DEMAND RESPONSE APPLICATIONS FOR UTILITIES

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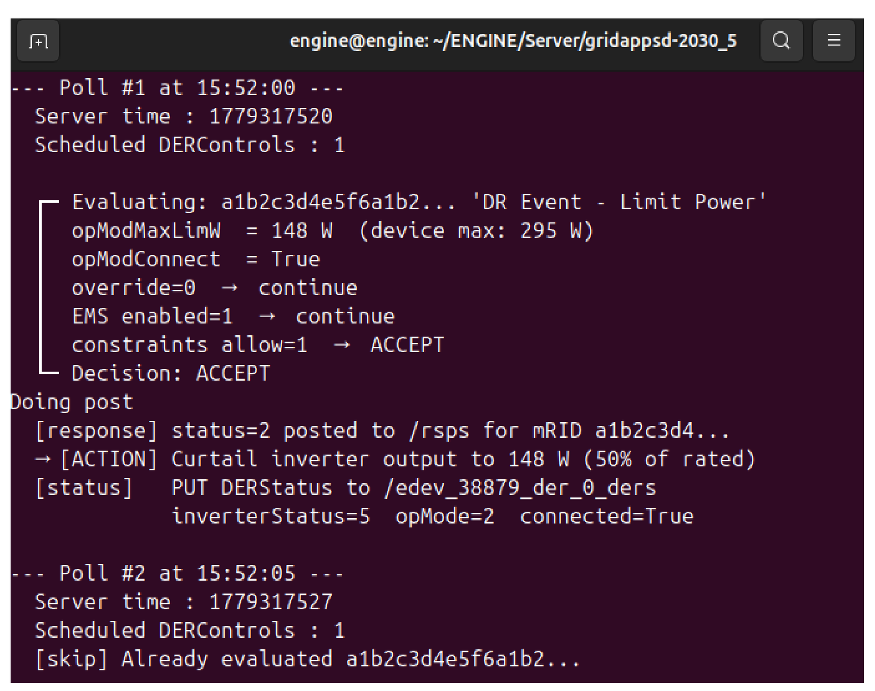
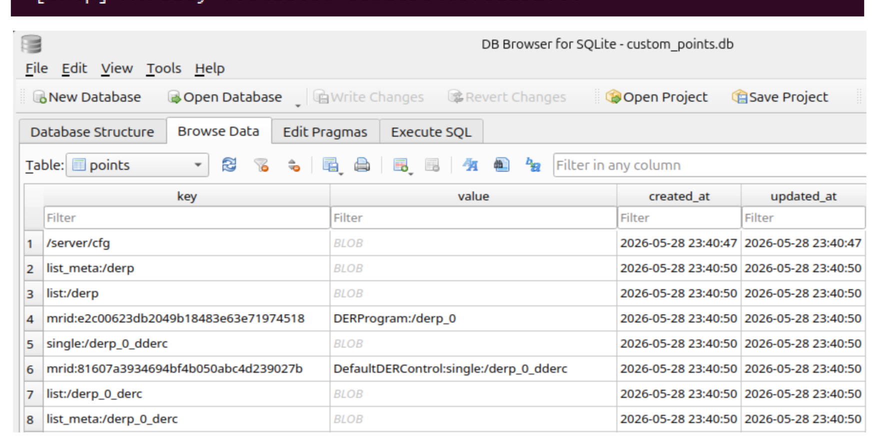
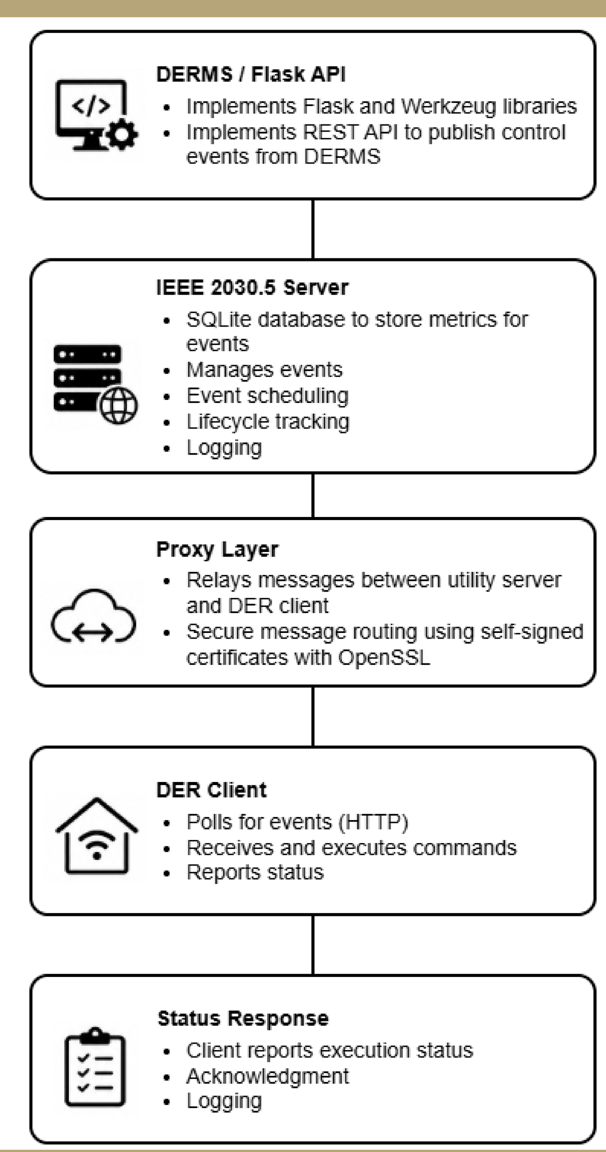
Project Preview

