New Architectures for Interacting with Demand Side Resources in Ancillary Services Markets

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Abstract

Emerging smart grid standards, such as OpenADR, allow demand side resources to participate in ancillary services markets in a fashion they have not been capable of in the past. This paper describes how OpenADR can be integrated with existing ISO control, dispatch and telemetry mechanisms such as ICCP and DNP3 to allow ISO's to interact with resources they traditionally have not had access to in the past. In addition real world results of this architecture will be given to show how it was used in actual pilots.

1. BACKGROUND

Independent System Operators (ISOs) and other balancing authorities use ancillary services to support the operation of the grid and maintain the transmission of electricity from its generation site to the customer. In general ancillary services are used to both maintain grid operations under normal operating conditions and provide contingencies when abnormal conditions arise. Such services may include load regulation, spinning reserve, non-spinning reserve, voltage support, black start, etc.

ISO's use so called "dispatchable" resources to provide the required ancillary services, wherein dispatchable refers to the ISO being able to interact with and send instructions to the resource. Historically ISO's have primarily utilized generation resources to provide ancillary services, but the use of demand side resources is becoming more prevalent. Demand side resources refer to customers loads. And this paper will focus on the use of demand side resources to provide ancillary services. Using demand side resources for ancillary services can be considered a type of demand response (DR) and more specifically is sometimes referred to as "fast DR" to reflect the more real time nature of these programs.

Figure 1 shows a generalized view of the interactions between the ISO and a demand side resource for the purpose of ancillary services.

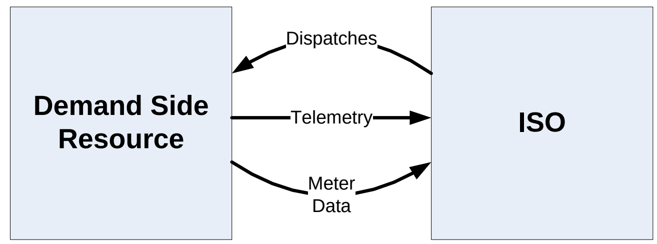

Figure 1

Note that figure 1 does not depict the administrative and market level interactions such as enrollment, bidding, settlement, etc. and only depicts the interactions necessary during the normal "operation" of the resource. It's also important to note that different ISO's have different types of DR programs and operate them in different ways. The ISO/RTO Council (IRC) has put together a survey [1] of the different types of programs in the United States.

Figure 1 depicts the following type of interactions:

- Dispatches – these are the instructions that are sent from the ISO to the resource. Typically these instructions are of the form of an operating point (i.e. generator) or the amount of load. Depending upon the ancillary service, resources are expected to respond to these instructions in real time ranging from 2-4 seconds (regulation) up to 10 minutes (non-spinning reserves).
- Telemetry – these are the real-time demand measurements of the resource. These measurements are typically required to be measured in 4 second intervals. These measurements allow the ISO to monitor the resources response to dispatches in real time.
- Meter Data – this is the revenue grade meter data that is used for settlement purposes. This is typically logged by the meter at the resource and exchanged once per day.

Potential demand side resources that exist today have revenue grade meters and methods for collecting that data, but they typically do not have dispatch or telemetry interfaces to facilitate interactions with ISO's. Therefore this paper will focus on the dispatch and telemetry interfaces.

This paper will not cover the internal operations of the ISO including sub-systems such as the Energy Management System (EMS), Automatic Generation Control (AGC), or Automated Dispatch System (ADS). Likewise this paper will not cover the internal operation of the demand side resources including the various sub-systems that may be used to their loads. This paper will instead focus on the interfaces and interactions between the ISO and demand side resources. The methodologies that exist today for dispatching and telemetry present a hurdle to many demand side resources and this paper will present alternate architectures that will help lower that hurdle while utilizing emerging smart grid standards such as OpenADR.

2. EXISTING ARCHITECTURES

Figure 2 shows a generalized breakdown of the type technologies that may be utilized for the interactions between the California ISO (CAISO) and demand side resources.

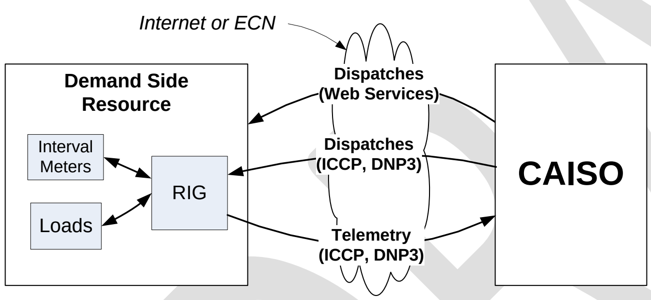

Figure 2

As can be seen the CAISO uses a Remote Intelligent Gateway (RIG) at the resource as the communications integration point between the ISO and the resource. The RIG is not used for all types of ancillary services, but is required for the most demanding services such as regulation. It represents a way for the CAISO to reach all the way down to the resource and interact directly with it. In general ISO's vary on their use of RIGs and on how they specify the means for interfacing to the resources.

