A Co-Simulation Platform for Modeling and Testing Dynamic Boundary Fractal Microgrids

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September 4, 2024

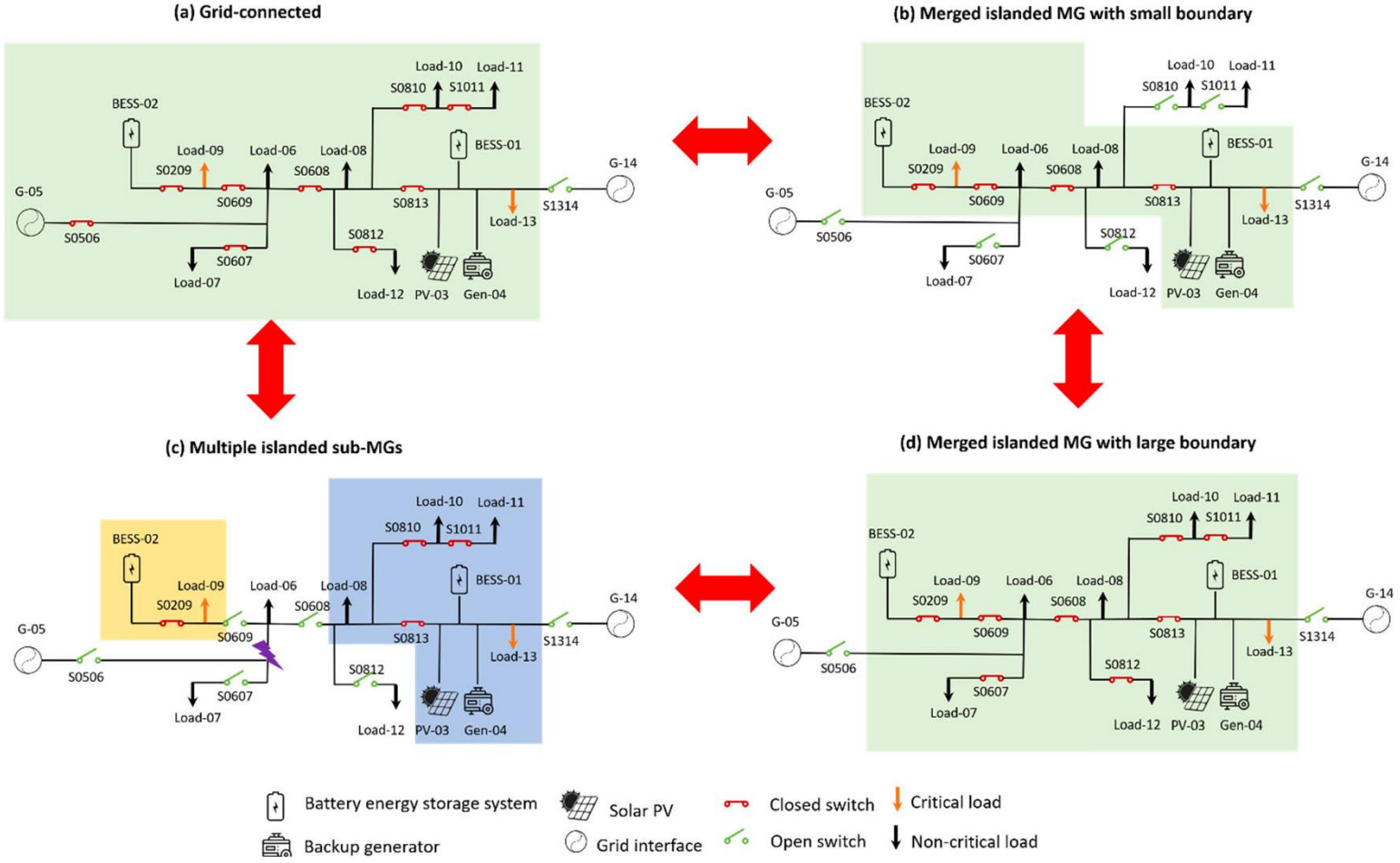
Outline

- Introduction
  - —Concept of dynamic boundary microgrids
  - —Motivation
  - —Co-simulation as validation
- Methodology
- Results
- Summary

