



Resilient and Secure Cyber Physical Systems:

Matching the Present and the Future!

Prof. Andrea Bondavalli – DIMAI

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Outline

- Key elements of Cyber Physical Systems
- Related domains and examples
 - Systems of Systems
 - Internet of Things
 - Industry 4.0
- Requirements and threats
- Matching the needs
 - The NEW Curriculum in Resilient and Secure Cyber Physical Systems
 - Key learning outcomes
 - Content
 - Programme structure
 - Career prospects

Computing evolution

- Mainframe computing (60's-70's)
 - Large computers to execute big 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 for desktops vs. billions for embedded processors
- **Cyber Physical Systems** (10's-20's)

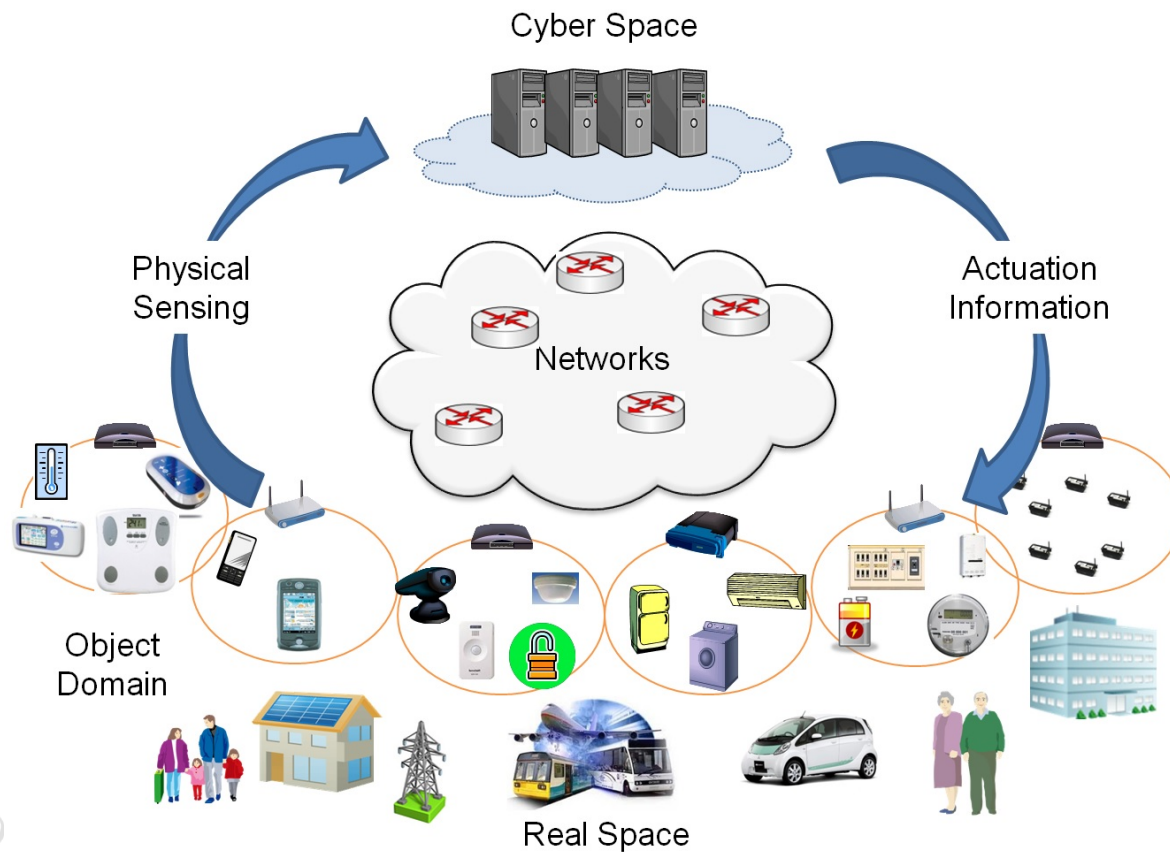


What are Cyber-Physical Systems?