The most prevalent protocol used for dispatching and telemetry is Inter-Control Center Communications Protocol (ICCP). Less commonly used is Distributed Network Protocol (DNP3) and in some cases it may even be IEC 61850. In some isolated cases there may be non-standard web services and data models that may be used. In that case of regulation services both the dispatches and telemetry interactions occur at intervals as low as 2 - 4 seconds. For spinning and non-spinning reserves the loads are required to respond to dispatches within 10 minutes while the telemetry is measured at 4 seconds intervals and required to report the data at 1 minute intervals. These parameters are indicative since every ISO structures their operations differently.

Security and reliability of the network connection is a primary concern and in many cases the resource can only communicate with the ISO via a physical private network that is sometimes referred to as the Energy Communications Network (ECN). Installing an ECN connection at the resource is expensive and entails not only an initial capital expenditure, but also ongoing monthly service charges.

The issues that arise for a demand side to interface with an ISO and participate in ancillary services in the manner described above include the following:

- Requirements to install physical RIGs that meet the ISO requirements add costs to the deployments
- Use of private networks such as the ECN add costs
- Use of protocols such as ICCP and DNP3 that are not typically used for their operations add cost and complexity to their operations
- The number and size of the demand side resources that the ISO can interact with is limited and not scalable

Currently ISOs address some of the concerns listed above through the use of third party aggregators. Aggregators are intermediaries that deploy a portfolio of loads and then aggregate them together to present them as a single load to the ISO. Since the ISO views the aggregator as a single load, all interactions and financial agreements are between the ISO and the aggregator. The aggregator has full responsibility for interacting with and deploying the resources in its portfolio and there is little or no visibility of the actual resources by the ISO. This model has a lot of benefits and will continue to operate in the ancillary services market.

3. EMERGING ARCHITECTURES

A number of entities including CAISO, Pacific Gas & Electric (PG&E), Lawrence Berkeley National Laboratory (LBNL), Akuacom/Honeywell, and Southern California Edison (SCE) have been experimenting with new architectures for ancillary services that would allow them to leverage OpenADR and reach a larger set of demand side resources than is typically used today.

To address the issues described above and allow a broader range of demand side resources to directly participate in ancillary services the CAISO, Pacific Gas & Electric, and Akuacom/Honeywell have been experimenting with the architectures as shown in figure 3.

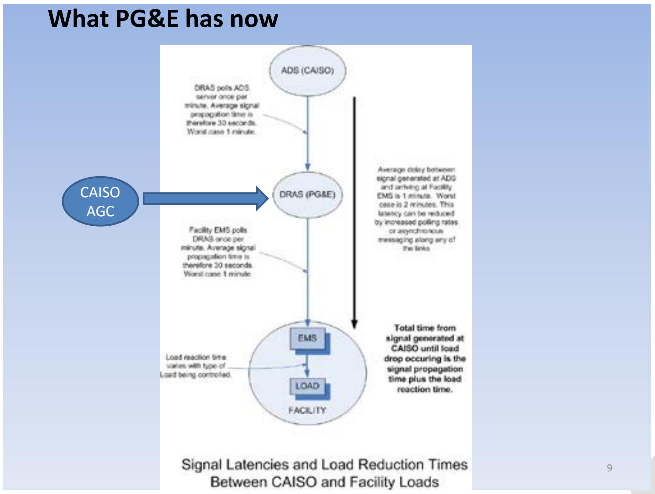

Figure 3

The main difference between this architecture and what is typically done today is that instead of the CAISO reaching all the way down to the resource there is now a so called communication aggregation point that mediates the interactions between the CAISO and the resources. In figure 3 this is depicted by PG&E's Demand Response Automation Server (DRAS).

The DRAS takes dispatches from the CAISO and converts them into OpenADR compatible DR signals that are then sent to the resources that are providing ancillary services. Likewise the DRAS receives telemetry data from the resources and converts it into a form (e.g. ICCP) that can be sent to the CAISO.

The main advantage of this approach is that it interfaces to the CAISO's sub-systems (e.g. ADS and AGC) using well established standards and methodologies such (e.g. ICCP), while also interfacing to the resources in a fashion (e.g. OpenADR) that is more consistent to how they operate in other DR programs. The benefits for the demand side resources are the following:

- Able to utilize a protocol (i.e. OpenADR) that is the same as what they use in other DR programs.
- Able to use the same communications infrastructure (i.e. Internet) without the need to install an expensive ECN connection to the CAISO.
- Because the dispatches are converted into OpenADR signals, the resources can utilize some of their existing load control strategies that were designed for other DR programs. This reduces the programming burden of their control systems.

