Foundations of Cyber-Physical Systems

- a workshop organized by ”Platforms4CPS”

www.platforms4cps.eu/

Co-arranged with CPSE-labs (www.cpse-labs.eu/) and the ICES competence network (www.ices.kth.se)

Workshop outline

Brief round of presentations!

Introduction – Platforms4CPS and Workshop introduction

First part: Foundational CPS topics

09.15-10.35: Initial set of inspirations talks < 10 min. presentations per speaker

10.55-11.10 – Short summaries of provided workshop inputs (existing roadmaps, positions)

11:10-12:40: **First world café session – 4 themes** (group work)

- Humans as part of CPS; CPS and systems engineering; Autonomy, AI and self-awareness; Composability

12:40-13.05: Plenary summaries of table discussions

13:05-14:05: Lunch!

Second part: Reconciling topics, how to address them and longer-term discussions

14:05-14.25: Initial inspirational short talks

14:25-15.50: **Second world café session - 3 themes** (group work)

- Reconciling the topics; How/where to address identified topics; How to stimulate and maintain a longer-term discussion among experts on CPS foundations

15.50-16.15: Plenary summaries of table discussions (25 mins)

16.15-16.40: Overall wrap up and next steps!

World café sessions

Divide into themes and corresponding tables for discussions!

Clock-driven and clock-wise rotation of groups among tables

Question-driven discussion at the Tables!

- based on apriori prepared questions and proceeding discussions/presentations
- Participants can add more topics

The table chair structures the discussion, will provide a short summary for the plenary and for the follow-up dialogue on the PlatForum

Workshop context and goals

The workshop has a two-fold purpose:

- to provide perspectives and reflections on what is currently perceived as "Foundations for CPS", reflecting state of the art, with suggestions for what might be missing (gaps) and how such topics should be addressed,
- to elicit ideas and discuss how a longer-term discussion among experts to evolve our understanding of CPS foundations can be stimulated and maintained.

Moreover, the activity as part of Platforms4CPS invites to an extended discussion through an on-line community (the PlatForum)

Intended results: Insights, perspectives and scoping, as seeds for a continued discussions!

Platforms4CPS PlatForum

Briefly go to wiki:

https://platforum.proj.kth.se/tiki-index.php?page=Foundations+of+CPS+Working+Group

We will come back to this topic in the discussions!

Cyber-physical systems (~2006)

Integration of computation, networking and physical processes where CPS range from minuscule (pace makers) to large-scale (e.g. national power-grid).

Not new but seeing

- Increasing level of integration and capabilities
  - Physical – Embedded – Networking – IT
  - Life-cycle integration, Cross-domains
  - Autonomy
- Synergies with other inventions/advances
- Business model evolution; servitization
- From closed to mass-market products/services

Unprecedented opportunities and societal reliance

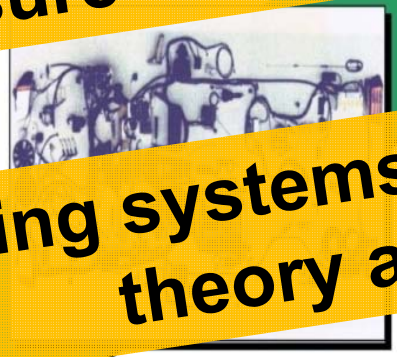
Electronics, software and CPS evolution

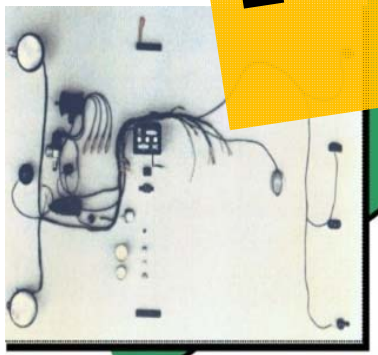
How to manage such large scale CPS?

How do ensure suitable properties of such systems?

Evolving systems, engineering methods, theory and knowledge!

Car electrical system <.





Car embedded system 1990

Cyber-Physical Systems of Systems!

Smart energy, water, transportation, health, cities, …

Opportunities, challenges and some confusion!

Intelligent systems that gather, synthesize and apply information will change the way entire societies operate …

Why a workshop on CPS foundations?