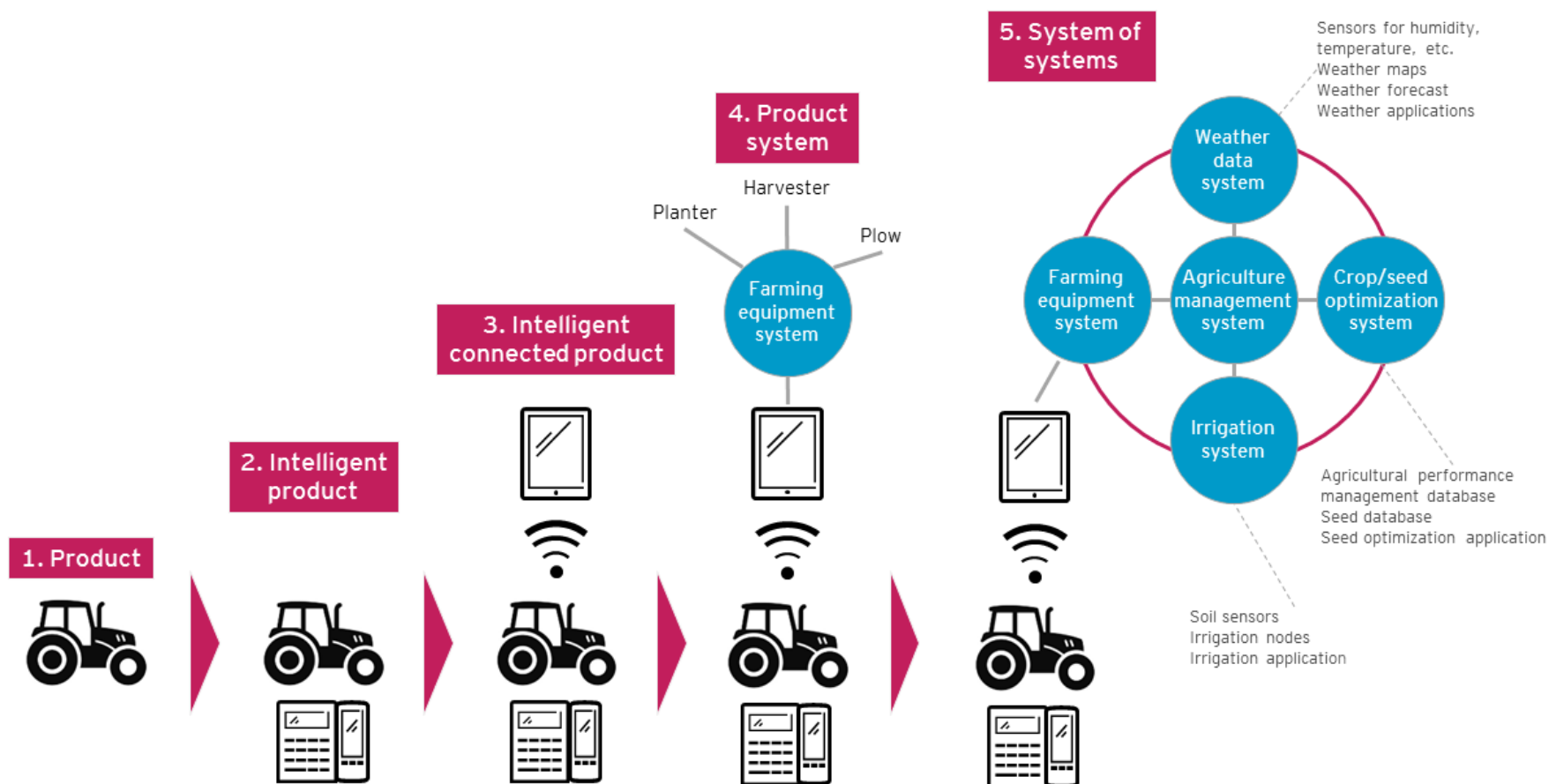
- **Cyber** – computation, communication, and control that are discrete, logical, and switched
- **Physical** – natural and human-made systems governed by the laws of physics and operating in continuous time
- **Cyber-Physical Systems** – a system consisting of a computer system (the cyber system), a controlled object (a physical system) and possibly of interacting humans.
- ***“CPS 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 view

- CPSs are physical and engineered systems whose operations are **monitored**, **coordinated**, **controlled** and **integrated** by a computing and communication core.

