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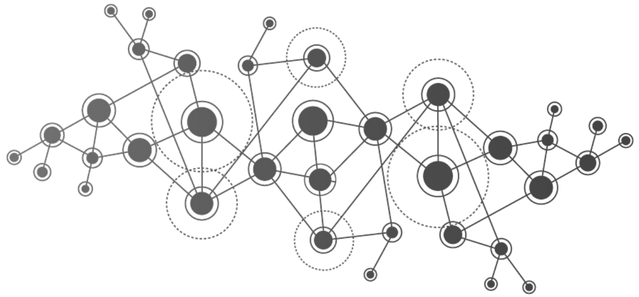


Distributed and Internet of Things Software Architectures

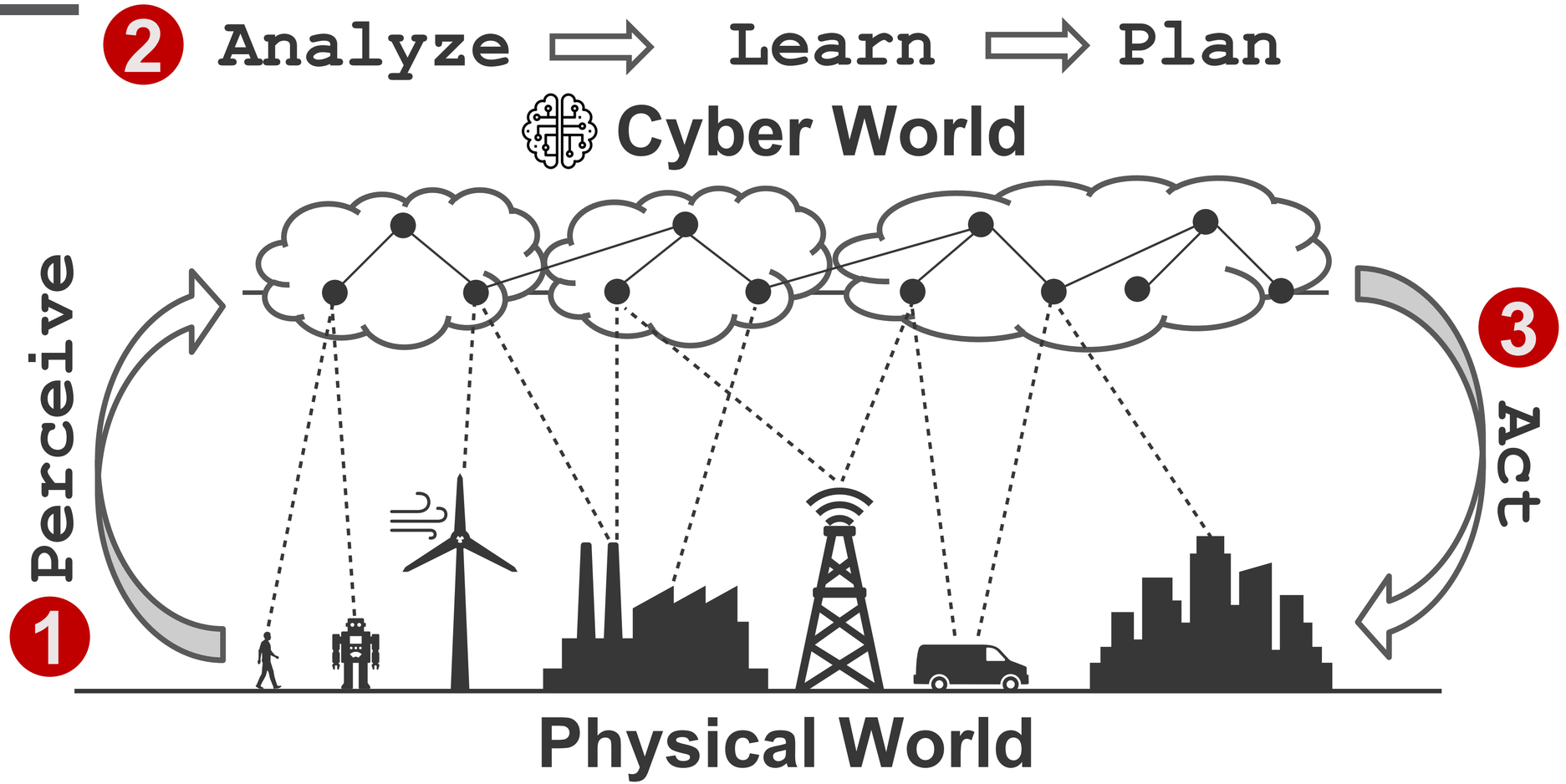
Digital Automation Engineering (D.M.270/04)

