Preliminary Concepts

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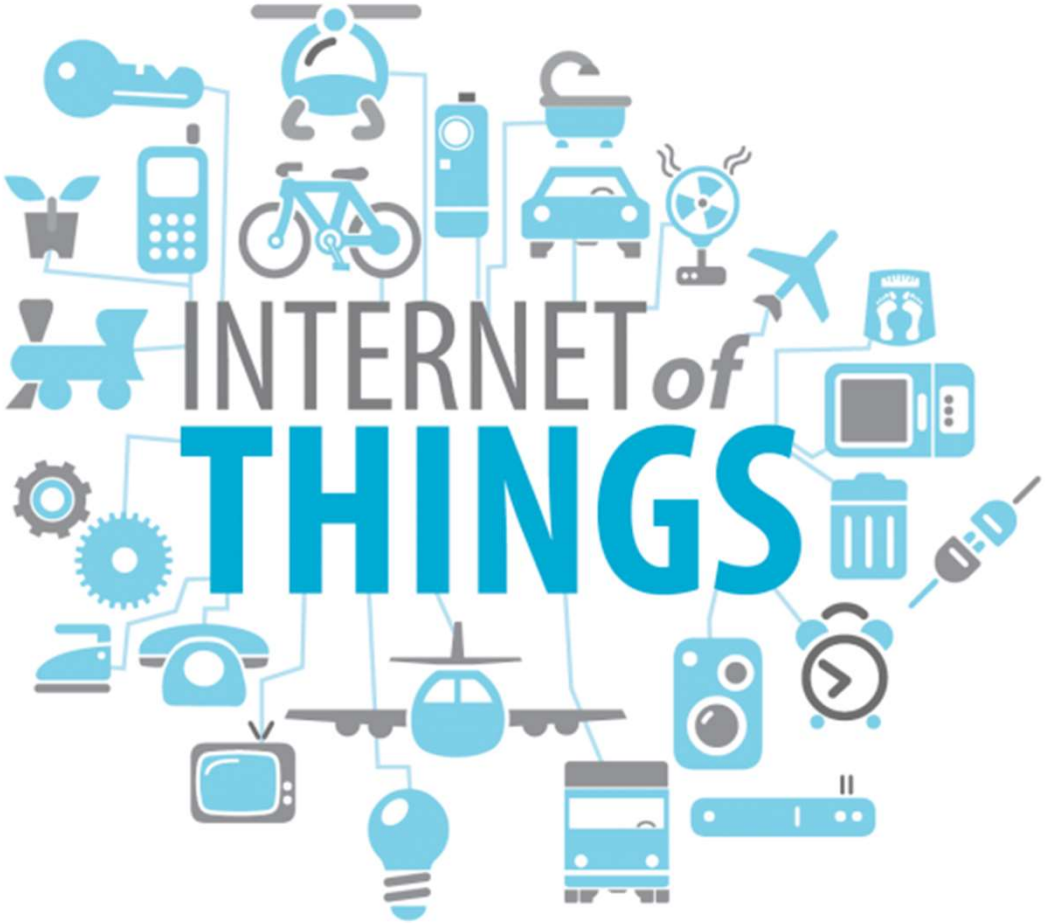
Innovation for industry 4.0

Internet of Things

"The next logical step in the technological revolution connecting people anytime, anywhere is to connect inanimate objects. This is the vision underlying the **Internet of things: anytime, anywhere, by anyone and anything"**
(ITU, Nov. 2005)



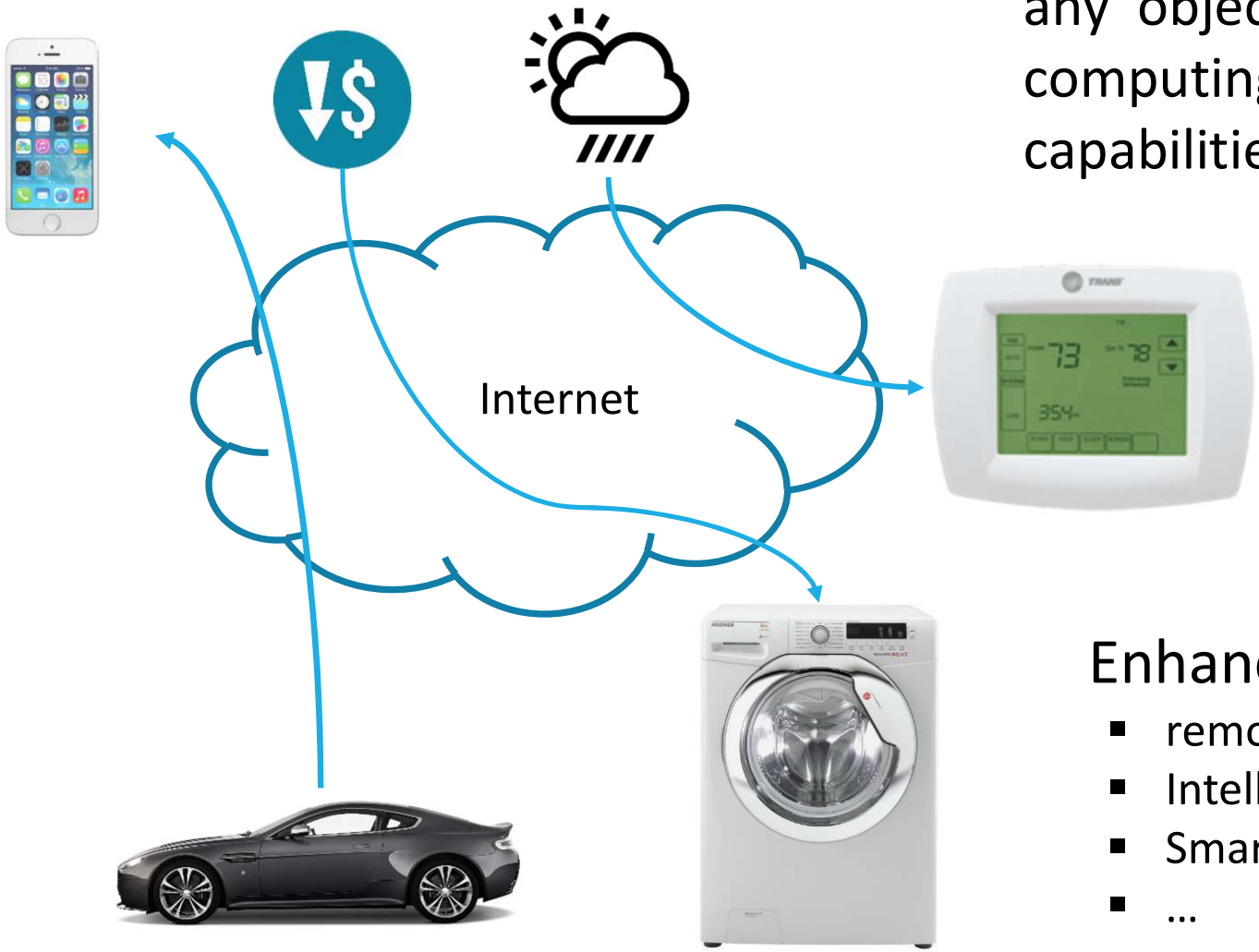
Any object can be addressed

- computers and communication devices
- cars, robots, machine tools
- persons, animals, and plants
- garments, food, drugs, etc.

Objects can be connected and communicate

Introduction

Internet of Things



IoT envisions a future in which any object is empowered with computing and communication capabilities

Enhanced services

- remote control of connected cars
- Intelligent thermostat
- Smart wash machine
- …

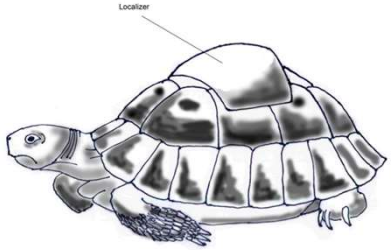
Smart Devices

Increasing Connectivity Capabilities

Increasing Sensing, Computing & Actuation Capabilities

Smart Object

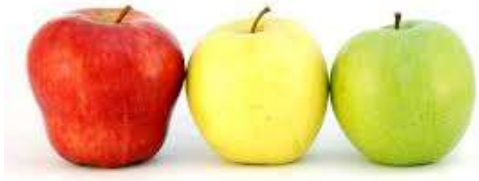
Any real-world object empowered with



- Communication capabilities
  - Allow the smart object to communicate

- Computing capabilities
  - Give the smart object its behavior
- Sensing/Actuating capabilities
  - Allow the smart object to interact with the physical world
- Power Source
  - Needed to feed electronic circuits





Smart Object

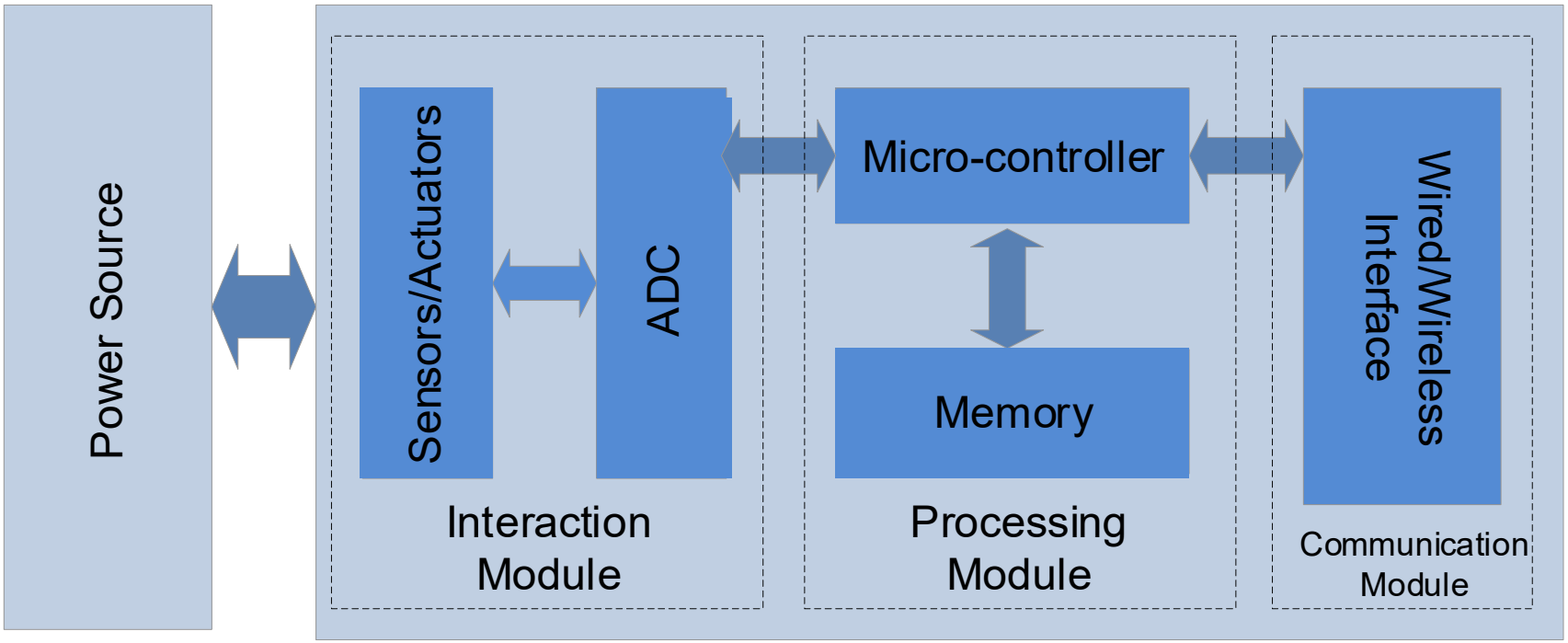
Real-world object + instrumenting device

