Curriculum

Resilient and Secure Cyber Physical Systems

(in English)

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Outline

- Key elements of Cyber Physical Systems (CPSs)
  - Related terms
  - Application domains
  - Challenges
- The curriculum Resilient and Secure CPSs
  - Goal
  - Study plan
  - Career opportunities

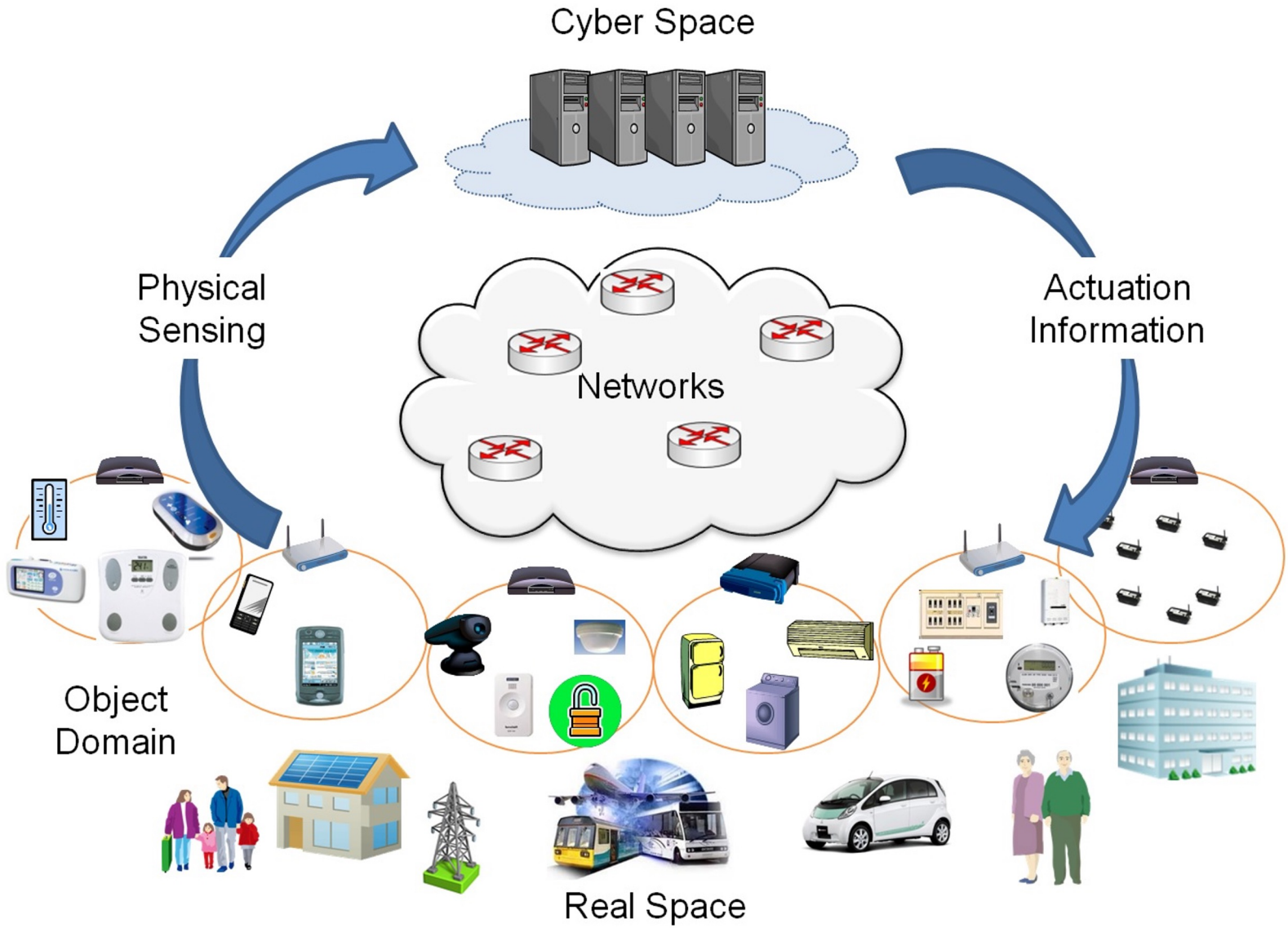
Computing evolution history

- Mainframe computing (60's-70's)
  - Large computers to execute data processing applications
- Desktop computing & Internet (80's-90's)
  - One computer at every desk to do business/personal activities
- Ubiquitous computing (00's)
  - Numerous computing devices in every place/person
  - "Invisible" part of the environment
  - Millions desktop devices and billions embedded processors
  - An increasing number of devices with which we interact on a daily basis are controlled by computer systems
