Computer Engineering for the Internet of Things

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI INGEGNERIA INFORMATICA, MODELLISTICA, ELETTRONICA E SISTEMISTICA
DIMES

Distributed Systems and Cloud/Edge Computing for IoT

Project topics and instructions

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TOPICS

- Smart Home
- Self-Driving Cars
- Smart City
- Smart Grid
- Body Sensor Network
- Smart Health
- Smart farming
- Industry 4.0

SMART HOME

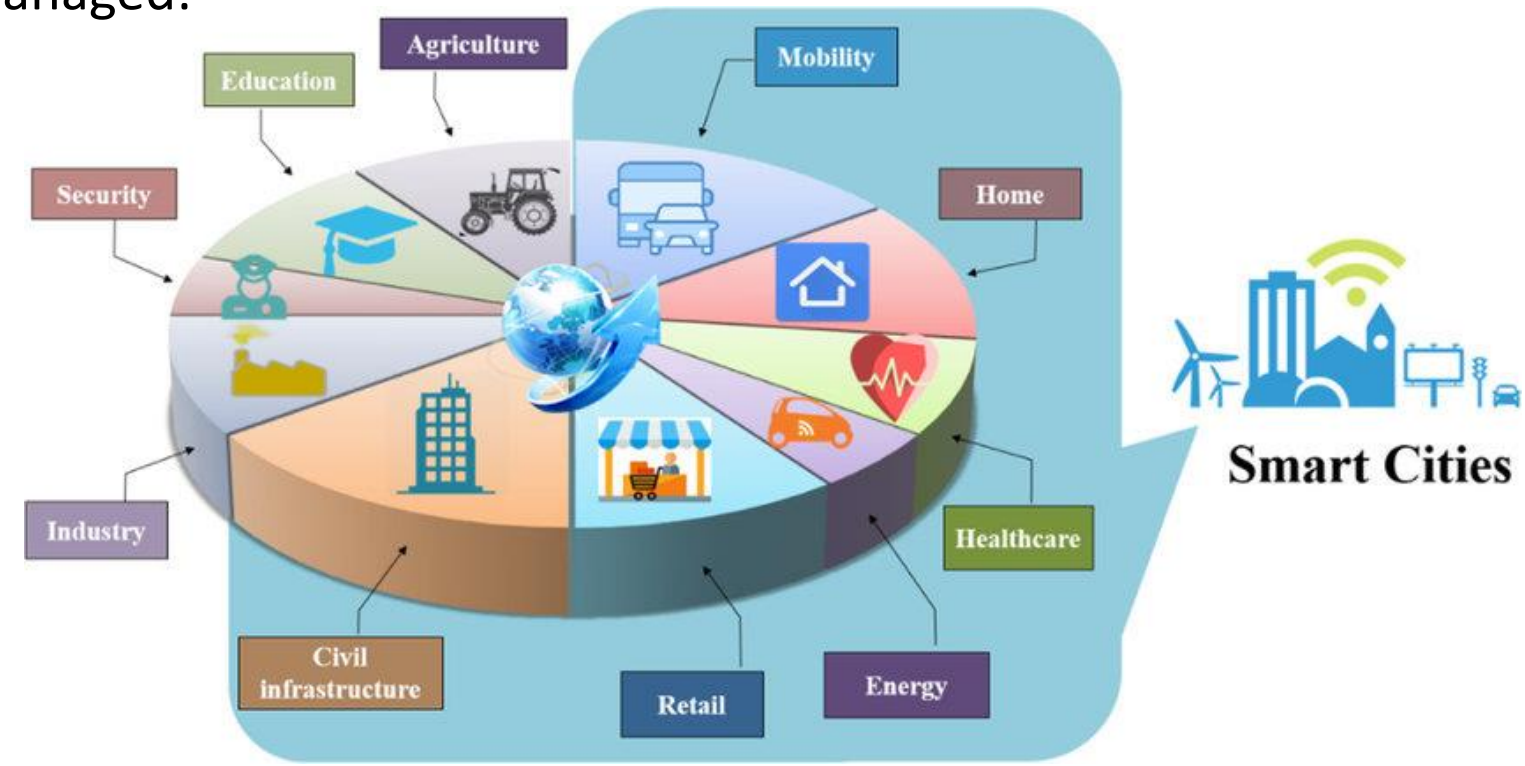
- **Home automation** or **domotics** is about building automation for a home, called a **smart home**, providing smart services for:
  - **Improving security**
    - Smart cameras and motion detectors
    - Water, fire and smoke detectors
    - Door and window monitoring sensors
  - **Reducing energy consumption**
    - Smart plugs and meters
    - Appliance monitoring
  - **Improving comfort**
    - Lighting, climate, entertainment systems and appliances control (smart lamps, …).
- Devices in a smart home are easily controllable by remote and can act autonomously in a smart way, maybe inferring the home owner behaviour.