Instrumenting device

Low-cost device, embedded to the object, with

- Communication capabilities
- Computing capabilities
- Sensing/Actuating capabilities
- Power Source

Instrumenting device



Instrumenting device

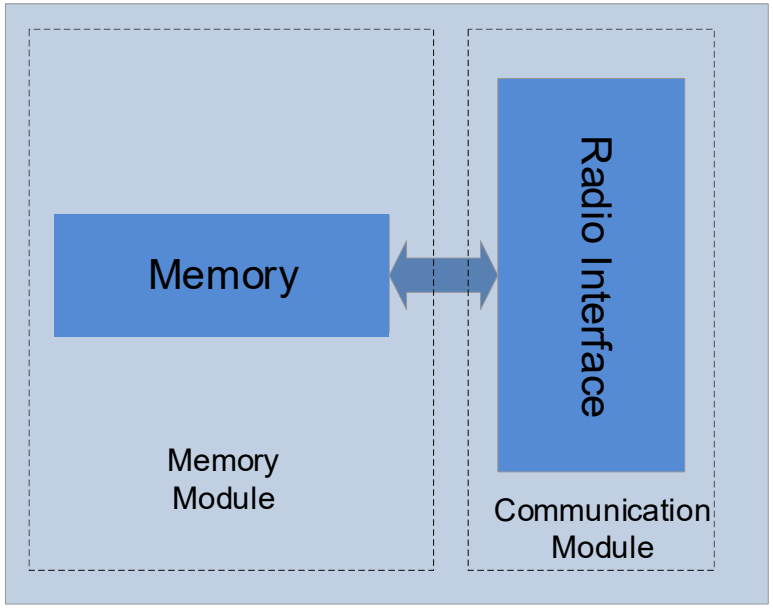
RFID Tags: only connectivity

RFID Reader required for communication

Instrumenting device

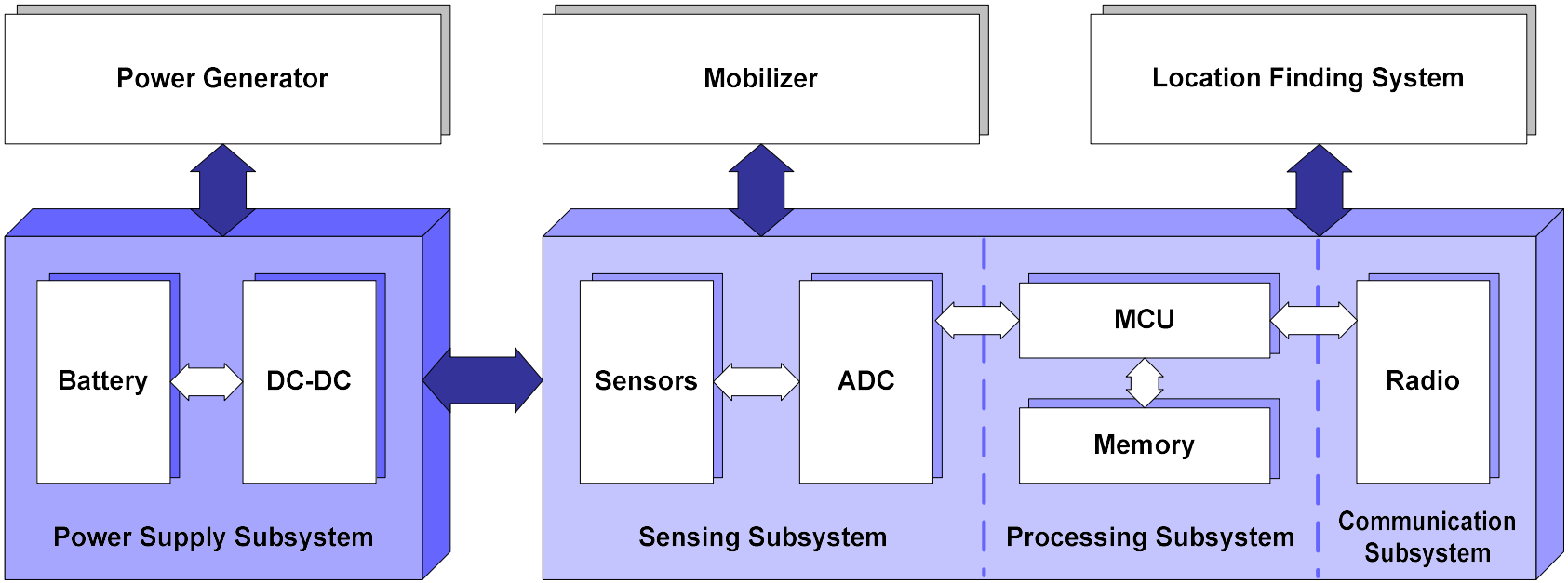
RFID Tags: only connectivity

RFID Reader required for communication



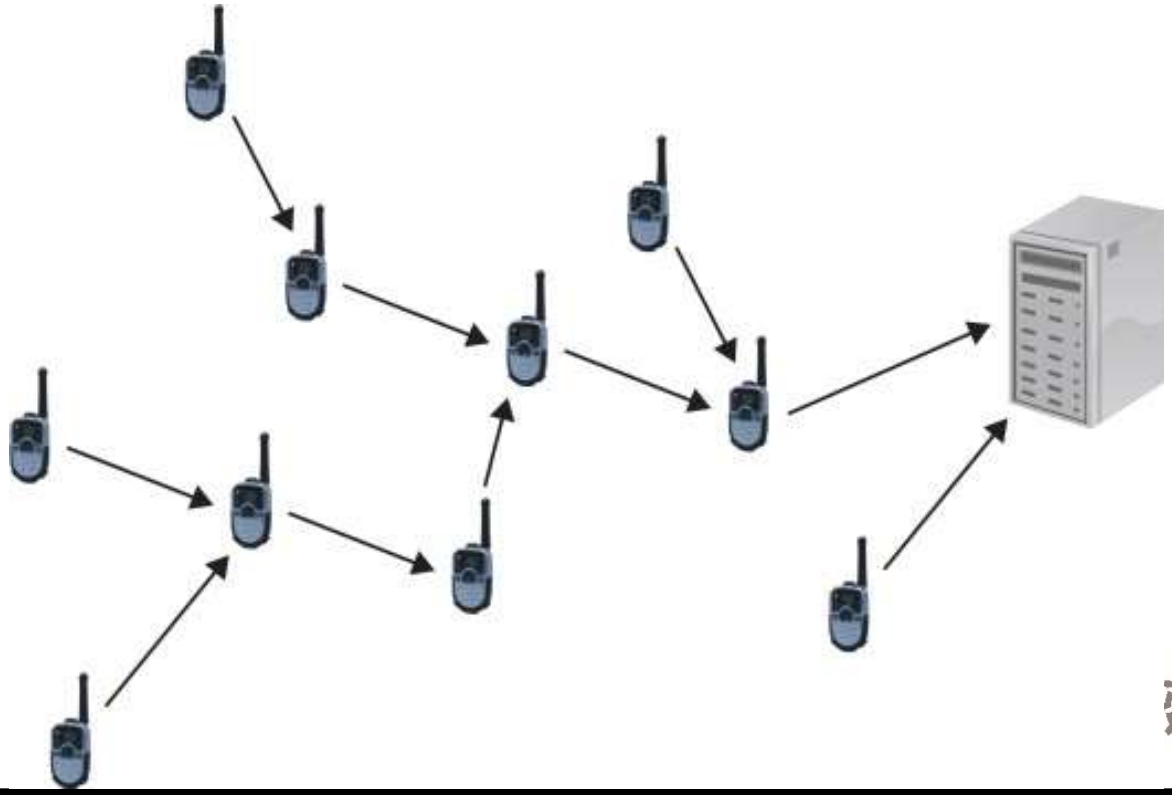
Instrumenting device

Sensor node



Smart Object Networks

- Smart Objects typically are part of a distributed system
  - Where different smart objects cooperate to perform a specific task
  - Wireless/Wired communication



Smart Environment

- Smart Objects are the building blocks for smart environments
  - Smart environment
    - ⇨ a place where human activities are assisted and supported by ICT
    - ⇨ Through cooperating smart objects
  - Most of the environments where we live, work, spend our time are smart, or can be made smart

Smart Environments

- Smart Cities
- Smart Mobility
- Smart Parking
- Smart Lighting
- Smart Waste/Water Management
- Smart Buildings
- Smart Energy (Smart Grid)
- Smart Healthcare
- Smart Factory (Smart Industry)
- Smart Manufacturing
- Smart *

