SEAS Communication Engine: An Extensible, Flexible Wrapper for Co-Simulation Agents

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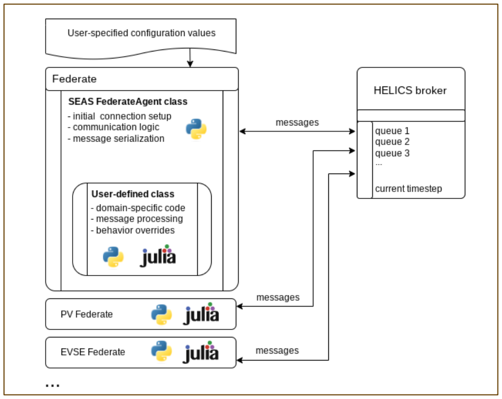

User-specified configuration values

Federate

SEAS FederateAgent class
- initial connection setup
- communication logic
- message serialization

User-defined class
- domain-specific code
- message processing
- behavior overrides

julia

PV Federate julia

EVSE Federate julia

...

messages

messages

messages

HELICS broker

queue 1
queue 2
queue 3
...

current timestep

Fig. 1: SEAS Communication Engine set up for simulating a distribution grid with photovoltaics (PV) and electric vehicle supply equipment (EVSE). Domain-specific Julia code is loaded for the simulated resource's lifecycle.

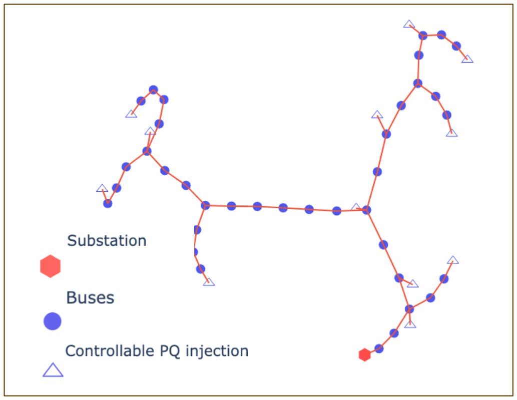

Fig. 2: SmartDS feeder[4] used to demonstrate the Realtime PV signal tracking controller.

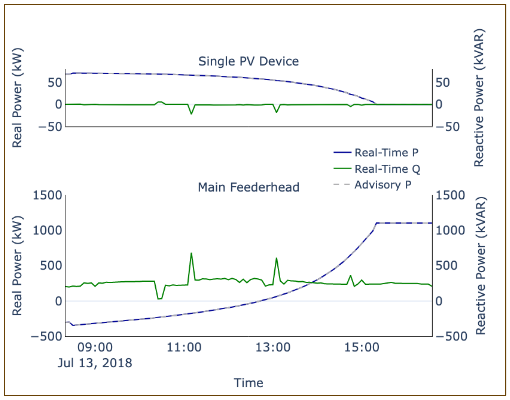

Fig. 3: Simulation results for tracking a set point for a distribution feeder head and a single PV device where the underlying communication between the various devices is handled by the SEAS Communication Engine.

The SEAS (Simulation and Emulation of Advanced Systems) Communication Engine is a flexible software library designed to enable large-scale co-simulation with simulated and emulated hardware for power systems.

Motivation

- Make it easier for power systems domain scientists to run advanced co-simulation experiments on local and HPC systems.
- Provide user-friendly high-level abstraction for HELICS that handles setup, low-level bookkeeping, and connection logic, enabling the researcher to focus on their domain-specific logic.
- Improve portability of code between different co-simulation experiments by using a common underlying engine and messaging system.

Use Cases

- Simulation of different control schemes for balancing power within distribution areas.
- Integration of different high-fidelity domain-specific simulation engines into larger experiments.
- Building portable, self-contained agents representing distributed energy resources that can be reused across simulations.

Engine Description

- Python package built on HELICS that uses a queue-based messaging system to coordinate between federates and broker for co-simulating grid-interactive models.
- Flexible, in that common logic and functionality can be inherited and adapted for a particular use case.
- Underlying models can be black-box and only need Python wrappers to interface.
- Automates network connection to a broker and the instantiation of message queues.
- Provides a simplified API for asynchronous communication between federates.
- Implements automated logic for time synchronization within co-simulation experiments.
- Adds simplified message-type annotation to prevent erroneous communication between federates and brokers.
- Includes examples demonstrating basic python usage as well as how to wrap domain-specific Julia code.

Outcome

- See **https://nrel.github.io/SEAS** for the full software package, included documentation. See the paper for a full description of validation and testing.

Future Work / Extensions

- Act as a management and load balancing layer for a group of HELICS federates, rather than just a single federate.
- Improve support for HELICS federates in different computing paradigms, e.g., the cloud, to connect using our API.
- Stronger data validation and structure; implement a full message-passing protocol on top of HELICS.

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