- **Cyber Physical Systems** (10's-20's)

What are Cyber-Physical Systems?

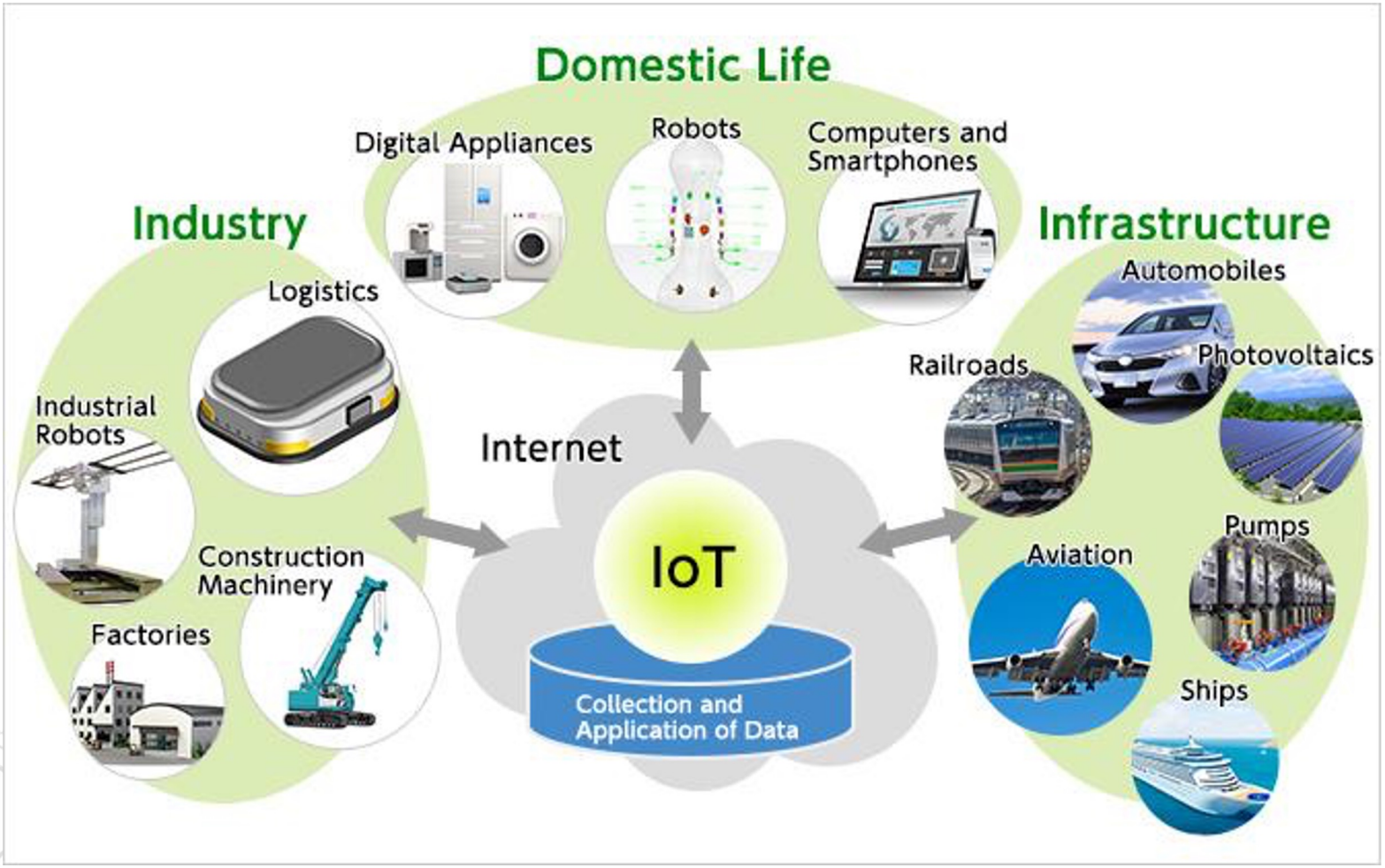
- A system consisting of a computer system (the cyber part), a controlled object (the physical part) and, possibly, interacting humans
- A system in which computational elements interact closely with physical entities, thus controlling individual, organizational or mechanical processes using information and communication technologies (computers, software and networks)
- A physical and engineered system whose operations are monitored, coordinated, controlled and integrated by a computing and communication core
- ***"CPSs will transform how we interact with the physical world just like the Internet transformed how we interact with one another"*** **[Fei Hu. Cyber-Physical Systems. CRC press. 2013]**

