

DOTs

Further evolution of an open-source energy system simulation platform

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Abstract: DOTs is a co-simulation platform that has the vision of becoming a valuable research tool for energy system research in the Netherlands. The platform has been used in a tariff instrument study in the Netherlands. The paper describes the architecture of the platform and the future development path.

Keywords: co-simulation, energy-system

An end to end Co-simulation workflow

With the energy transition in progress, the electricity grid is transforming from a grid with central generation using large fossil-fueled power plants to a grid with decentralized electricity generation using smaller distributed energy generators such as solar panels and windmills. Due to these changes, new challenges arise for the electricity grid as the grid was not designed for distributed generation. To overcome the challenge of grid congestion, policy makers are tasked with implementing policies that reduce congestion and keep the electricity grid accessible to everyone. To gather insights into the effectiveness of different policies, researchers require tools to easily implement different policies on an energy system level. Such tools would make it very easy and accessible to test certain policies on an accurate model of the energy system as a whole. A commonly used method for energy system research is co-simulation. This is the process of coupling multiple simulators together and letting them interact with each other. Although there are co-simulation tools out there such as Mozaik [1], Helics [2] or Gridlab-D [3] a fully integrated platform with a standardized way of working seems to be lacking. Hence, the goal of our research is to develop a co-simulation platform that offers tools for answering a wide variety of energy system research questions.

A start has been made in developing a tool chain that has the goal of accurately simulating the Dutch energy system as a whole. Distributed Orchestrated Time Simulation (DOTs) is a recently developed open source co-simulation platform for the energy system [4]. The platform currently offers a solution for the software engineering challenges regarding co-simulation. To combat the challenge of grid congestion in the Dutch electricity grid, DOTs has been utilized for research on net tariff instruments [5]. In this study, low-voltage networks of different sizes have been evaluated to determine their ability to eliminate congestion using different net tariff schemes.