The keyword «smart» is extremely popular

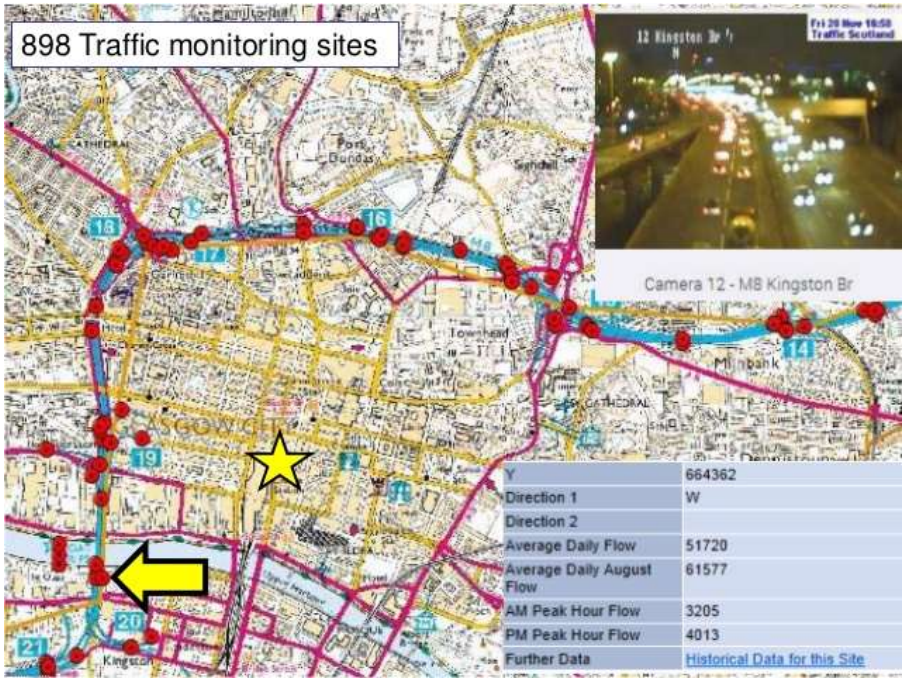
Smart Cities

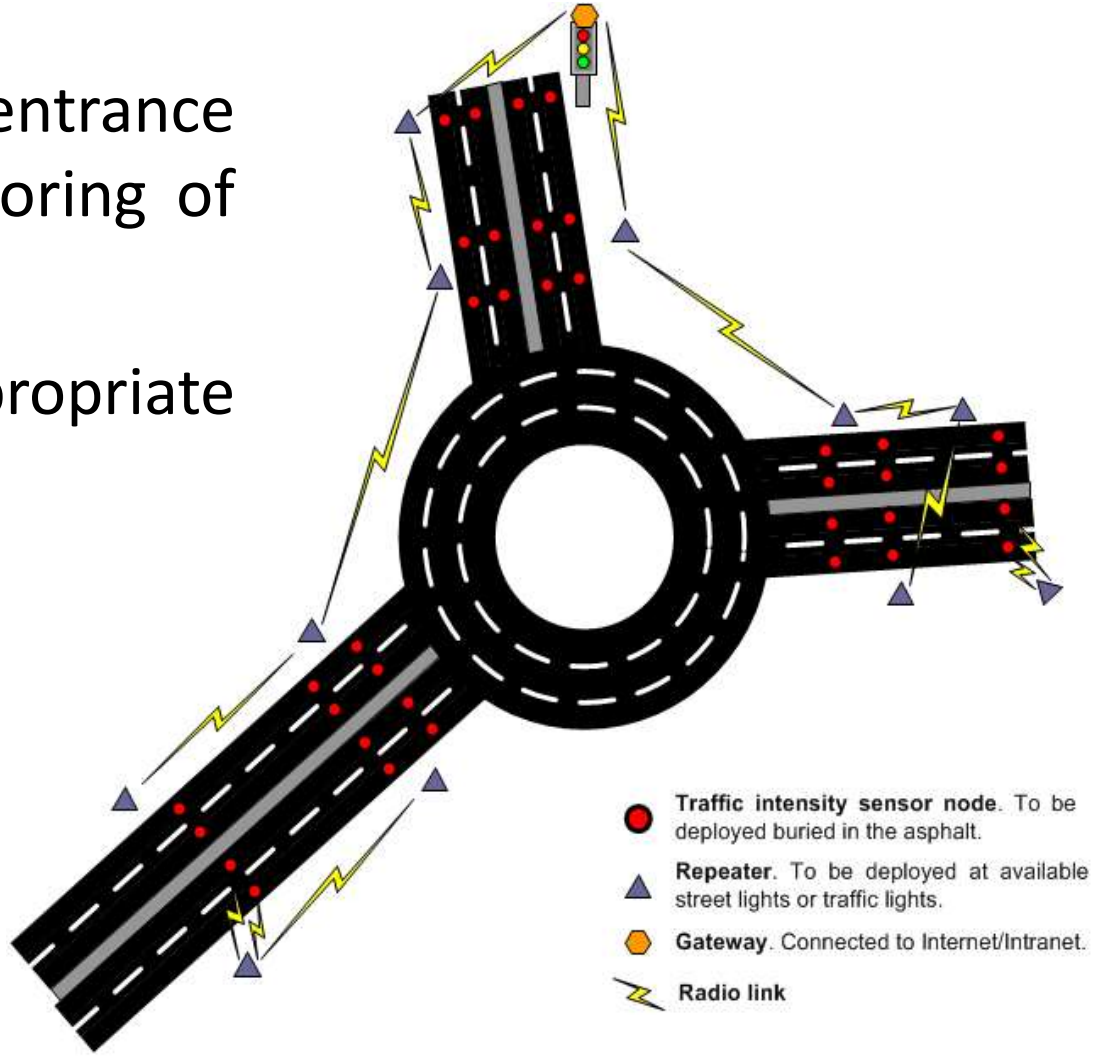
A city instrumented with ICT tools to provide improved efficiency, sustainable development, better quality of life, incresaed security, citizens' participation, inclusion of disadvantged people, ...

Smart Mobility

Sensors deployed at the main entrance of the city for real-time monitoring of urban traffic

Allows to take timely and appropriate decision





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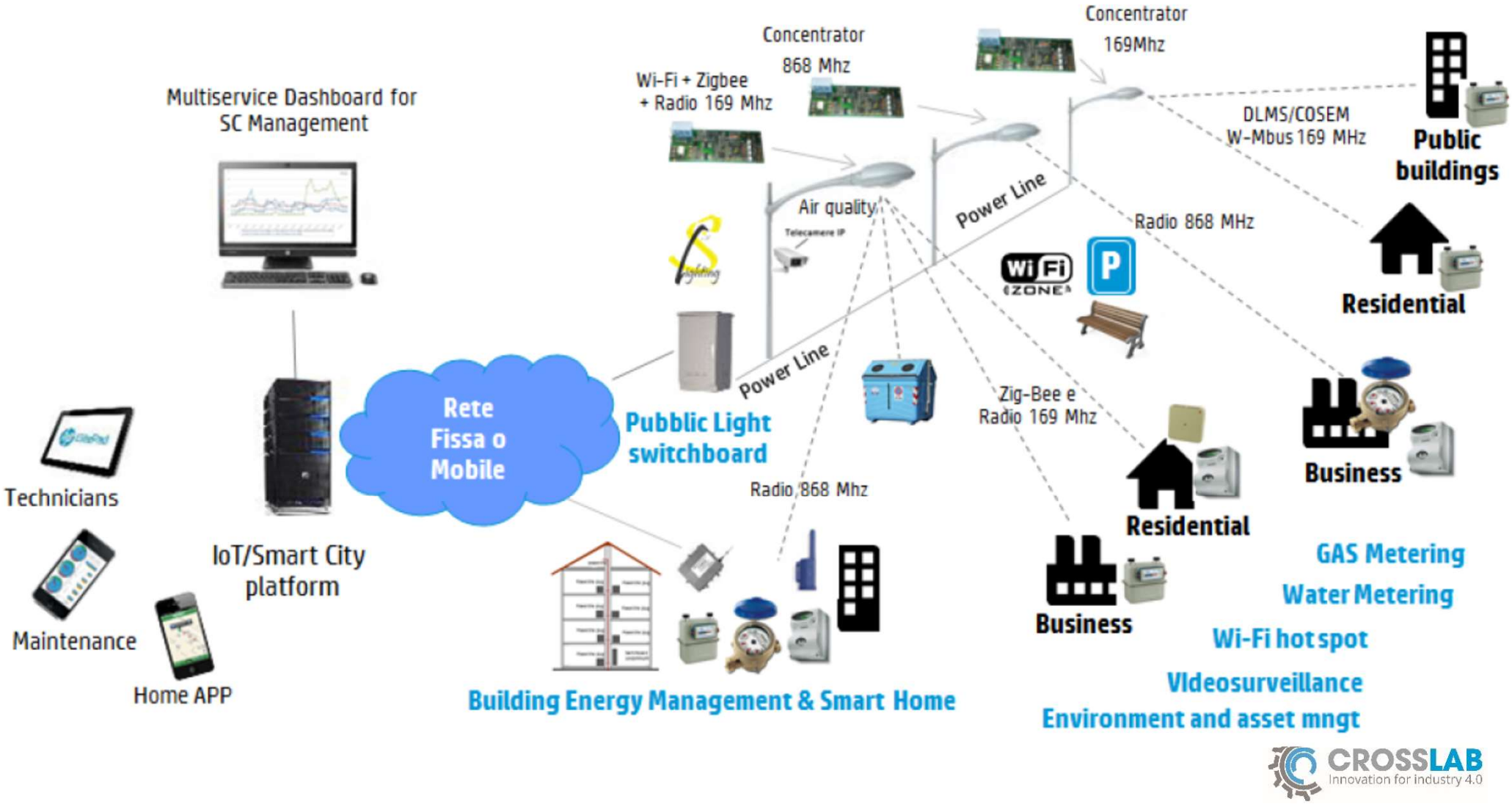
Efficient Management of Parking Areas

Sensors deployed at each parking lot allows to monitor the status of parking lots and send information to a server

Drivers are guided to the closest parking area

Smart Lighting

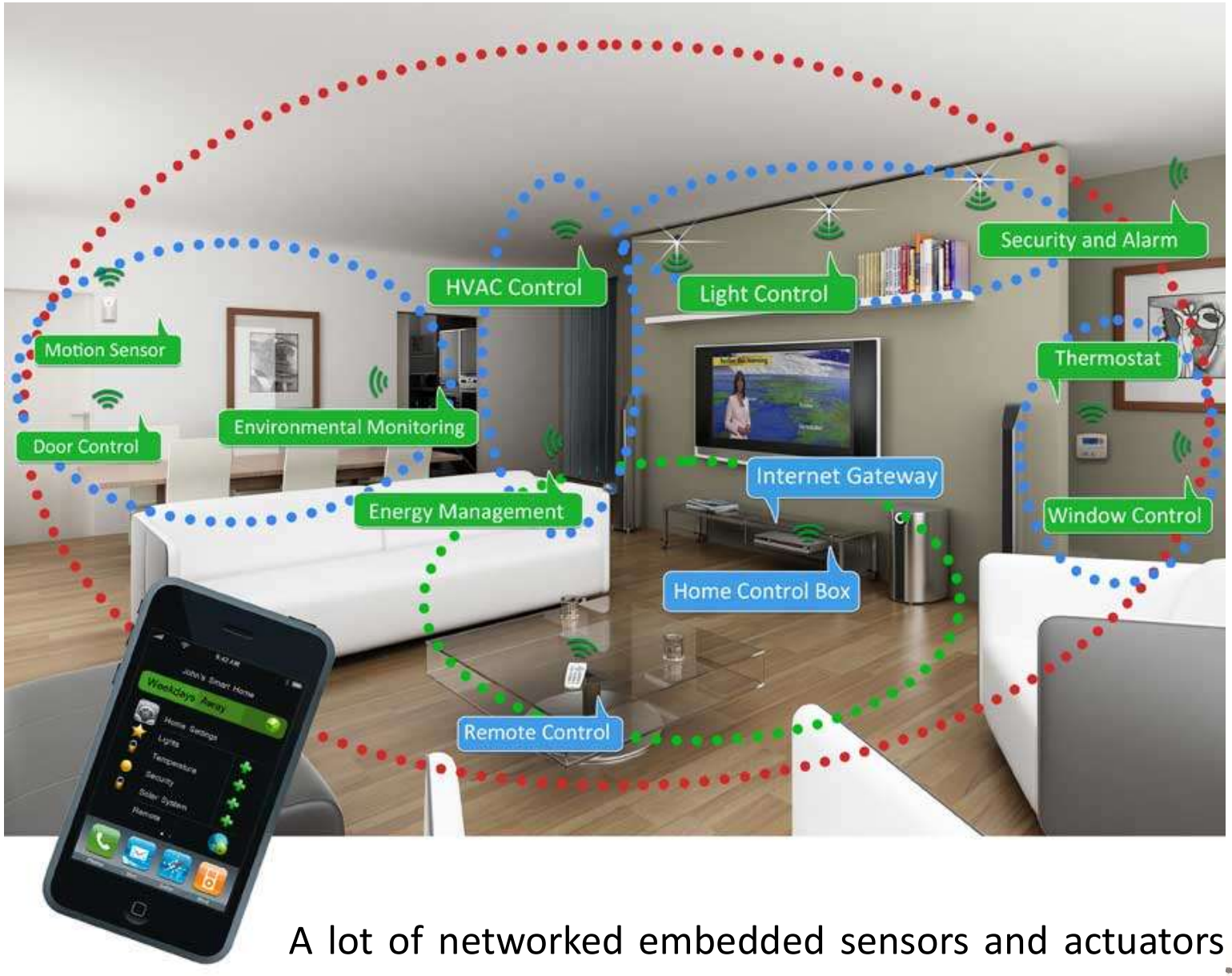
Energy effiency + innovative city services