CPS main ingredients



Related term: *Internet of Things (IoT)*

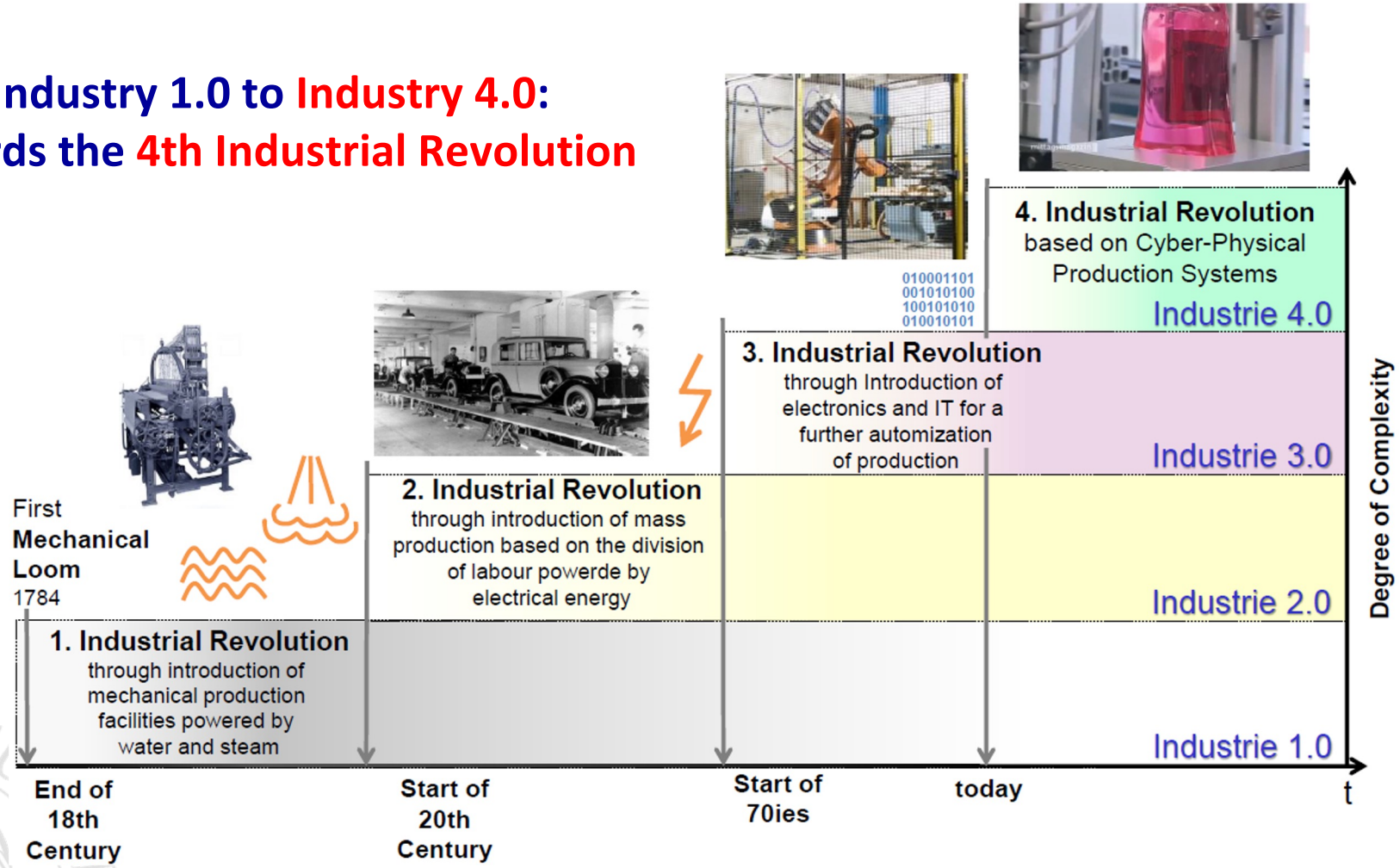
The network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these things to connect and exchange data