Snohomish County Public Utility District **(PUD)** is exploring methods to control the growing number of **distributed energy resources (DERs)** remotely. Remote control of DERs would allow PUD to automate power grid management processes such as **demand response.**
This project investigates the implementation of the **IEEE 2030.5 communication standard** which allows utilities to control residential devices connected to the power grid.
We develop a simulated **server–client environment** modeling utility-issued control events and device responses. The system includes device identification, event scheduling, polling-based communication, and status reporting.

Server

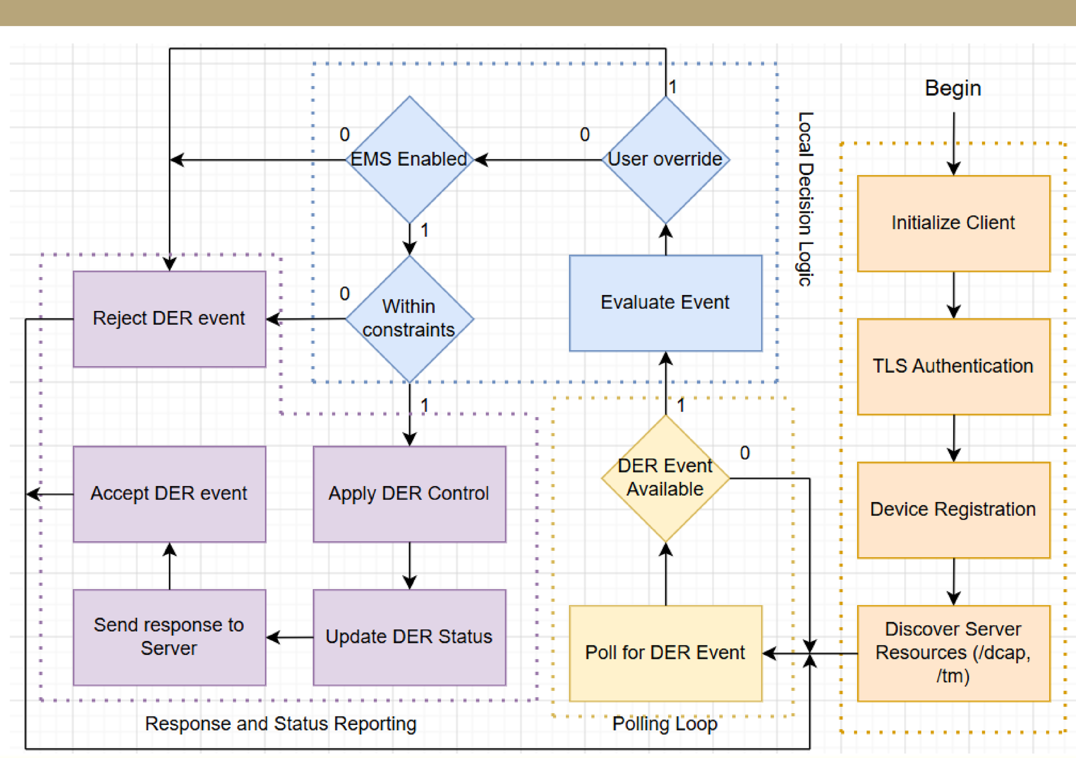




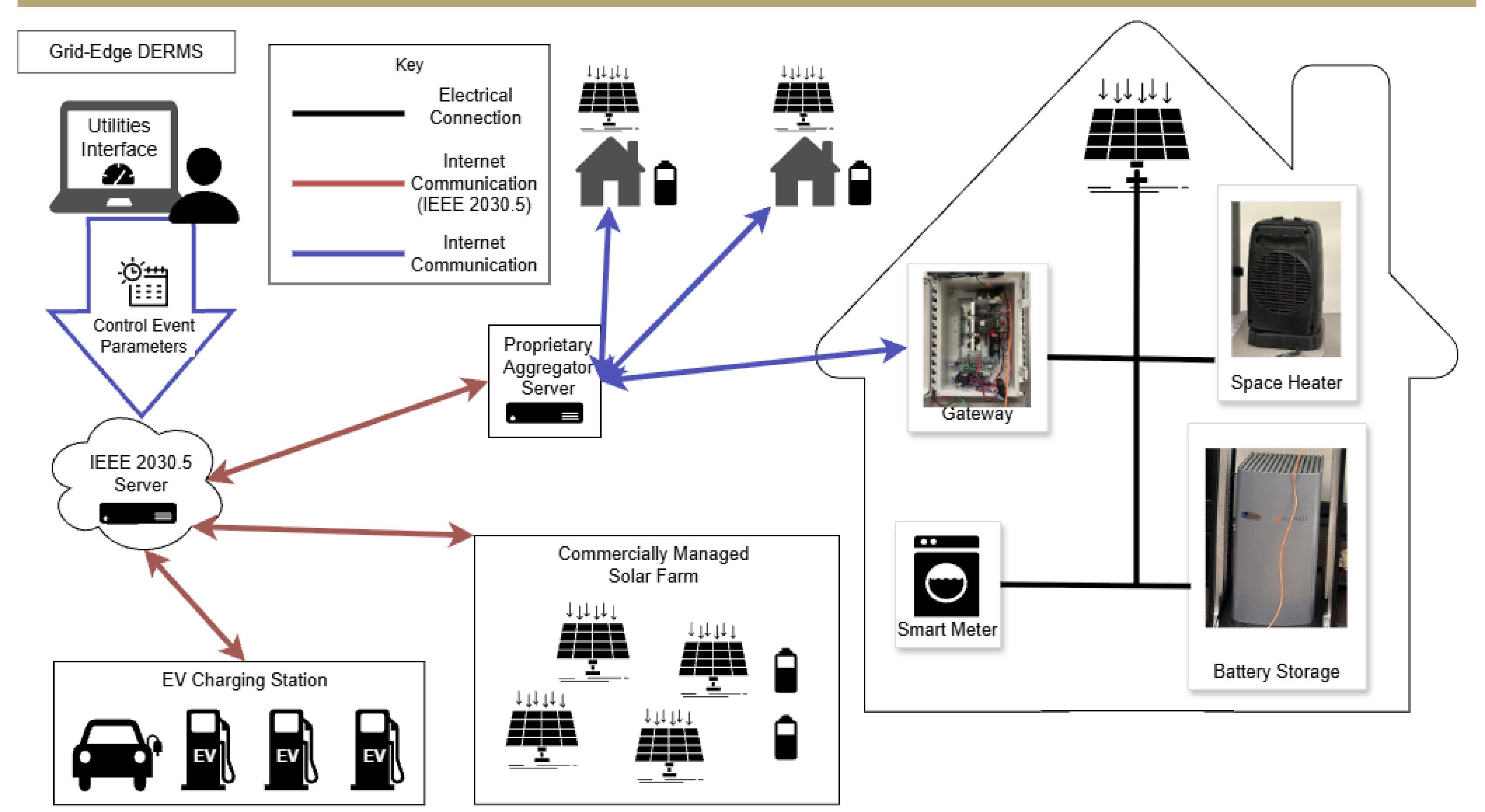


Client Control Flow

A client is developed in python to simulate how a DER would communicate with an IEEE 2030.5 compliant server developed by Snohomish Public Utility District.