SELF-DRIVING CARS

- A **self-driving car**, also known as an *autonomous vehicle* (*AV*) or *smart car*, is a vehicle that is capable of sensing its environment and moving safely with little or no human input.
- Big volume of data to be handled and high QoS requirements in connectivity.
- Real-time interaction with the owner.
- Vehicles are interconnected to each other and with the environment infrastructure.
  - Prevent accidents
  - Efficient handling of viability in a **smart city** (smart semaphores' green wave)

SMART CITY

- A **Smart city** is an urban area that uses IoT sensors to collect data, analyzing them in order to monitor and manage assets, resources and services in an intelligent and efficient way.
- Data are collected from heterogeneous IoT devices.
- Elements to be Monitored and managed:
  - Traffic
  - Transportation systems
  - Power grids
  - Water supply networks
  - Waste management
  - Crime detection
  - Information systems
  - Hospitals
  - …



SMART GRID

- A **Smart grid** is an electrical grid which includes a variety of operation and energy measures including smart meters, smart appliances, renewable energy resources, and energy efficient resources.
- Smart grids allow for controlling the production and distribution of electricity.
- Smart grids applications can be integrated with smart home automation system, using data gathered form smart meters to analyze the power consumption trends of different groups of homes.
- A smart meter can give an estimate of how much energy will be needed in a future moment, minimizing energy trading.

BODY SENSOR NETWORK & SMART HEALTH

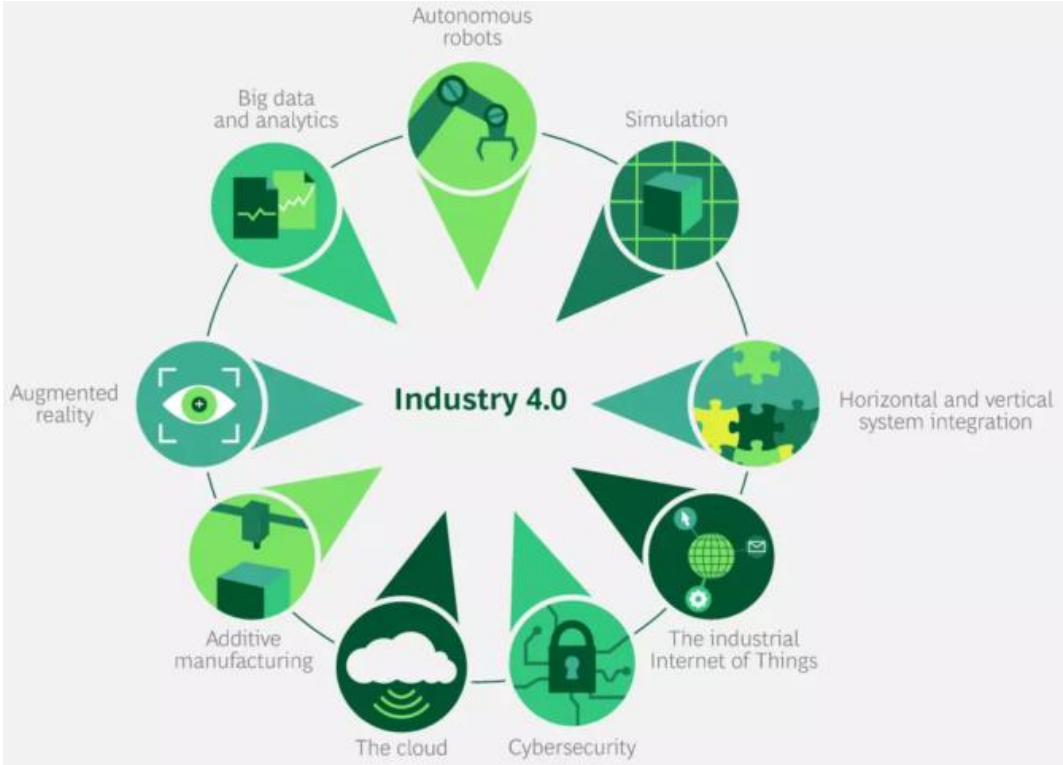
- A **Body Sensor Network** (BSN) is a wireless network of wearable computing devices.
- The main application of BSNs are related to the **healthcare** domain, where BSNs are used for continuous monitoring and logging vital parameters of patients suffering from chronic diseases, such as diabetes, asthma and heart attacks.
- Can alert the hospital, even before they have a heart attack, through measuring changes in their vital signs.
- Can auto inject insulin through a pump on a diabetic patient, as soon as his insulin level declines.
- Other applications of this technology include sports, military or security.