Dynamic microgrids

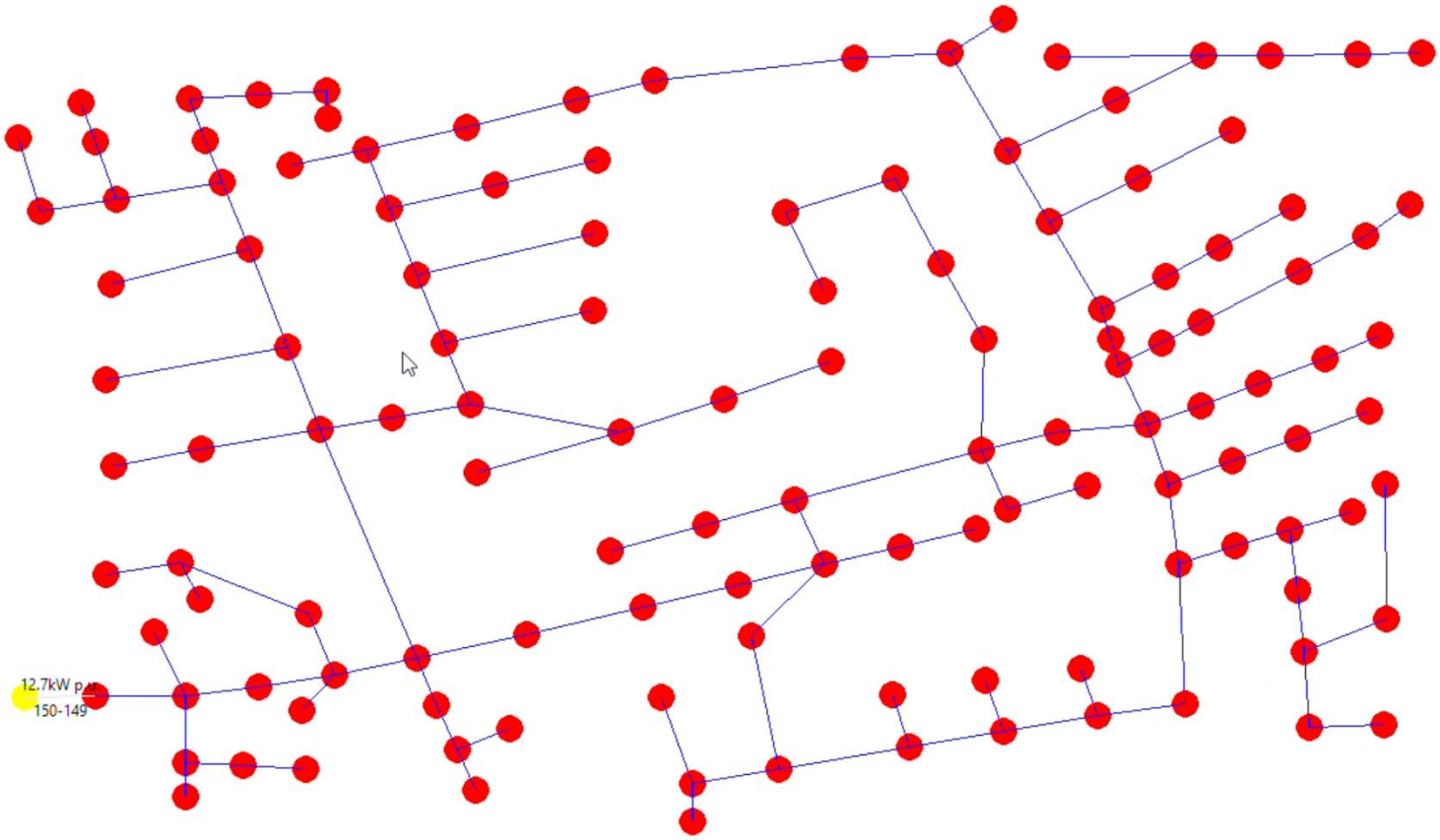
- Able to reconfigure boundaries to support loads.
- Utilizes grid-forming DERs and energy storage to their full potential in the system.

