

# An Interdisciplinary Collaboration Platform for Smart Grid Research

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Energy Informatics



## 2 Energy Informatics in Oldenburg

### ▶ General Conditions

- ▶ energy transition in Germany
- ▶ fluctuating and decentralized energy generation
- ▶ increasing requirements on ICT-infrastructure

### ▶ Challenges

- ▶ integration, coordination und participation
- ▶ management of small or decentralized generators such as wind, sun and heat power production
- ▶ technical and/or market integration of decentralized or fluctuating generators

### ▶ University of Oldenburg

- ▶ masters programme “ICT for the energy industry”
- ▶ “energy information systems”, “smart grid management”, “modeling and simulation of future energy systems”, ...

### ▶ OFFIS – Institute for Information Technology

- ▶ application-oriented ICT research institute
- ▶ ~200 researchers (transportation, health, energy (~50))



Energie  
Energy

## 3 Topics and Groups in the Energy Division

OFFIS – Institute for Information Technology

- ▶ **System analysis and Optimization (SO)**
  - ▶ Technical and economical system analysis
  - ▶ Distributed heuristic optimization
- ▶ **Architecture Engineering and Interoperability (AEI)**
  - ▶ Methods for smart grid project management: maturity stages and cost models
  - ▶ Technical standards and information integration
  - ▶ Cross-sectional topics: security and interoperability
- ▶ **Smart Resource Integration (SRI)**
  - ▶ System-oriented consumers / energetic neighborhoods
  - ▶ Modelling of system components and their behavior
  - ▶ Big Data for energy data management
- ▶ **Simulation and Automation of complex Energy systems (SAE)**
  - ▶ Automation technology
  - ▶ Modular and scalable simulation of Smart Grids



Dr. Christoph Mayer  
Group Manager SO (temp.)



Dr.-Ing. Mathias Uslar  
Group Manager AEI



Dr.-Ing. Sven Rosinger  
Group Manager SRI



Dr.-Ing. Sebastian Rohjans  
Group Manager SAE

# Relevant Influencing Factors of Future Energy Systems

- ▶ Interconnection of hitherto loosely-coupled systems
  - ▶ Renewable – fossil generation
  - ▶ Distribution grid – transmission grid
  - ▶ Users – consumers
  - ▶ Power – gas – heat
  - ▶ Markets
  - ▶ ICT
  - ▶ ...



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

# SESA-Lab

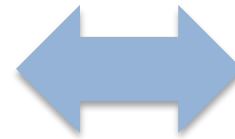
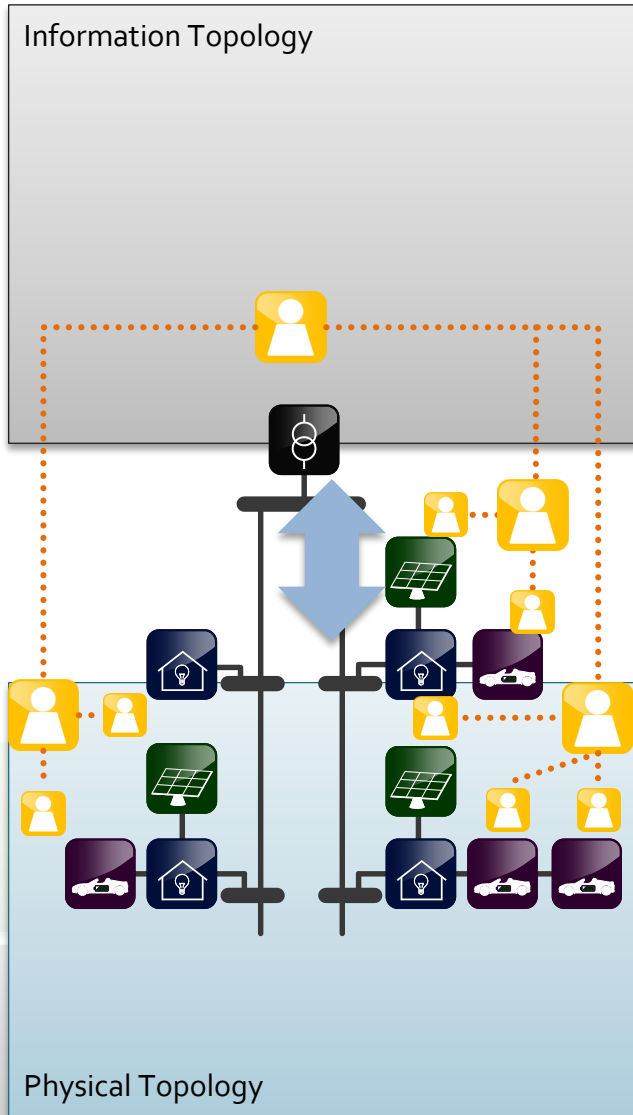
Smart Energy Simulation and Automation Laboratory  
(Hard- and Software Integration Platform)



