Technical Session

IoT/CPS: Convergence of IoT and CPS for Smart and Dependable Socio-technical Systems

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ICT Policy, Research and Innovation for a Smart Society

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PICASSO has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 687874.

Cyber-physical Systems (CPS)

- **Tight interaction of real-time computing systems and physical systems**
- **Ubiquitious: Cars, ships, household devices, HVAC, robots, power plants, …**
- **Rigorous treatment of the interplay of computing and physical systems is still not possible for larger systems**
- **An area of European strength**
  - € 410 billion market
  - 4 million jobs worldwide, of which one quarter are in Europe

The Internet of Things (IoT)

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- **The Internet of Things (IoT)** – A paradigm based on the convergence of:
  - Low-cost sensing and computation
  - Ubiquitous connectivity and mobile apps
  - Cloud analytics and big data
- IoT annual global economic potential: Between **$1.4 trillion** to **$14.4 trillion** by 2020
- IoT initiatives, alliances, and clusters
  - **US:** Several alliances with international membership
  - **European IoT Research and Innovation Cluster** with over 40 European projects
  - **Alliance for Internet of Things Innovation (AIOTI**)

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Convergence of IoT and CPS

- **Beyond connectivity:**
  - How can the data be transformed into useful knowledge and actions?
  - **Challenge: From sensing to actuation, closing the loop**

→ IoT is an enabling technology for CPS, especially for large-scale SoS

→CPSoS

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Cyber-physical Systems of Systems

What are Cyber-Physical Systems of Systems (CPSoS)?

Large, complex, often spatially distributed Cyber-physical Systems (CPS) that exhibit the features of Systems of Systems (SoS)

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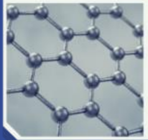
Cyber-physical Systems (CPS)

Tight interaction
of many distributed, real-time computing systems and physical systems


Examples
- Airplanes
- Cars
- Ships
- Buildings with advanced HVAC controls
- Manufacturing plants
- Power plants
- ...

Systems of Systems (SoS)

Many interacting components



Examples
- Large industrial sites with many production units
- Large networks of systems (electric grid, traffic systems, water distribution)

Physical connections

- Material/energy streams
- Shared resources (e.g. roads, airspace, rails, steam)
- Communication networks

Dynamic reconfiguration

Components may...
- be switched on and off (as in living cells)
- enter or leave (as in air traffic control)

Continuous evolution

Continuous addition, removal, and modification of hardware and software over the complete life cycle (often many years)

Emerging behavior
The overall SoS shows behaviours that do not result from simple interactions of subsystems

Usually not desired in technical systems, may lead to reduced performance or shut-downs

Examples
- Power oscillations in the European power grid
- Oscillations in supply chains

Partial autonomy
Local actors with local authority and priorities

Autonomous systems ...
- cannot be fully controlled on the SoS level
- need incentives towards global SoS goals

Examples
- Local energy generation companies
- Process units of a large chemical site

Examples of Cyber-physical Systems of Systems

Integrated large production complexes
- Major source of employment and income in Europe
- Major consumer of energy and raw materials
- Many interconnected production plants that are operated mostly autonomously with distributed management structures

Transportation networks (road, rail, air, maritime, ...)
- Vital to the mobility of EU citizens and the movement of goods
- Large integrated infrastructures with complex interactions, also across national borders
- Involve multiple organizational and political structures

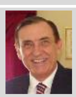
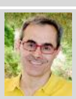
Many more examples, e.g. smart (energy, water, gas, ...) networks, supply chains, or manufacturing

PICASSO Expert Group on IoT/CPS

Members

Sebastian Engell, TU Dortmund, Germany

http://www.picasso-project.eu/iotcps-expert-group/

Name	Organization Position	Background
Sebastian Engell (Chair) 	**TU Dortmund, Germany** Professor	Automation and Control / Systems Management / CPS
Tariq Samad (Co-chair) 	**TLI, University of Minnesota, US** Professor	Industrial Automation
Massoud Amin 	**TLI, University of Minnesota, US** Director / Professor	Infrastructures / Smart Grid
Chris Greer 	**NIST, US** Program Office Director and National Coordinator	CPS / Smart Grid
Amit B. Kulkarni 	**Honeywell, US** Global R&D Leader for Wireless and IoT	Wireless, Internet of Things
Paul Nielsen 	**Software Engineering Institute, CMU, US** Director / CEO	Software development / CPS / Cyber-security
Haydn Thompson 	**THHINK, UK** Director	Wireless sensors / Transpor-tation / Manufacturing / Smart Cities
O. Sinan Tumer 	**SAP Co-Innovation Lab, US** Senior Director	Co-Innovation / Research Commercialization
Hubertus Tummescheit 	**Modelon Inc., US / Modelon AB, Sweden** CEO / Co-founder	Modeling / Simulation
Ovidiu Vermesan 	**SINTEF ICT, Norway** Chief Scientist, Chair WG01 AIOTI	Internet of Things

Session Agenda

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Networked CPS and IoT

John Baras

Lockheed Martin Chair in Systems Engineering, University of Maryland, USA
Director, Maryland Hybrid Networks Center, USA

Systems and Control in IoT and CPS: Opportunities and Challenges

Rolf Findeisen

Head of the Institute for Automation Engineering (IFAT), Otto-von-Guericke University, Germany

IoT/CPS Beyond the Hype: A Vision for Connected Smart City Systems & Edge Services

Martin Serrano

Principal Investigator and Data Scientist, Insight Centre for Data Analytics, Ireland