Curriculum: **Digital Infrastructure**

Course Presentation

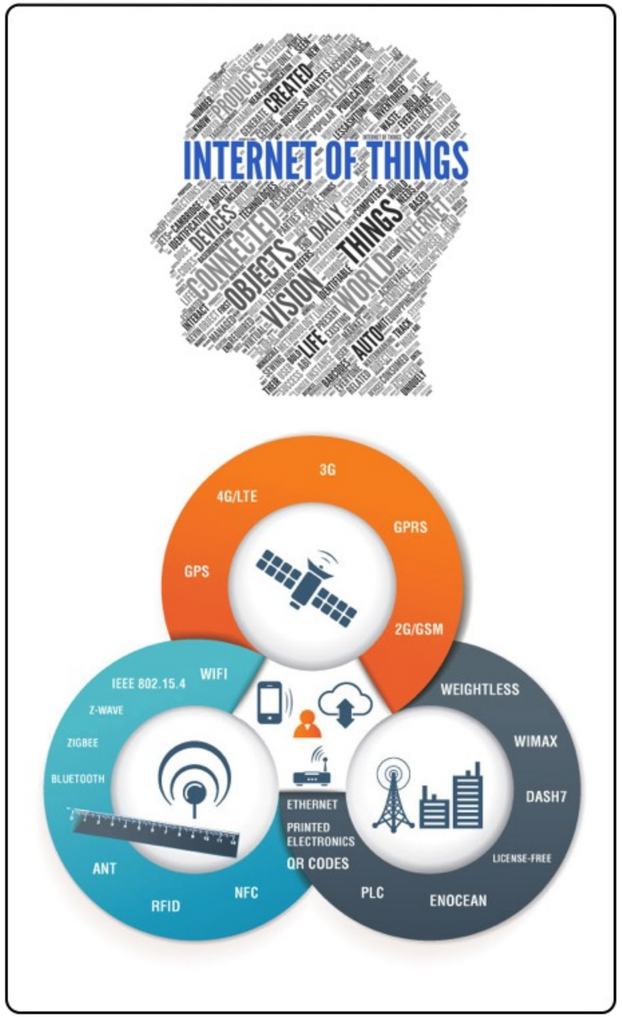
Prof. Marco Picone

The Context: Intelligent Cyber-Physical Systems



Cyber-Physical Systems (CPS) refer to integrated systems that combine **computational elements with physical components**, enabling the interaction and **collaboration between the digital and physical worlds**. CPS typically involve a **network of sensors**, **actuators**, and **computational devices** that **collect data** from the physical environment, **process it**, and **control physical processes or objects**.