Dynamic microgrids

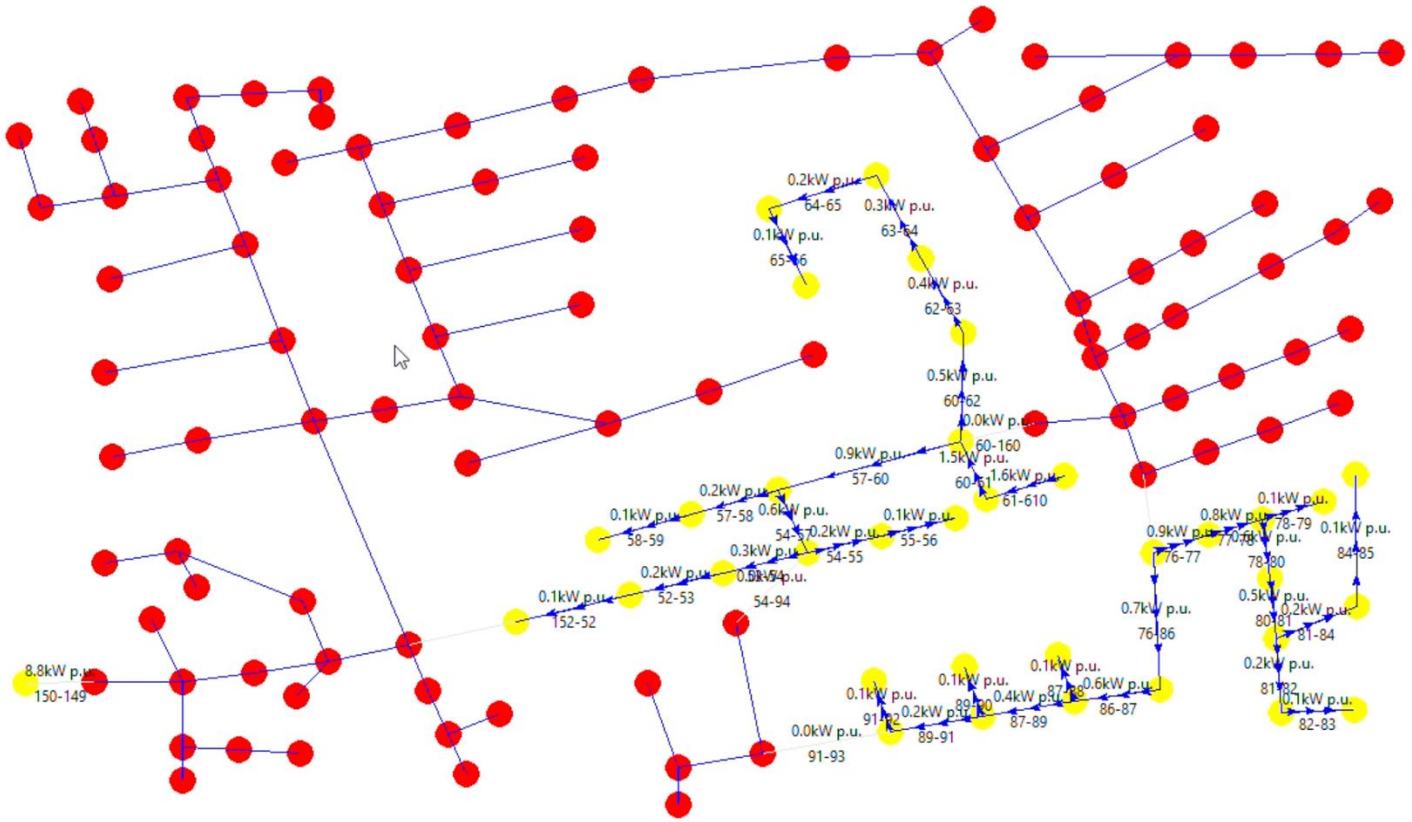


L. Zhu *et al.*, "A Smart and Flexible Microgrid With a Low-Cost Scalable Open-Source Controller," in *IEEE Access*, vol. 9, 2021

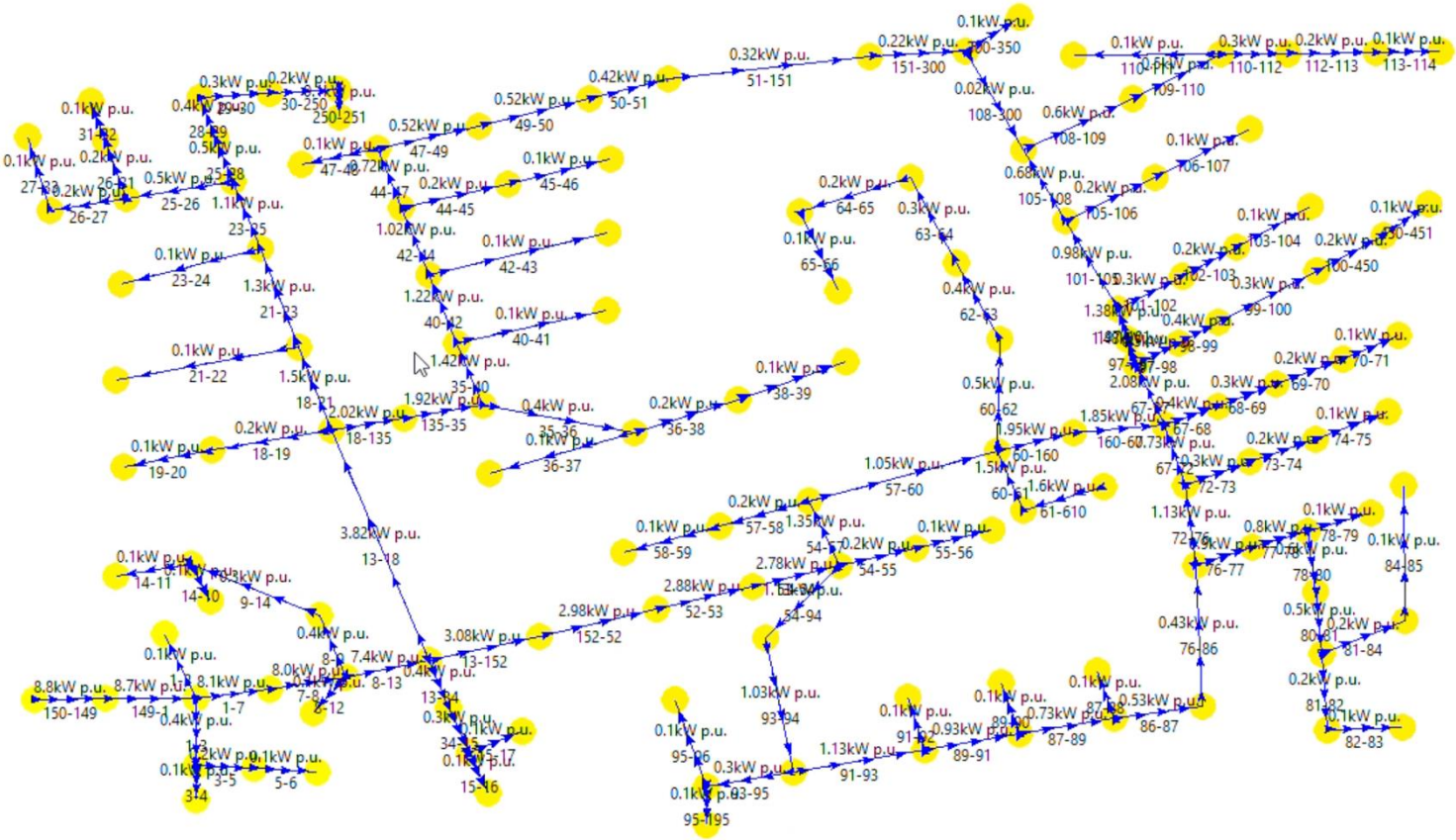
Dynamic microgrids



Dynamic microgrids

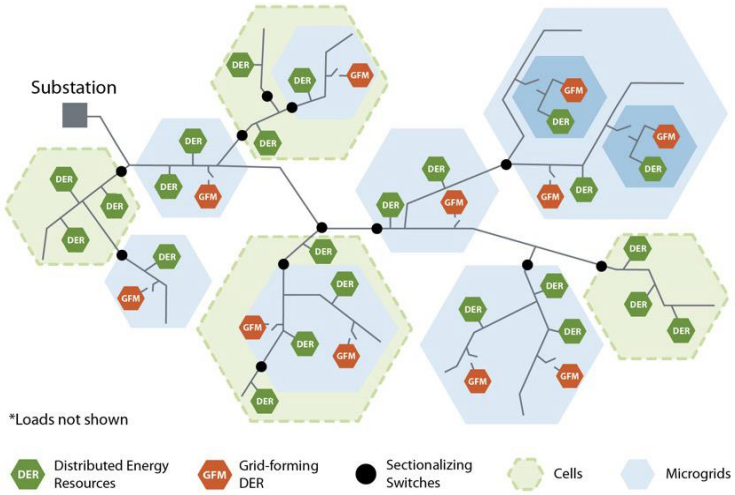


Dynamic microgrids



Objectives

- Develop resilient control strategy for dynamic microgrid formation and operations.
- Address increasing penetration of DERs and integrate equity and energy justice into the equation.