Smart Buildings/Homes

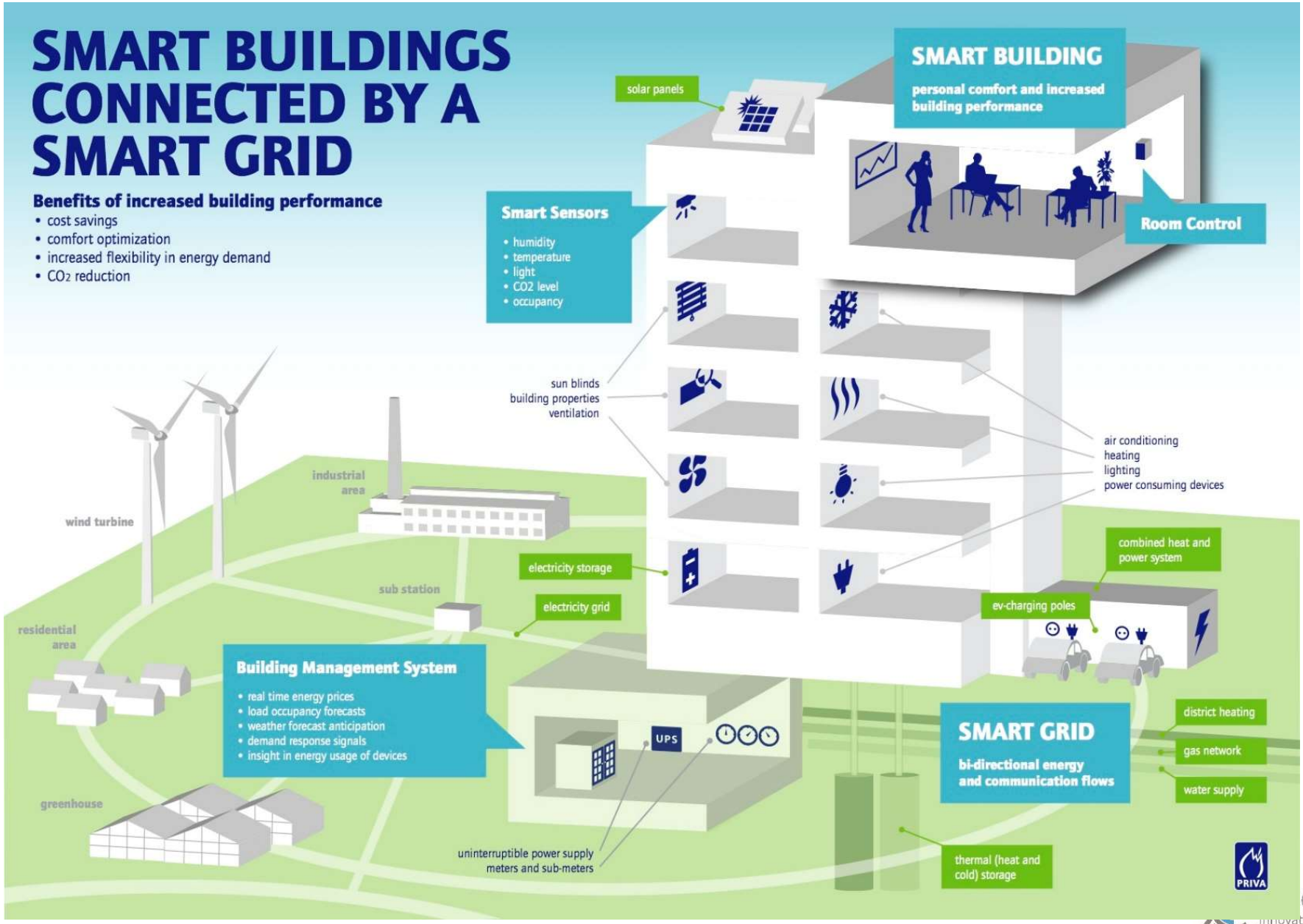
Buildings providing their owner, operator, and occupants with an environment that is flexible, effective, comfortable, and secure through the use of ICT solutions

Smart Homes



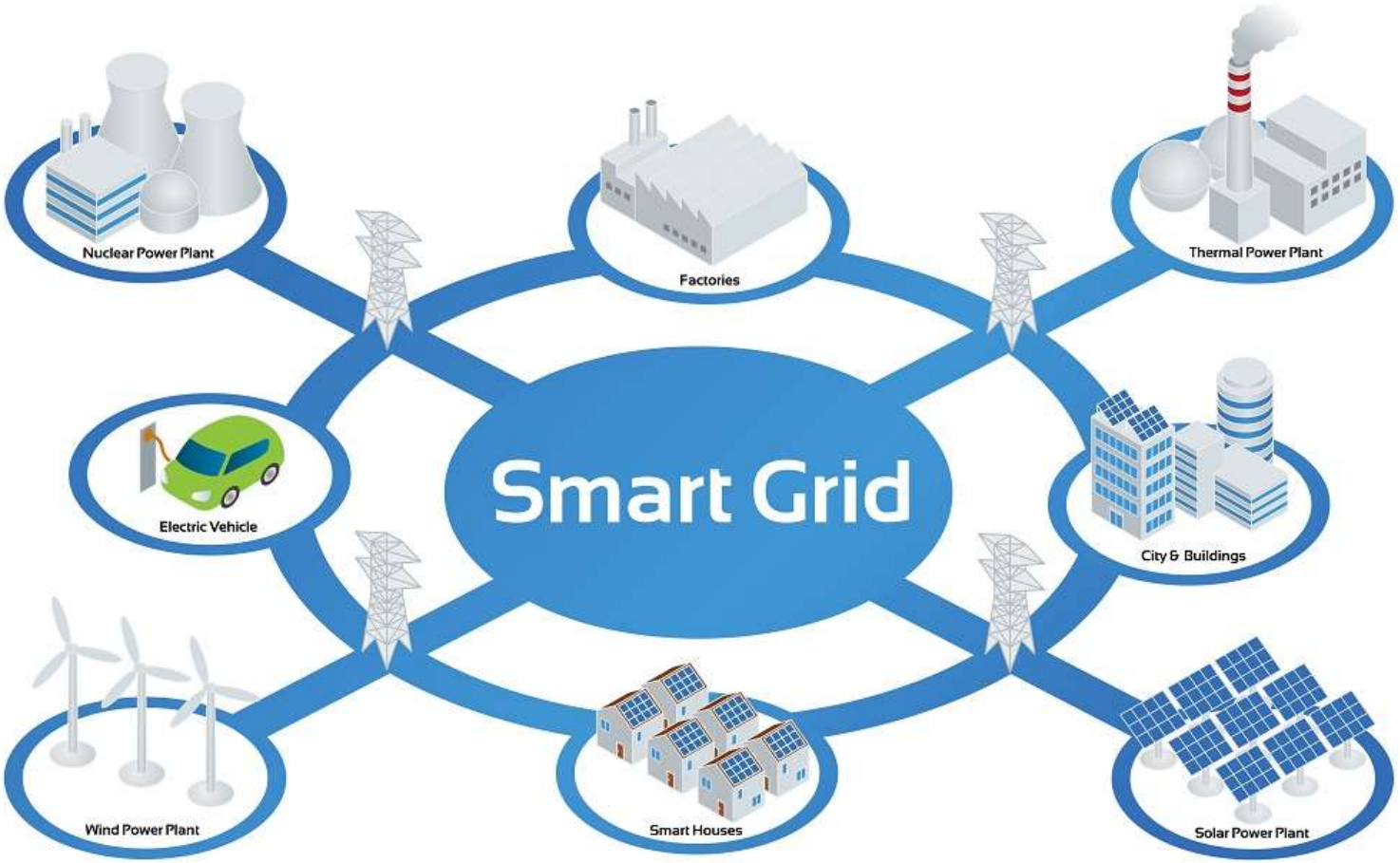
A lot of networked embedded sensors and actuators that monitors and automatically control all the home activities

Smart Energy



Smart Grid

- **Electrical Grid augmented with ICT**
  - Information management is essential in smart grids
  - for improved efficiency, security, safety, ...

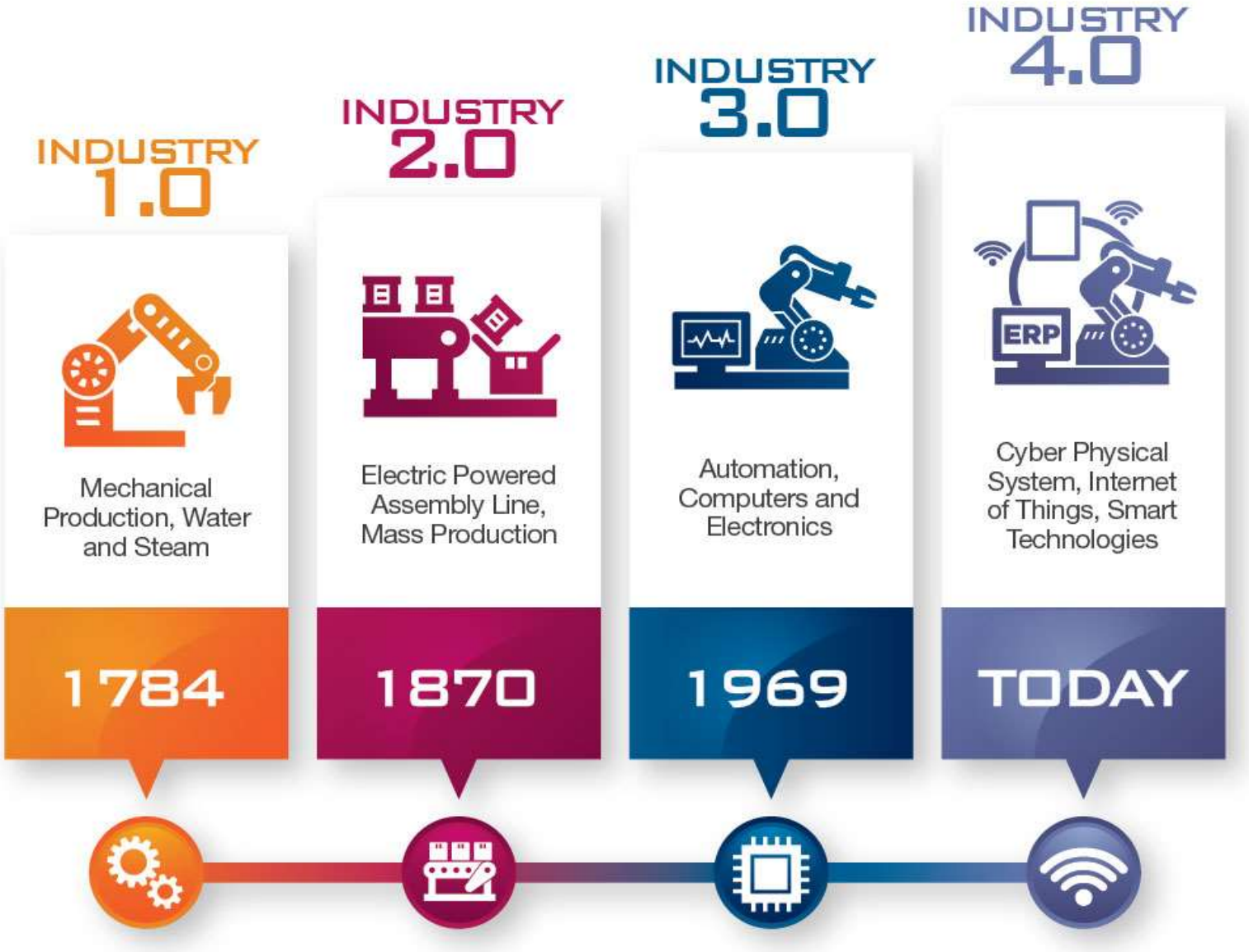


Smart Factory

Real-time networking of human beings, machines, and smart objects for intelligent factory management

- Emergency actions
- Process control
- Alerting
- Logging & monitoring
- Predictive maintenance
- Intra-logistics
- …

