OFFIS Energy
INSTITUTE FOR INFORMATION TECHNOLOGY

Smart Grid Co-Simulation with mosaik and the SESA-Lab

Rapid Prototyping of Future Energy Systems

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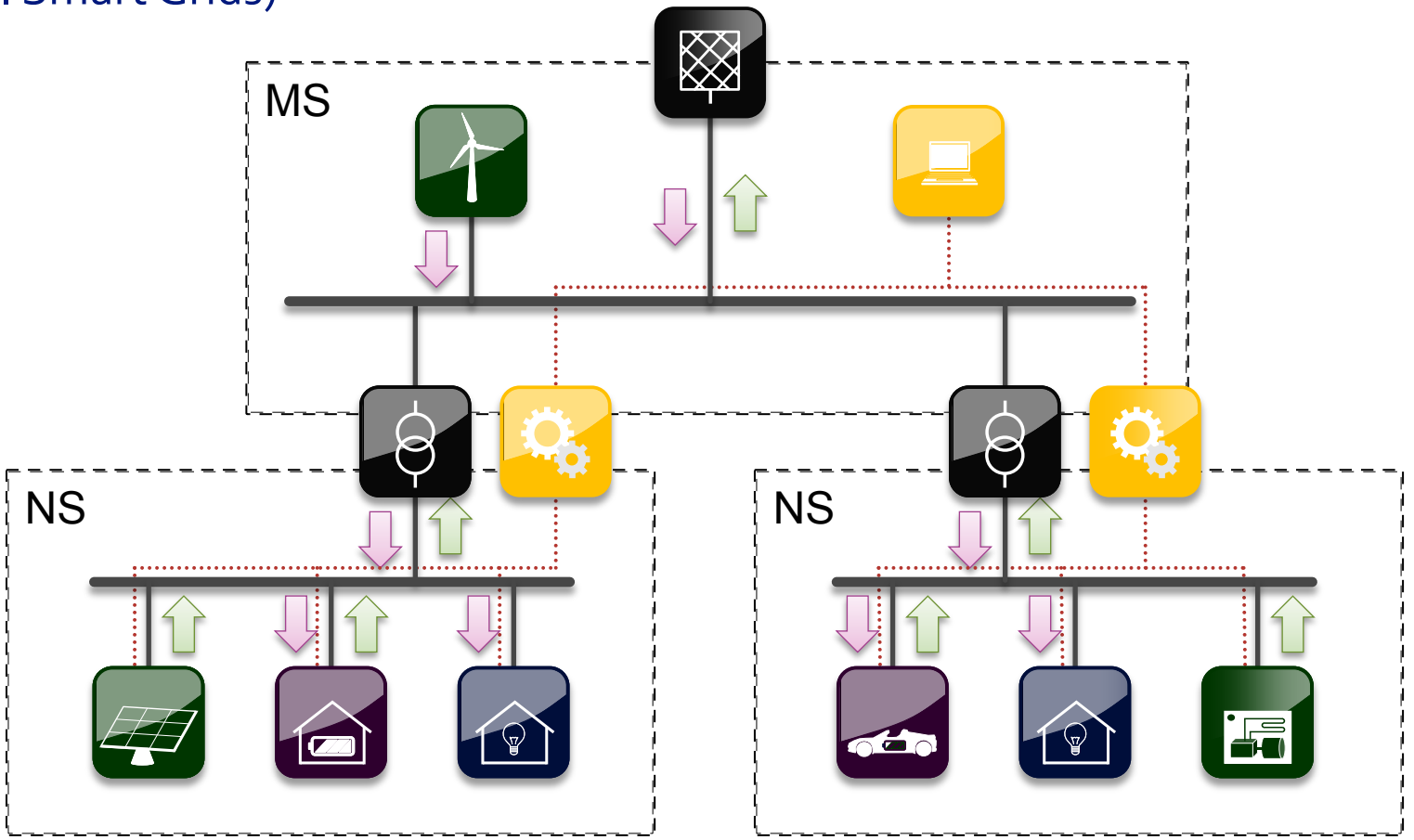
Future Energy Systems
(a.k.a. Smart Grids)



- Integrating large amounts of active components into operation
  - Environmentally dependent and hard to forecast
  - Automated operation and (on-line) optimization necessary