Related term: *Industry 4.0*

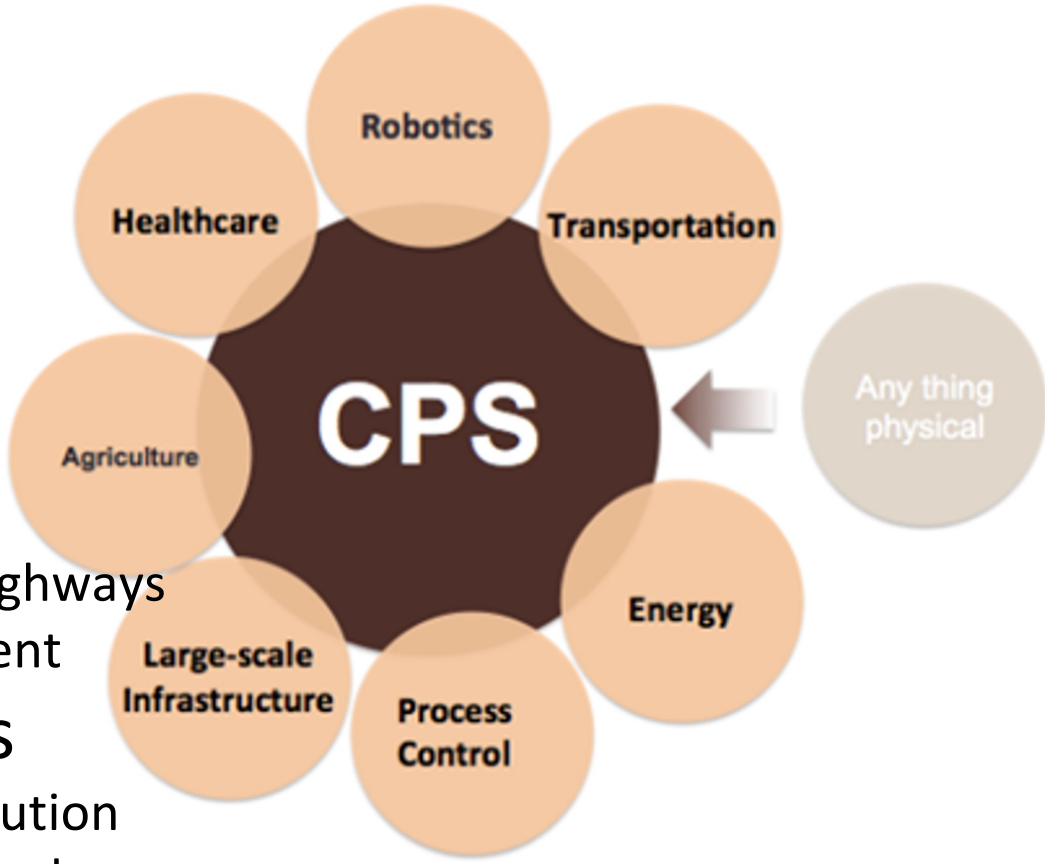
The current trend of automation and data exchange in manufacturing technologies