Co-Simulation Framework  
(OFFIS – Institute for Information Technology)



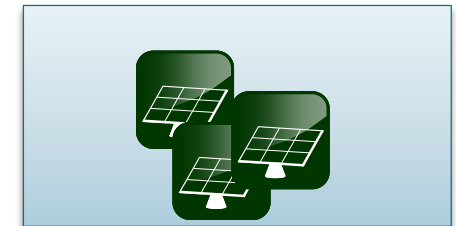
Real-time Automation Lab  
(University of Oldenburg)



### Consumers (Modelica)



### PV-Model (MATLAB)



### EV-Model (Python/Jade)



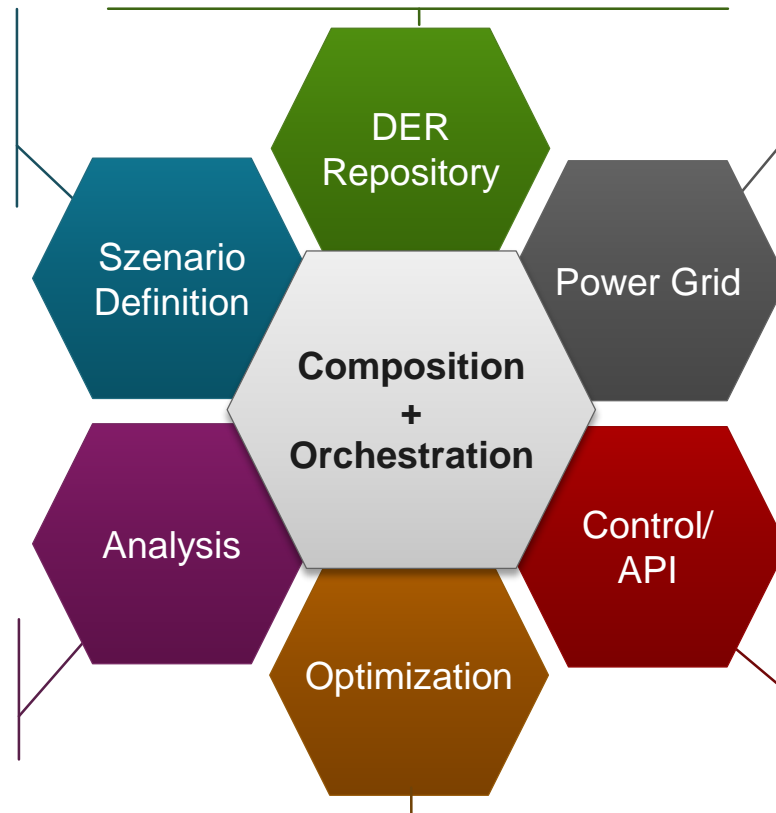


## Component Models/Interfaces



Scenarios  
- Tool-Support  
- Hierarchical  
- Scalable

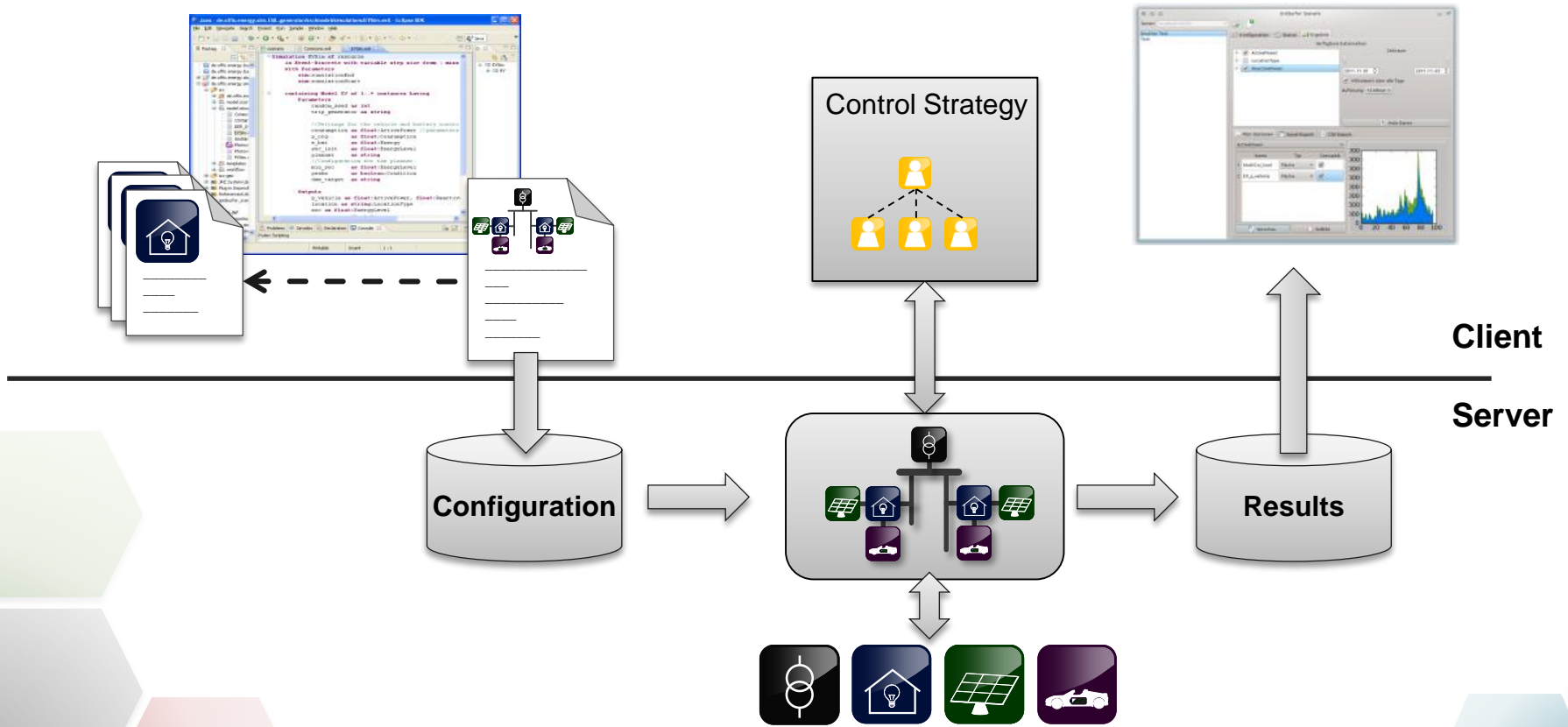
Power Grid Simulators  
- COTS-Tools (Power Factory)  
- OSS Tools (PyPower)  
- ...



## Experimental Design/Optimization

Analysis  
- Event Databases  
- Tooling for Data Mining

- Synchronization  
- Standard-compliance  
- Real-time coupling (Wall Clock)





- ▶ Software suite developed at the OFFIS for automatic composition and orchestration of heterogeneous energy system models
- ▶ Flexible interfaces for simulators (grids, markets, environment etc.) and controllers (users, intelligent ICT etc.)
- ▶ Powerful scenario description language (rule-based instantiation and coupling of models)
- ▶ coordinated execution (simulation)
- ▶ After test phase with international research partners **Open Source** available (<http://mosaik.offis.de>) since March 2014
  - ▶ Currently ~1.500 downloads per month



