communication simulation with agents

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Who are we?

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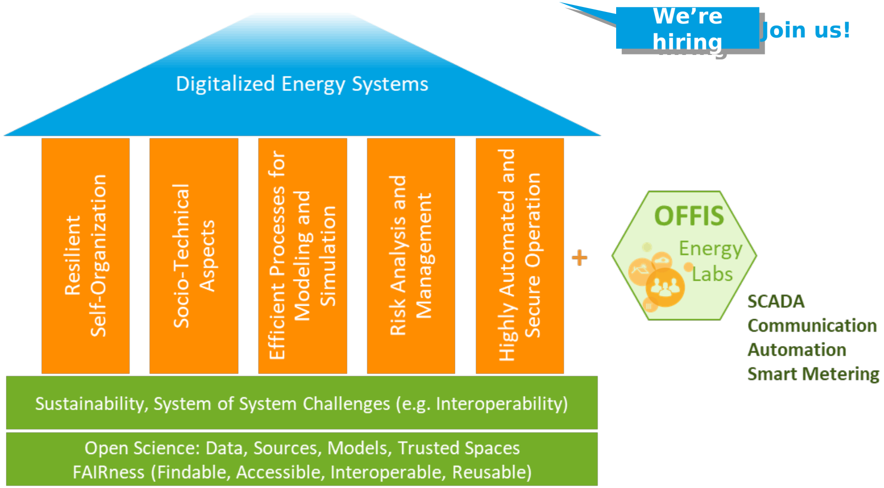
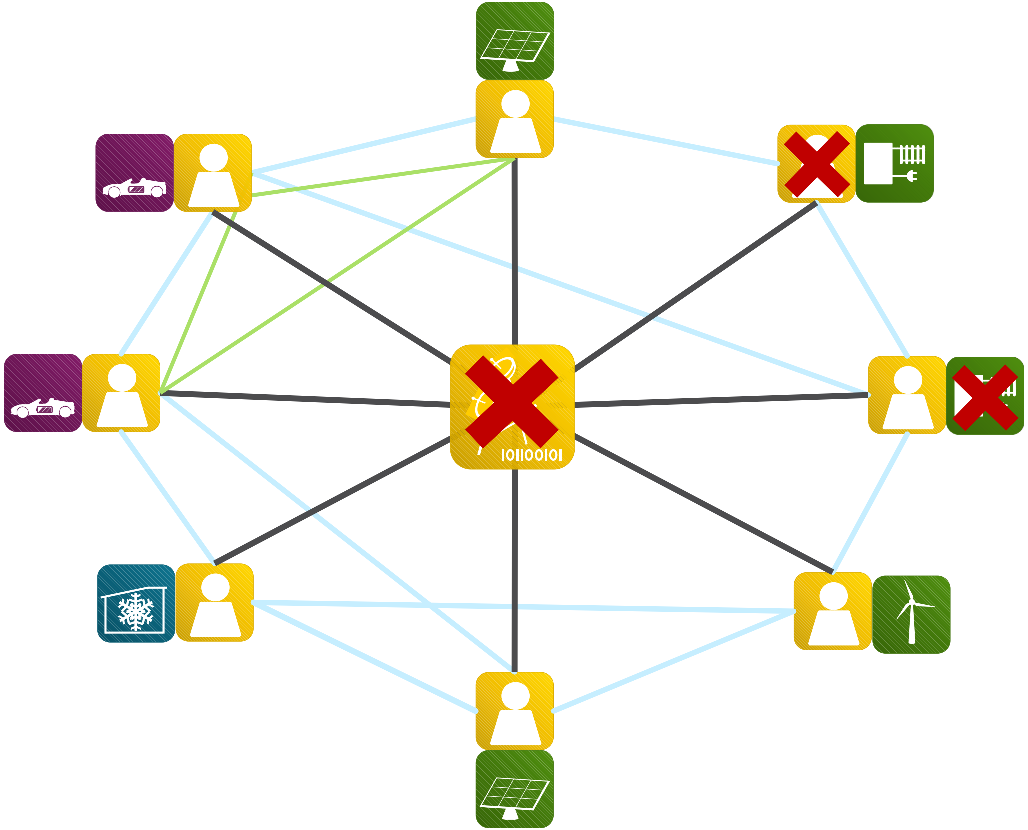
OFFIS– Institute for Information Technology

- State-funded Research Institute in Oldenburg, Germany (founded in 1991)
  - 250 Scientist in 4 R&D Divisions (Energy, Health, Manufacturing, Society)
- Energy Informatics at OFFIS & UOL
  - 1995: First wind power information system in Germany
  - 2003: Early “decentralized energy management systems”
  - 2010: First Energy Informatics Professorship in Germany (we now have 4!)
  - 2022: ~30 ongoing research projects
    - Largest EI team in D/EU (>100 researchers)