ICT-based Solutions Necessary

- Appropriate information, communication and automation systems are known from other domains
  - But: long-term use in safety-critical energy systems mostly untested
  - High risk for stakeholders in energy supply

- Rigorous testing necessary!
  - Learning from other application domains…
  - **„Hardware in the Loop"**
  - Operation of the real electric controller hardware or a mechatronic component in a simulation of the real environment
  - *But: what belongs into this simulated environment?*

Quelle: Daimler „Driving Simulator in Sindelfingen", 2014

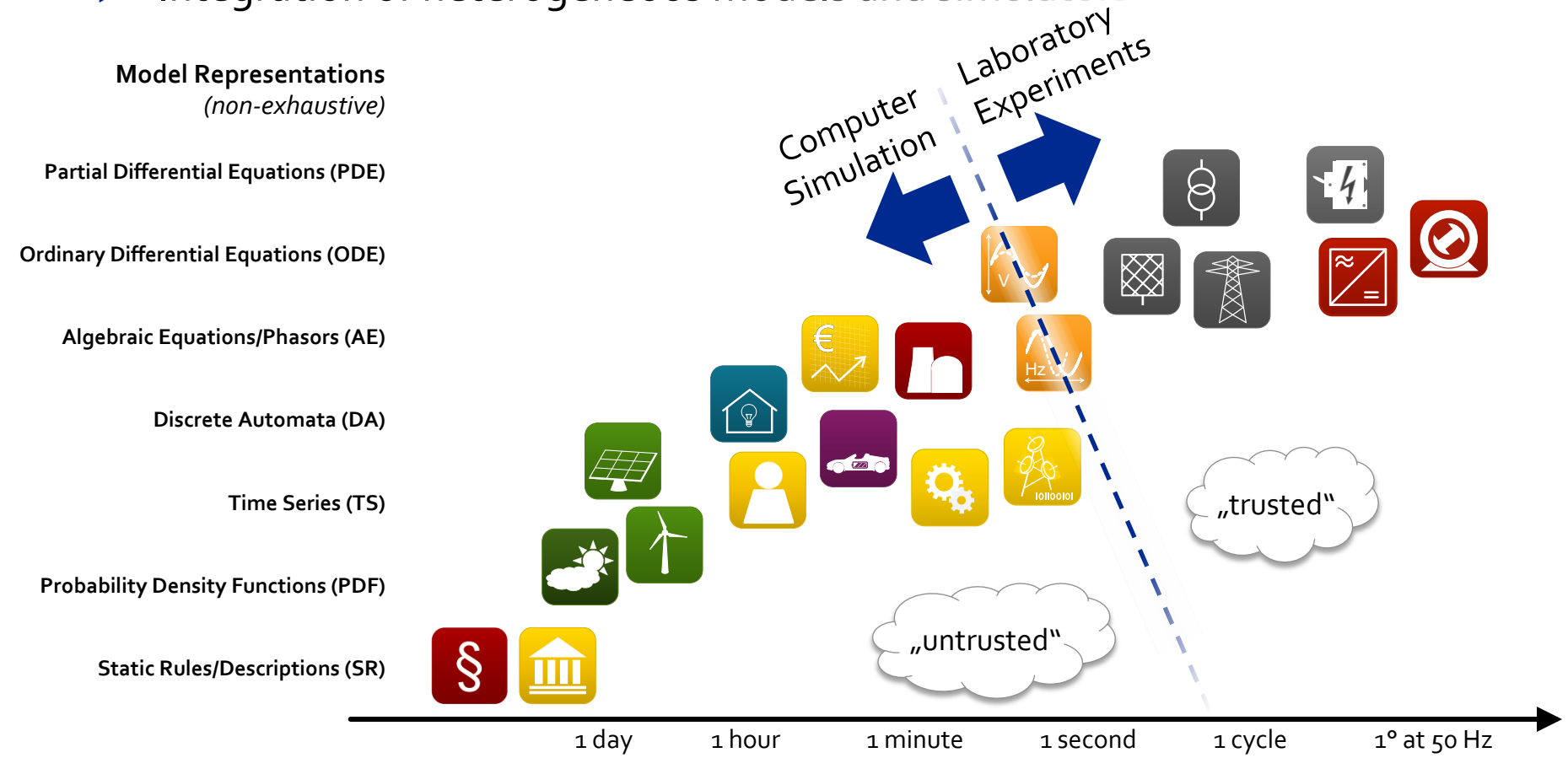
Influencing Factors of Future Energy Systems