# Practical Hands-on Workshops

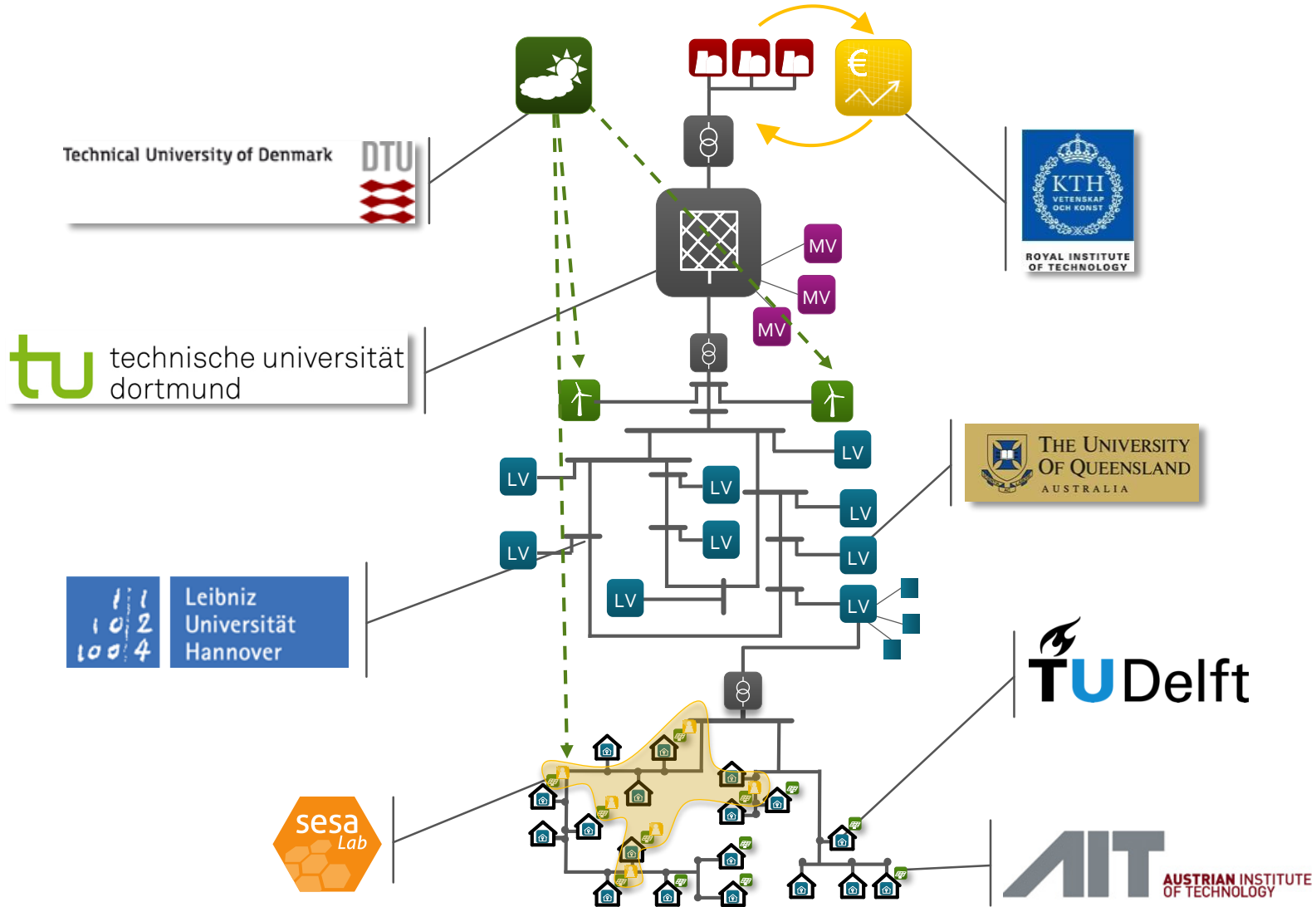
## and PhD-Students Exchanges

- ▶ Hands-on model integration (simulators and hardware)
- ▶ Recent workshops on 24.09.2014
  - ▶ DTU Denmark (Sept. 2014)
  - ▶ Carnegie Mellon University, Pittsburgh (March 2015, DFG-sponsored)
  - ▶ AIT Vienna (April 2015)
  - ▶ ~20 international participants from el. engineering, physics, mathematics and computer science
- ▶ “Bring your own model/simulator!”
- ▶ Integration into coupled experiments
  - ▶ Capturing of domain knowledge
  - ▶ Identification of inter-/transdisciplinary research questions