While this architecture could be used to aggregate the resources themselves and present them as single load to the CAISO the main difference between this architecture and that used in the aggregator model is that it allows the ISO to interact with and get visibility to the individual resources if so desired.

4. PILOT PROGRAMS

This section presents an overview of a number of pilots which are utilizing the architecture presented in this paper.

3.1 Non-Spinning Reserves Ancillary Services

In 2009 a pilot was performed by PG&E in which it took some of the C&I resources that were participating in their existing auto-Dr programs and made them available to the CAISO as a Participating Load providing non-spinning reserve. The pilot team consisted of PG&E, LBNL, CAISO and Akuacom/Honeywell. The basic architecture is shown in figure 4 [2].

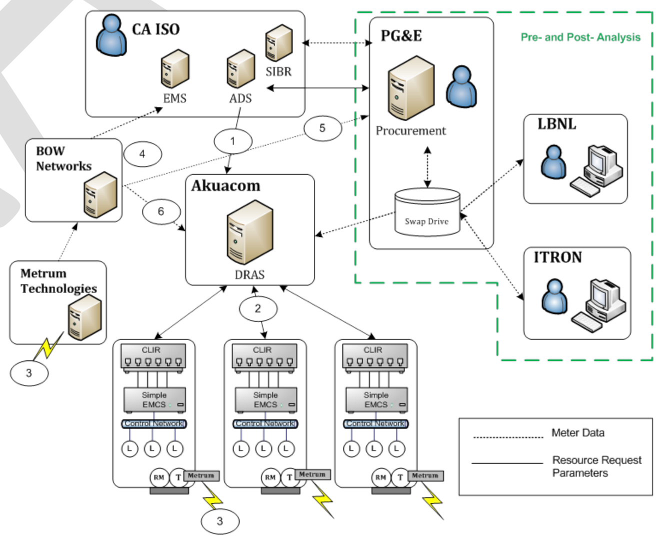

Figure 4

The dispatches were generated by the CAISO's ADS system and were received by the DRAS using an existing web service. The dispatches were translated into OpenADR signals and sent to the resources. The telemetry was collected from the resources and sent to the CAISO using the existing DNP3 interface.

A number of different resources were chosen for the pilot and they were moved from what was essentially a priced based program (CPP) into the ancillary services dispatch based program without having to make significant changes to their infrastructure or their DR strategies. The resources were bid into the CAISO ancillary services market and they were all able to respond within the 10 minute requirement and provide the necessary telemetry.

3.2 Intermittent Renewable Integration - Regulation Ancillary Services

Building on the success of the 2009 pilot, in 2010 PG&E did a pilot to begin examining how demand side resources could provide ancillary services for the integration of intermittent renewable resources. The pilot team again consisted of PG&E, CAISO, LBNL, and Akuacom/Honeywell [3]. In this case the goal was to see if demand side resources could provide regulation ancillary services with 4 second telemetry and dispatches. Figure 5 shows the basic architecture.

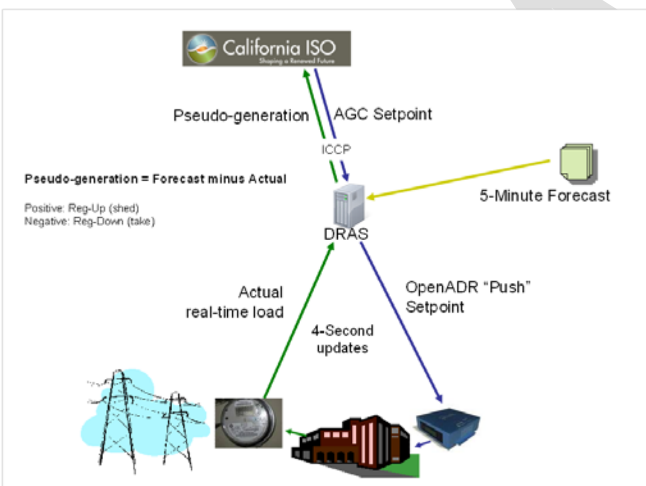

Figure 5

One of the significant differences in this pilot was that the DRAS interfaced to the CAISO's AGC system using ICCP over the ECN network. Also because of the nature of regulation and the CAISO's AGC system the demand side resource was treated as a "pseudo-generator." The DRAS was responsible for making sure that the telemetry signals received from the resources were translated into the appropriate pseudo generator values that the CAISO was expecting to see. This was done by comparing the telemetry to the resources baseline to see where its operating point was [3] and is an example of a new form of telemetry that did not entail directly metering loads as is done today. With the emergence of new CAISO models such as the non-generator resource model this type of pseudo-generator modeling may not be necessary in the future.