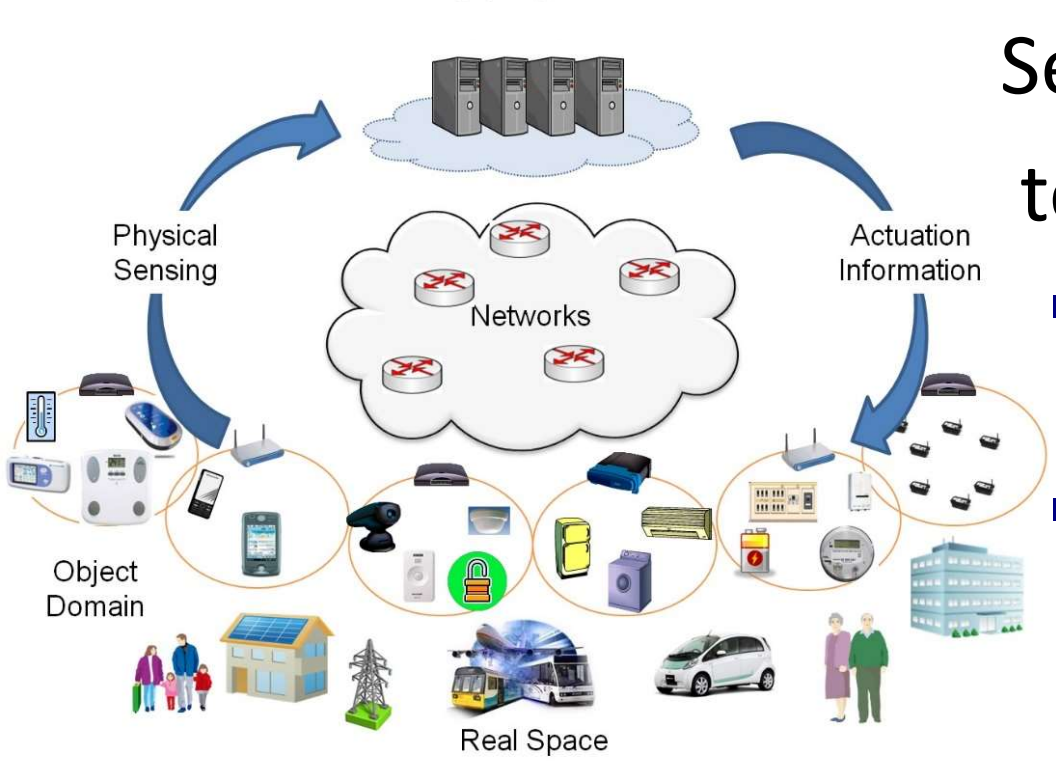
Industry 4.0


INDUSTRY 1.0
Mechanical Production, Water and Steam
1784
INDUSTRY 2.0
Electric Powered Assembly Line, Mass Production
1870
INDUSTRY 3.0
Automation, Computers and Electronics
1969
INDUSTRY 4.0
ERP
Cyber Physical System, Internet of Things, Smart Technologies
TODAY

Summary

In the considered systems we observe

Lots of *smart objects (with embedded sensors and/or actuators)* ... *pervasively* deployed ... and *wirelessly* connected



Sensors *collect data* ...

to be *processed* for

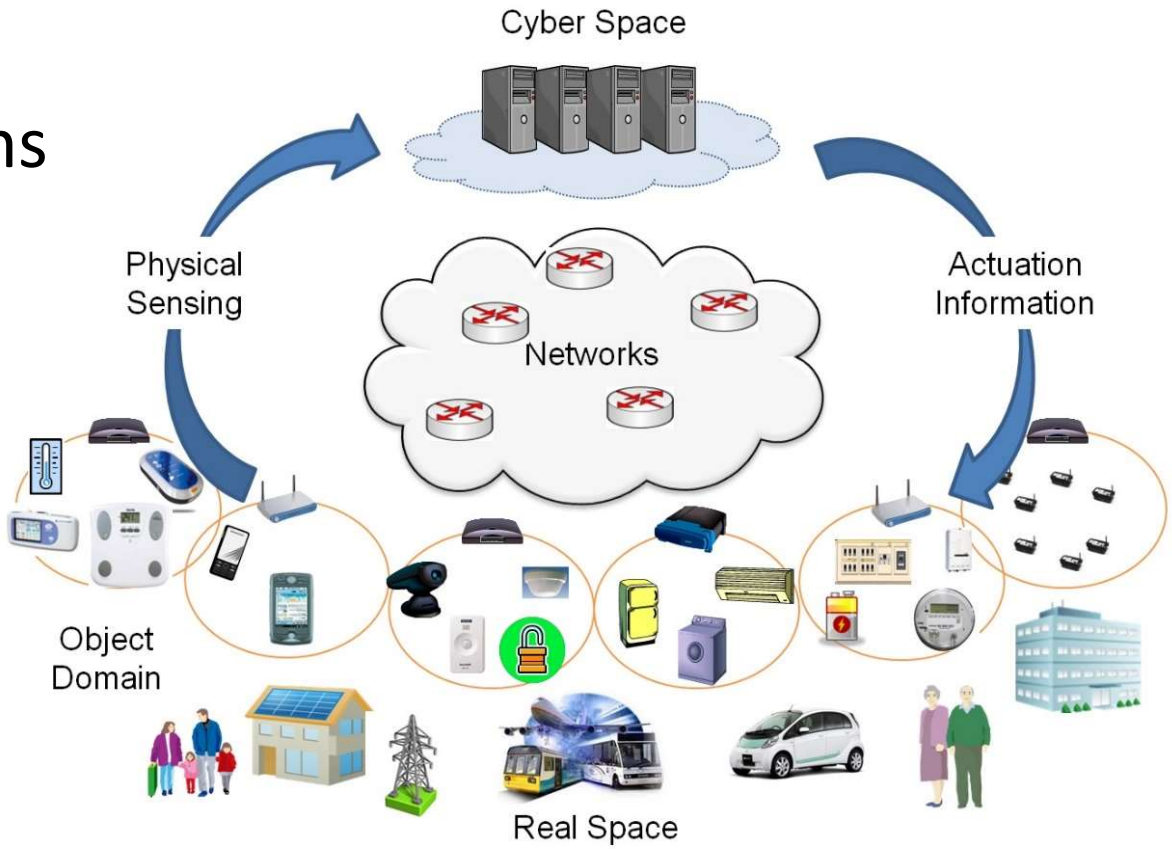
- *services*
  - ⇨ users, operators, ...
- *intelligent decision making*
  - ⇨ actuators, people

Cyber-Physical System

In the considered systems we observe

- a real space
  - people, appliances, cars, machines, …
- a cyber-space
  - hw, sw, algorithms

