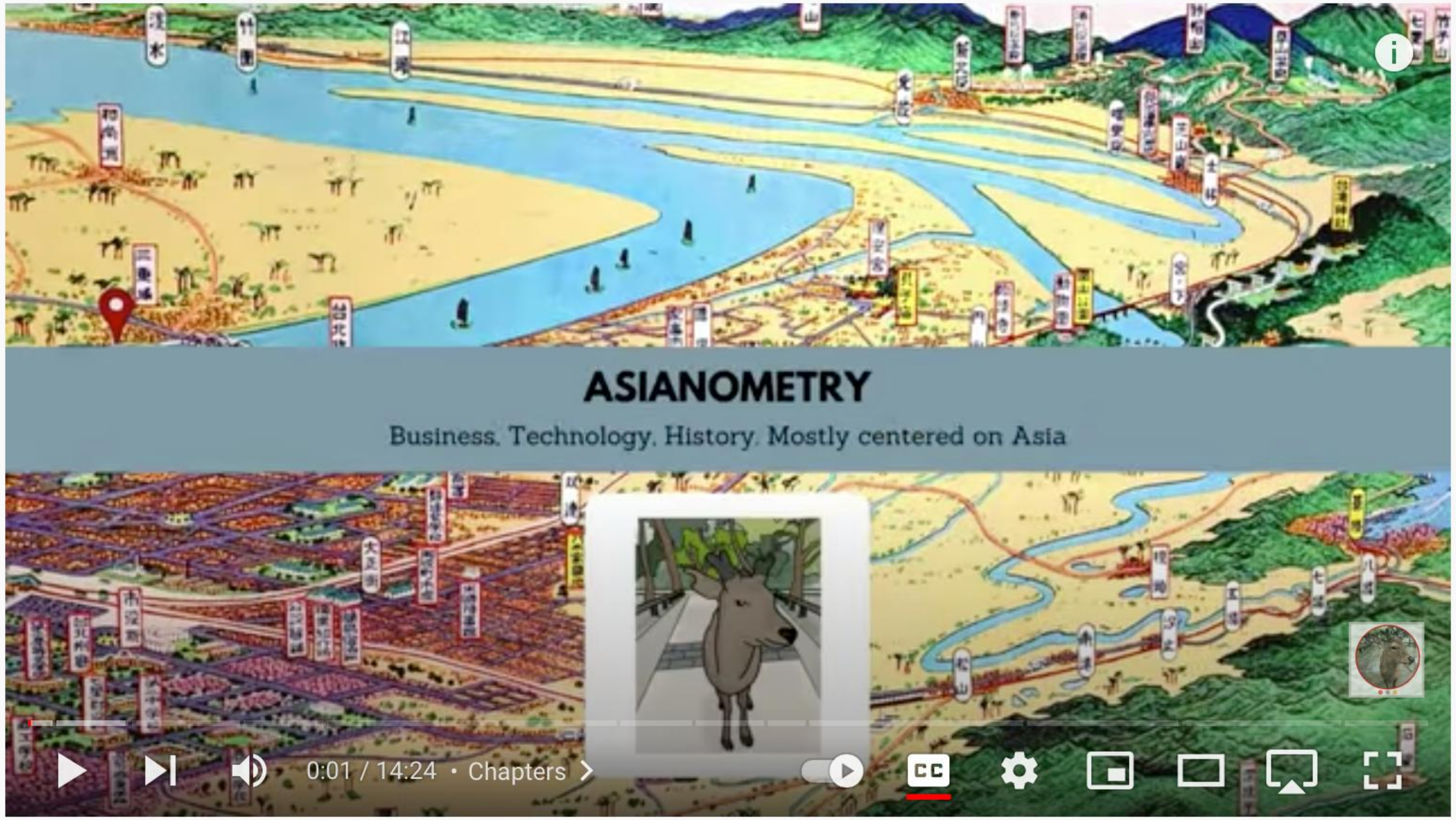
https://www.youtube.com/watch?v=eqZgxR6eRjo