- Relevant scope of „Smart Energy Systems" is hard to determine
  - Renewable – fossil generation
  - Distribution grid – transmission grid
  - Users – consumers
  - Markets
  - ICT
  - …

- *Complex interactions*
- *Small effects gain relevance through scaling*

Simulation of Smart Energy Systems

- Adequate consideration of ALL facets required!
  - Formal analysis (*not feasible anymore*) vs. simulation
- Integration of heterogeneous models and simulators



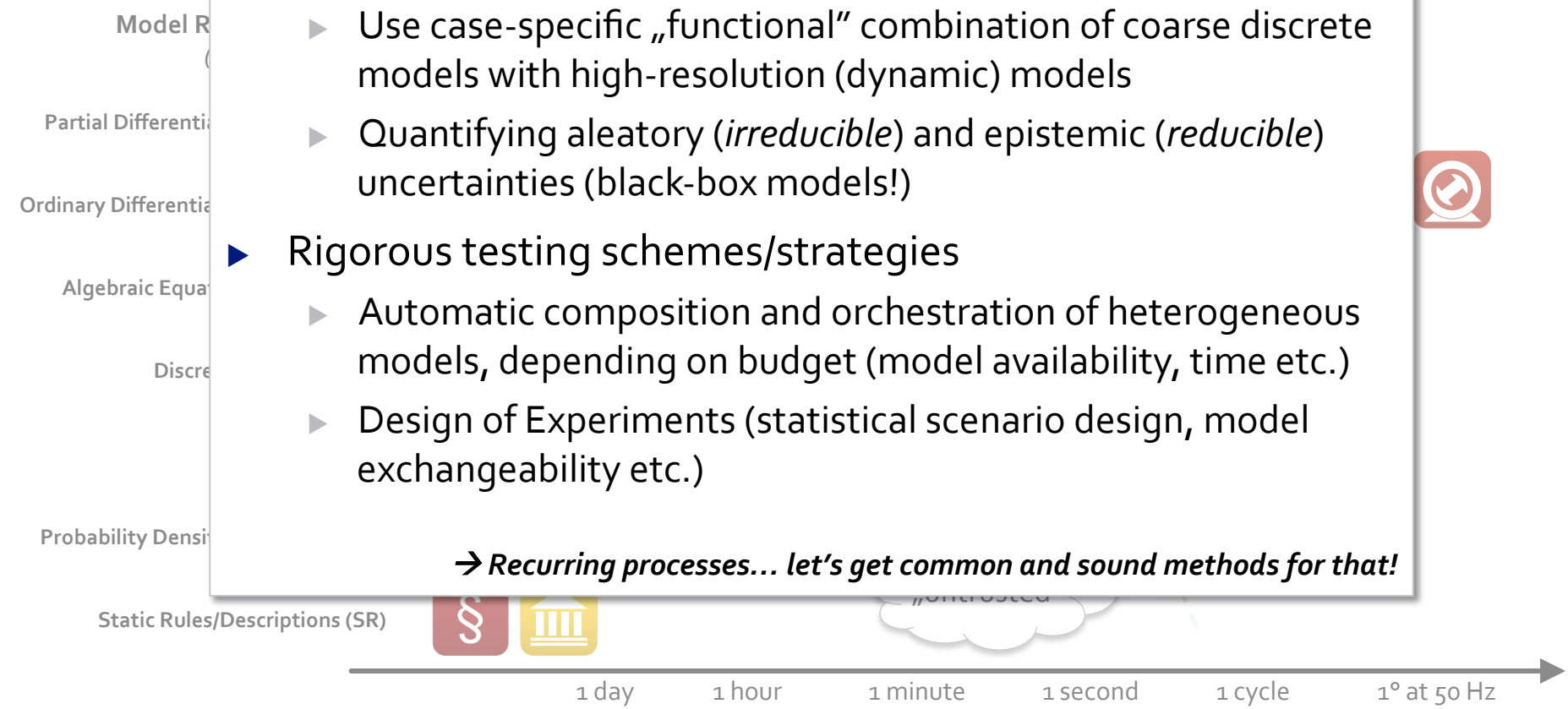
Simulation of Smart Energy Systems

- Adequate consideration of ALL facets required!
- Int

Major Challenges

- Properly integrating hardware and software environments
  - Use case-specific „functional" combination of coarse discrete models with high-resolution (dynamic) models
  - Quantifying aleatory (*irreducible*) and epistemic (*reducible*) uncertainties (black-box models!)
- Rigorous testing schemes/strategies
  - Automatic composition and orchestration of heterogeneous models, depending on budget (model availability, time etc.)
  - Design of Experiments (statistical scenario design, model exchangeability etc.)