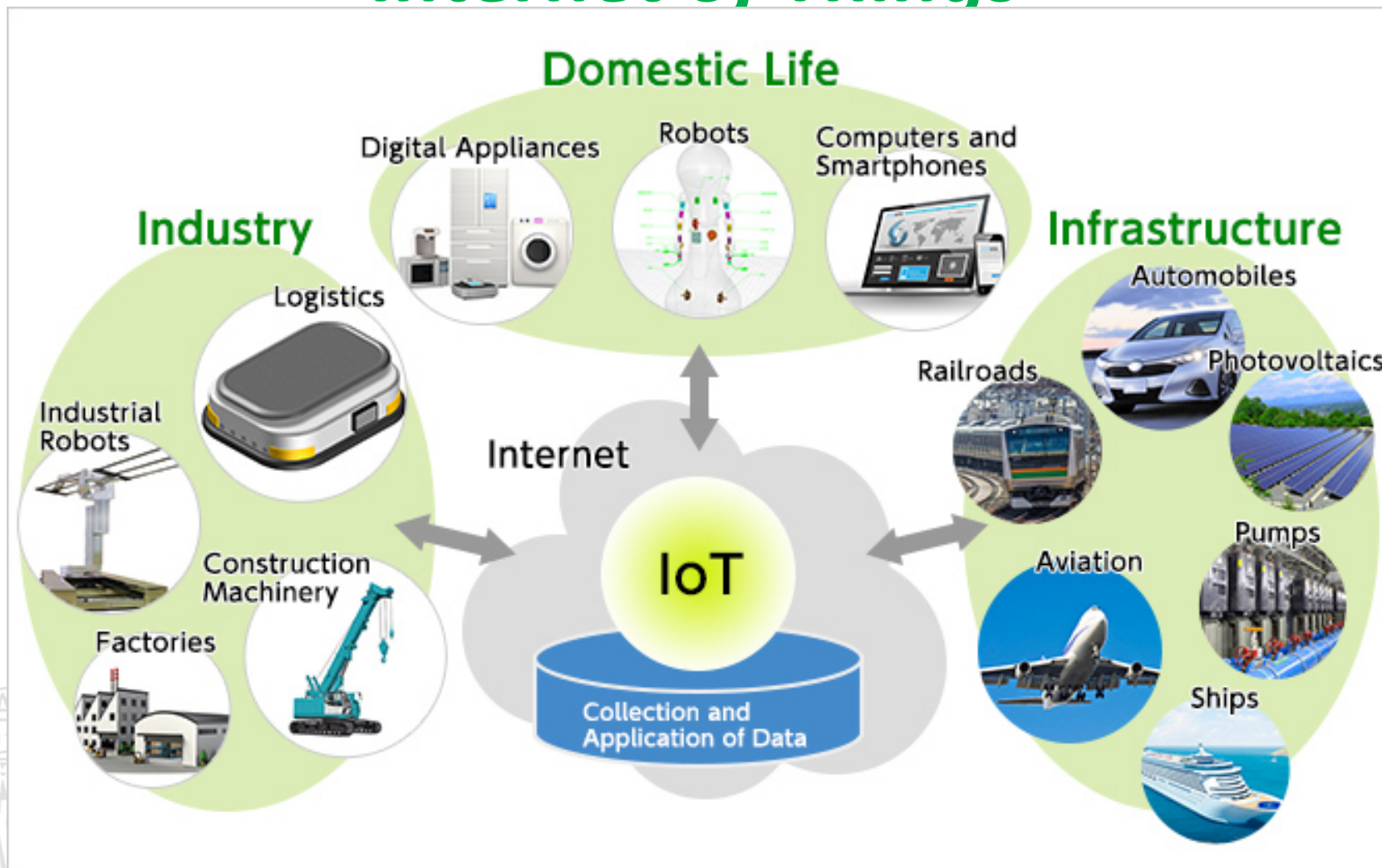


CPS... and related terms: *(Cyber-Physical) Systems of Systems*



CPS... and related terms:

Internet of Things





IoT in a nutshell



CPS & Industry 4.0

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



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010001101
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3. Industrial Revolution

through Introduction of electronics and IT for a further automatization of production

Industrie 3.0

Start of 70ies

today



4. Industrial Revolution
based on Cyber-Physical
Production Systems

Industrie 4.0

Degree of Complexity

First
Mechanical
Loom
1784



2. Industrial Revolution
through introduction of mass
production based on the division
of labour powered by
electrical energy