Cyber-Physical Systems

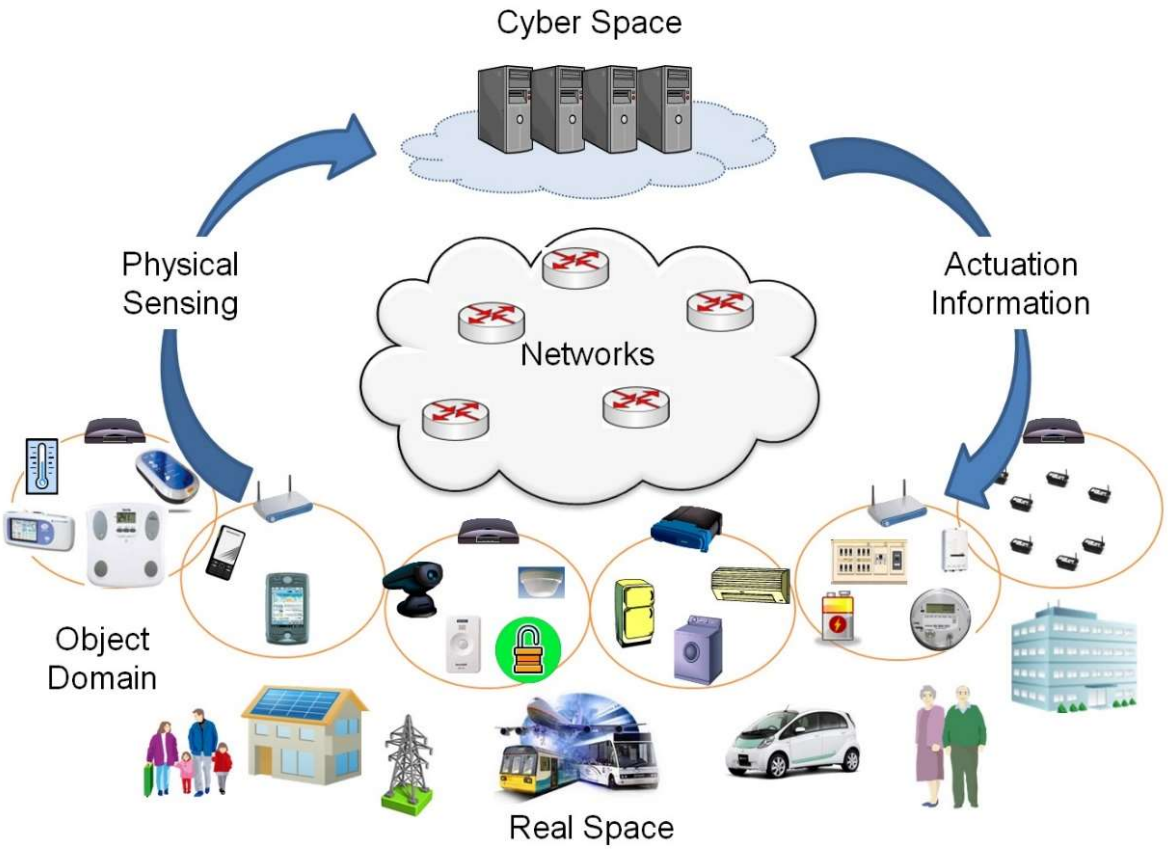


Summary

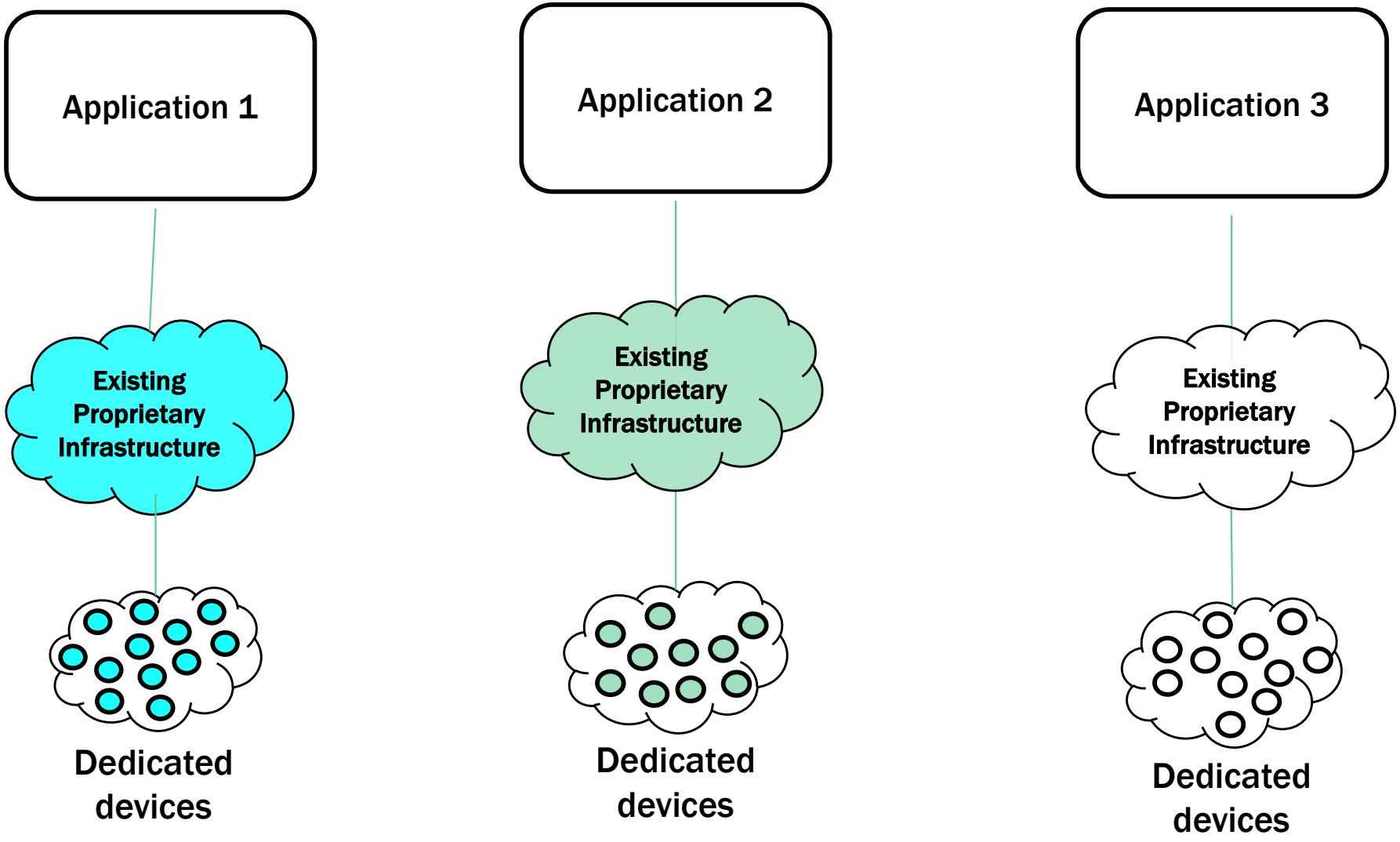
In the considered systems we observe

People in the loop as

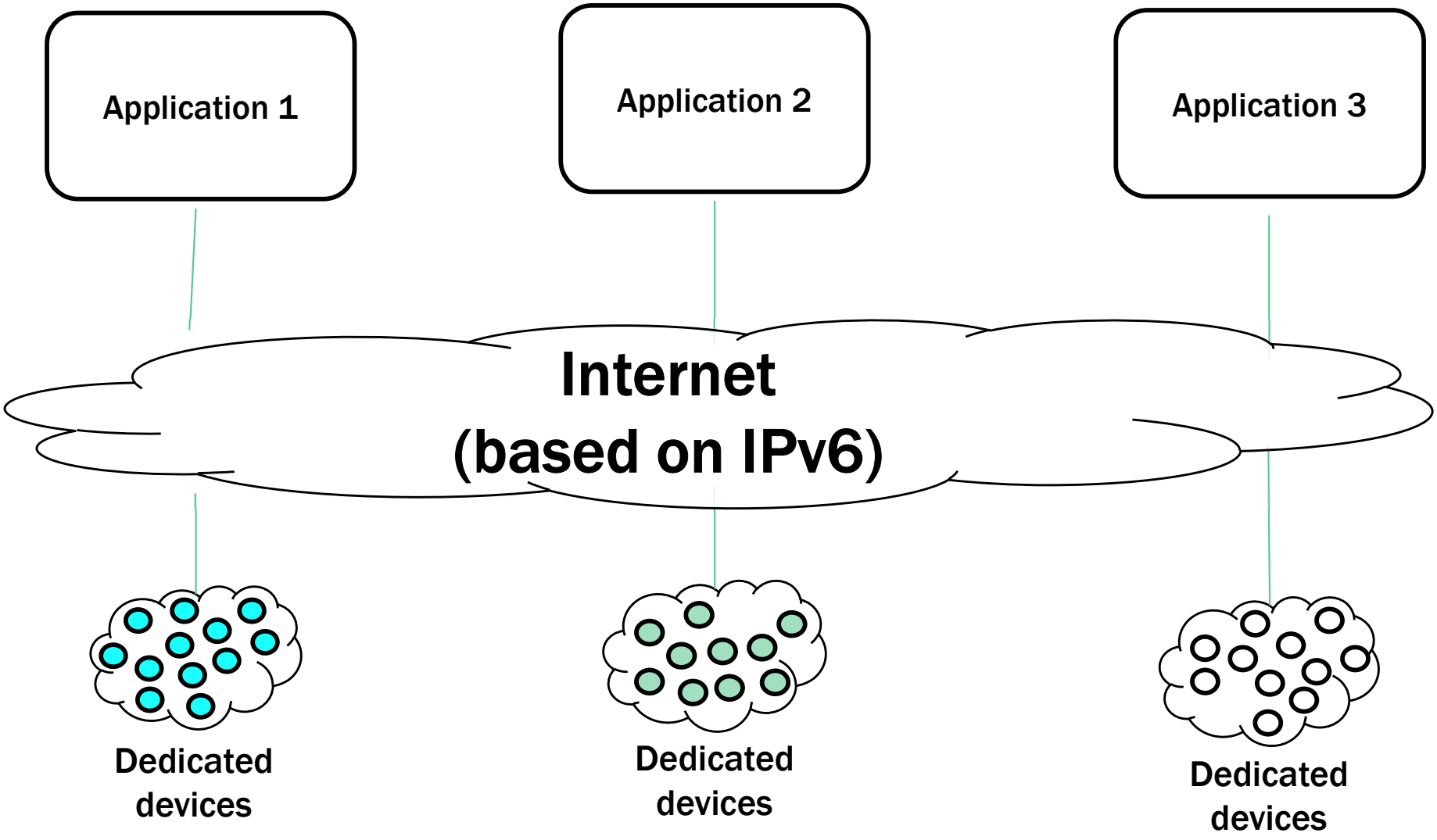
- users
- sensors
- actuators



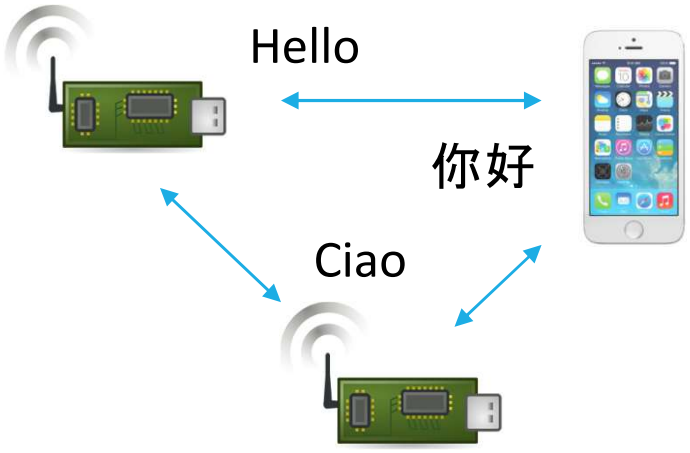
Current solutions: verticals



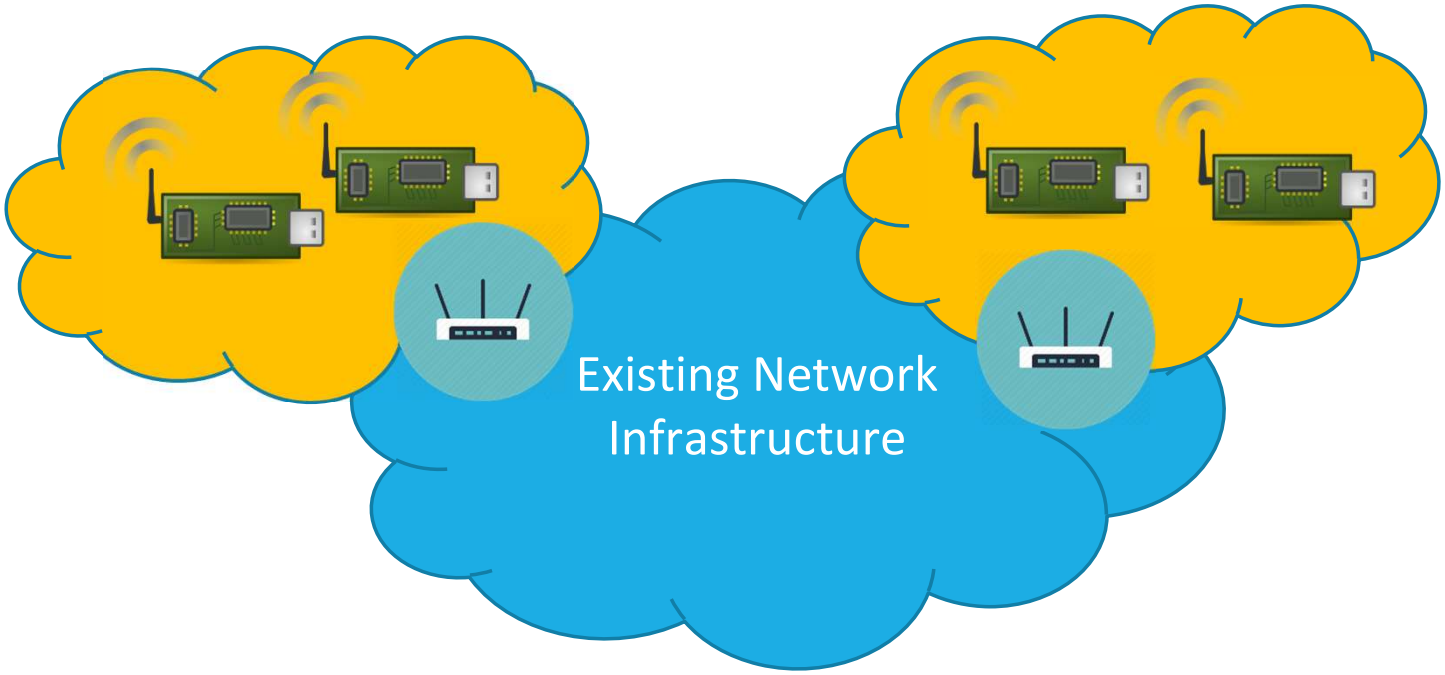
Current solutions: verticals



Communication Standards



Interoperable and *open* communication standards



Standardization Bodies

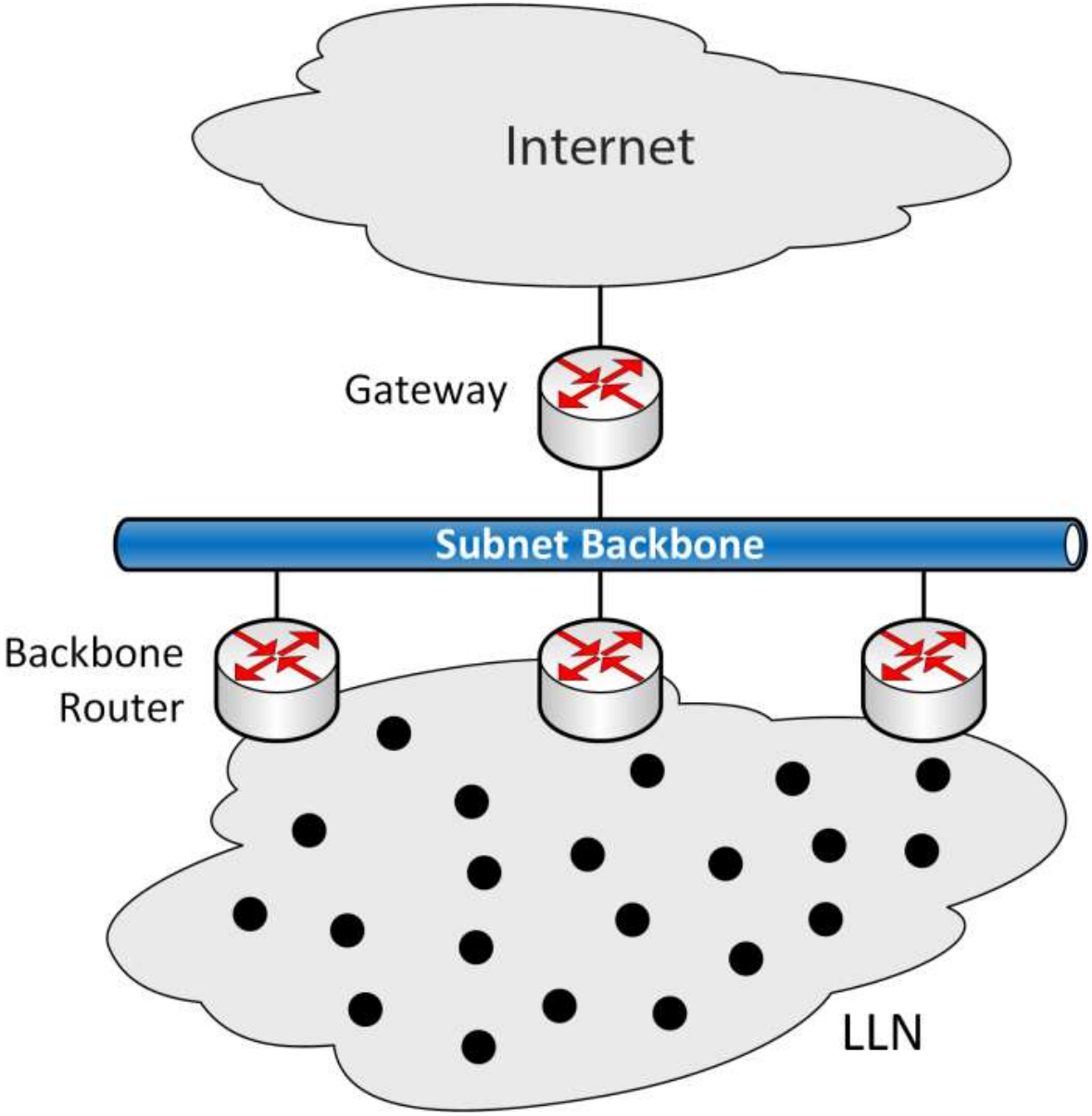
IP for Smart Objects

- Set of IPv6-based solutions defined (or under definition) by IETF
- Supported by the IPSO alliance

Machine-to-Machine (M2M)

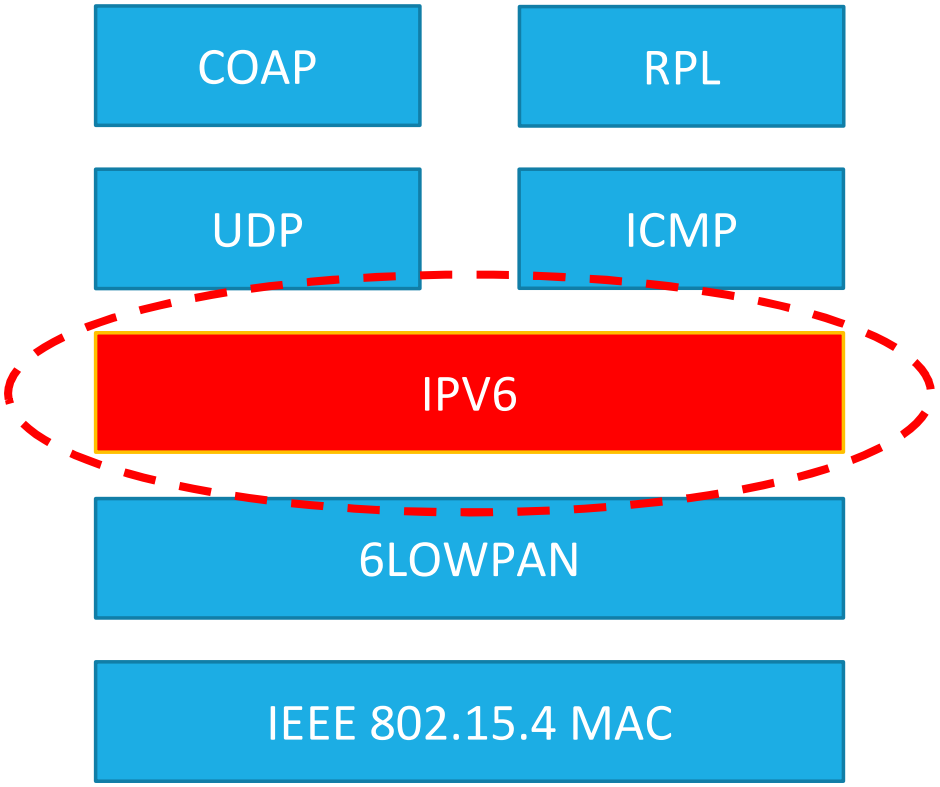
- Service architecture defined by the ETSI M2M Technical Committee

IETF Reference Architecture for IoT



LLN: Low-power and Lossy Network

IETF Protocol Stack for IoT



Protocol stack built around the IPv6 protocol

Common “language” used by communication networks nowadays

Why IPv6 for Smart Objects?

Interoperability

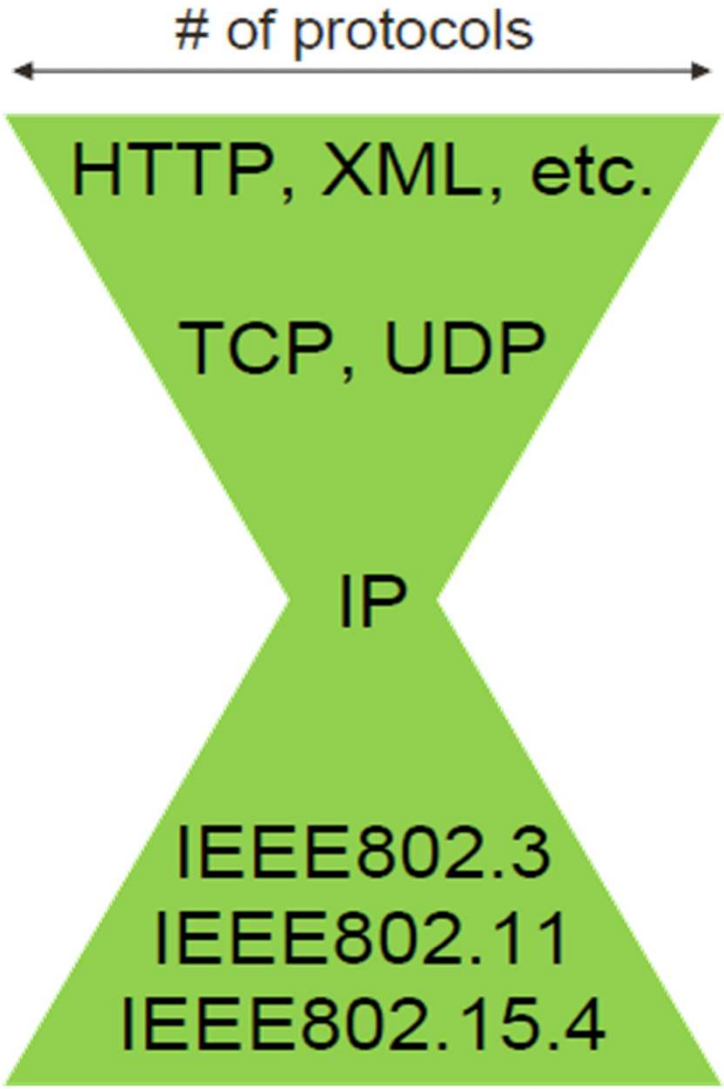
- Layered approach for independence of underlying technologies

Scalability