→ ***Recurring processes… let's get common and sound methods for that!***



SESA-Lab

Smart Energy Simulation and Automation Laboratory

(Hard- and Software Integration Platform)

mosaik

Co-Simulation Framework

(OFFIS – Institute for Information Technology)

Real-time Automation Lab

(University of Oldenburg)

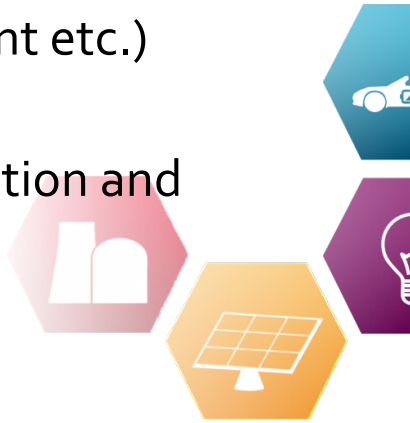
SESA-Lab

mosaik – modular Smart Grid Co-Simulation

OFFIS Energy
INSTITUTE FOR INFORMATION TECHNOLOGY

- Software suite developed at the OFFIS for automated composition and orchestration of heterogeneous energy system models

- Flexible interfaces for simulators (grids, markets, environment etc.) and controllers (users, „smart" ICT etc.)
- Powerful scenario description language (rule-based instantiation and coupling of models)
- coordinated execution (simulation)



- After testing phase with international research partners now open source available (http://mosaik.offis.de)
  - Currently ~1.000 downloads per month

LGPL V2
Free Software

Practical mosaik Workshops

- Regular mosaik courses and user workshops abroad
- Hands-on model integration (simulators and hardware)

- Most recent workshop on 24.09.2014
  - DTU Denmark
  - 20 international participants from engineering, physics, mathematics computer science

- Next workshops
  - Tomorrow (CMU)
  - April, 28-29 (AIT)

    ...registration still open!