Importance of CPS and their increasing spread in society

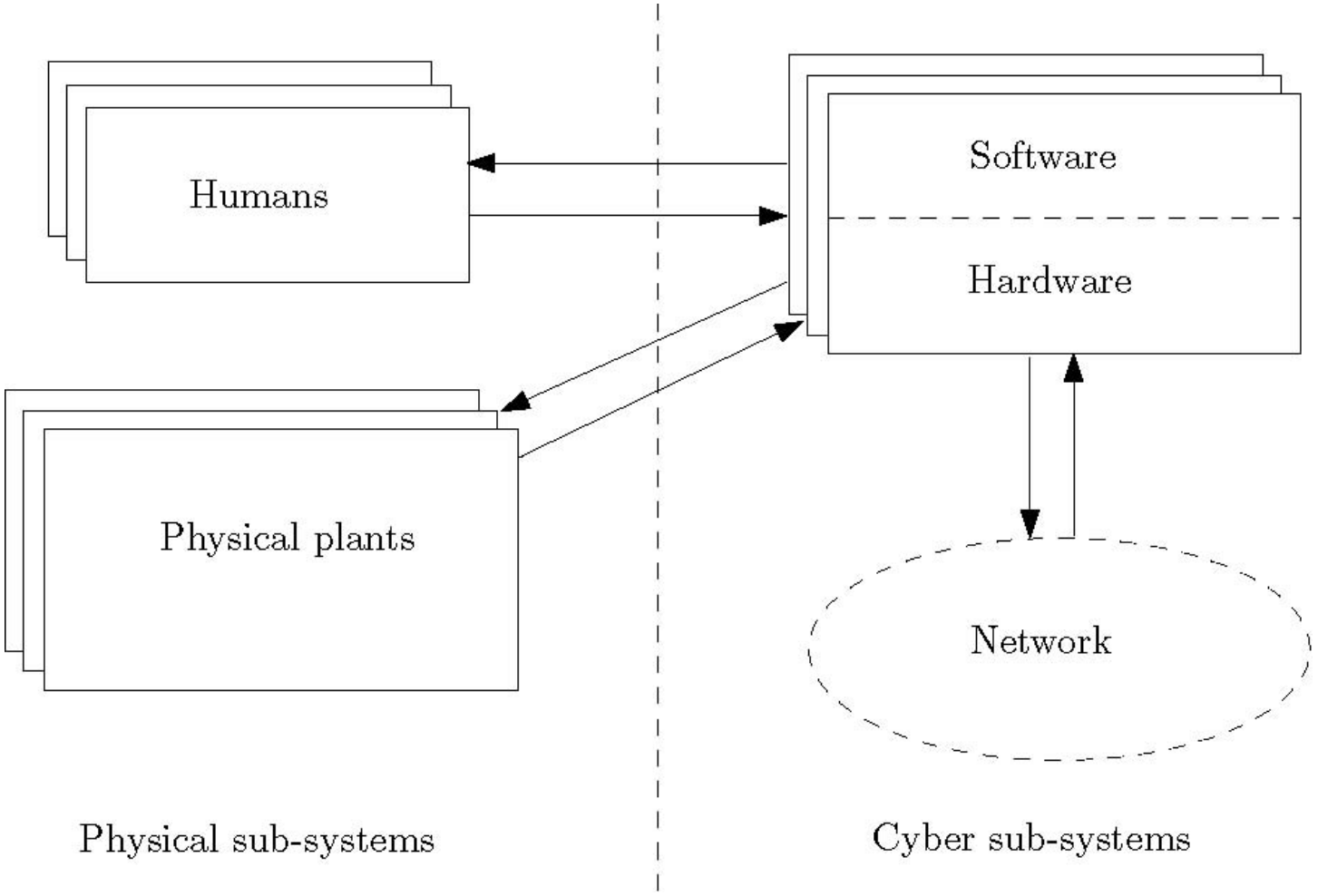
Quote from CPS summit, action plan, April 2016:

- "… we do not yet have a mature science and technology for the rigorous engineering of CPS. …"
- With lacking "… scalable principles of combining large heterogeneous ensembles of physical systems, humans, and cyber-systems; and it lacks suitable methodologies and systems engineering processes applied to cross-domain CPS …"

"The lack of foundations and methodologies creates barriers that may prevent market success of new CPS applications and hinders the implementation of cross-sectorial, horizontal value chains."

