MOSAIK - A FLEXIBLE SMART GRID CO-SIMULATION FRAMEWORK

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Power system simulation and assessment in the context of future smart energy systems is a key facet of evaluating the efficiency (or even feasibility) of novel "intelligent" control schemes. While future energy systems comprise a large variety of complex systems and domains (markets, weather environment, users, information and communication technology (ICT) systems etc.) the electrical grid utilization and dynamic behavior still takes on a dominant role as the primary infrastructure with its critical operational constraints. Thus, simulating the power grid is usually essential to all energy system simulations. Commercially available power flow simulators (PFS), yet powerful, are usually expensive and tend to be rather complicated to use as they oftentimes integrate functionalities for modeling additional operating equipment, load dynamics or controller behavior, or provide environments to perform parameter optimization such as OPF. Open source PFS, on the other hand, are free of charge, oftentimes very straight forward to use, but provide less functionality in terms of modeling, higher optimization functions etc.

A promising way to use the advantages of open source PFS without having to forgo the comfortable use of modeling environments for secondary components, load/generation behavior etc. as well as higher optimization functions is the use of co-simulation environments that facilitate the use and coupling/orchestration of different simulators (e.g. proprietary runtime environments such as MATLAB, Modelica) and frameworks for data analytics and optimization (e.g. IBM ILOG CPLEX, SPSS etc.). However, even with providing technical solutions for coupling and using open source PFS implementations, the question of correctness and accuracy remains. While commercially available PFS have the clear advantage of being well established and thus well trusted by the industry, it is oftentimes unclear if freely available PFS produce the same results and thus are "as good as" established – probably even verified – commercial PFS.

In [1], requirements for future Smart Grid simulation tools are presented. In order to keep pace with the current velocity of technical and societal changes to the energy system, it is imperative for the development of future Smart Grid simulation tools not to "re-invent the wheel" but rather to re-use already existing models and simulators of relevant facets and subsystems. This requires developing integration platforms that allow for flexible co-simulation composition. Since 2010 the University of Oldenburg together with the OFFIS – Institute for Information Technology has been developing the Smart Grid co-simulation framework *mosaik* [2] allowing for functional coupling of heterogeneous hard- and software simulators. This concept takes co-simulation for future energy systems to a new level: it facilitates the composition of energy system simulators and their environments based on existing component models, specialized tools from different domains as well as hardware setups that may be operated at a single site or distributed and connected through the Internet. Mosaik has been published[1] as Open Source Software in March 2014 and registers a strongly growing community.

Mosaik's main goal is to use existing simulators in a common context in order to perform a coordinated simulation of relevant future energy system scenarios. That means that all simulators (or other tools and hardware-in-the-loop components) involved in a simulation are executed as individual processes each with its own event loop. Mosaik synchronizes these processes and manages the exchange of data between them. To facilitate this, mosaik:

1. provides an API for simulators to communicate with mosaik,
2. implements handlers for different kinds of simulator processes,
3. allows the systematic composition of extensive simulation scenarios involving the different simulators, and
4. schedules the step-wise execution of the different simulators and manages the data-flows between them.

Although mosaik is implemented in Python 3, its simulator API is completely language agnostic. This allows for coupling of simulators and models implemented with any technology such as any other version of Python, Java, C (++/#), MATLAB or FMI/Modelica etc.

With its high-level API for coupling existing simulator and runtime environments for specific component models it allows for using trusted simulation environments within the context of a comprehensive energy system (co-)simulation. On the one hand, this reduces learning/training overhead with new tools. On the other hand, it enables substituting detailed (possibly dynamic) and computationally expensive simulators with coarser (discretized) simulators – if feasible – for the sake of performance, supporting budget (time) oriented design of experiments.

References

[1] S. Rohjans, S. Lehnhoff, S. Schütte, F. Andren, and T. Strasser, „Requirements for Smart Grid Simulation Tools," IEEE 23rd IEEE International Symposium on Industrial Electronics, 2014.

[2] M. Büscher, A. Claassen, M. Kube, S. Lehnhoff, K. Piech, S. Rohjans, S. Scherfke, C. Steinbrink, J. Velasquez, F. Tempez, and Y. Bouzid, „Integrated Smart Grid Simulation for Generic Automation Architectures with RT-LAB and mosaik," in 5th International Conference on Smart Grid Communications, Venice, 2014.

[1] http://mosaik.offis.de