Distributed Energy Storage Network Control

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ABSTRACT

Greensmith Energy Management System's control architecture relies on two principles to create the most resilient and rapid control system available today. First, Greensmith builds a distributed network with localized intelligence at the unit level; such that each unit may independently operate based on local load and generation conditions. Second, Greensmith networks those in-unit computing devices over an internet or intra-net network connection to create peer groups with cloud-based network control. This architecture enables end-users to take real-time control of a system or group of systems for applications such as frequency regulation or optimization of Smart Grid assets such as EV charging, while minimizing minute-to-minute reliance on grid operators and network controls. In addition, this combination of a distributed and centralized approach enables remote firmware and software updates on units in the field, as well as collection and upload of operational data.

Keywords: distributed computing, network control, fleet management, energy storage systems, remote management, distributed generation

1 INTRODUCTION

The modern electrical grid requires multi-functional, highly robust energy storage systems, distributed at strategic points on the nodal transmission and distribution networks. Specifically, this energy storage is needed to address the challenges of renewable integration, including renewable ramp rate control, intermittency smoothing, and replacement of traditional fossil-based generation capacity for purposes such as frequency regulation. In addition, these energy storage systems are needed to manage and leverage the increasing deployment of "Smart Grid" infrastructure, including electric vehicles and their charge stations, microgrids, and Smart Meters, each of which provide increasing opportunitites to control local electric load.

Greensmith Energy Management Systems ("Greensmith") builds battery-based distributed energy storage systems, and their associated computing equipment, to provide secure, highly-functional battery systems for utilities, wholesale renewable developers, and other commercial & industrial customers. This paper provides an overview of the proven control architecture which Greensmith has deployed in over twenty field installations to date, of system sizes ranging from 5 kW to 2 MW, and battery durations up to 4 hours.

2 CONTROL ARCHITECTURE

Greensmith builds its disributed energy storage systems with the principles of distributed computing. Each energy storage system includes an industrial CPU in-unit to provide local intelligence and optimization based on the customer's priority stack.

Every one of these CPUs is also connected to an intra-net or internet network, providing remote on-line control of every device in the customer's fleet. Through this networked in-unit CPU, each energy storage device may receive commands through multiple protocols and interfaces, including Local RS232 interface, secure VPN IP and port, Modbus/TCP, and DNP3/TCP. Table 1 below shows each protocol, method of communication, and system response time to commands.

Protocol	Communication	Response Time
Web Services	XML/HTTP(S)	2-10 seconds
Modbus/TCP	TCP	<10 ms
DNP3/TCP	TCP	<10 ms
Web Portal	HTML/HTTP(S) AJAX	2-10 seconds
Serial	RS232	<10 ms

Table 1: Protocol Summary for Distributed Energy Storage Computing Systems

These two layers of control work closely with the Battery Management System ("BMS") layer, which comprises the electronics directly on the battery terminals, and collects critical battery information such as charge limits, temperature, state of charge, etc. This information is also included in the momentary decision-making within each energy storage unit's control algorithms.

All operational data, as well as BMS-layer data are collected and uploaded in data packets, over the secured network connection. This data collection and upload enables frequent reporting on the end-user interface for operators to review and tune priorities and system operation.

Because this overall control architecture integrates with a BMS control layer, it is a battery-agnostic framework which may leverage a variety of different battery brands and chemistries. This is critical for long-term system longevity, as the battery market evolves and higher quality, longer-cycle life cells and modules become available.

2.1 Networked Fleet Control

With this control architecture, users may enable fleet control across mutliple units or defined groups of units. This use case is clear in cases where utility customers own multiple energy storage units at various points on their grid network. User-defined groups might include those which are distribution-level, those which are near-by solar genertaion resources, units of a certain size, or units which operate in microgrids.

With these groups, the user may opt in to group-level priorities and heirarchies, while still being able to take real-time control of the entire group or fleet as desired. This latter scenario may be useful when Ancillary Services and Frequency Regulation are particuarly valuable.

Figure 1 below depicts and example of this fleet control architecture of groups and across groups on various days of the week.

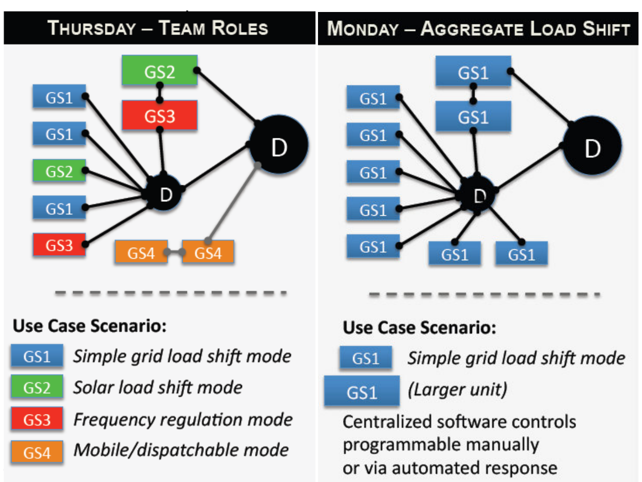

Figure 1: Example Fleet Control Framework

This framework itself resembles a distributed computing network; multiple energy storage systems create secure capacity redundancies and the ability to build an extermely large "virtual" energy storage unit within a grid network. As such, this architecture is highly modular and scalable as capacity needs for distributed energy storage changes over time. As previously mentioned, this fleet control framework is capable of managing many different battery brands and chemistries within a customer's fleet, providing long-term forward integration capabilities as battery technology improves.

For more information about Greensmith's fleet control framework, please see US Trademark & Patent Office Patent Application No. 61/714,470, "Group Control System for Distributed Energy Storage Devices" [1].

3 DISTRIBUTED APPLICATIONS

This fully programmable control system is also highly flexible in terms of end-user inputs, with the ability to intake a wide variety of local data including smart meters, building management systems, AGC signals, microgrid software information, and other industrial load information to tailor local operations for each individual customer site. More specifically, the distributed energy storage systems may address any/all of the following applications as needed in their deployed locations:

- Load Following
- Renewable Ramp Rate
- Solar PV Following
- EV Charge Stations
- Frequency Regulation
- Voltage & VAR Control
- Energy Arbitrage
- Peak Shaving
- Time of Use Optimization
- Demand Charge Rate Management
- Grid Islanding, Backup Power, Micro-grid
- Calibration & Battery Maintenance

By integrating with various utility-grade meters, smart meters, and building management system protocols, the energy storage device can be optimized around various tarriffs, inculidng time-of-use rates or real time rates, if available.

4 CONCLUSION

The Greensmith distributed energy storage network control architecture provides redundancy and flexibility in operation of energy storage devices, much like a distributed computing network architecture. This framework enables fleet control across a network of distributed energy storage devices, and a wide variety of Smart Grid applications.

REFERENCES

[1] Zhang, S., "Group Control System for Distributed Energy Storage Devices," USTPO Patent Application 61/714,470, 2012.

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