A. Bernstein, D. Fobes, V. Donde, M. Reno, and L. Roald, "DynaGrid: Dynamic microgrids for large-scale DER integration and electrification." [Online]. Available: https://www.osti.gov/biblio/1891199.

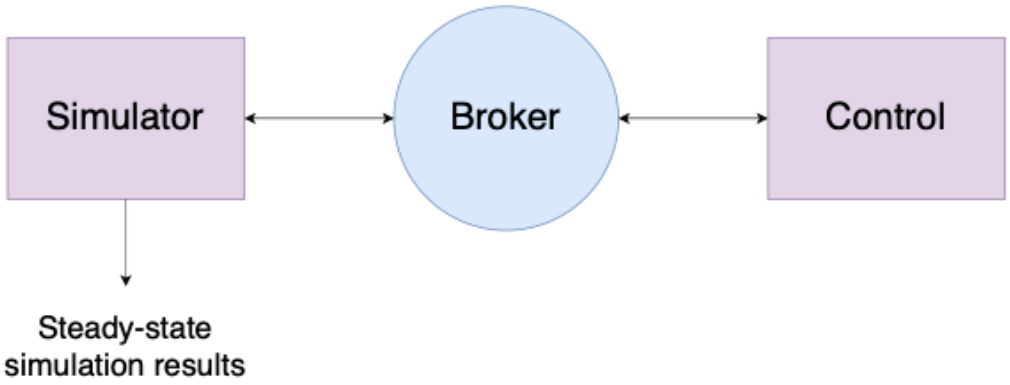
Co-simulation

- How to validate new control strategies on the field without impacting customers?
  —Co-simulation with simulated models.
- Allows control strategies and simulators to interact during runtime.

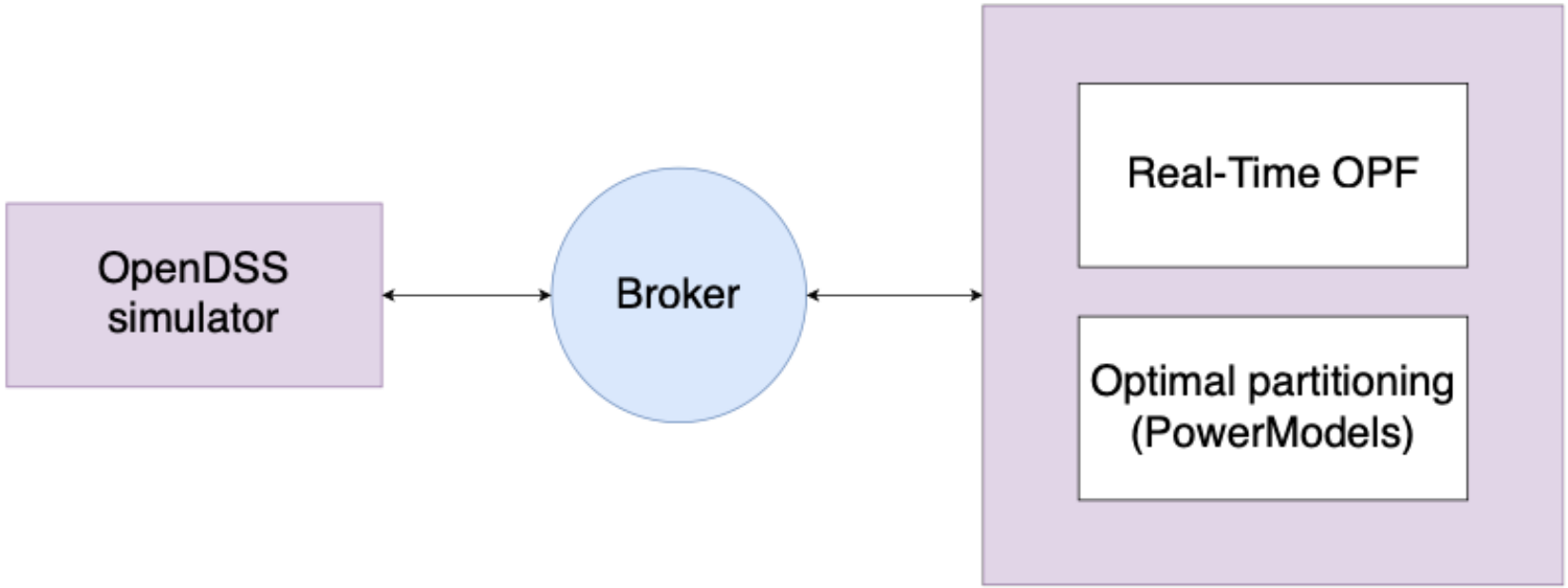
Utilizing co-simulation for validation

- Develop a co-simulation platform built on the HELICS framework.
- Validate dynamic microgrid control strategy with test model as a representation of real-world behavior.