From Industry 1.0 to Industry 4.0:
Towards the 4th Industrial Revolution



Application Domains of CPSs

- Healthcare
  - Medical devices
  - Health management networks
- Transportation
  - Automotive electronics
  - Railroad systems
  - Vehicular networks and smart highways
  - Aviation and airspace management
- Large-scale Infrastructures
  - Electricity generation and distribution
  - Building and environmental controls
  - Physical infrastructure monitoring and control



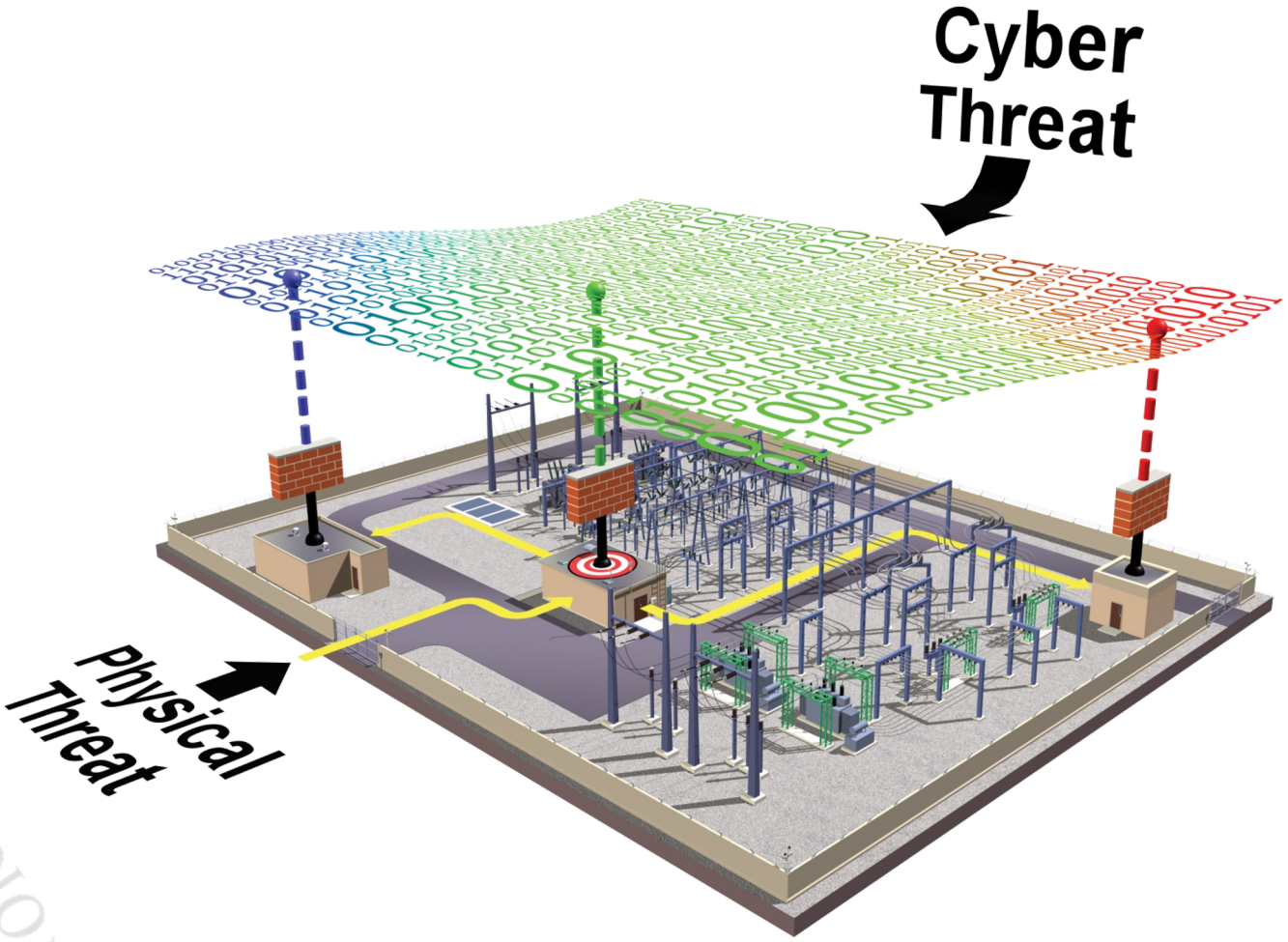
Huge interest in EU, US and … the world!