# Collaborative Smart Grid Experiments

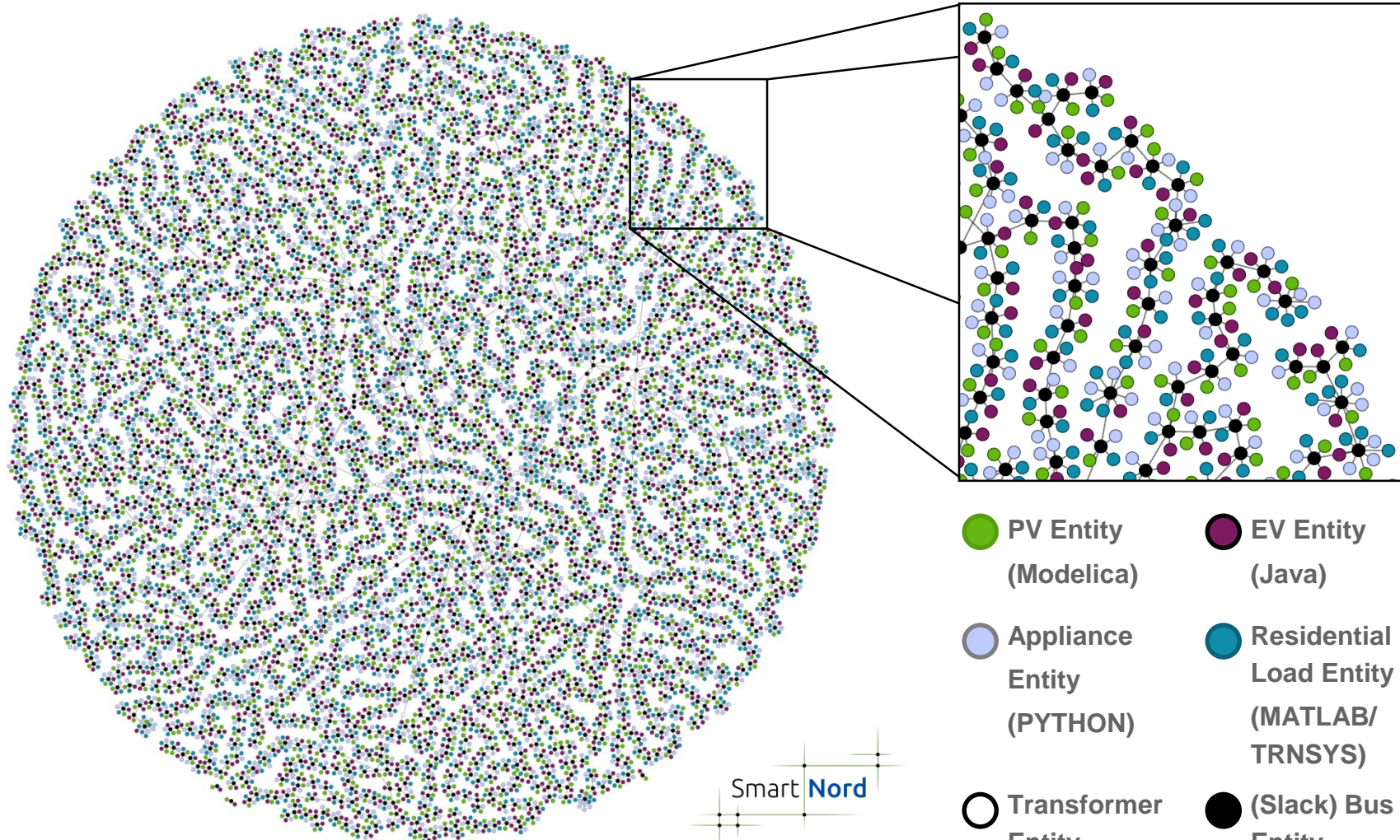
with SESA and mosaik





# Large-Scale Scenarios

## Research Network "Smart Nord"



~8.000 grid nodes (MV/LV), ~ 55.000 simulated entities

- |                                   |   |
|-----------------------------------|---|
| PV Entity<br>(Modelica)           | EV Entity<br>(Java)                               |
| Appliance<br>Entity<br>(PYTHON)   | Residential<br>Load Entity<br>(MATLAB/<br>TRNSYS) |
| Transformer<br>Entity<br>(MATLAB) | (Slack) Bus<br>Entity<br>(PyPower)                |

# SESA-Lab

Smart Energy Simulation and Automation Lab  
(Hard- and Software Integration Platform)



Co-Simulation Framework  
(OFFIS – Institute for Information Technology)



Real-time Automation Lab  
(University of Oldenburg)