- Survived the current Internet evolution
- Unique (IPv6) addressing
- Direct support for self-configuration and management

End-to-end

- No multi-protocol intermediate gateways that:
  - Are expensive and difficult to manage
  - Lack of QoS end-to-end
  - Have security holes



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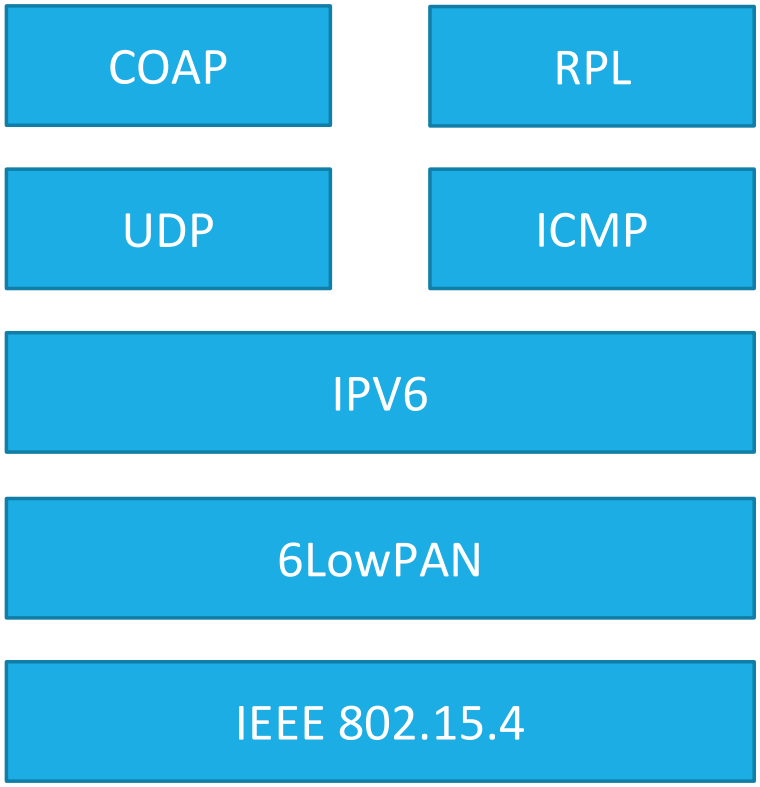
Is IoT Still a Vision?

IoT vs. Cyber-Physical Sistems

- Cyber component + physical component
  - The cyber component receives data from the physical world
  - Processes the received data and takes intelligent decisions that are communicated to actuators
  - Smart object interact with the physical world
    - ⇨ Border between the cyber and physical world

- In IoT smart objects are connected to the Internet and communicate through IoT protocols

IoT Protocol Stack



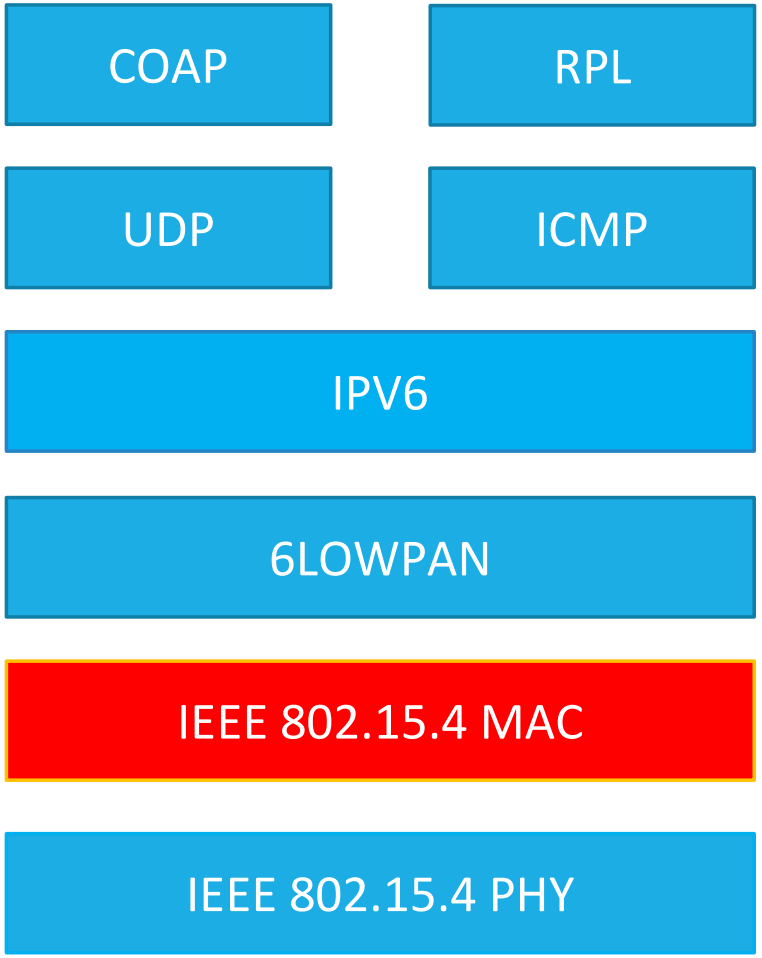
MAC Protocol

The IETF architecture assumes the IEEE 802.15.4 MAC protocol

The IEEE802.15.4 standard has been designed for low-power communications

It is the de-facto standard for the communication of low-power wireless devices and sensor networks

Small frames, up to 127 bytes!

