UNIMORE
UNIVERSITÀ DEGLI STUDI DI
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Dipartimento di Scienze Fisiche,
Informatiche e Matematiche

IoT Systems

The IoT scenario

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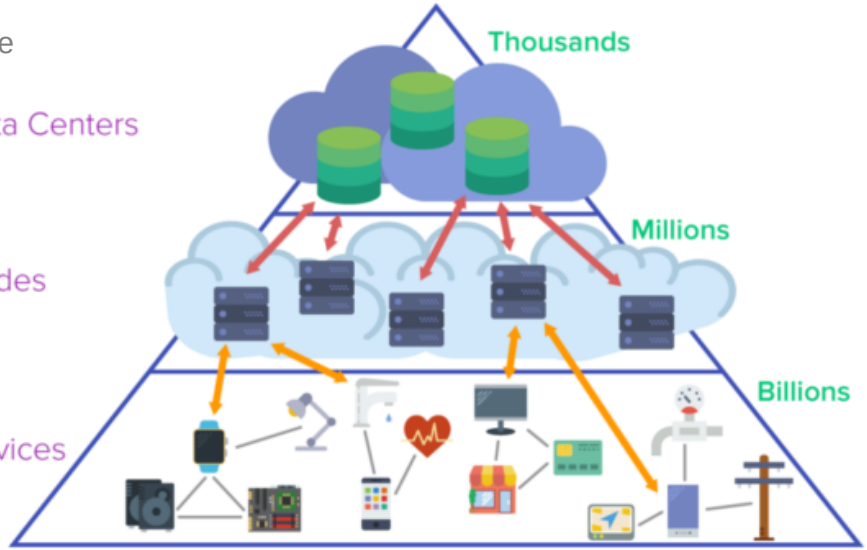
Background on the IoT

- It is a junction of different technologies
  - ICT and its pervasiveness
  - Communication technology
  - Data analysis

Edge Fog and Cloud Computing

- **Cloud Computing**
  - High Power, High computation, Typically far from the edge
  - Many on-demand services
  - Can scale with the application
- **Fog Computing**
  - May connect the Cloud to the Edge
  - Similar to the cloud, but closer to the Edge
- **Edge Computing**
  - These are the edge of the networks
  - Close to the scenario
  - Some operations may be carried out directly here



Source: 01Net

Remember this?

Smart building

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Data Gathering

Data Processing

Communication to the fog

Communication to the cloud

Data Analysis

Awareness

Communication to the fog

Communication to the edge

Communication

Smart building

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Data Gathering

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Communication to the edge

Data analysis

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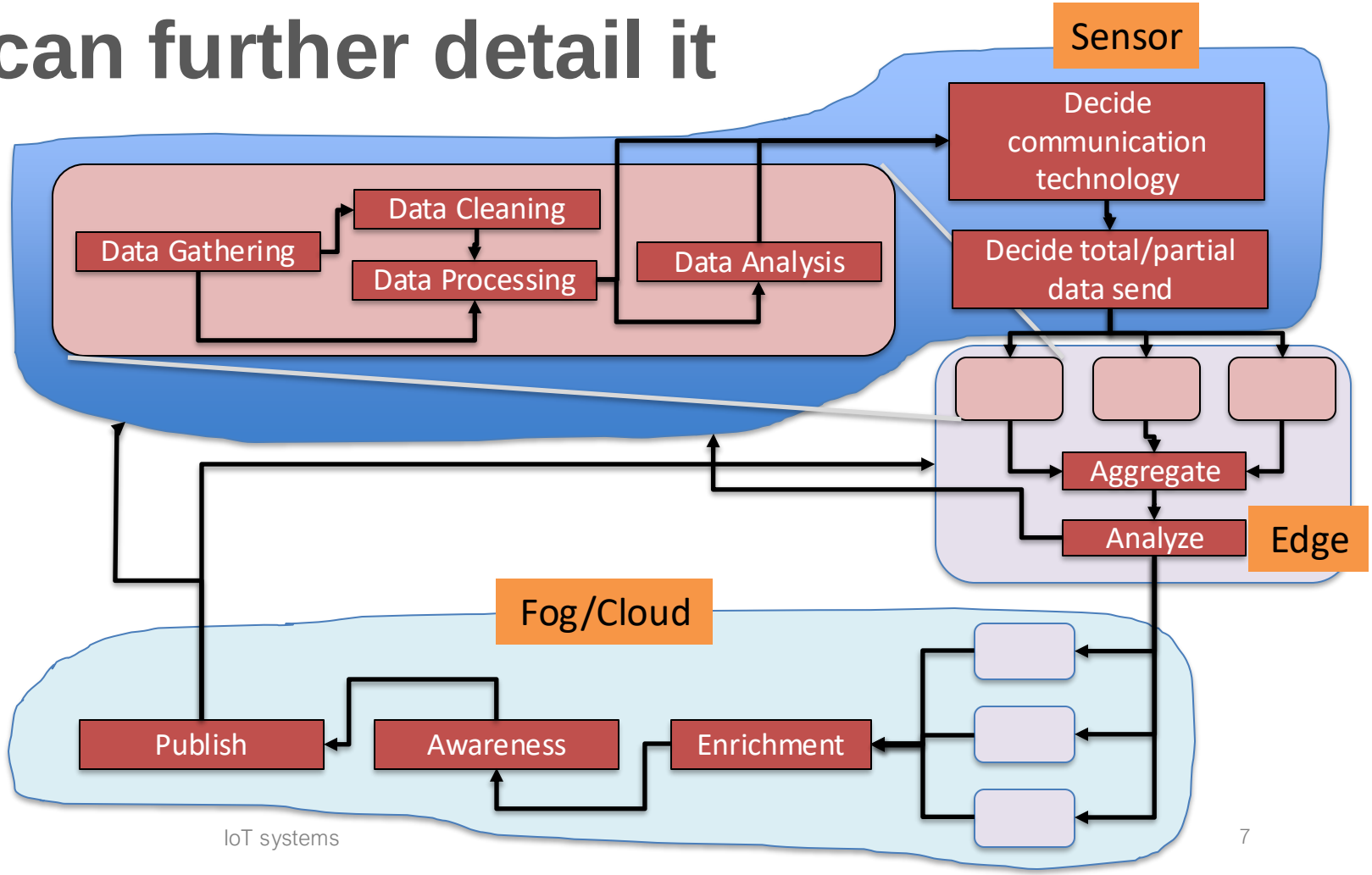
Data Gathering → Data Processing → Communication to the fog → Communication to the cloud → Data Analysis → Awareness → Communication to the fog → Communication to the edge