Communication Use Cases in Energy Informatics



- Create MAS robust to failures
- Consider the interaction between power and communication system
- Optimize the communication flow for multiple smart grid applications

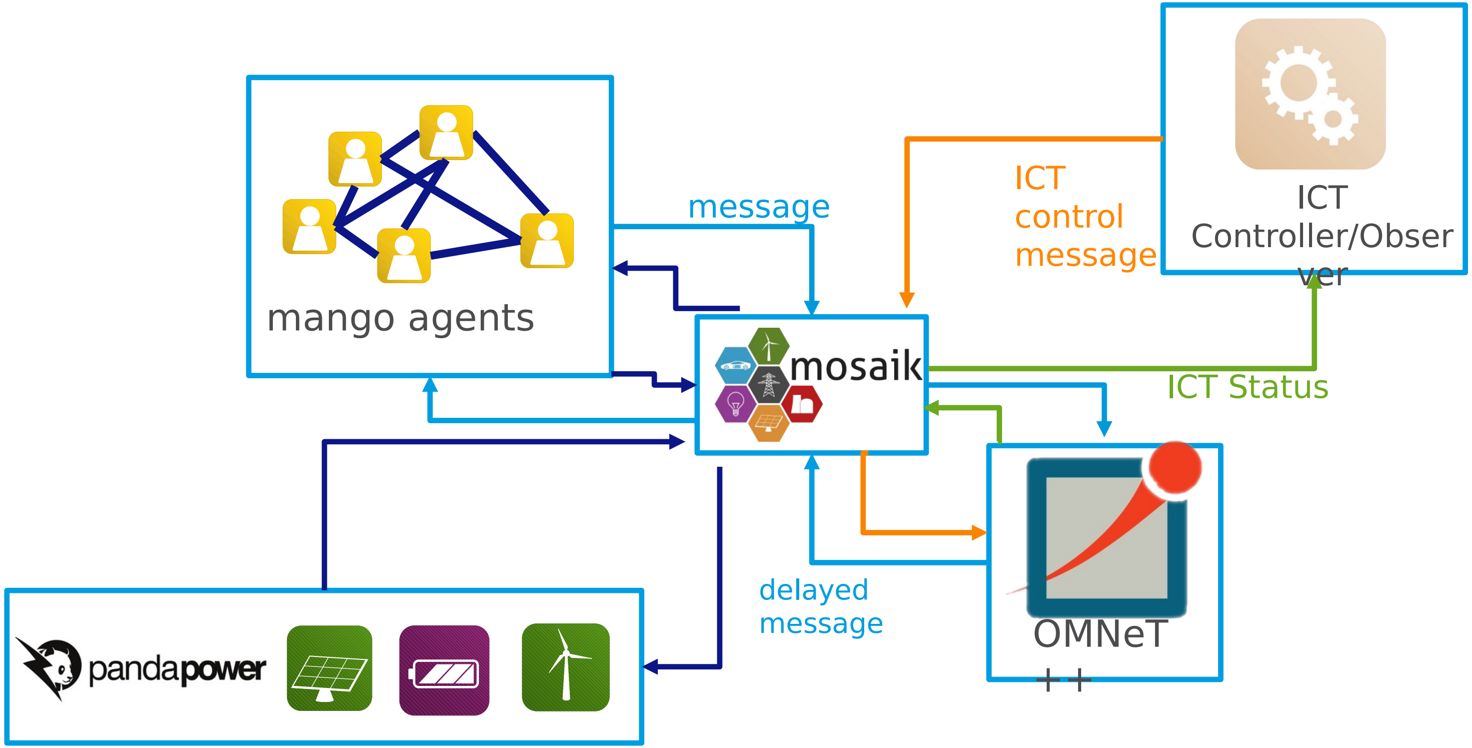
Requirements for the communication simulation

objectives for cosima

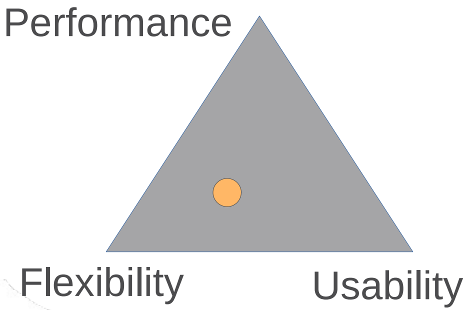
- Ability to model and simulate wired and wireless communication systems with regards to different OSI-Layers (e.g. 5G, LTE-A, Ethernet)
- Capability to flexibly and fast configure the network (e. g. by SDN)
- Able to ensure QoS (e. g. traffic shaping, prioritiziation)
- External control of networks
- Ability to manipulate infrastrucure devices in simulation runtime
- Co-simulation with power system to integrate information of OT availibility into the communication simulation

