Fraunhofer

IEE

FRAUNHOFER INSTITUTE FOR ENERGY ECONOMICS AND ENERGY SYSTEM TECHNOLOGY

Asynchronous Integration of a Real-Time Simulator to a Geographically Distributed Controller through a Co-Simulation Environment

Juan Montoya [1, 2]
Ron Brandl [1, 2]
Mike Vogt [1]
Frank Marten [1]
Marios Maniatopoulos [3]
Alejandra Fabian [4]

Contact:
juan.montoya@iee.fraunhofer.de
Phone: +49 561 7294-211

Fraunhofer IEE
Koenigstor 59
34119 Kassel/Germany

www.iee.fraunhofer.de/en

[1] *Fraunhofer Institute for Energy Economics and Energy System Technology, Kassel, Germany*

[2] *European Distributed Energy Resources Laboratories (DERlab) e.V., Kassel, Germany.*

[3] *National Technical University of Athens, Athens, Greece.*

[4] *DNV GL - Group Technology Research, Power and Renewables, Arnhem, Netherlands*

Coupling different research institutes via co-simulation

Two different simulators were interfaced over a distance up to 2800 km (Kassel-Athens) through an asynchronous TCP/IP communication into a distributed co-simulation. This work has been motivated by:

- Sharing resources of different RIs.
- Assessing latencies and delays of two geographically distributed simulators
- Defining boundaries for the co-simulation environment.

Defining boundaries and setting up the experiment

Three main components involved:

- OPAL-RT® Simulator
  - Photovoltaics (PV)
  - Battery Energy Storage System (BESS)
  - On-Load Tap Changer (OLTC)
  - Based on CIGRE LV Grid
- Coordinated Voltage Control (CVC)
  - OPF Solution
  - P/Q control for PV and BESS
  - OLTC control
- OpSim
  - Message Bus Architechture
  - Conservative Synchronization

Fig. 1 depicts the test case, and its 3 different types of connection through OpSim.

In Fig. 2 is shown how OpSim manages the exchange of information between the OPAL-RT® Simulator and the CVC, paying special attention to the data transactions, identifying 12 time-related variables.

For the co-simulation test case, the experiment was performed multiple times, using different publish rates for OpSim. A publish rate of **5s** was selected for the CVC, while the OPAL-RT® simulator was tested with 5 different publish rates: **500ms**, **1s**, **2s**, **3s**, and **4s**.