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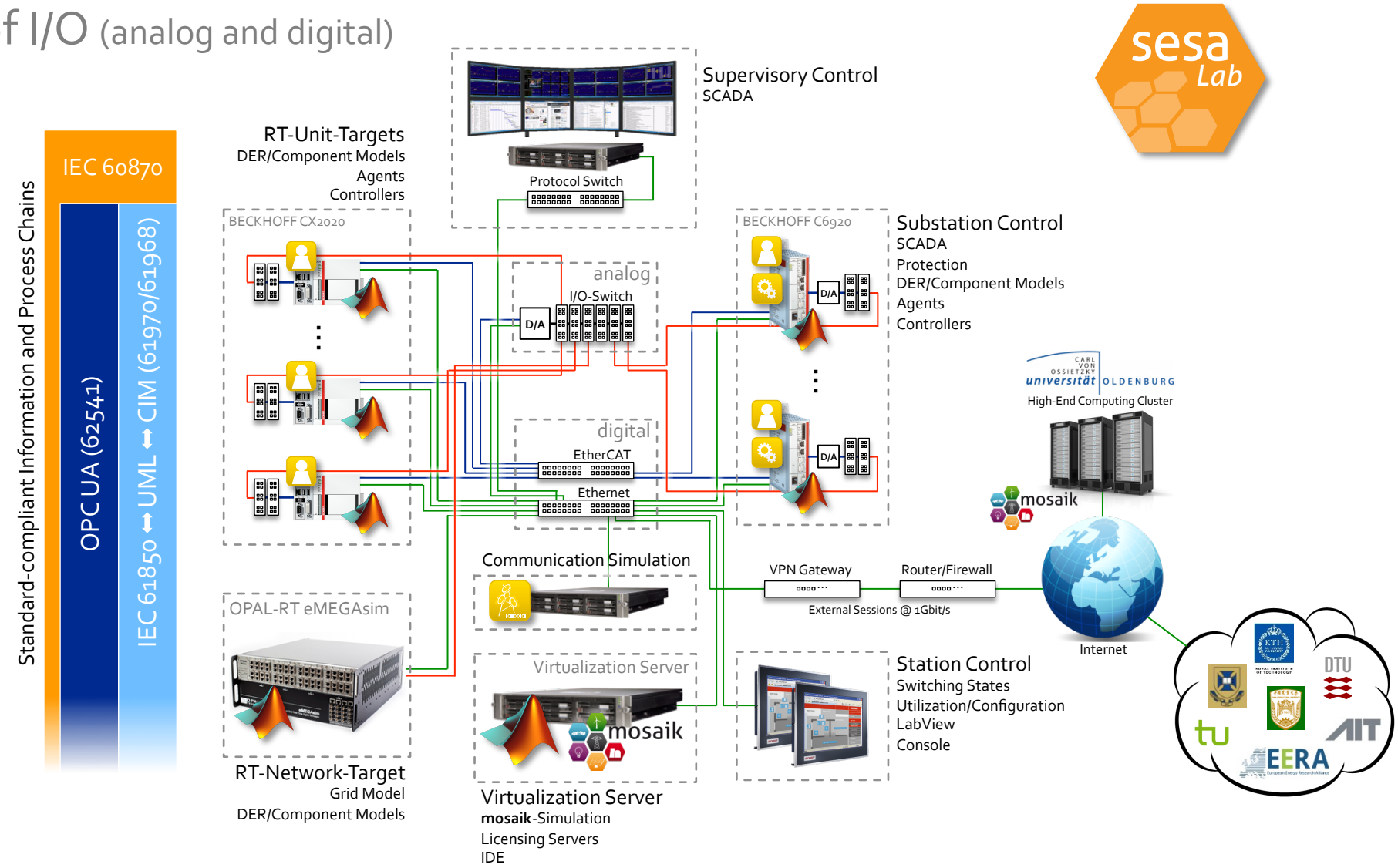
Topology-free Interconnection and Assignment of I/O (analog and digital)

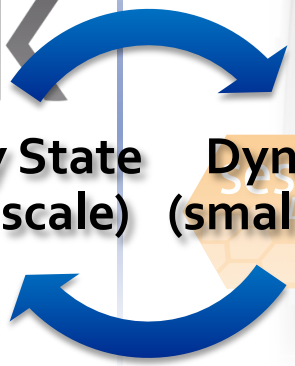


SESA-Lab

Smart Energy Simulation and Automation Laboratory

(Hard- and Software Integration Platform)

mosaik



- Hardware (emulation) in the simulation loop…
- Studying dynamic effects of a large amount of active components
  - Dynamic stability of distributed control
  - Oscillatory effects of market interactions
  - Dynamic effects of synchronized user behavior due to DR/DSM schemes

SESA-Lab

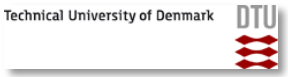
Mission

- Systematic design of operational concepts/controllers in more and more complex/extensive energy systems
- Development of tools/models for systematic integration and handling of heterogeneous/external models and processes
- SESA-Lab is NO replacement for existing tools and models
  - Integration platform for established tools and approaches
- Goal of energy informatics at OFFIS/University of Oldenburg
  - Interdisciplinary collaboration with domain experts from electrical engineering, economy, social sciences etc.
  - Creating system competence, developing system intelligence
- International network
  - **CO**-simulation-based energy **SY**stem **M**odeling pl**A**tform (COSYMA)
  - UC Berkeley/Berkeley National Lab (us), NREL (us), CMU (us), TU Delft (nl), AIT (at), DTU (dk), OFFIS (de)

References

Integration of *Aristo*
(Real-Time el. Grid Simulation)

Integration of Power Hardware (-in-the-loop),
Integration of *Modelica* Models through *FMI*



Integration of *SYSLAB*
(Flexible Intelligent Energy Laboratory)

Substation Modeling and Simulation,
Integration of MAS-based Transmission System Control

Integration of Real-Time Low-Voltage Grid Simulation
and State Estimation

Hybrid Simulation of large-scale
Distribution Networks

Statistical Scenario Design and Validation

What about you?

CARL VON OSSIETZKY universität OLDENBURG

OFFIS Energie
INSTITUT FÜR INFORMATIK

Thank you!

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