Envisioned Simulation Environment

with our MAS Framework mango and mosaik DES

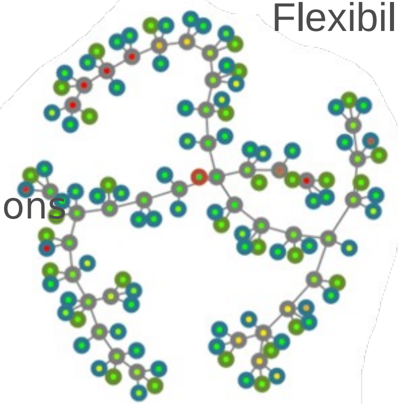


Co-simulation framework mosaik



Abilities and properties

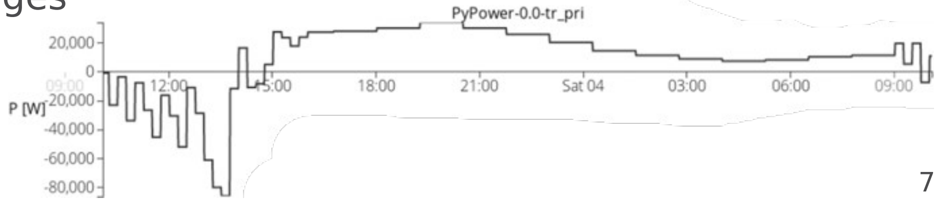
- Discrete time and discrete event simulation
- Accelerated and real time simulation
- Ability to integrate IP-protected components
- Scaling of simulations on compute clusters
- Python-based
- In principle: able to connect to simulators of all languages through TCP- and JSON-based connections



Open source (LGPL) https://gitlab.com/mosaik

Utility ecosystem

- Simulation models
- Wrappers for programming languages
- Interfaces for simulation tools
- Visualization and data storage



Mosaik 3.0.0.: Discrete Event Capabilitites

https://ieeexplore.ieee.org/abstract/document/9769116

Time-based

- >Simulation components can only schedule steps for themselves (regular times)
- >In order to not miss any potential message from other components, simulators have to step themselves for every simulation step
- >Performance Issues in some scenarios, where very high time resolution is needed (communication simulation)

Event-based (coming with mosaik 3.0.0)

- >state of the system can change at a specific time: simulator is stepped as soon as there is new data available
- >Can optionally still trigger themselves

Mosaik 3.0.0.: Discrete Event Capabilitites

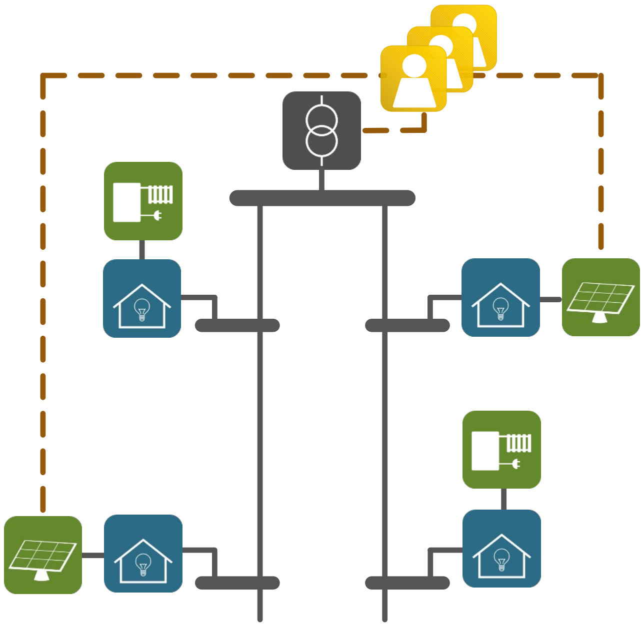
https://ieeexplore.ieee.org/abstract/document/9769116