Industrie 2.0

Industrie 1.0

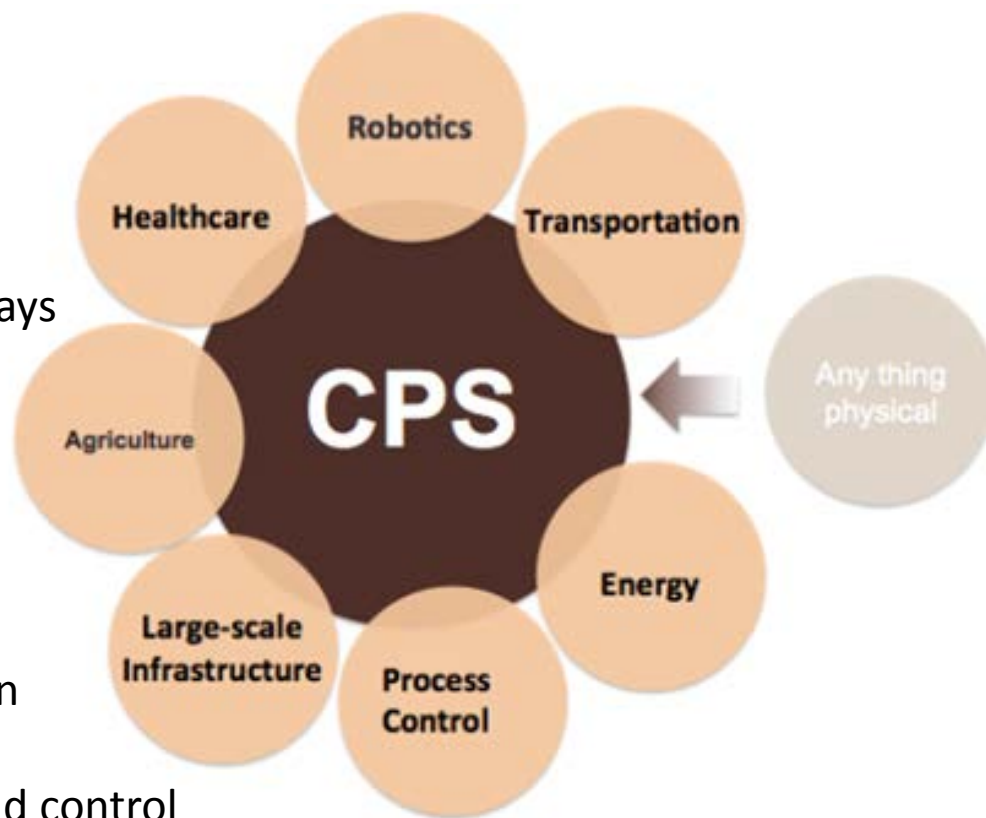
End of
18th
Century

Start of
20th
Century

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Application Domains of CP Systems

- Healthcare
 - Medical devices
 - Health management networks
- Transportation
 - Automotive electronics
 - Vehicular networks and smart highways
 - Aviation and airspace management
 - Avionics
 - Railroad systems
- Process control
- Large-scale Infrastructure
 - Electricity generation and distribution
 - Building and environmental controls
 - Physical infrastructure monitoring and control
- Defense systems
- Tele-physical operations
 - Telemedicine
 - Tele-manipulation





Example in the transport domain: **the driverless car**





Example in the transport domain:

Mobileye[®] Shield+ Collision Avoidance System



High Interest in EC, US and the world!