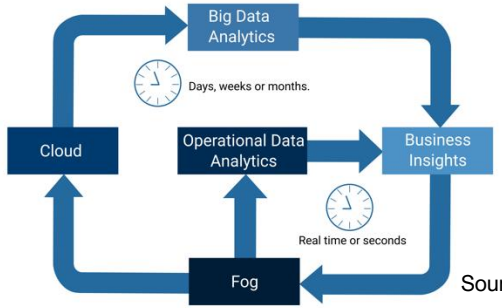
We can further detail it



The IoT as a nervous system

- You feel an unexpected pain
- Try to act as you could
- Think
- Monitor
- If pain has gone away: ok
- Otherwise: go to the doctor

- A sensor provides an unusual data
- Activate other sensors to gather more data and aggregate them
- The algorithm looks for a possible problem and sends instructions on how to solve it
- Monitor
- If the problem has gone away: I learn
- Otherwise: I learn, and I try something different



Source: Machine Designs

Networks in IoT

- Networks are truly everywhere
  - Body area networks
  - Bluetooth
  - Smartphones
  - Internet
  - …

This enables the rapid dissemination of data and information among a multitude of actors. Networks are also heterogeneous, due to different bandwidth requirements, energy efficiency, communication range ecc ecc.

F. Montori, L. Bedogni, M. Di Felice, L. Bononi, "Machine-to-machine wireless communication technologies for the Internet of Things: Taxonomy, comparison and open issues", in Elsevier Pervasive and Mobile Computing, 2018

A first discussion on networks

- Networks enables sharing the data
  - In the IoT there is a fundamental difference: peers are not always humans
    - This brings us to Machine to Machine Communication (M2M)
  - Networks of things may be connected to the internet, providing and consuming data
  - Web of Things

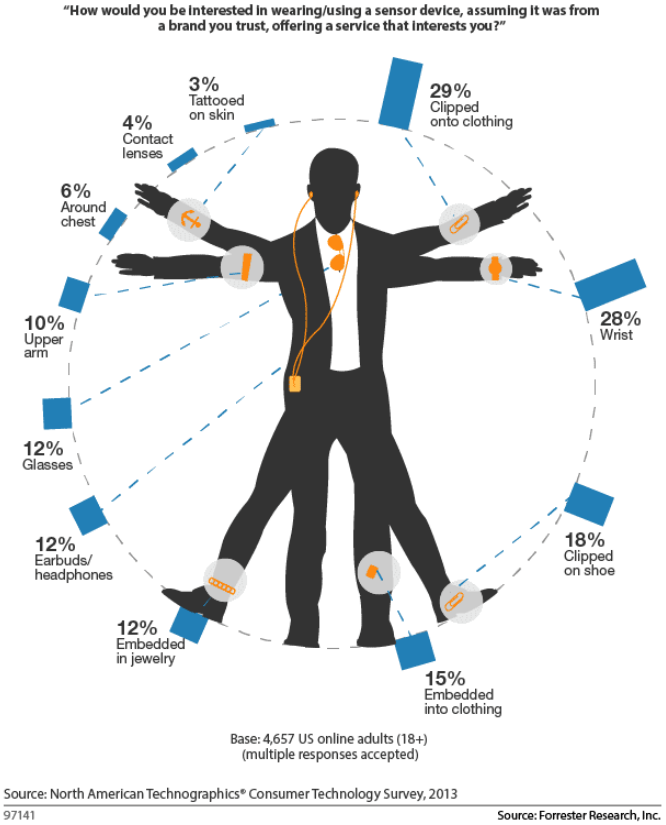
What to sense?