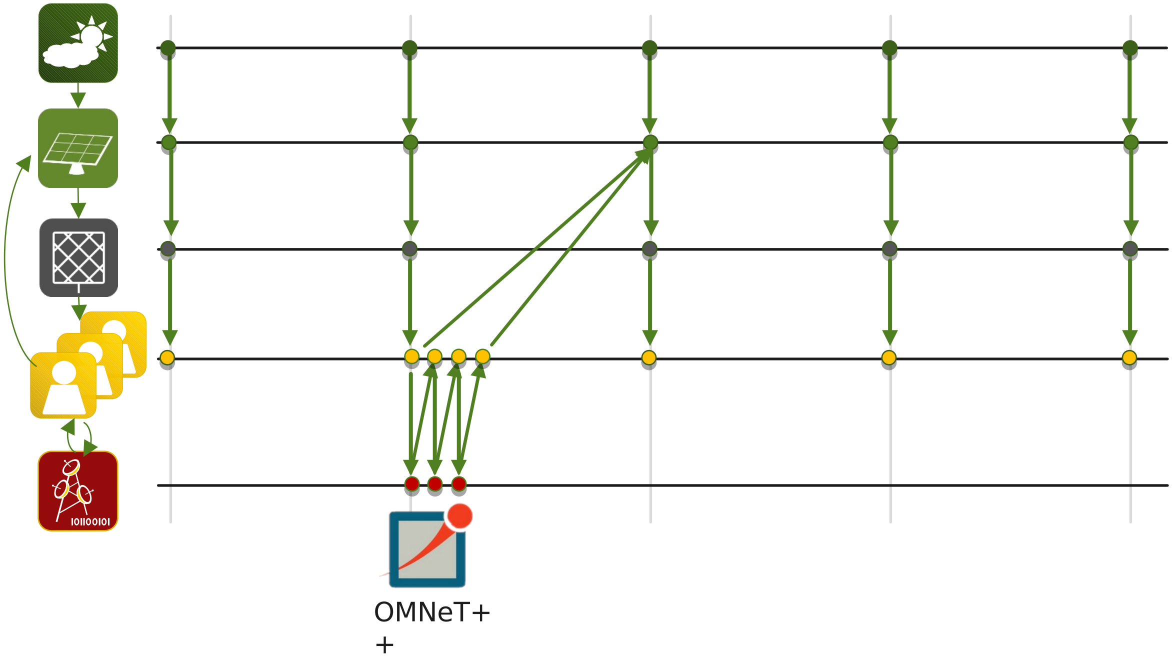
Event-based (coming with mosaik 3.0.0)

- Max_advance value
  - Information how far a simulator can advance in time without expecting new inputs
  - Simulator can progress until max_advance without being interrupted by mosaik and risking causality errors