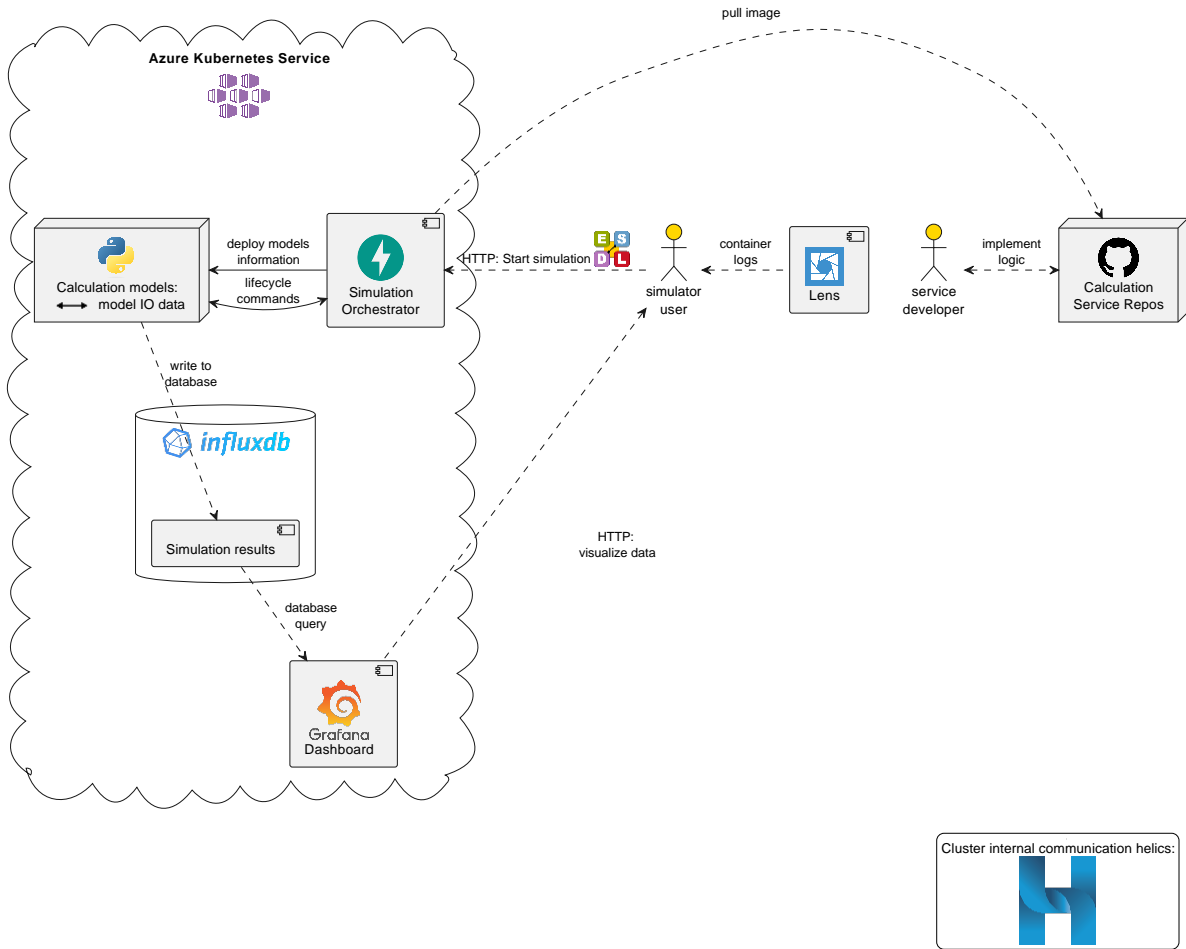


Figure 1. Architecture overview of the DOTs platform [6]

The architecture of DOTs is designed such that researchers can implement a model of an energy asset and deploy it in a DOTs co-simulation. In addition, the architecture makes use of existing open source tools which have proven themselves in industry as well as in research. In Figure 1 the architecture of the DOTs platform is depicted. The proposed way of working consists of five steps. First, researchers can develop a model (or in DOTs terms a calculation service) for an energy asset and manage that in a Github¹ repository, i.e. the rightmost part of Figure 1. Second, within the Github repository, automated workflows are in place to build a Docker Image² of the model. The third step for a researcher is to develop their energy system scenario. With the help of a domain specific language (DSL) called the Energy System Description Language (ESDL)³, an energy system scenario can be described in a single file. The ESDL file can describe anything an energy system would entail, for example, energy networks, energy assets, or demand profiles. Fourth, with the developed ESDL file the researchers can start the co-simulation of their energy system with a web interface. The behavior of the energy system is determined by the earlier developed models. The platform will take care of deploying all the models to an Azure Kubernetes⁴ cluster where all the models interact with each other using Helics⁵ [2]. Finally, once the simulation is finished, the

¹<https://github.com/>

²<https://docs.docker.com/get-started/docker-concepts/the-basics/what-is-an-image/>

³<https://www.esdl.nl/>

⁴<https://kubernetes.io/>

⁵<https://helics.org/>

results will be written to an InfluxDb⁶ database. After the results have been written into the database, researchers can analyze the results using Grafana⁷, which is a data dashboard tool to visualize the data. This architecture enables researchers to develop models specific for their research and allows them to reuse existing models. Existing models can be reused by simply reusing docker images that have been build in the third step. In addition, ESDL allows researchers to describe their energy system in a uniform way which can be shared with other researchers.

Our wish is to extend this tool chain with scenario generation tools, co-simulation debug tools, and an extensive library with out-of-the-box validated energy system models. A scenario generation tool will include the generation of different energy system scenarios. The tool will be based on open real data from the Dutch energy system. Generated scenarios will entail load profiles of energy system assets, environmental profiles, and topologies of different types of energy networks, such as heat electricity or gas. In turn these scenarios can then be used by researchers to test new hypothesis on different types of energy systems. Furthermore, to aid researchers in the process identifying potential errors in their developed models, debugging tools will be developed to make the process of validating models easier. In the current version of DOTs this is possible, but limited to the log files generated by an individual calculation service as indicated by the Lens component in Figure 1. Next, open source solvers for energy system's will be used such that all researchers can utilize the DOTs platform without being hindered by software licenses. These can include power grid model [7] for powerflow or z3 [8] for optimization. Finally, a library with validated calculation services will be made available to researchers so that they can kick start their energy system research and not reinvent the wheel. These calculation services will contain models that accurately simulate a specific asset of the energy system.

Data availability statement

The submission is not based on data. The biggest part of the contribution is a software framework was not developed with the help of data sources.

Underlying and related material

The open-source implementation of DOTs as well as its documentation can be found on Github organization DOTs-Energy [6].

Author contributions

Leo van Schooten performed writing – original draft, conceptualization and software. Koen Kok and Tony Xiang performed writing – review and editing; conceptualization.

Competing interests

The authors declare that they have no competing interests.

⁶<https://www.influxdata.com/>

⁷<https://grafana.com/>

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