Management and Control of Cyber-physical Systems of Systems

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Examples: Industrial Symbiosis

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Courtesy: Mark Lewis, Nepic, UK
Examples: Industrial Sites

Legend:
- Stock
- Intermediate Production Units
- Final Production Units
- Import / Export from / to External Market

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Examples: Electrical Grid

- Supports distributed energy resource deployment
- Enables self-healing and autonomous restoration
- Allows for bi-directional flow of energy and information
- Enhances security of supply and power quality
- Minimizes investment and operations costs
- Protects against technical and commercial losses
- Reduces maintenance and intervention

Courtesy: HEP-ODS, Croatia

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Examples: Smart Buildings

A Smart Grid Needs Smart Buildings

Power and Bi-directional Data Communication
- Dynamic Pricing
- Curtailment Signals
- Load Forecasts
- Capacity Bids
- Emission Reduction Info

PHEV Parking Deck

Renewable Energy

Combined Heat and Power Plant

Internet

Solar PV

HVAC

Security

Lighting

Information Technology

Electrical Storage

Thermal Storage

Institute for Building Efficiency

Courtesy: Institute for Building Efficiency

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Examples: Charging of EVs
Challenges

• Decision structures and system architectures
  — What are the most suitable management and control mechanisms for certain classes of CPSoS?

• Coordination mechanisms for systems with autonomously managed units

• Understanding how the management and control structure (centralized, hierarchical, distributed, clustered) influences system performance, robustness and stability

• Dealing with uncertainty, neglected couplings, stochastic effects, user interactions
Management of cyber-physical systems of systems that are constituted of a (moderate to large) number of complex sub-systems:

• Which possess partial local autonomy
• Are tightly interconnected by streams of material and energy
• Examples:
  – Electric power grid
  – Electric vehicles charging
  – Chemical plants
DYMASOS Consortium

Chemical production and operation

DYMASOS
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Electric power distribution systems

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Management and Control Methods

• Population Control
  – Coordinated distributed convergence to Nash equilibrium in non-cooperative large-scale multi-agent CPSoS

• Market-based Methods
  – Coordinated distributed convergence to social optimum of cooperative multi-agent CPSoS

• Coalitional Control
  – Local interactions to converge towards a coalitional equilibrium in semi-cooperative multi-agent CPSoS
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