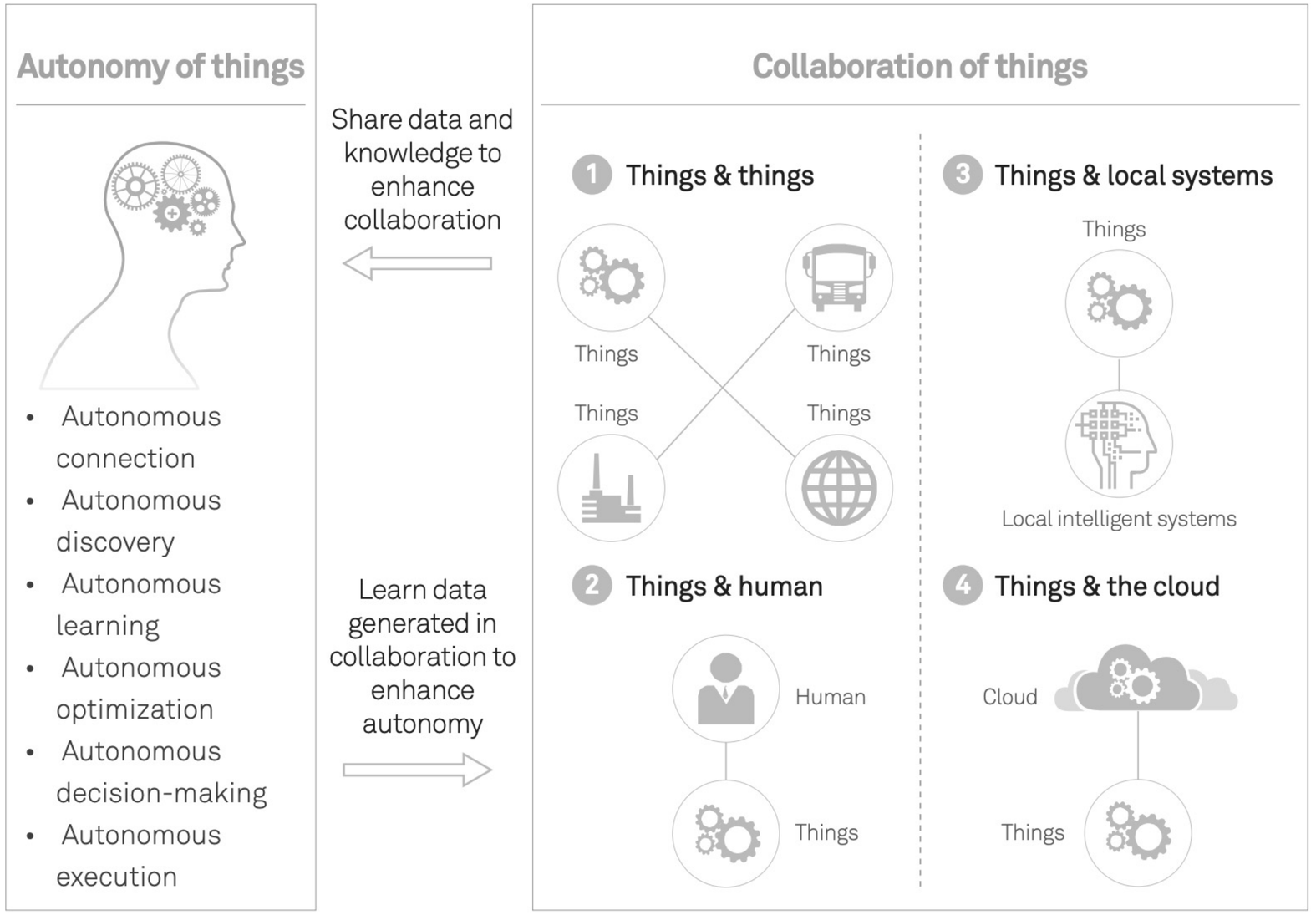
The Internet of Things (R)Evolution



A network of networks with billions of **uniquely identified** physical **Smart Objects** organized in an **Internet-like structure**

Smart Objects are items such as sensors, consumer devices, and enterprise assets that are **connected to both the Internet and each other**

Intelligent Distributed IoT Architecture



- An intelligent distributed Cyber-Physical Architecture drives intelligence capabilities to enable autonomy and collaboration of things, people and services:
  - **Autonomy of things**: Things can perform autonomous connection, discovery, learning, optimization, decision-making, and execution.
  - **Collaboration of things**: including collaboration between things, between things and human, between things and local smart systems, and between things and the cloud

Edge Computing Reference Architecture 2.0 - http://en.ecconsortium.net/Uploads/file/20180328/1522232376480704.pdf