How MEMS Accelerometer Gyroscope Magnetometer Work & Arduino Tutorial

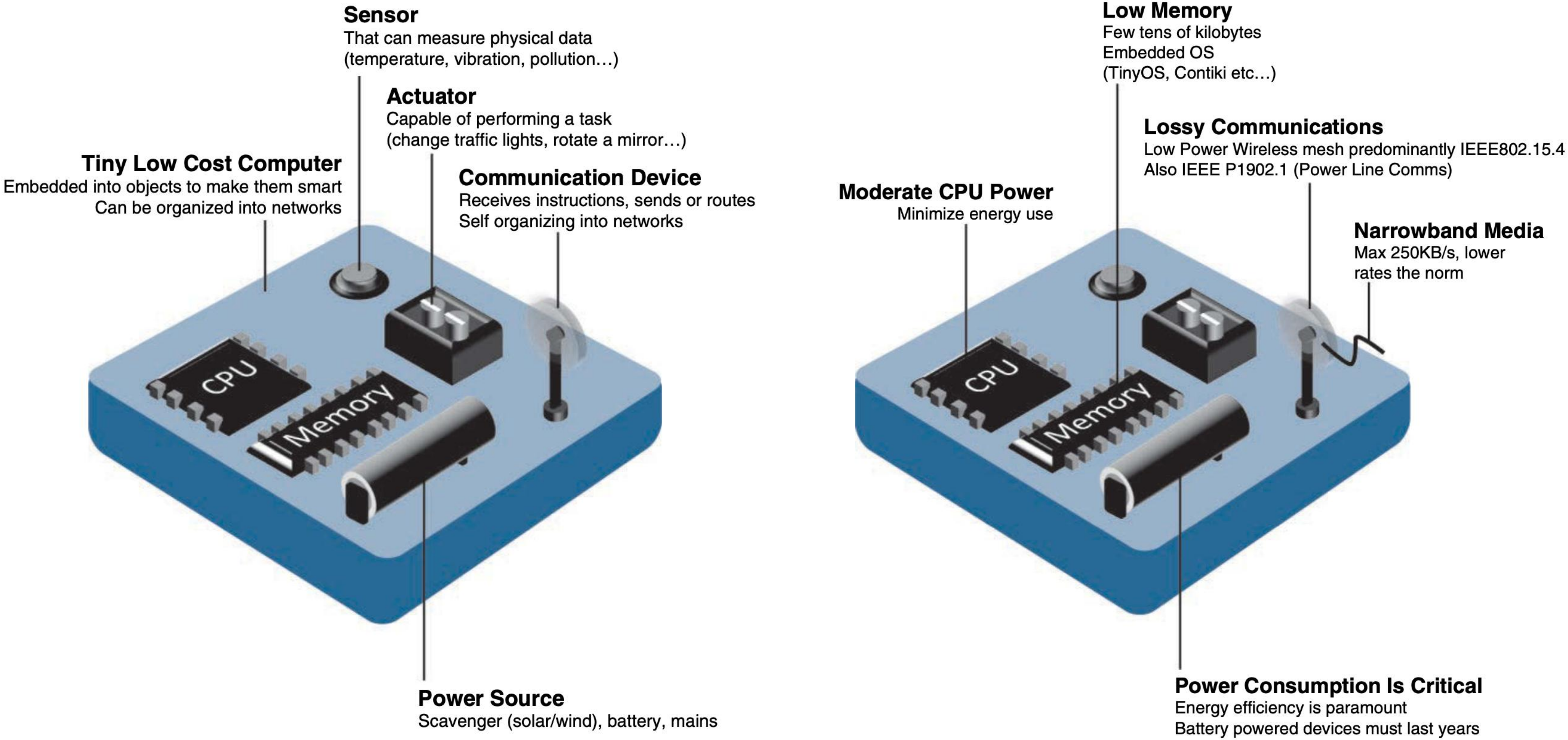
More about MEMS

- https://www.youtube.com/watch?v=RiRyap-EVg0



MEMS: The Second Silicon Revolution?

Smart sensor: E.g. Arduino boards



Outline

- Introduction
- Design perspective
- Sensors and actuators
- **Conclusions**

Summary

- We introduced the design perspective: defines things and computing stack requirements.
- We reviewed sensors and actuators:
  - Fundamentals and types.
  - Definition of smart ”thing”.
- We highlighted the relevance of the hardware platform for deployment of the IoT system as a sensor layer.