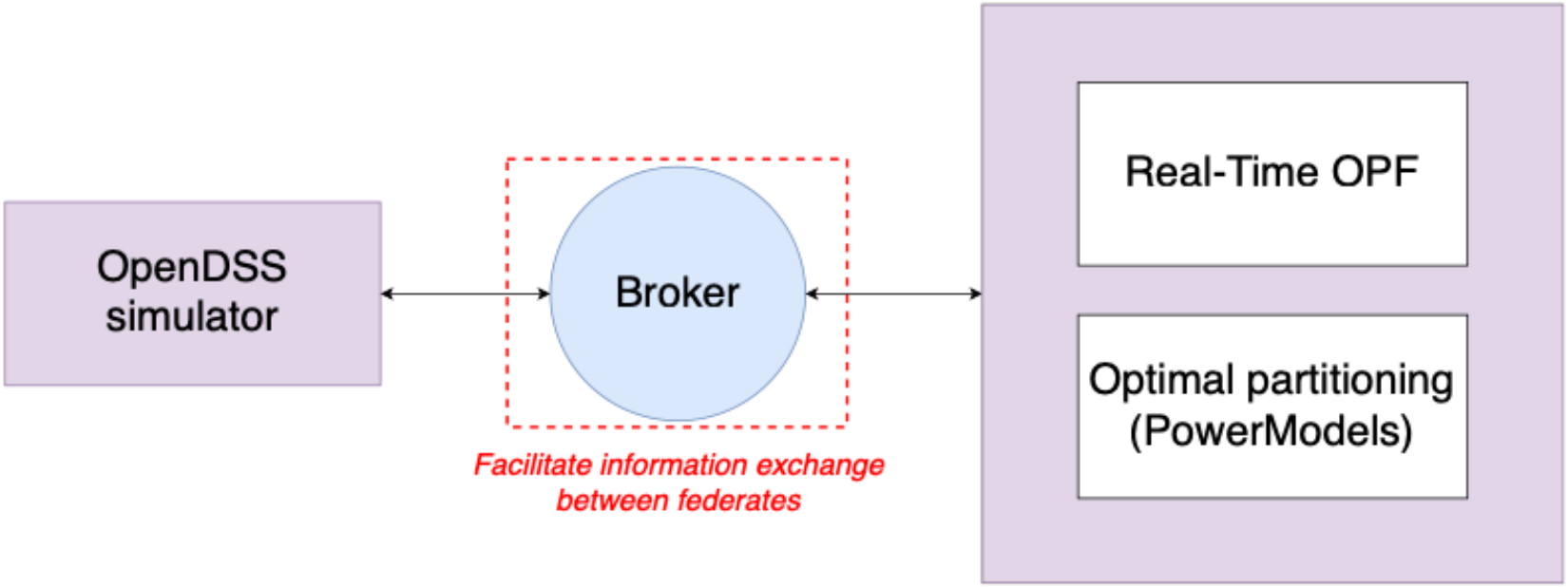
T. D. Hardy, B. Palmintier, P. L. Top, D. Krishnamurthy and J. C. Fuller, "HELICS: A Co-Simulation Framework for Scalable Multi-Domain Modeling and Analysis," in *IEEE Access*, vol. 12, pp. 24325-24347, 2024, doi: 10.1109/ACCESS.2024.3363615.