(Some) Cyber-Physical Systems Technology Pillars

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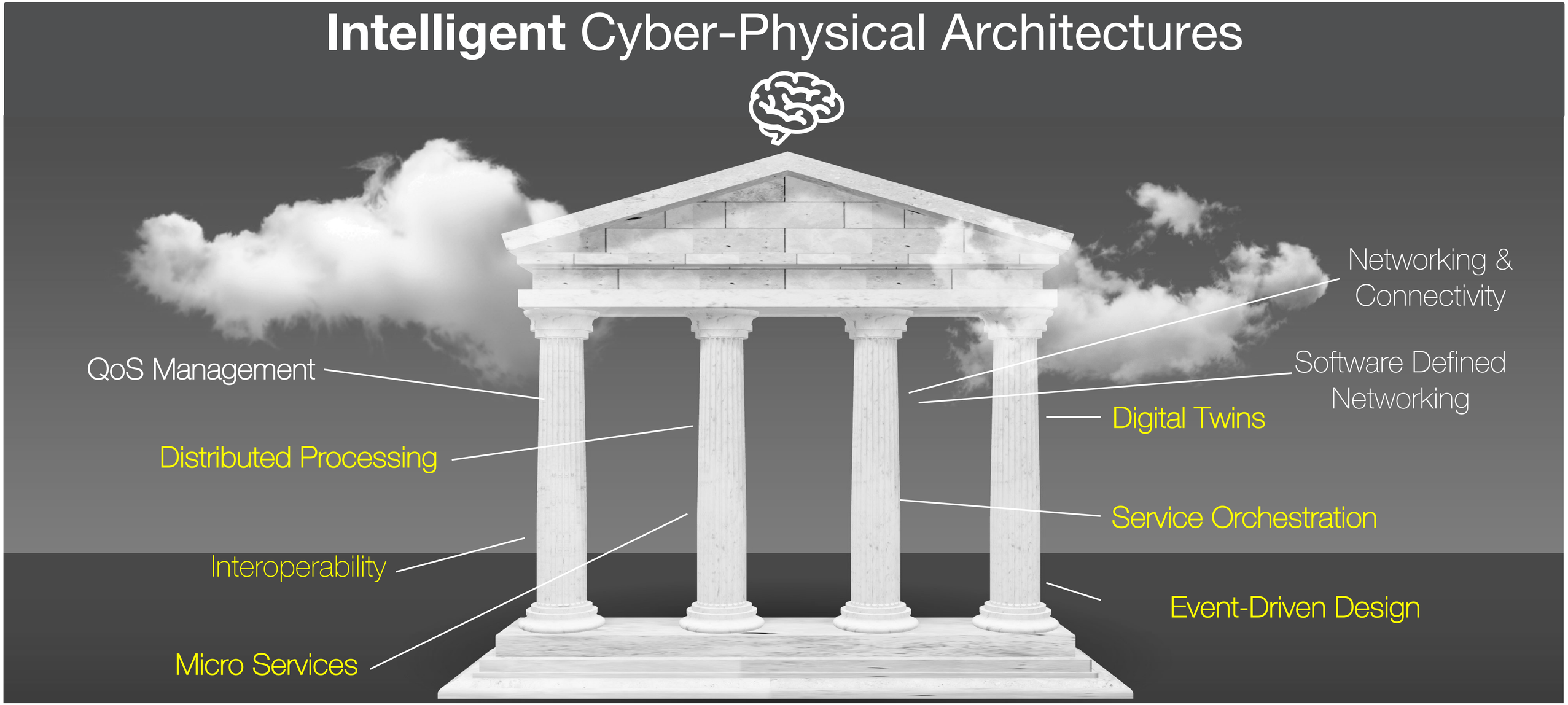

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Distributed and Internet of Things Software Architectures

- Provide the student with a **knowledge** of the challenges and characteristics of **Cyber-Physical and Internet of Things Distributed Systems**
- Study and Analyse the main principles of **distributed architectures and software systems** with a specific focus on **communication patterns, design principles and development techniques**;
- Apply these principles with particular attention to **interoperability, design and development of end-to-end architectures**;
- Provide the student with applied knowledge through the use of **state-of the art cutting-edge technologies** such as **development tools**, **software libraries**, **microservice solutions**, and the use of **IoT devices**, prototyping boards, computational facilities and **edge/cloud assets** within the course laboratories
- Provide an insight into the technological and research trends affecting the world of the distributed intelligent cyber-physical and Internet of Things systems such as designing and building **Digital Twins** solutions,