# SESA-Lab

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

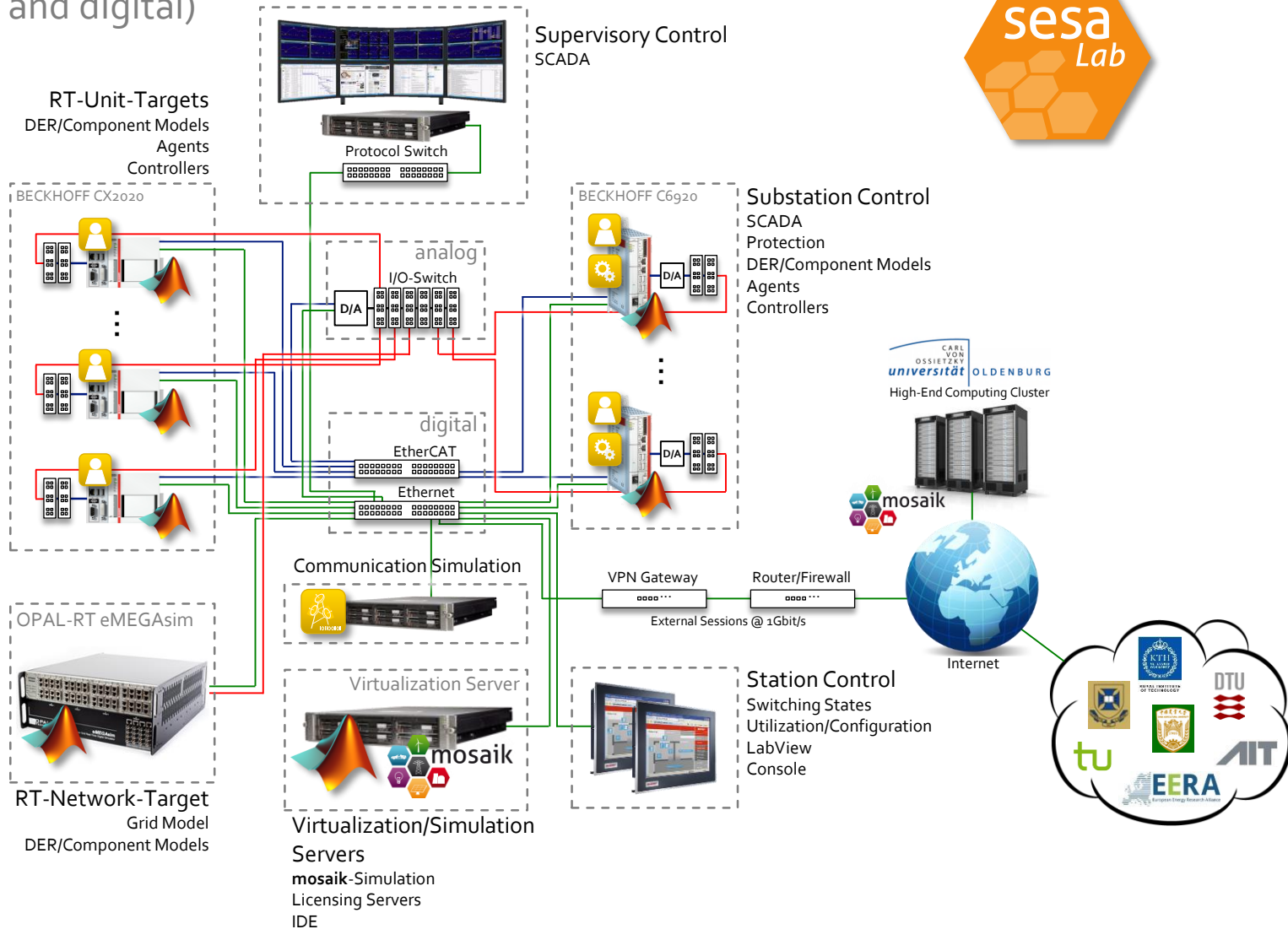


Standard-compliant Information and Process Chains

IEC 60870

OPC UA (62541)

IEC 61850 ↔ UML ↔ CIM (61970/61968)



- ▶ mosaik and SESA-Lab are NO replacement for existing tools and models
  - ▶ Integration platform for established tools and approaches → put in broader context
- ▶ Goal of energy informatics at OFFIS/University of Oldenburg
  - ▶ Interdisciplinary collaboration with domain experts from electrical engineering, economy, social sciences etc.
  - ▶ Orchestration, creating system competence, developing system intelligence
- ▶ **Numerous fundamental research challenges**
  - ▶ Uncertainty quantification of black-box multirate/multiscale co-simulations
  - ▶ Automated generation/validation of large-scale scenarios
  - ▶ Stable/resilient system design/optimization
  - ▶ ...
- ▶ International network (under construction)
  - ▶ **CO**-simulation-based energy **SY**stem **M**odeling **plA**tform (COSYMA)
  - ▶ UC Berkeley/Berkeley National Lab (us), NREL (us), CMU (us), TU Delft (nl), AIT (at), DTU (dk), OFFIS (de), ...







Thank you!

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