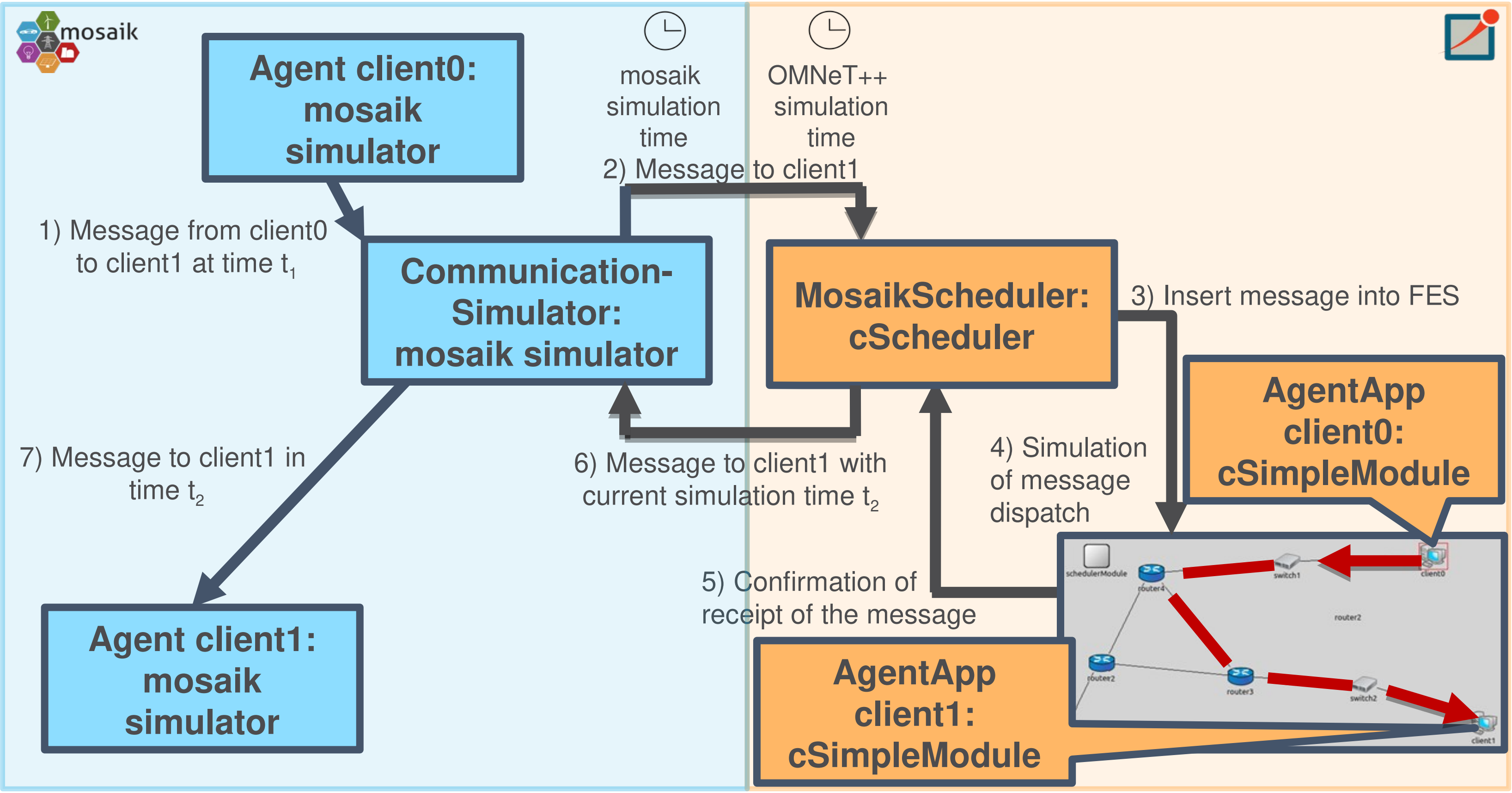
mosaik

Integration of communication simulation

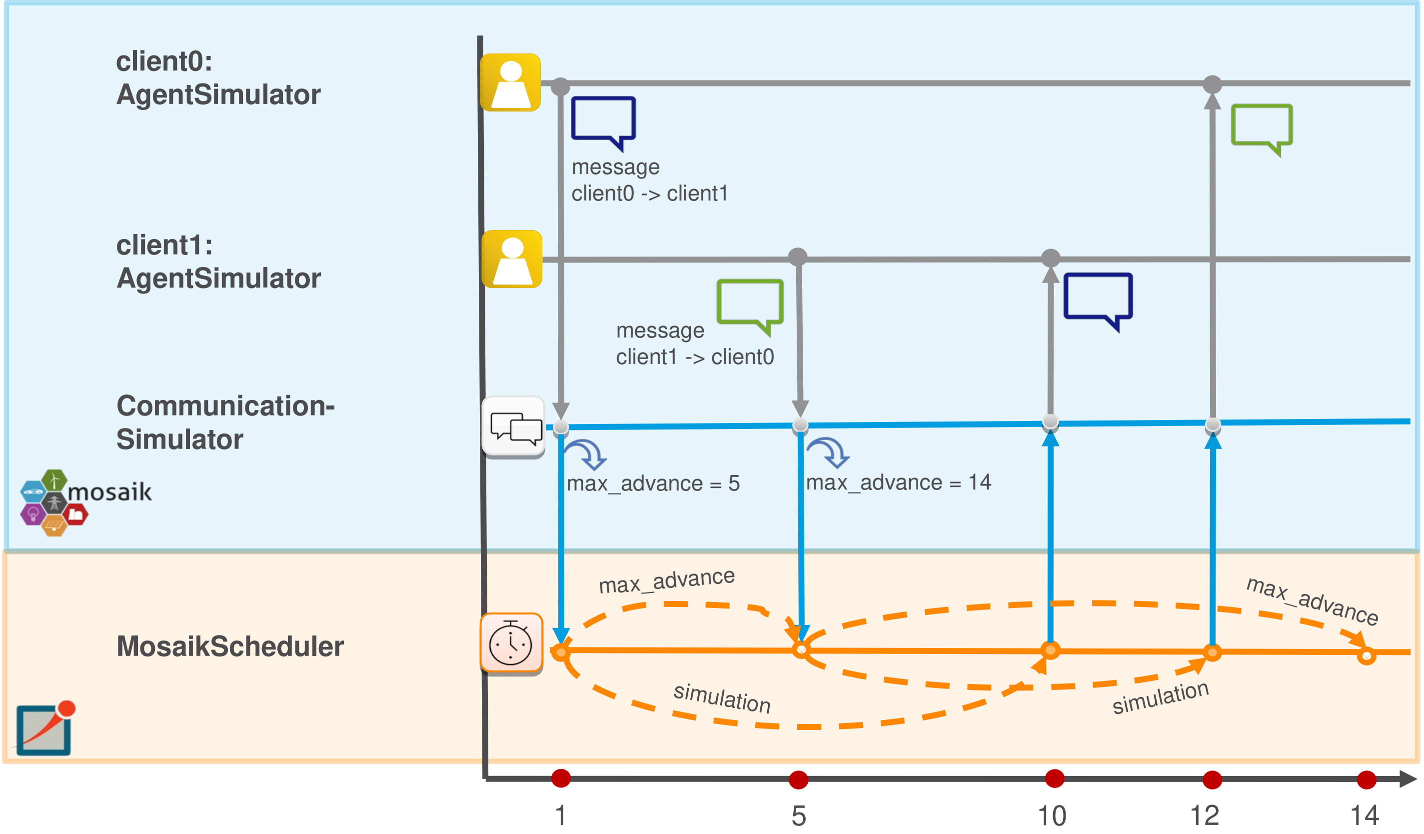




General Architecture



Synchronisation between mosaik and OMNeT++

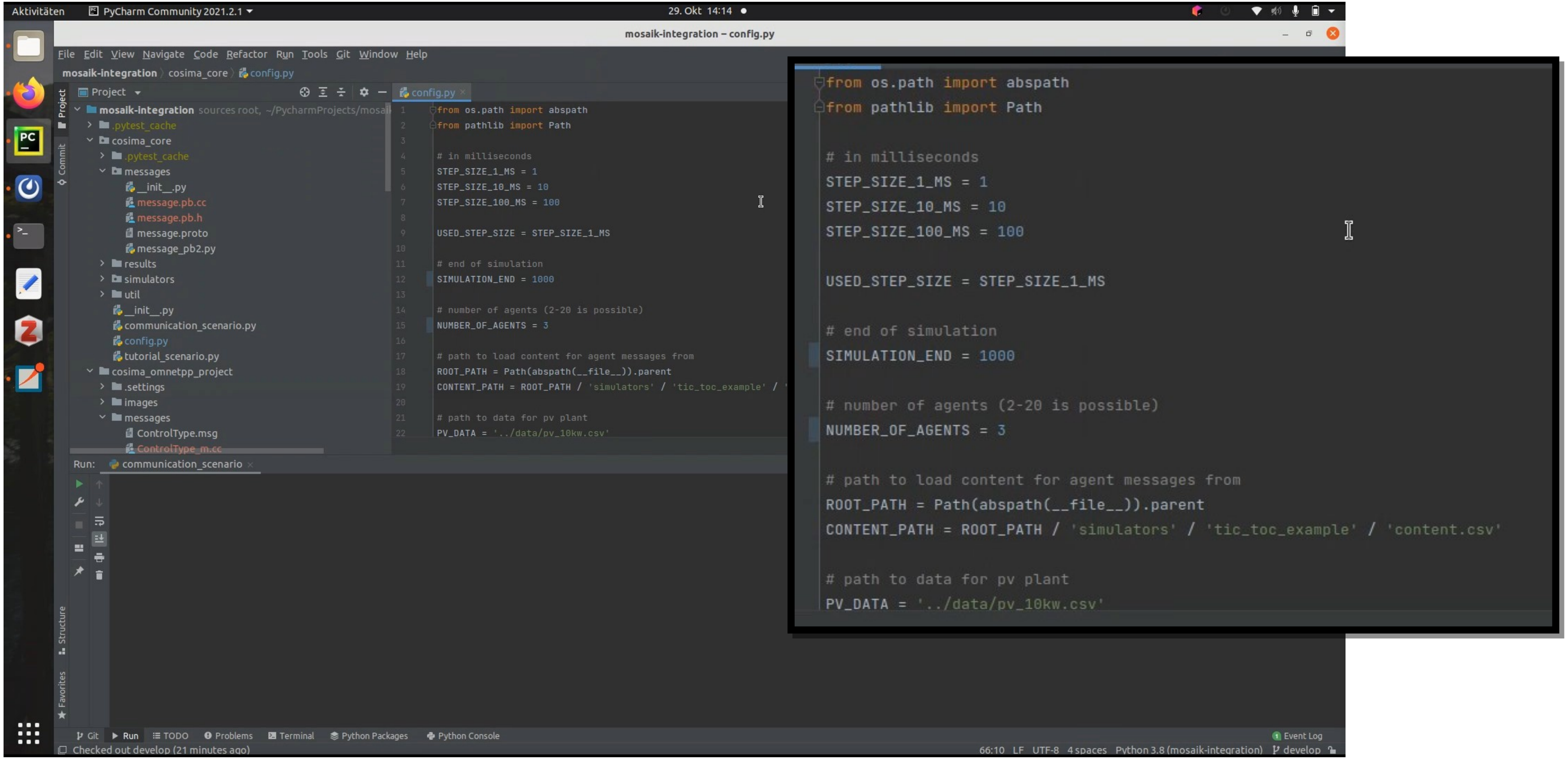


Features

- >Start modes using IDE or compiled executables (Qtenv or cmd)
- >Adjust the number of agents
- >Apply infrastructure changes (dis- and reconnects of clients, routers and switches) during simulation
- >Connect PV plant simulators to agent(s)
- > Multiple exemplary OMNeT++ networks
- >Overview of the simulation based on collected information
  - >e.g., number of simulation steps and evaluation graphs