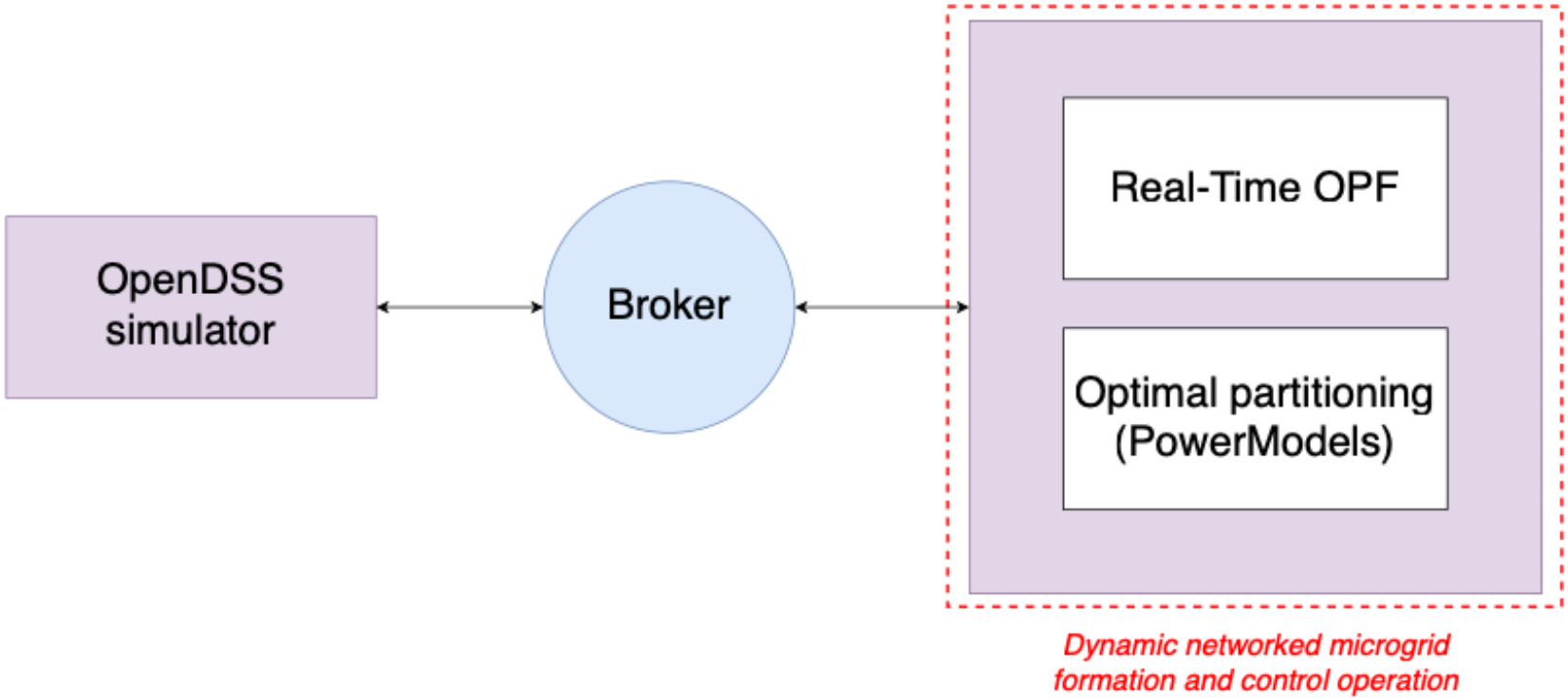
Methodology



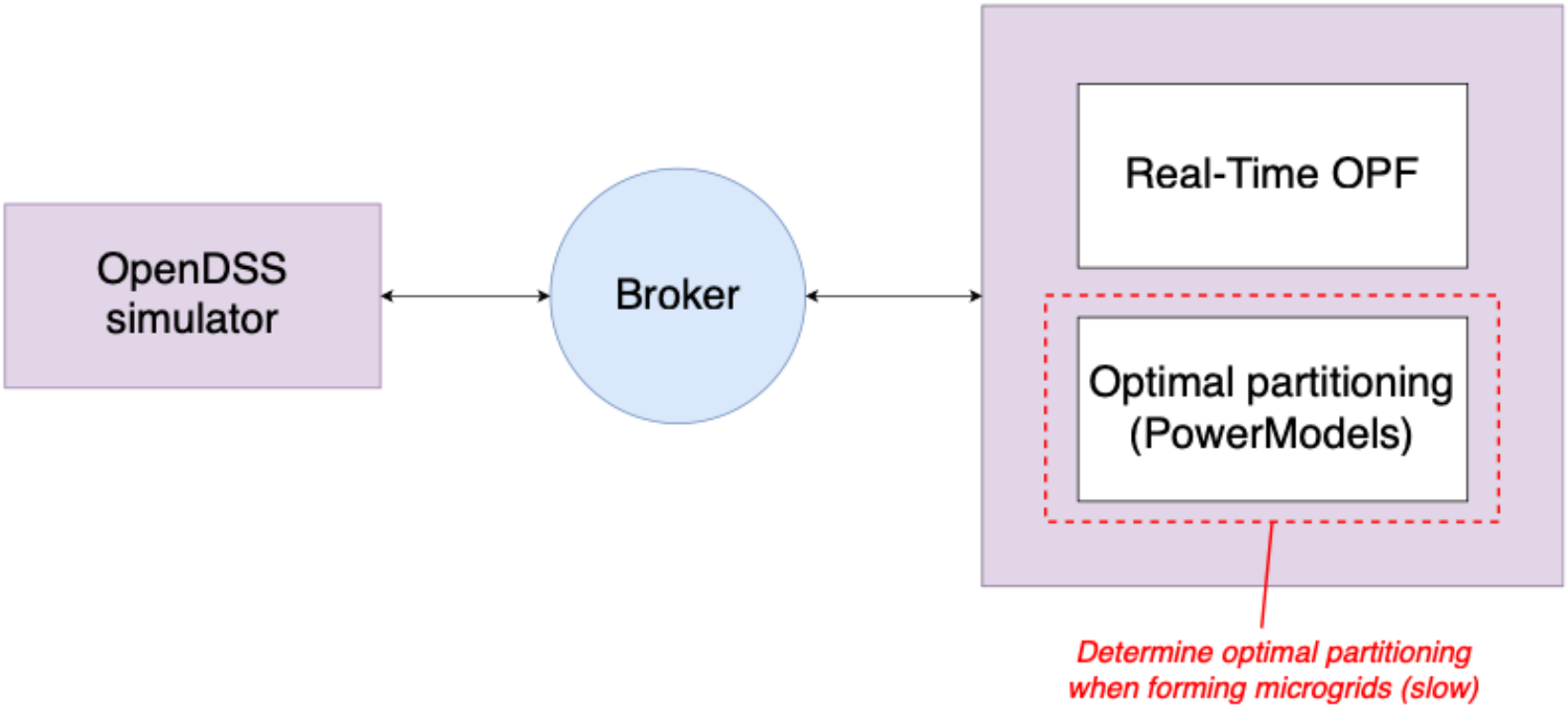
Methodology



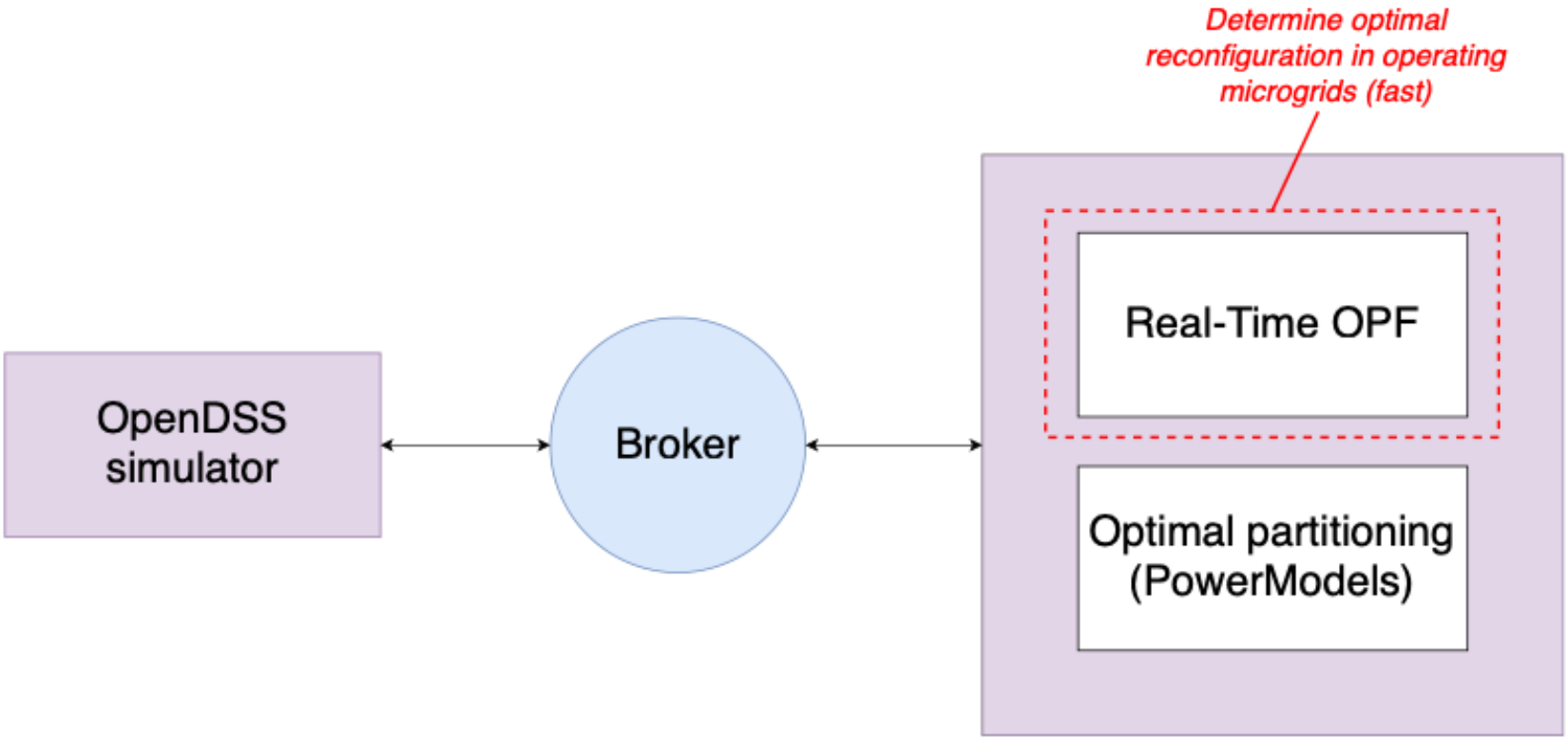
Methodology



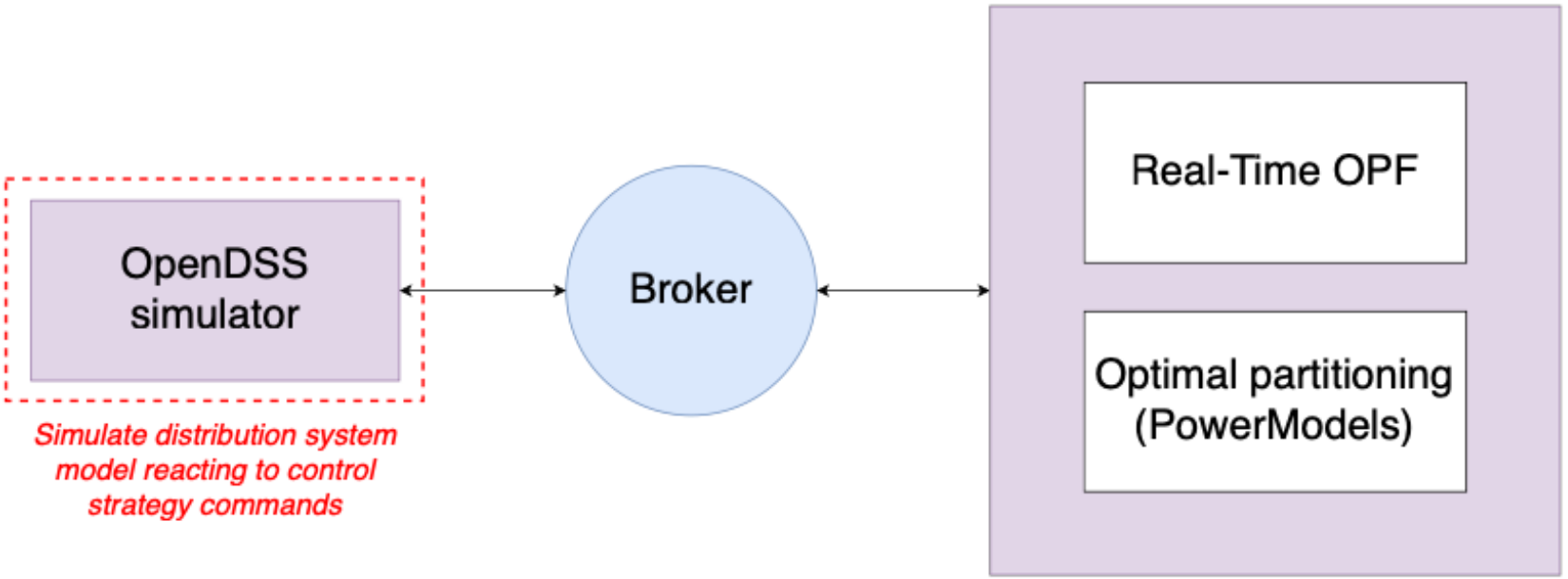
Methodology



Methodology



Methodology



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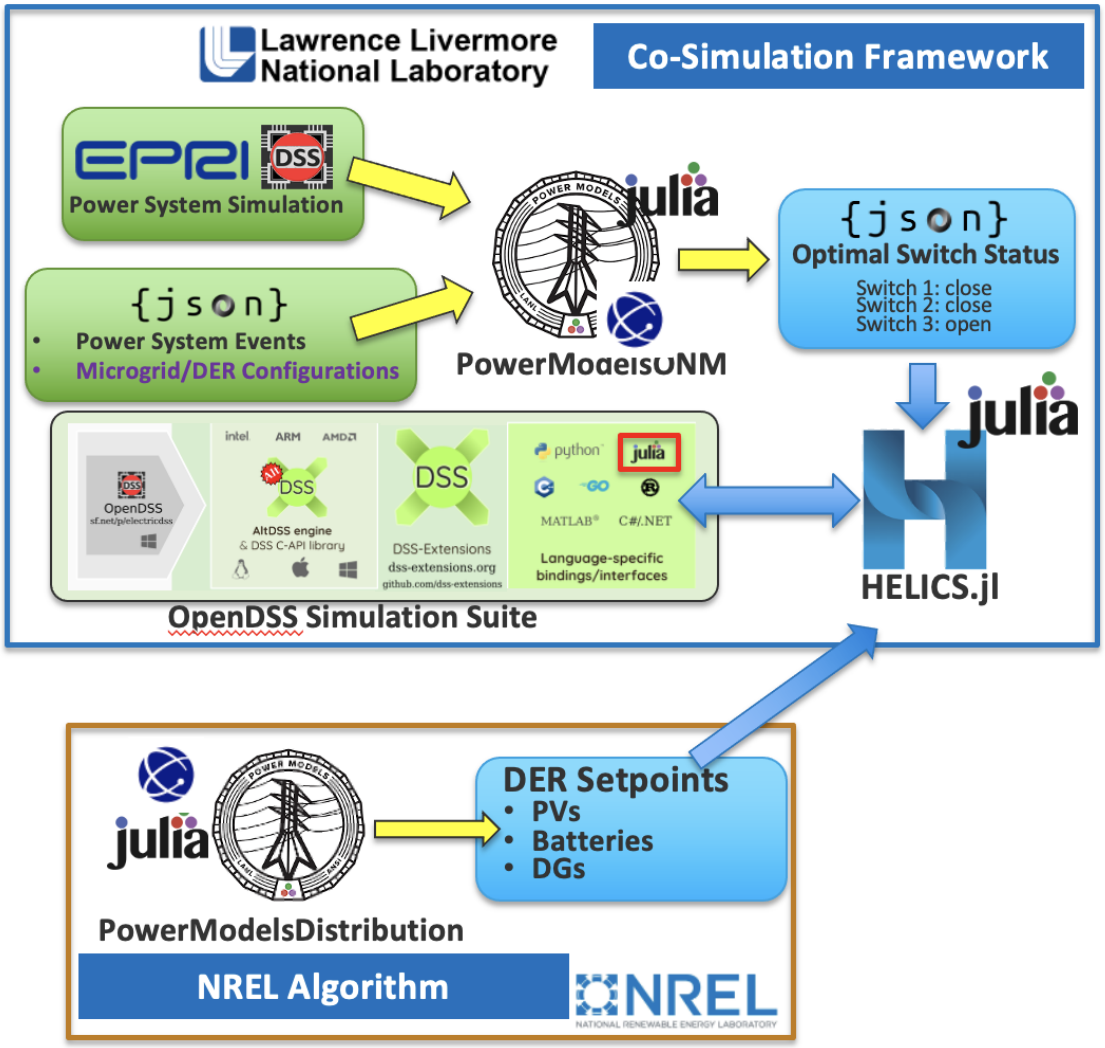

Results

- Control federate sends optimal switch commands at each fixed hour for partitioning.
- Optimal switch commands applied to simulator model in runtime.

```
HOUR 1: Published OPEN to n801675_sw_status at 1.000000
HOUR 1: Published OPEN to n671700_sw_status at 1.000000