Architecture Overview



- **Utilities Interface**
  - Controls communication and commands sends control events to devices according to grid status from DERMS.
- **Cloud Interface**
  - Digital Ocean's Droplet Infrastructure-as-a-Service platform provides DNS and Firewall services
  - Contains IEEE 2030.5 compliant server implementation
- **Enphase IQ Gateway Device**
  - Requests control events from server by HTTPs
  - Translates IEEE 2030.5 communication to home power system
- **Home Load**
  - Microinverter to convert solar energy as a usable source
  - Battery has discharge or charge commands

Hardware Specifications:

Microinverter
- Output Voltage: **240V**
- Peak Efficiency: **97.5%**
- Peak Output Power: **295 VA**

Battery
- Energy Capacity: **3.36 kWh**
- Power Rating: **1.28 kVA**
- DC Efficiency: **96%**

Motivation for Hardware:

- Representative of what is used in real homes
- IEEE 2030.5 compliant

Metrics

Metric	Target Metrics	Achieved	Description
Scheduling Accuracy	±1 second scheduling accuracy	✓ ±1 s	Difference between intended and actual event execution time
Reliability and Error Handling	Reliable polling and bidirectional communication	✓ accept/reject logic correct	Ability to correctly process scheduled and cancelled events
Polling Response Time	Event status reporting every 5 seconds	✓ 5 s cycle	Time between client polling cycles
Communication Success Rate	100% success during tested simulation scenarios	✓ 3/3 scenarios, 100%	Percentage of successful message exchanges
System Logging Accuracy	≥95% of client-server interactions	✓ full event lifecycle logged	Ability to correctly record event lifecycle and state changing
Compatibility	Successful communication using IEEE 2030.5	✓ valid sep+xml parsed	Communication between components using IEEE 2030.5 structures