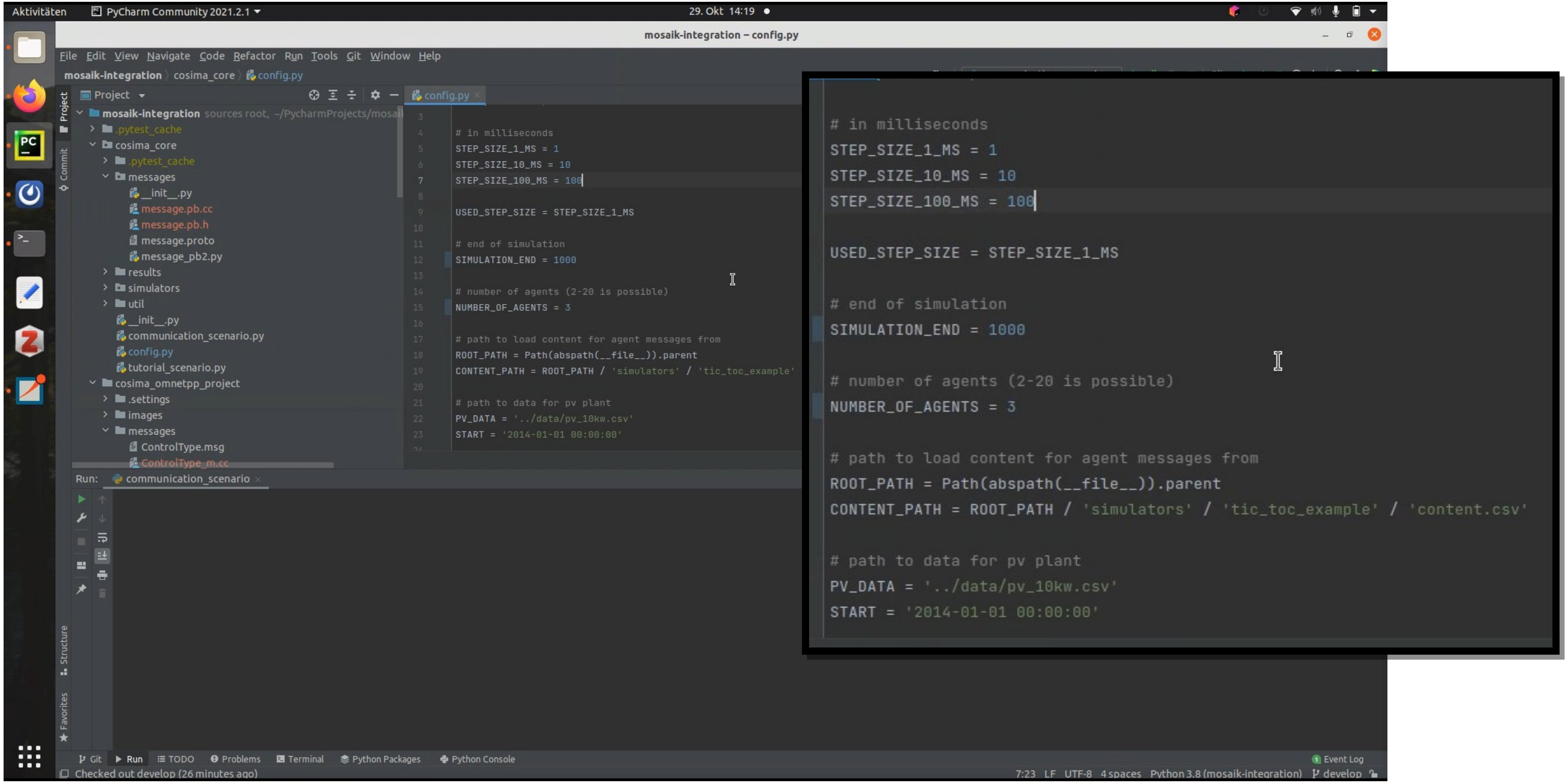
Scenarios

Disconnect end device client1 at time 2ms



Scenarios

Large Networks, 50 agents with PV plants



Evaluation

Comparing event-based and time-based simulation

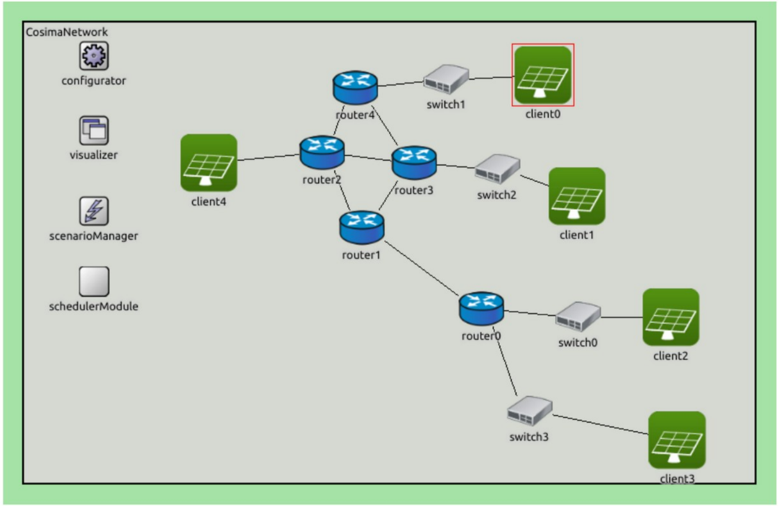


Fig. 3. Small network set-up in OMNeT++

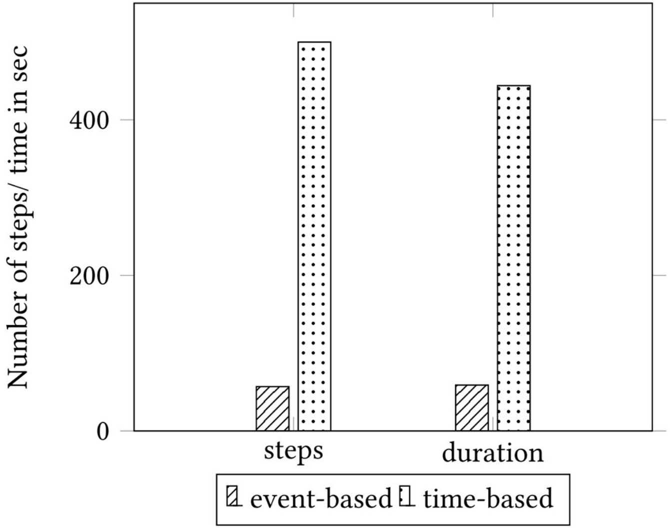


Fig. 4. Evaluation of steps and simulation duration

The number of simulation steps and the simulation duration are significantly higher for the time-based simulation.

Evaluation

Evaluation of scalability

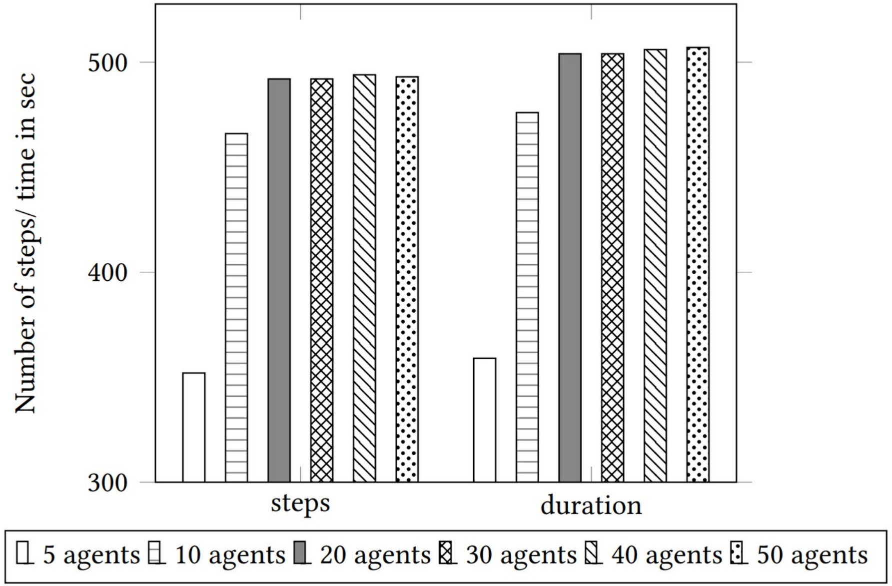


Fig. 6. Evaluation of steps and simulation duration

The number of simulation steps and the simulation duration do not significantly increase with the number of agents.

Future Work & Further Information

- Integrate the multiagent system library *mango* (https://gitlab.com/mango-agents/mango)
- Enhance usability
- Add more functionality to the ICT-controller

Further Information:

- cosima.offis.de
  - https://cosima.readthedocs.io
  - https://gitlab.com/mosaik/examples/cosima
  - Oest, F., Frost, E., Radtke, M., & Lehnhoff, S. (2022). *Coupling OMNeT++ and mosaik for integrated Co-Simulation of ICT-reliant Smart Grids*. In *arXiv*. https://doi.org/10.48550/arXiv.2209.12550
- https://www.offis.de/en/applications/energy/distributed-artificial-intelligence.html