SMART FARM & AGRICULTURE 4.0

- **Smart Farm**, also known as **Precision Agriculture** (PA), is the application of different IoT technologies to agriculture.
- PA provides a decision support system for whole farm management by collecting, measuring and analyzing data gathered from the field.
- Main applications:
  - Soil preparation
  - Crop status monitoring
  - Irrigation
  - Insect and pest detection
  - Animal health status monitoring

INDUSTRY 4.0

- **Industry 4.0** refers to the use of automation and data exchange for creating a **smart factory** where machines, systems, and humans communicate with each other in order to coordinate and monitor progress along the assembly line.
- According to the **Boston Consulting Group** there are nine principal technologies that make up Industry 4.0:
  - Autonomous Robots
  - Simulation Engines
  - Horizontal and Vertical System Integration
  - Industrial Internet of Things
  - Cybersecurity
  - Cloud services & resources
  - Additive Manufacturing (3D print)
  - Big Data analytics
  - Augmented Intelligence & Reality



PROJECT 1:
STUDY, MODELING AND SIMULATION OF A REAL USE CASE

1. Select a topic among those previously discussed
2. Study of the state of art solutions (Edge/Fog, Cloud, IoT) related to the selected topic.
3. Modeling & Simulation using **iFogSim**.
   - Model the selected use case by paying close attention to the **parameter setting phase**.
   - Test different placement policies (*cloud-only*, *hybrid/fog*, *edge-only*), selecting the best one, according to your needs.
   - A comparison of the obtained results is required in terms of:
     - Latency
     - Network usage
     - Energy consumption
4. Write a **report** and deliver it at least seven days before the exam.
5. Prepare a **presentation** that will help you explain your work during the exam.

EDGE ANALYTICS

- **Edge analytics** is a model of data analysis where incoming data streams are analyzed at a non-central point in the system such as a switch, a peripheral node, a connected device or a sensor.
- Unlike traditional analytics models, edge analytics:
  - Emphasize decentralization and speed
  - Pursue a trade-off between accuracy and QoS/QoE aspects, such as latency, energy or bandwidth consumption.
- This concept is relatively new and is closely tied with the emergence of the **Internet of Things** as a viable technology for the future.

PROJECT 2:
MODELING AND SIMULATION OF AN EDGE-BASED DATA MINING USE CASE

1. Study the paper «*Analysis of Eight Data Mining Algorithms for Smarter Internet of Things (IoT)*», which analyze data generated by sensors and accelerometers for classifying human activities (link dataset)
2. Repeat some of the experiments present in the paper. Try out different data mining algorithms (e.g. implemented in Python) on the dataset.
3. Modeling & Simulation using **iFogSim**.
   - Model the selected use case by paying close attention to the **parameter setting phase**.
   - Test different placement policies (*cloud-only*, *hybrid/fog*, *edge-only*), selecting the best one, according to your needs.
   - A comparison of the obtained results is required in terms of:
     - Latency, Network usage, Energy consumption
4. Write a **report** and deliver it at least seven days before the exam.
5. Prepare a **presentation** that will help you explain your work during the exam.

ABOUT PARAMETER SETTING PHASE

All the parameters of the simulation must be carefully established. In particular, attention must be paid to:

- **Application parameters**. For example, let's take a sensor that generates data. How often is the data generated (*mean* value) and with what *variance*? What is the *distribution* that describes how the data is generated (eg Poisson, Normal, Exponential)?
- **Hardware parameters**: Describe the hardware characteristics of each component used in the simulation (e.g., sensors, edge nodes, cloud nodes). Specify all the characteristics, such as CPU, RAM, bandwidth, power consumption. Take these parameters either from a scientific paper or from a reference site on the web.
- **Architecture parameters**: Describe how many levels the architecture is composed of, what types of nodes are used, how many nodes are there for each level. For each simulated policy (e.g., *cloud-only*, *hybrid/fog*, *edge-only*), specify the architecture parameters.