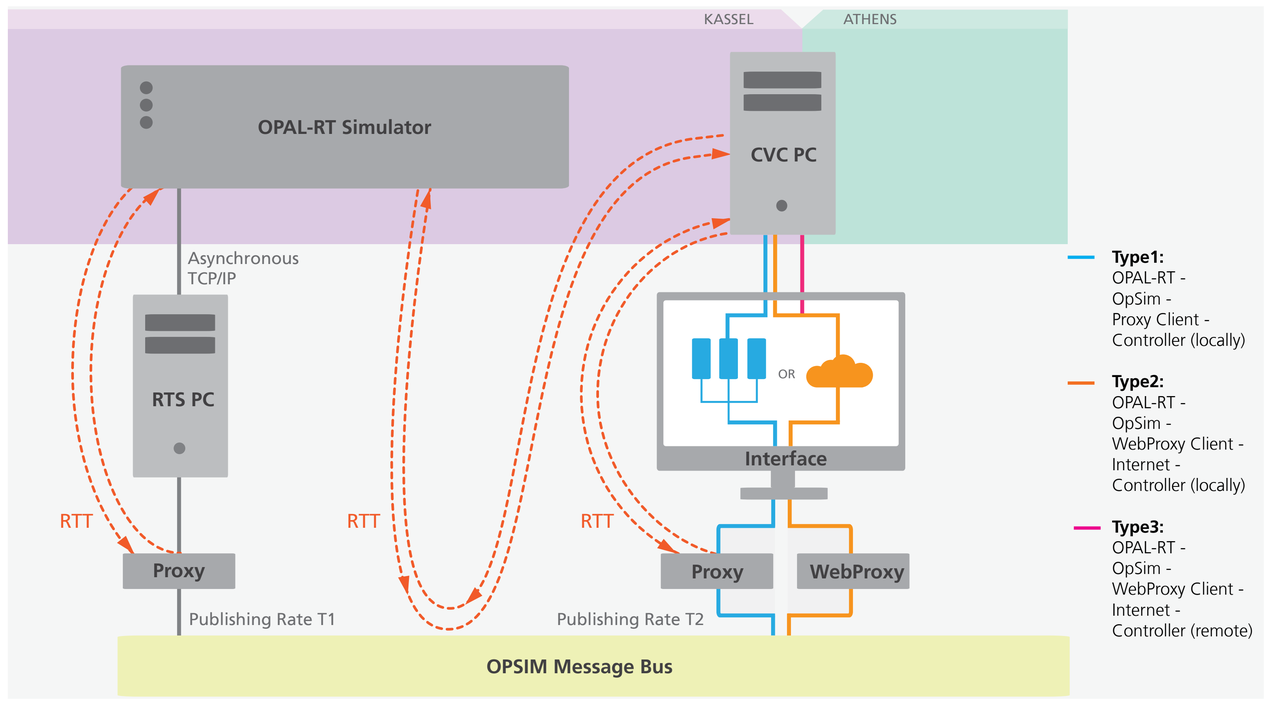

Figure 1: Test case setup

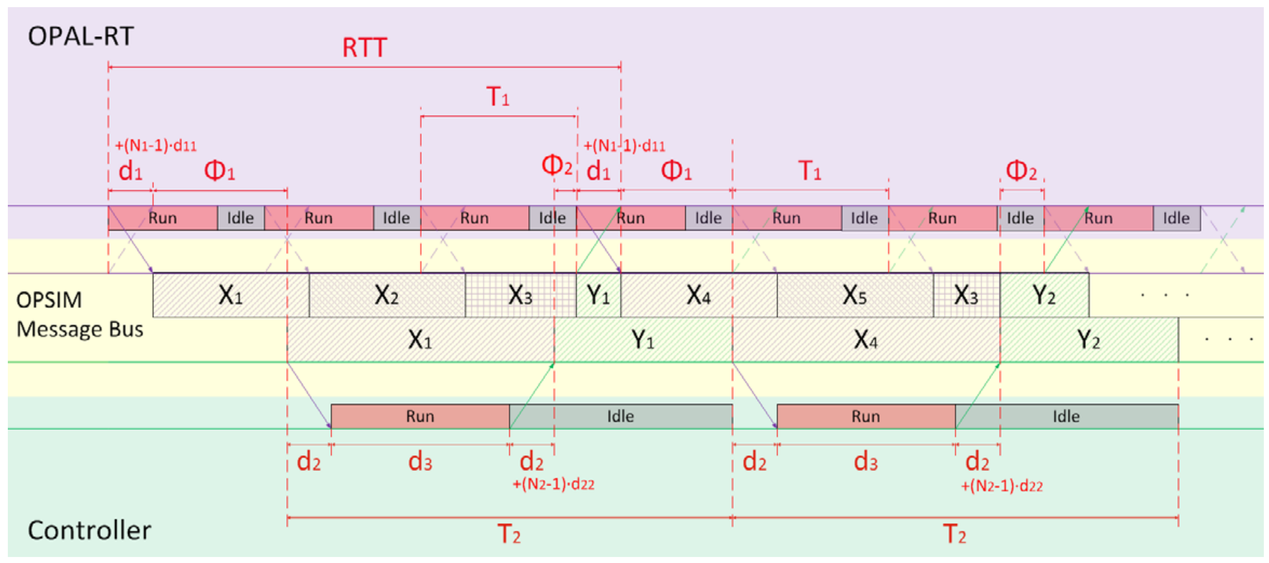

Figure 2: OpSim MB time behavior with one power system simulator (OPAL-RT) and a controller

Validation

The error between the co-simulation and software simulations is small. The most interesting observation is related to the results of the State of Charge (SoC) of the BESS (Fig.3).

For modeling purposes in the RTS, SoC is estimated based on the energy stored in the BESS. Energy is calculated by integrating the active power of the BESS over time and, as a result, even slight differences in timing have a noticeable effect on the SoC results.

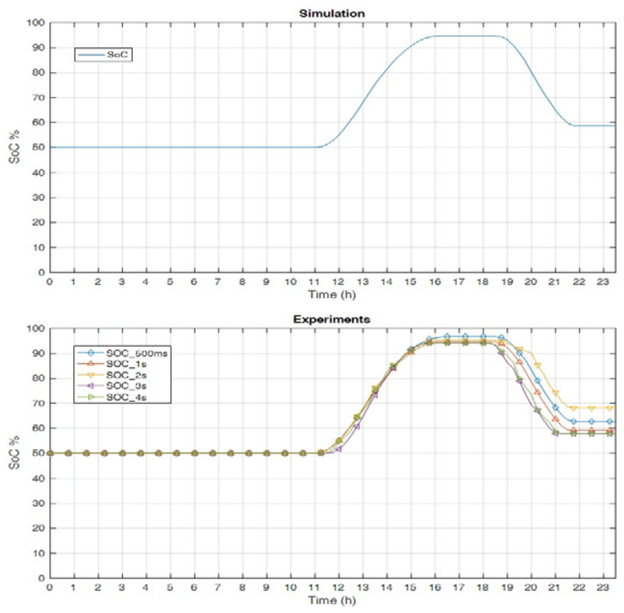

Figure 3: Daily profile of the State of Charge of the BESS, for the reference simulation test (Top) and the 500ms, 1s, 2s, 3s, and 4s publish rate experiments. (Bottom)

OpSim: Real-Time capabilities for distributed simulators

The results presented show an accurate response compared to a reference software simulation test, confirming the real-time capabilities of OpSim to integrate asynchronously geographically distributed simulators, suitable for applications of low-bandwidth grid voltage control.

The experiment is planned to be extended with physical laboratory-based domains, to enhance hardware validations methods (HIL capability) and combine various research facilities with several simulations and controllers to an overall holistic testbed.

Supported by the H2020 Programme under Contract No. 654113

We acknowledge the support of our work by the European Community's Horizon 2020 Program (H2020/2014-2020) within the project "ERIGrid: European Research Infrastructure supporting Smart Grid Systems Technology Development, Validation and Roll Out" (Grant Agreement No. 654113).