- "Since current CPS are engineered and maintained at very high cost and sometimes with unknown risks we are about to make our economy and society completely dependent on a technology, whose risks have been insufficiently reflected upon."

What are foundational aspects of CPS?



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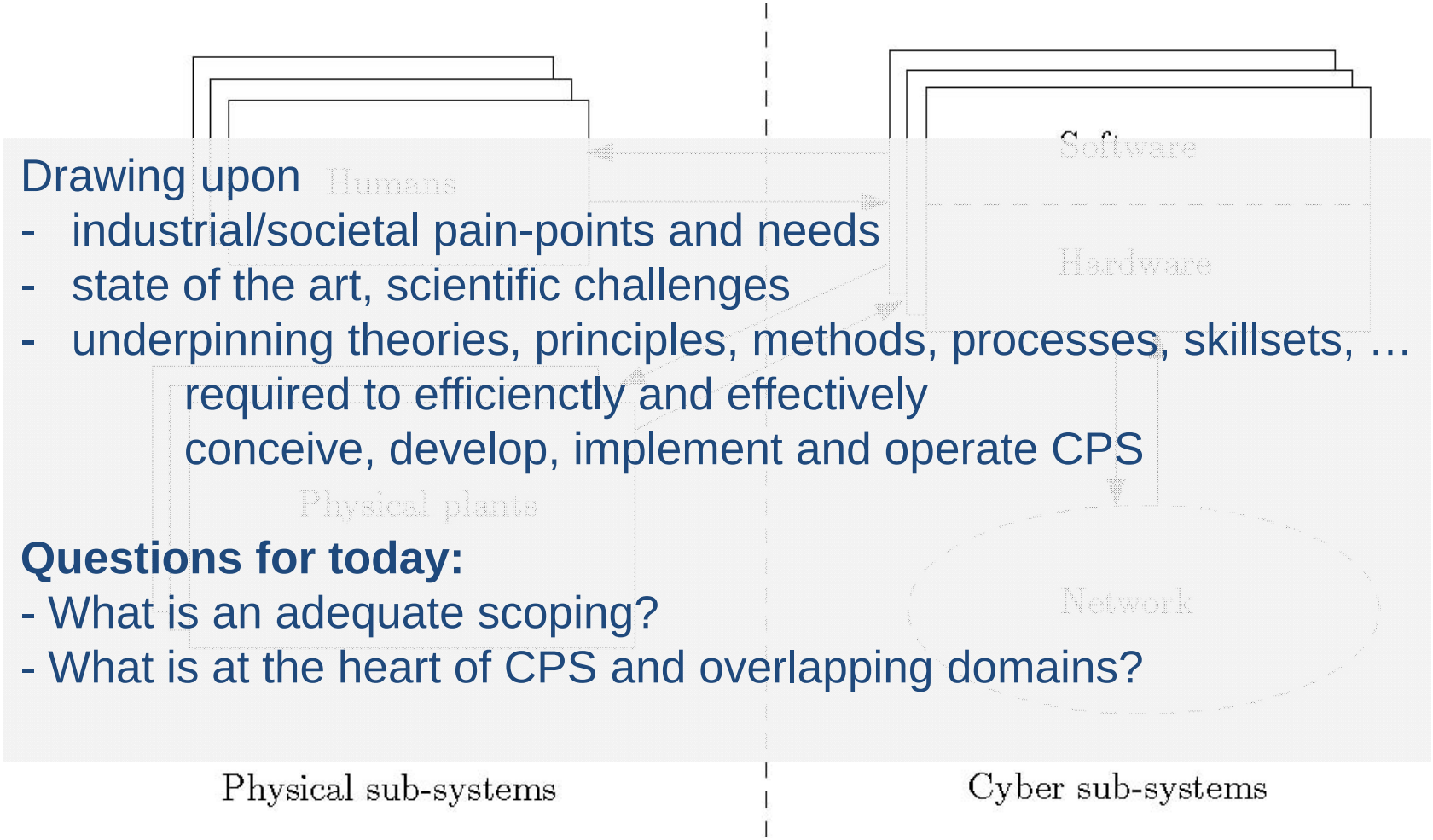


Drawing upon
- industrial/societal pain-points and needs
- state of the art, scientific challenges
- underpinning theories, principles, methods, processes, skillsets, …

required to efficienctly and effectively
conceive, develop, implement and operate CPS

Questions for today:
- What is an adequate scoping?
- What is at the heart of CPS and overlapping domains?