Calls within the Horizon Programme funded by the EU

- Focus on physical and cyber threats to the critical infrastructure of Europe
  - *Critical infrastructure* is a term used by governments to describe assets that are essential for the functioning of a society and economy
  - Public health; Transportation systems; Communication systems; Electricity generation, transmission and distribution; Water supply; Financial services …
- Scope:
  - Prevention, detection, response, and, in case of failure, mitigation of consequences over the life span of the infrastructure, for achieving the security and resilience of all functions performed by the installations

Challenges

How to design,develop and assess resilient and secure CPSs
Especially on the software side



The Curriculum

Resilient and Secure Cyber Physical Systems

(RS-CPS)

Goal

- To provide the students with solid software and system knowledge and skills for the definition, design, verification and certification of resilient and secure CPSs
- Realizing CPSs is challenging and requires multidisciplinary knowledge ranging from distributed systems to sensor networks, from software engineering to artificial intelligence
- Assuring resilience and security of CPSs also requires verification and certification methodologies and tools

Interdisciplinary training in multiple areas

- Design and implementation of distributed and real-time (cyber-physical) systems
- Principles to design secure systems
- Paradigms and methodologies for the development of distributed and CPS-oriented applications
- Design, validation and certification of resilient systems
- Advanced programming and software development techniques
- Elements of numerical analysis and statistics to handle the large amount of generated data, obtain system information, and support decision making

Mandatory Courses

First year:

- Architecture, Model and Analysis of Cyber Physical Systems
- Penetration Testing
- Resiliency, Real time and Certification
- Advanced Programming Techniques

Second year:

- Security Engineering
- Secure Wireless and Mobile Networks ING/INF03

Some Optional Courses

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- Algorithms and Programming for Massive Data
- Computer Forensics
- Architectures and Methods for Software Engineering
- Software Dependability
- Cyber Security and ICT Policies
- Computer Science Education (in italiano)

6

- Multivariate Analysis and Statistical Learning
- Statistical Inference

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- Advanced Numerical Analysis
- Approximation Methods
- Elements of Numerical Calculus
- Stochastic Processes

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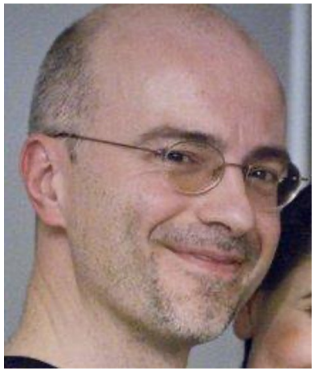
Some Teachers













Admission Requirements

To access the Master's Degree in Computer Science (class LM-18) you need to:

- Have acquired a suitable bachelor’s degree (e.g., Computer Science, Computer Engineering)
- Meet the minimum curriculum requirements (have passed courses equivalent to at least 24 CFUs in INF/01 or ING/INF-05 and 24 CFUs in MAT/01-09, FIS/01-08 or SECS/01-06 sectors)
- Possess an adequate entry preparation

Career Opportunities

- The graduate will have the knowledge and skills requested by companies in the field of **design**, **development**, **validation** and **certification** of *complex systems*, CPSs, *IoT, systems of systems, critical infrastructures*
- Some examples of professional profiles are:
  - Project manager / software developer
  - Analyst/designer/developer of CPSs
- The master's graduate training is also targeted at advanced scientific and technological research, and at teaching activities
- The master's graduate in Computer Science can enroll in the Italian Information Engineers' Registry and access PhD programs in Computer Science

Thank you
for your attention!