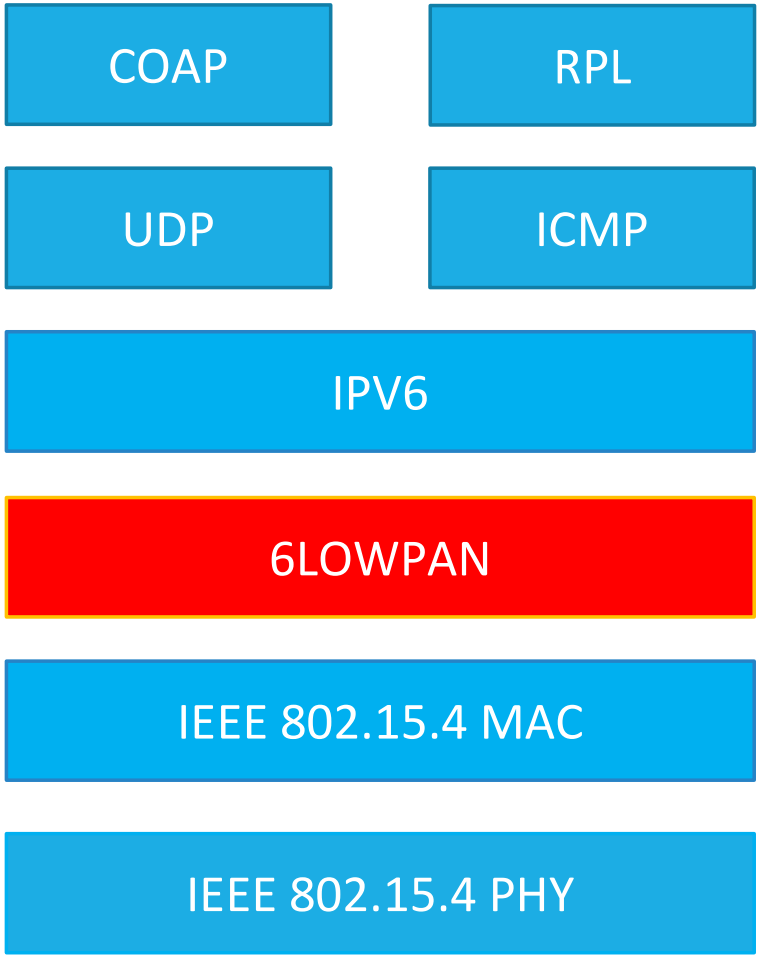


6LowPAN Adaptation Layer

Adaptation Layer to allow the transmission of IPv6 datagram on a IEEE 802.15.4 frame

6LowPAN defines the operations to be performed to transmit IPv6 packets in such networks

- How compress/translate the header
- How fragmentation can be performed
- How discovery is performed



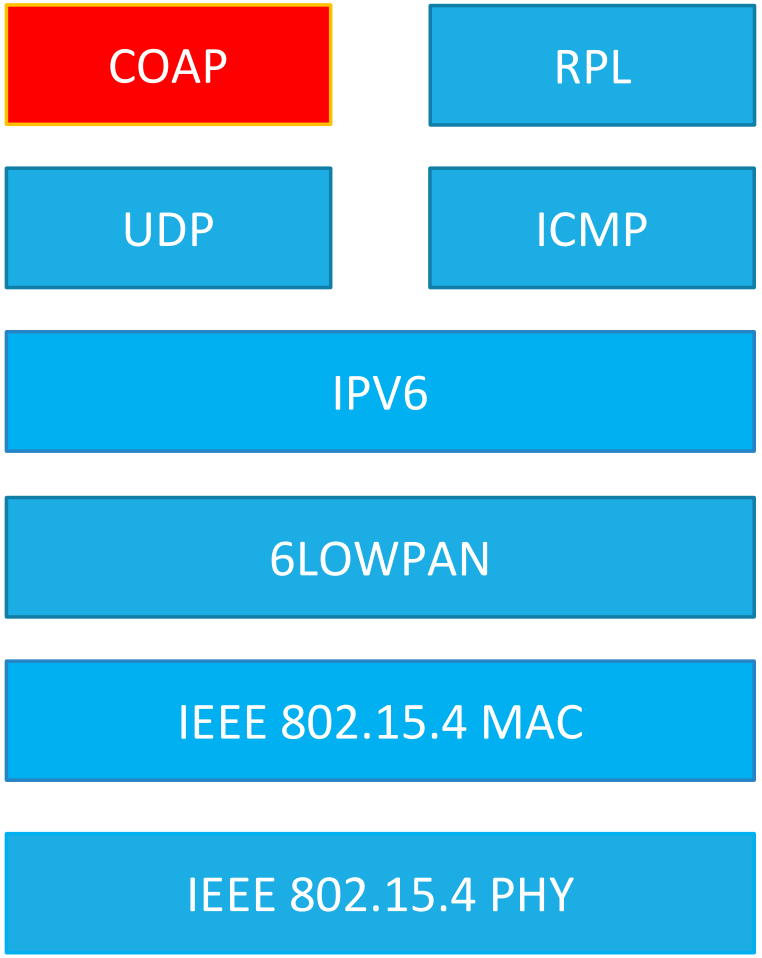
Application Layer

In principle smart objects could use HTTP as application-layer protocol

In practice, they do NOT have enough memory to implement a complex application protocol

The *Constrained Application Protocol* (CoAP) to fulfill their needs

Simplified version of HTTP with specific features for the IoT

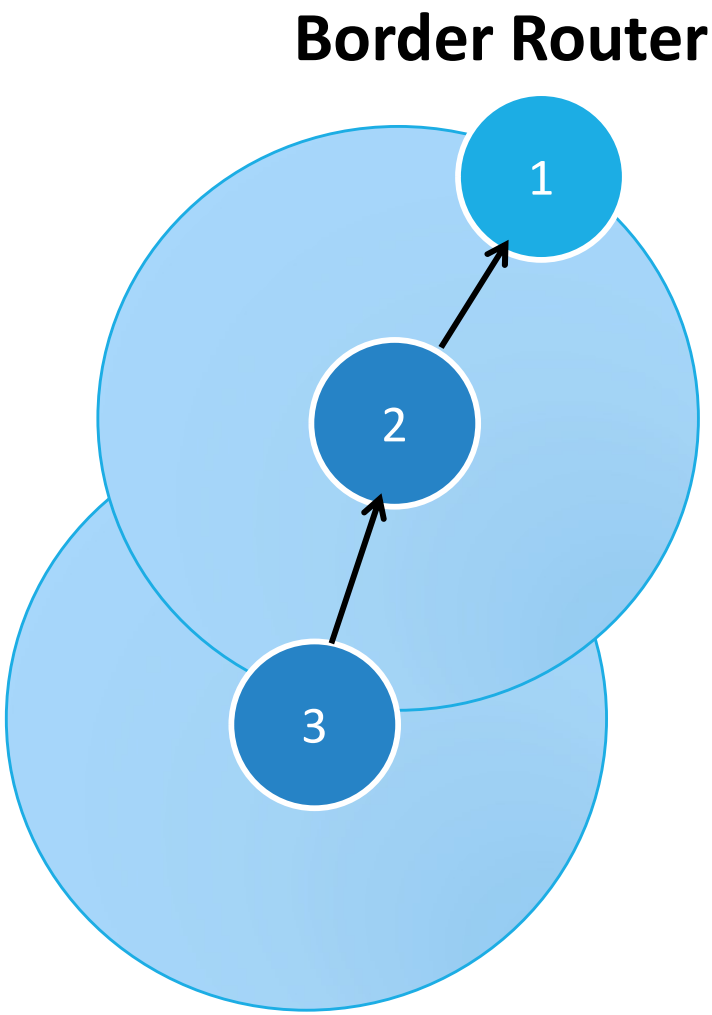


Multi-hop communication

Wireless technologies for IoT devices are typically low-power

The transmission range of devices is limited

Multi-hop communication used to reach the destination when it is outside of the transmission range of the sending device



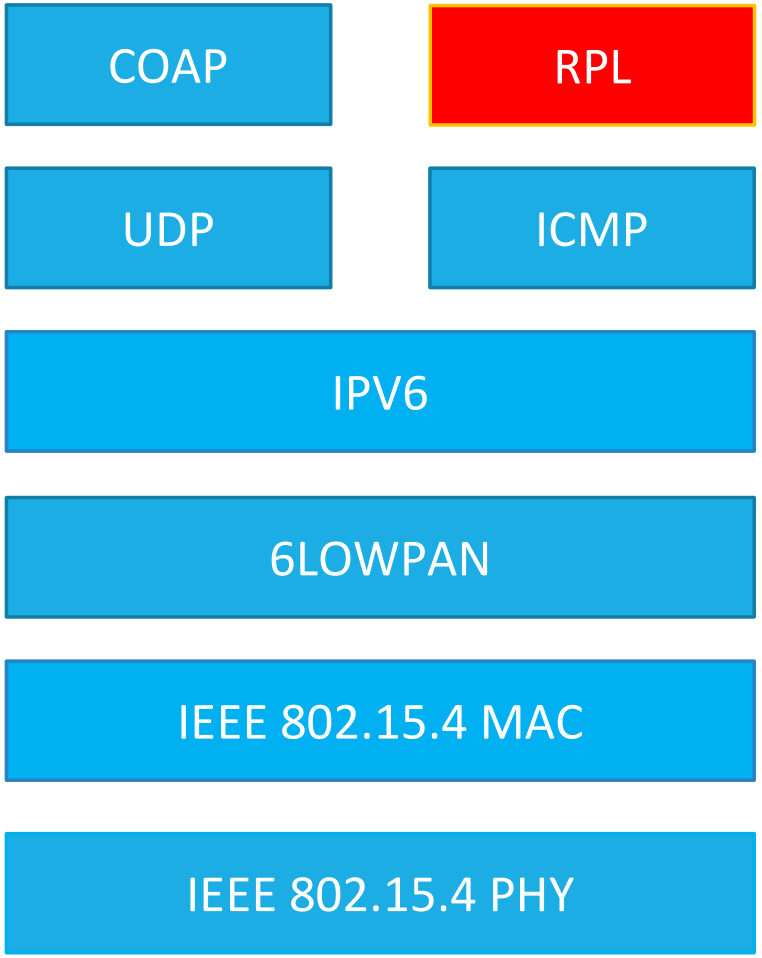
RPL Routing Protocol

IPv6 Routing Protocol for Low-Power and Lossy Networks

RPL routing protocol for multi-hop communication

RPL

- collects information on the network topology
- computes the multi-hop routes
- populates the routing tables of each node



Questions