What are foundational aspects of CPS? Common answers include …

Complexity of CPS

- Interactions between cyber and physical components
- Interactions and collaboration among CPS developers, across viewpoints, theories and methodologies, where a decisions in one domain is likely to have an impact on other domains

Interrelating and combining relevant theories and engineering methodologies

- Reconciling and bridging theories/metodologies
  - E.g. Software and network theory vs. Newtonian mechanics
- Predictability, composability principles, contract theory, dealing with uncertainty, …

Platforms4CPS in a nutshell

Platforms4CPS:
Creating the CPS Vision, Strategy, Technology Building Blocks and Supporting Ecosystem for Future CPS Platforms

Coordination and Support Action, co-financed by the EC - H2020 - ICT 1-2016:
Smart Cyber-Physical Systems

7 Partners from 4 European countries

Coordinator: THALES Research & Technology, France, Dr. Charles Robinson
EC Project Officer: Dr. Werner Steinhögl

Project duration:
November 2016 - October 2018, 24 months

Total EC contribution: EUR 998.900,00

GA No.: 731599

Web: **www.platforms4CPS.eu**

THALES SA France (Coordinator)	THALES
Steinbeis 2i GmbH Germany	STEINBEIS 2i
THHINK Wireless Technologies Limited United Kindom	THHINK WIRELESS TECHNOLOGIES LTD
FESTO AG & Co KG Germany	FESTO
Kungliga Tekniska Hoegskolan Sweden	KTH VETENSKAP OCH KONST
FORTISS GmbH Germany	fortiss
Systematic Paris Region Association France	Systematic Paris Region Digital Ecosystem

Platforms4CPS - Objectives

Creating the CPS Vision, Strategy, Technology Building Blocks and Supporting Ecosystem for Future CPS Platforms

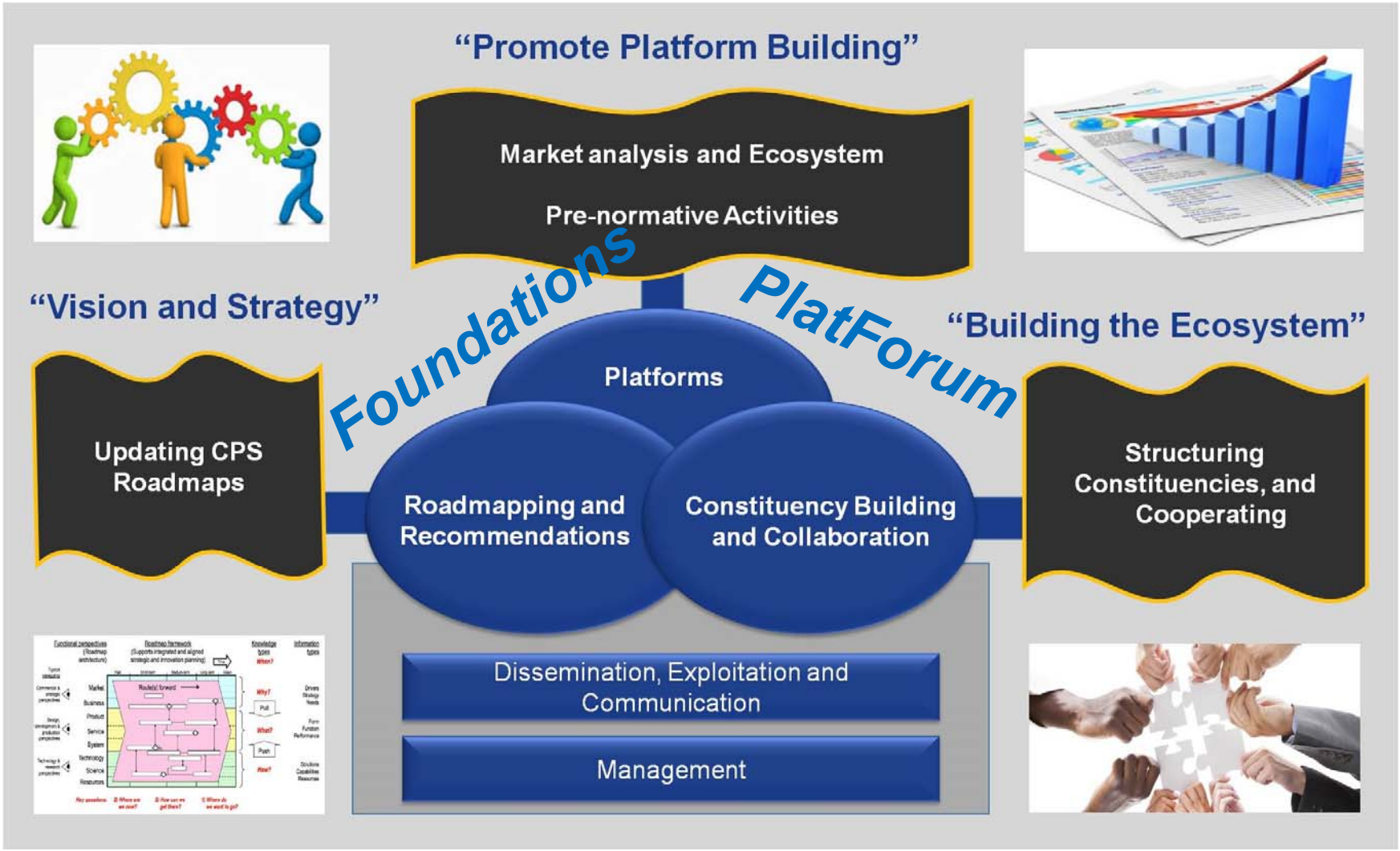
- Create a **vision and strategy** for future European CPS by analyzing the ecosystem and **market perspective** and strategically updating and validating existing **CPS roadmaps** across multiple domains
- Promote **platform building**, bringing together industry and academic experts and create a repository of CPS technology building blocks
- **Build up an ecosystem** by creating a **constituency** and through **cooperating** on the **foundations of CPS engineering**, and supporting **consensus-building** on societal and legal issues