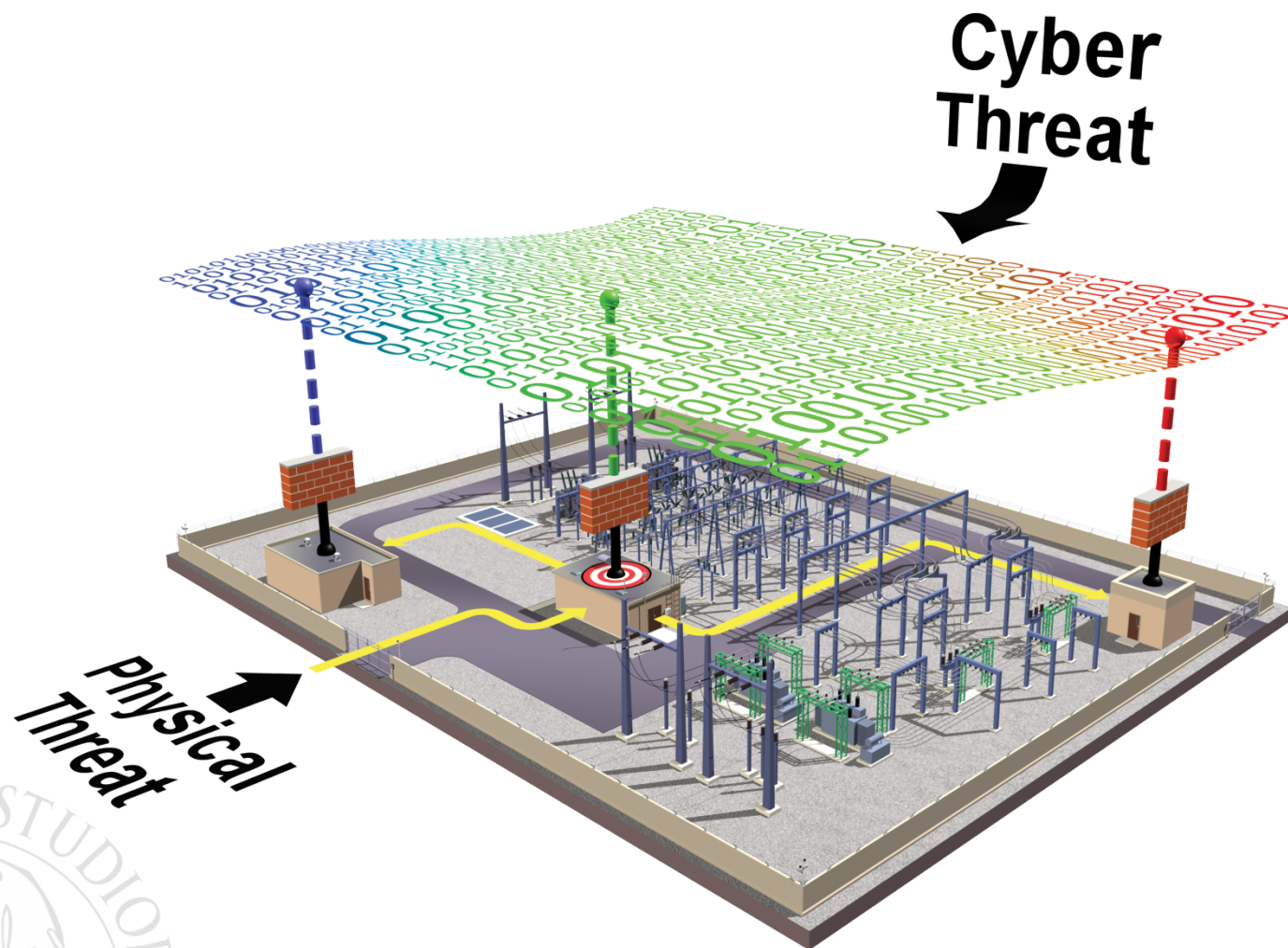
E.g. H2020 CPS-related running call

- TOPIC: Prevention, detection, response and mitigation of the combination of **physical** and **cyber threats** to the **critical infrastructure** of Europe.



- Targeted critical infrastructures:
 - Water Systems, Energy Infrastructure, Transport Infrastructure and means of transportation, Communication Infrastructure, Health Services, Financial Services.
- Scope:
 - Prevention, detection, response, and in case of failure, mitigation of consequences over the life span of the infrastructure, with a view to achieving the **security** and **resilience** of all functions performed by the installations...