- Sensors are eveywhere, closer than you think!

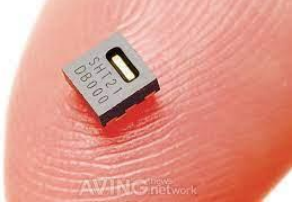
Accelerometer
Gyroscope
Magnetometer
Barometer
Proximity
…

Pedometer
ECG
Temperature
Humidity
…

The Sky is the limit



Sensor miniaturization



- Sensors are becoming smaller and smaller
  - Possible to fit them in many devices
  - Devices can carry more of them
- Sensors are also becoming cheaper
  - Many of them can be found at < 1$
  - Economy of scale

Microcontrollers

- Microcontrollers are used to perform computing operations
- They are typically small
- Already carry a lot of useful technologies
  - Wifi, BLE, Sensors and so on
  - Low power operations

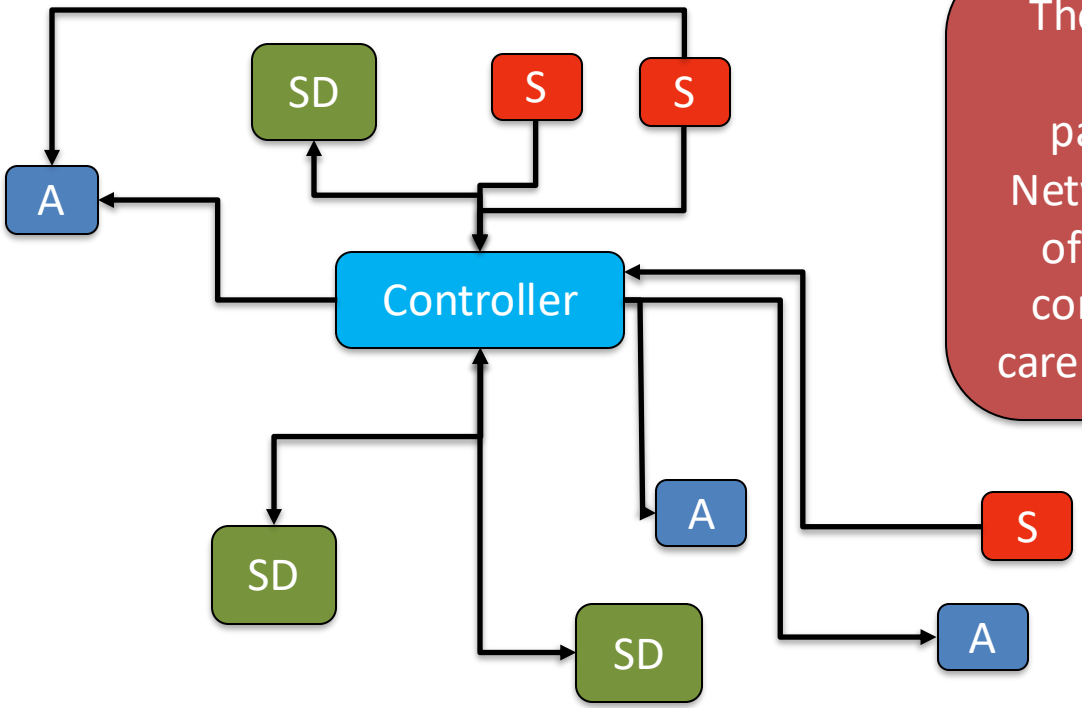
Up to now

- Sensors collect data, possibly stored on microcrontrollers
- In case data needs to be sent, we can use network technologies
- Microcontrollers may also take (autonomous) decisions
  - “If the temperature is more than 25, turn on the cooling system”

Smart things

- The possibility for a device to take autonomous decisions makes it a Smart Device
  - Smart devices can communicate together to enhance services or provide missing ones
- So what it looks like an IoT network?

An example of an IoT network



The **controller** provides the set of rules, the configuration, the parameters, the logic of the IoT Network. We can see it as the brain of it. There may be also multiple controllers, each one which takes care of a specifc part of the network.

Collective awareness

- Sensors sense the environment and collect data
  - They can also share such data with others
  - “Others” do not need to be static
  - Through massive data collection, it is possible to understand a phenomenon
- What should the user do?
  - Define services and objectives
    - Things will work together to provide them in the best possible way
    - “Best” may differ: more battery efficient, fastest, more precise and so on

Life simplified