Teaching Objectives

Cyber-Physical System + Software Architectures + Design + Development + Deployment

Course's Main Topics

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1

1. Distributed System & Internet of Things
a. Software Development Patterns Overview
b. Centralized, Decentralized and Distributed Systems
c. Internet of Things & Cyber-Physical Systems

2

2. Protocols & Communication Patterns
a. RESTful & Request/Response Communication Patterns
b. HTTP & CoAP RESTful Protocols Overview
c. Pub/Sub & Event Driven Communication Pattern
d. Interoperability & Heterogeneity Management

3

3. Distributed Infrastructures
a. Cloud Computing
b. Edge Computing
c. Cloud, Edge & IoT
d. End-To-End Architecture Design
e. Digital Twins & Physical World Digitalization

4

4. Building Distributed Software Architectures
a. Monolithic & Microservice Architectures
b. Microservices Patterns
c. Event-Driven Microservices
d. Microservice Technologies & Software Design

Teaching, HandsOn Sessions & Laboratories

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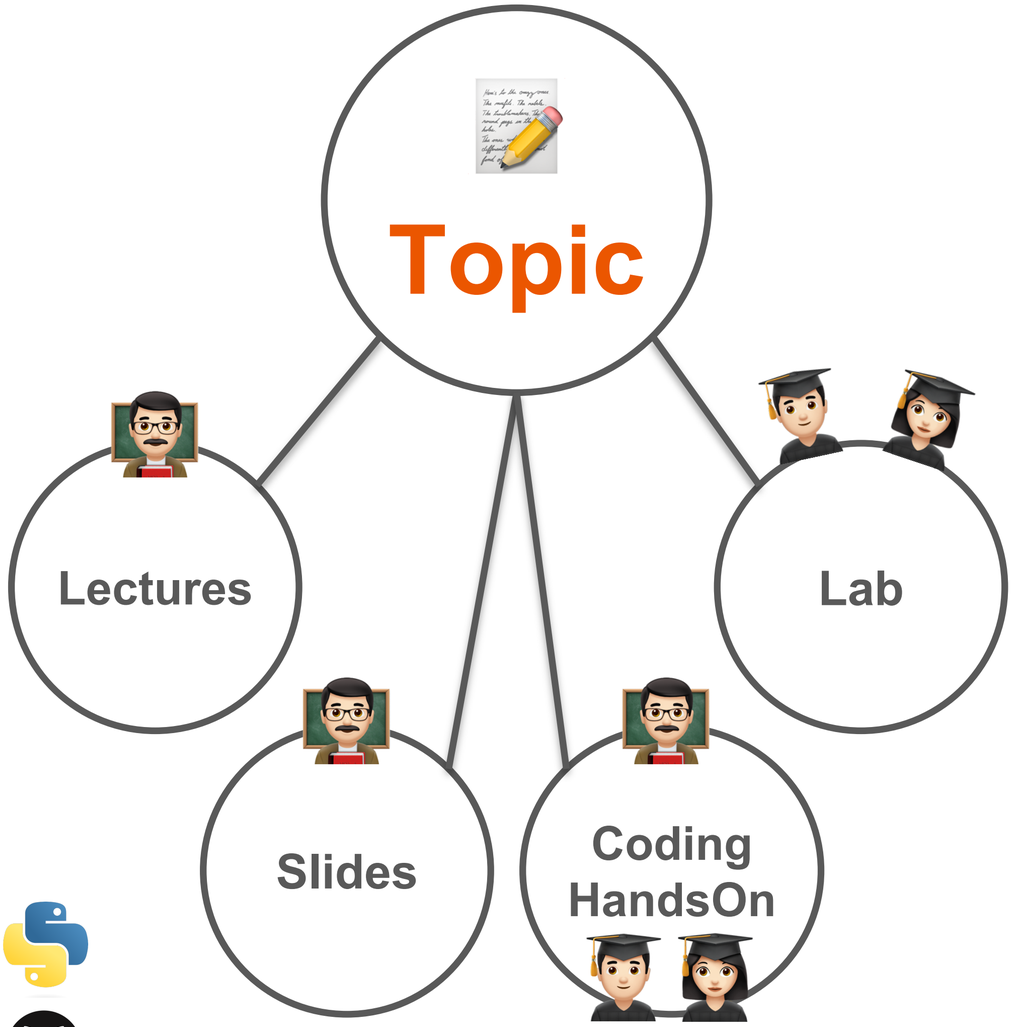
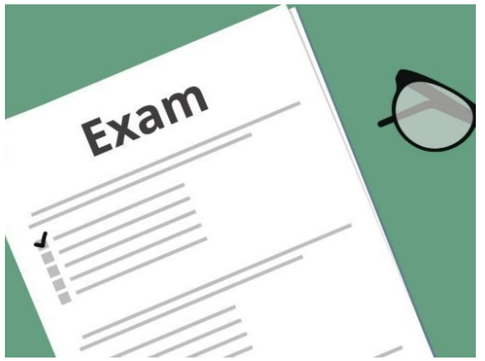
- Each Course Topic will be addressed with the following pattern:
  - **Slide** (in Inglese)
  - **Class Lecture**
  - **Coding HandsOn**
    (Bring your laptop 💻)
  - **Laboratory**
    (Tutorial step-by-step & Final Code on GitHub)
    (Uni-Lab or bring your laptop 💻)
- Additional Information:
  - All the source code associated to Course resources, laboratories and/or HandsOn Session will be available on a shared GitHub Organization
  - The main Programming Language of the Course will be Python and all the provided resource will be in **Python**. Additionally, some target HandsOn and Laboratories will be provided **also** in **Java.**