Threats





Effects of Threats: few examples **Ariane V**





Effects of Threats: few examples

Hackers on a Jeep



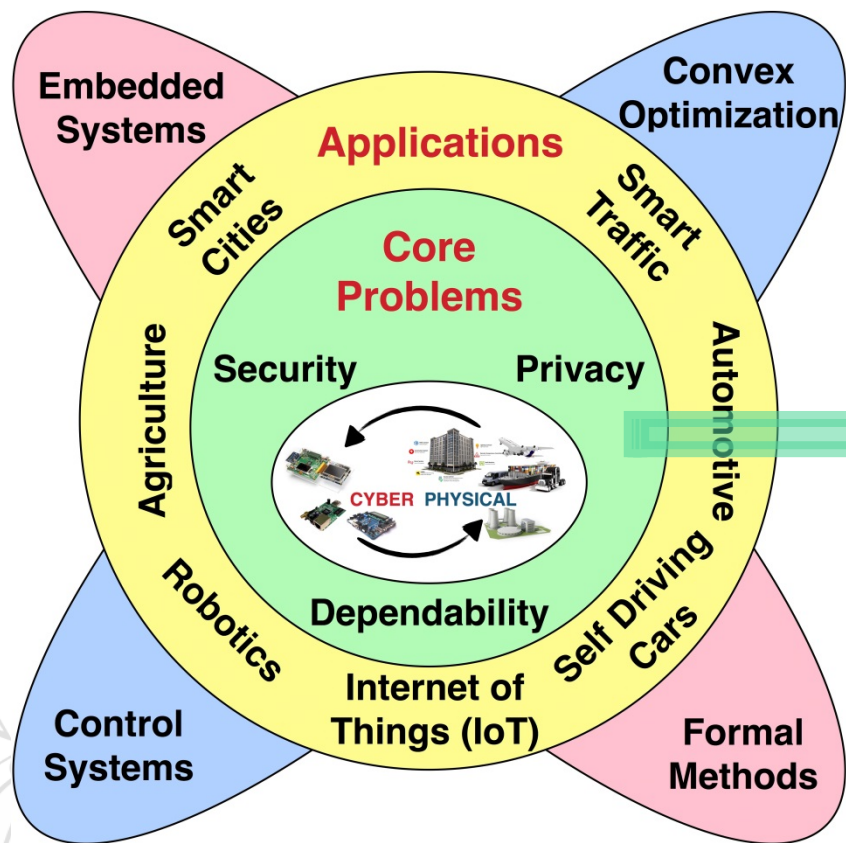


Effects of Threats: few examples

WannaCry



Core problem: how to make such systems *Secure*, *Resilient*, ...





The Brand New Curriculum in Resilient and Secure Cyber Physical Systems



Curriculum in RS-CPS

- The new Master in Resilient and Secure Cyber-Physical Systems (RS-CPS) covers the key design and development aspects of cyber systems interacting with the real world, including Internet of Things, Smart Manufacturing, Systems of Systems.
- The program provides students with the latest knowledge and skills to make a real impact in this exciting and rapidly expanding area.

Objectives

This curriculum aims to provide the students with a solid background for **designing, development, verification and certification of complex systems** like *Internet of Things, Smart systems and Safety Critical Infrastructures*.

Areas of Interests

- Development of distributed and real-time CPS
- Security Engineering
- Languages and Paradigms for programming of CPS
- Design, Validation and Certification of Resilient *Systems*
- Advanced programming techniques for complex software development (*build automation, test driven development,...*)
- Elements of Numerical Calculus and Statistics for data analysis and decision supporting.

Main Lectures

First year:

- Advanced Techniques and Tools for Software Development
- Quantitative Analysis of Systems
- Distributed Programming of IoT
- Distributed Real Time Cyber Physical Systems

Second year:

- Security Engineering
- Secure Wireless and Mobile Networks

Optional Lectures

- Advanced Algorithms and Graph Mining
- Advanced Programming Techniques
- Computer Forensics
- Quality and Certifications
- Architectures and Methods for Software Engineering
- Software Dependability
- Multivariate Analysis and Statistical Learning
- Statistics
- Advanced Numerical Analysis
- Approximation Methods
- Elements of Numerical Calculus

Career Opportunities

- The master's graduate will have the **skills requested by companies** in the field of **design, development, validation and certification** of *critical infrastructures, system of systems, complex systems, and IoT*.
- **!There are many around Florence!**
- **We are negotiating with some of them for sending students for stages and external master theses!!**
- Some examples of professional profiles are:
 - Project manager and software developer
 - Analyst/designer of cyber-physical systems
 - Developer of cyber-physical systems.
 - RAMS Engineers for CPSs



**Thank you
for your attention!**