Platforms4CPS - Objectives

Platforms4CPS will bring together leading CPS experts from academia and industry to collaborate on future CPS, to:

- Structure **constituencies**
- Update and validate existing **CPS roadmaps**
- Address the **foundations of CPS engineering** and the science of system integration
- **Cooperate** with other **European programmes** (ECSEL/ITEA/Artemis-IA/Big Data, 5G etc. PPPs)
- Create a **PlatForum** for information exchange, identify **best practice** and create a **repository of CPS technology blocks** for industry and academic developers
- Support **consensus building** on societal and legal issues related to the deployment of CPS

Platforms4CPS - Objectives



Roadmaps – Screening, as part of Platforms4CPS

- ECSEL MASRIA, ATREMIS-SRA, Artemis ITEA vision, EPoSS
- CyPhERS, CPSoS, CPSSummit, Road2SoS, Road4FAME, Road2CPS
- Internet of Things, Artificial Intelligence
- Industry 4.0, Factories of the Future (EFFRA Roadmap)

Platforms4CPS - Expected Outputs and Products

- Platforms4CPS **market analysis** and recommendations for **business opportunities**
- **CPS Community Roadmap** and **recommendations for research priorities** and **innovation strategies**
- CPS **platforms survey**
- Platforms4CPS **repository of building blocks**
- **PlatformArenas** – showrooms
- **PlatForum** communication platform
- Platforms4CPS constituency building and clustering events

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09.15-10.35: Initial inspirational talks (< 10 min.)

- Challenges in industrial CPS, ABB, Stefan Svensson
- Intelligence, connectivity and cloud, Ericsson, Elena Fersman
- CPS frameworks and challenges, Edward Griffor, NIST
- Frameworks for cyber-physical-human systems; Vladimir Cvetkovic, Prof. KTH
- Complexity Management from a Systems Engineering Perspective, Bud Lawson, IEEE computer pioneer
- Model-driven engineering of CPS, Hans Vangheluwe, Univ. of Antwerp
- Security concerns and their impact on our understanding of Cyber-Physical Systems, Panagiotis Papadimitratos, KTH