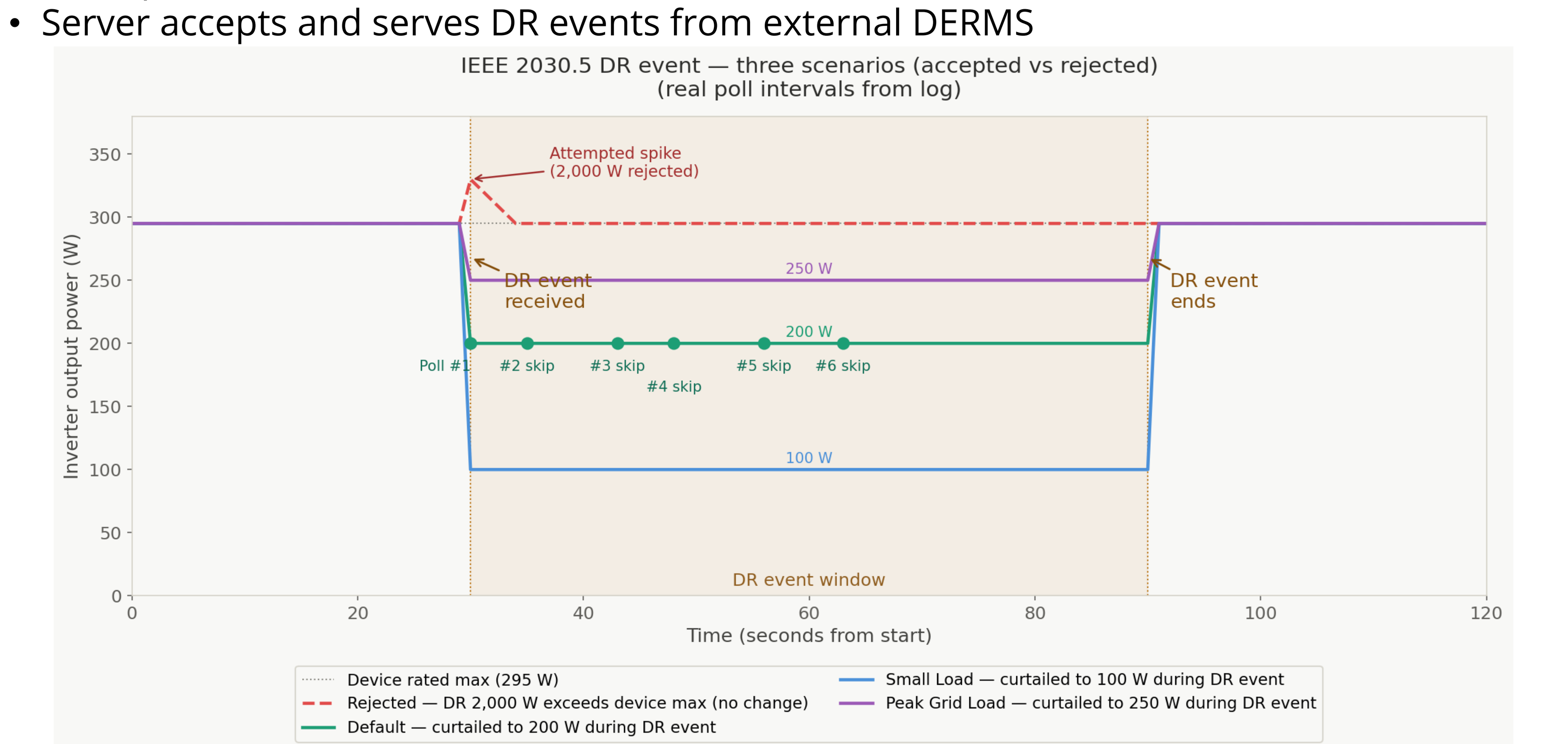
Requirements

- IEEE 2030.5 compliant
  - HTTPS/TLS secure transport
  - XML-based messaging
  - Periodically polling for status
    - Update appliance state and aggregate power
  - Unique device identity
  - RESTful API resource endpoints
- Handle event updates correctly
  - Supersede, scheduled, active, and cancelled events
- Enforce user-defined limits
  - Delay tolerance, operating windows, usability

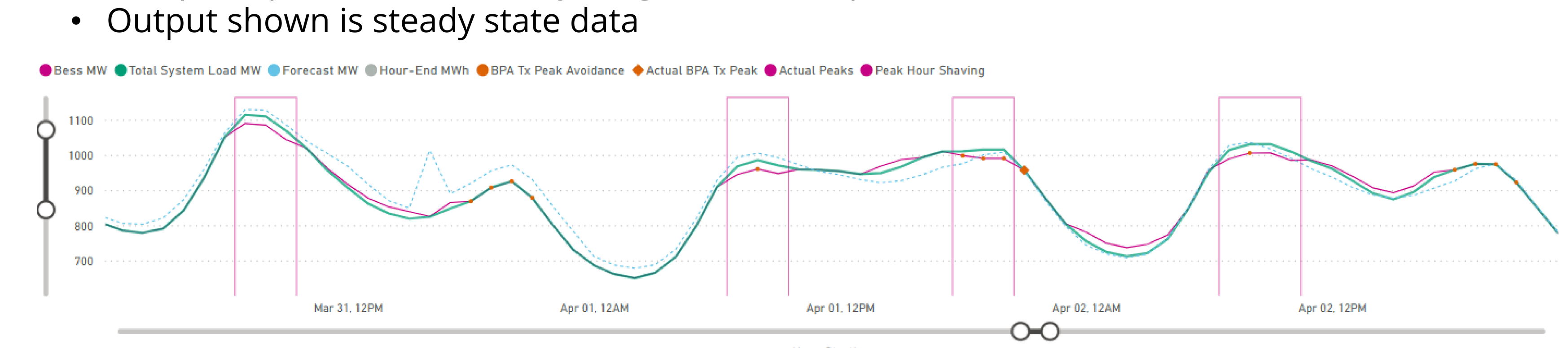
System logs will include:
- Control events issued
- Time received/applied
- Appliance state changes
- Estimated or measured impact

Analysis and Improvements

Analysis:
- Follows SunSpec out-of-band device discovery requirements
- Client reads and interprets IEEE 2030.5 server messages
- Direct Enphase IQ Gateway communication not yet possible — security relaxed for proof of concept
- Server accepts and serves DR events from external DERMS



- Rejected: request exceeded max power limit → status unchanged
- Accepted: power within safety range → status updated
- Output shown is steady state data



The graph above shows residential battery data from Snohomish PUD. DER events at different times influence the battery's operating state and power output. Future work would incorporate our implementation into real-world DER deployments.

Improvements:
- Scaling up this proof of concept into a professional IEEE 2030.5 server
  - Setting up a Nginx or Apache reverse proxy with load balancing to improve performance
  - Setting up a database to store event information from utility DERMS and efficiently retrieve information
- Implementing security policies like discretionary access control lists (DACL) and whitelisting
- QualityLogic certification for the server implementation as compliant to IEEE 2030.5
- Supplying URL of the server to customers. (http://powercontrolserver.me)

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