The existing market structures and models in the CAISO's system prevented an actual market transaction to be performed, but experiments proved that the communications infrastructure could support the exchange of dispatches and telemetry between the CAISO and resources in a manner that met the CAISO requirements for latency and throughput. Nevertheless the pilot did expose some improvements that would be necessary to control loads at the customer's site and improvements that would be necessary for the CAISO to properly model these resources. Much of these improvements are reflected in the CAISO's new non-generator resource model.

Finally, while the communications infrastructure met the necessary requirements there were identified some improvements to OpenADR that would allow it to be more "firewall" friendly at the customer's site and thus make it more cost effective to deploy. These improvements are reflected in the new OpenADR 2.0 specification.

3.3 LA Air Force Base Electric Vehicle Fleet – Regulation Ancillary Services

There is a pilot currently underway at the Los Angeles Air Force base, funded under the Department of Defense Environmental Security Technology Certification Program (ESTCP). The project entails managing a fleet of electric vehicles and providing their charge/discharge capacity into the CAISO's regulation ancillary services market. Team participants include Air Force, LBNL, CAISO, SCE, Akuacom/Honeywell, Bosch, California Public Utilities Commission (CA PUC), California Energy Commission (CEC), and Concurrent Technologies Corporation (CTC). The basic architecture is shown in figure 6.

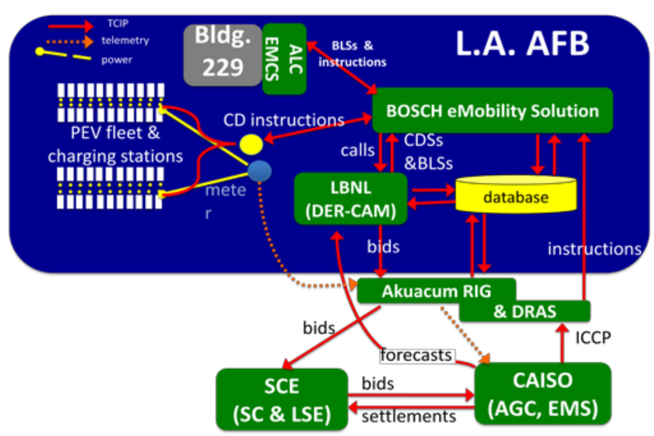

Figure 6

Since this is a regulation ancillary service, like what was described in section 3.3, the intention is to use the same architecture. One of the main differences is that the CAISO's new NGR model will be deployed. Since this is still a work in progress it is too early to make any conclusions.

5. CONCLUSIONS

There is a growing need for more ancillary services, especially with the increased integration of renewable resources. Demand side resources can and will play a significant role in providing ancillary services and it is therefore a benefit to the ISO's and other balancing authorities if they can reach a broader range of demand side resources for the purposes of ancillary services. Any changes in the current practices of the ISO that can lower the barrier to entry of additional demand side resources is therefore of benefit.

The architectures presented in this paper have been proven to be a technically viable approach to lowering the barrier of entry to demand side resources in a cost effective way. Existing ISO's like the CAISO are actively investigating how these new architectures will change their existing business practices in an effort to leverage their benefits as much as possible.

Biographies

Ed Koch, Akuacom/Honeywell

Ed is currently a Senior Fellow at Honeywell and CTO/Co-Founder of Akuacom, a wholly owned subsidiary of Honeywell. Ed was the leader of the workgroup at LBNL that drafted the OpenADR specification and currently sits on the Board of Directors of the OpenADR Alliance. Ed also is the co-chair of the OpenADR Task Force within UCAIug and is actively involved in a number of Smart Grid standardization efforts including the NIST Building to Grid Domain Expert Working Group, the OASIS Energy Interoperation Technical Committee, and the NAESB Smart Grid Standards Taskforce.

Sirajul Chowdhury, CAISO

Sirajul received his BSEE (1990) from the University of Oklahoma. He worked at Landis & Gyr as a senior power system engineer from 1990 to 1999. He has been working at California ISO as a technical lead in EMS department. His professional interests include control system, energy market, Automatic Generation Control, and real-time system design and development. His recent work at ISO involves designing new control logic for demand response and storage model. He has been leading contributor to various DR pilot projects. He has an active role in California ISO's goal for renewable penetration.

John Hernandez, PG&E

John is currently a Senior Product Manager at Pacific Gas & Electric's (PG&E) Customer Energy Solution - Demand Response Emerging Market Department. John currently leads PG&E's DR integration and demonstration efforts across the various operations. He has led PG&E's Participating Load Pilot and Intermittent Renewable Pilot – which showcases DR resources responding to ISO signals in seconds using OpenADR communicating standards. His responsibilities include the design, development and implementation of demand response programs for retail electricity customers that is incorporated into wholesale market, transmission and distribution operations. He has a BS in Business Management from the University of San Francisco.

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