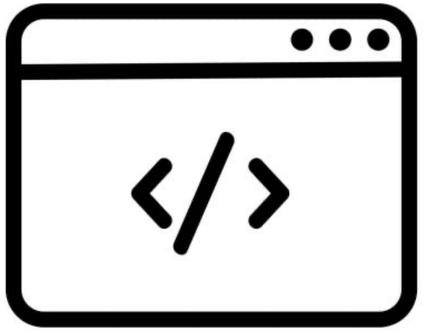
Exams & Evaluation

The exam consists of the following tests:

- **1) Written Exam:** Indicatively 4 questions on the theoretical and design aspects related to the topics presented in class. The exam duration is two hours. The exam will be assigned a score between 0 and 30 and it is considered passed if the obtained mark is greater than or equal to 18.



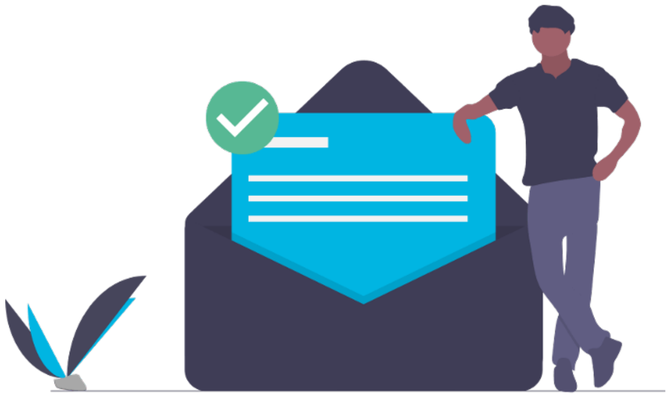
- **2) Project:** Design, development and presentation of a project (single and / or in a group with a limit of maximum 3 students) starting from a list of projects and topics presented in class, with report and discussion of the same during the examination



- **The final mark is an average value of the marks in the written exam and in the project (both >= 18). The final honours can be assigned by the lecturer in case of remarkable results in both tests**

Thesis, Internships & Seminars

- For interested students, it will be possible to carry out thesis work and internship activities and laboratory work related to the topics of the course and the research activities carried out.
- The activities can be conducted within the research laboratories and/or in collaboration with the companies with whom we collaborate and are in contact.
- For information regarding topics and availability, you can contact me via email based on your study program and the identified graduation session.
- If a student chooses in advance to carry out their thesis activity associated with the course, the topic of the project for the exam can be aligned with the thesis topic.
- According to the course schedule and organization, the course can also include seminars related to the world of Cyber-Physical Systems and Internet of Things, organized with companies and researchers from the academic world



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