HOUR 1: Published OPEN to n671692_sw_status at 1.000000
HOUR 1: Published OPEN to n703800_sw_status at 1.000000
HOUR 1: Published OPEN to n701702_sw_status at 1.000000
HOUR 1: Published OPEN to n800801_sw_status at 1.000000
HOUR 2: Published CLOSED to n801675_sw_status at 2.000000
HOUR 2: Published OPEN to n671700_sw_status at 2.000000
HOUR 2: Published OPEN to n671692_sw_status at 2.000000
HOUR 2: Published OPEN to n703800_sw_status at 2.000000
HOUR 2: Published OPEN to n701702_sw_status at 2.000000
HOUR 2: Published OPEN to n800801_sw_status at 2.000000
HOUR 3: Published CLOSED to n801675_sw_status at 3.000000
HOUR 3: Published CLOSED to n671700_sw_status at 3.000000
HOUR 3: Published OPEN to n671692_sw_status at 3.000000
HOUR 3: Published OPEN to n703800_sw_status at 3.000000
HOUR 3: Published OPEN to n701702_sw_status at 3.000000
```

Conclusion

- Co-simulation platform (in Julia) developed to validate slower timescale portion of algorithm (partitioning).
- Switch operations confirmed to happen through HELICS publications.
- Ongoing effort in integrating faster timescale portion of the control algorithm.
- Ongoing discussions on demonstrating behavior on field microgrids.

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This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC