Natural Resources Canada
Ressources naturelles Canada

CanmetENERGY
Leadership in ecoInnovation

Comparison of Demand Response Communication Protocols

Canada

COMPARISON OF DEMAND RESPONSE COMMUNICATION PROTOCOLS

Prepared by:

***Scott Coe**, Ph.D., Vice President*

UISOL AN ALSTOM COMPANY

Present to:

CanmetENERGY, Varennes Research Centre

Date

March, 2011

Citation

Scott Coe; Comparison of Demand Response Communication Protocols, CanmetENERGY Report 2011-061 (RP-TEC) 411-DERCOM , 16 pages

Disclaimer

Authors

Dr. Scott Coe, Vice President at UISOL, has 15 years of experience in wholesale electricity markets, ranging from technical design to process improvement. For the past several years, Scott has focused on implementing demand response management solutions and furthering standards related to demand response. In particular, Scott has assisting the ISO/RTO Council (IRC) develop standards for a variety of initiatives, including demand response measurement & verification standards at NAESB and application communication standards at CIGRÉ. Scott has spent time at many of the ISOs and RTOs over the years, with projects at ISO New England, PJM, the California ISO, the Midwest ISO, and the Alberta Electricity System Operator. Scott sits on the North American Energy Standards Board and heads the UISOL Demand Response Integration Lab. Scott holds a M.S. in Engineering Physics from Rensselaer Polytechnic Institute and a Ph.D. in Physics from Yale University.

TABLE OF CONTENT

ORGANIZATION OF PAPER

This document is split into the following sections:

1. Overview of OpenADR
2. Overview of NIST PAP09 Protocols
3. Comparison of OpenADR & NAESB Retail
4. Overview of the Other Actors in DR Signaling

Section 3 comprises the majority of the analysis results, with a function-by-function comparison of the two relevant standards introduced in Section 1 and Section 2. Section 4 provides additional information on some recent work currently being performed which add other important layers to the full picture.

1 OVERVIEW OF OPENADR

1.1 Background

OpenADR research began in 2002, funded by the California Energy Commission. Originally known as Automated Demand Response (AutoDR), the specification was renamed to OpenADR (Open Automated Demand Response) as it became used publically. Lawrence Berkeley National Lab (LBNL) published the OpenADR version 1.0 specification on its website in 2009.

1.2 The Focus of OpenADR

The OpenADR protocol is centered on the demand response automation server (DRAS). On one side of the DRAS is the utility: defining programs, checking capacity, calling events, and so on. On the other side is the participant/client: opting in or out of programs, collecting event information, and so on.

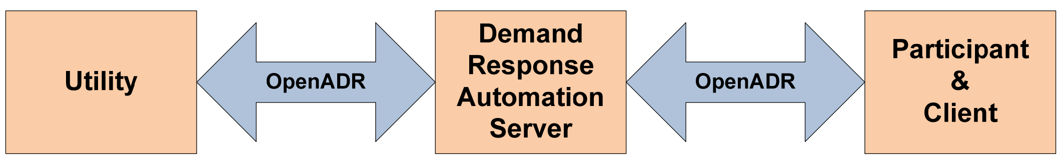

Figure 1: OpenADR Communication Path

Every OpenADR function is classified into one side of the process: Utility or Participant/Client. In many cases, there are related functions on each side; for example a client might submit a bid (part of "Automate Bidding" category) while the utility might retrieve all bids after the bidding windows closes (also part of "Automate Bidding" category).

Utility Category	Participant/Client Category
Configure DRAS	Configure DRAS
Monitor DRAS-Related Activities	Monitor DRAS-Related Activities
Automate Bidding	Automate Bidding
Handle DR events	Receive DR Event Information
-	Opt In/Out of DR Events
-	Notify Operator
-	Submit Feedback

As a messaging specification, OpenADR does not prescribe details about the implementation or performance of the DRAS itself. For example, there is no direction about what screens might exist on either the client side or on the utility side. And there are no requirements or pointers for how data is internally stored within the DRAS. This leaves the field open for software developers to create their own version of different DRAS implementations, with the only key requirement being that the appropriate OpenADR messages be communicated properly.

It should be noted that DRAS implementations are often also limited in the number of interfaces supported as well. Depending on the utility program design, certain messages will be unnecessary. The most commonly used functions include:

1. Create/Modify/Delete/Get DRAS Client
2. Get DR Event Information
3. Create/Delete/Get Opt-Out State
4. Set/Get Event Feedback

In fact, assuming participant information is collected via other means, nearly any demand response program could be automated with this simple subset of functions. And even with this frequently used subset, the third and fourth functions may also be viewed as optional.

The success of OpenADR may be view as a by-product of this simplicity. As an example, members of the UISOL Demand Response Integration Lab have demonstrated basic OpenADR connectivity after only a few days of development and testing time to load new software onto an internet-enabled control device and poll the DRAS for event information. As a general rule, most implementations of OpenADR utilize polling as opposed pushing events into the device to eliminate issues of internet security on the client side.

2 OVERVIEW OF NIST PAP09 PROTOCOLS

2.1 Background

In parallel to the OpenADR development effort, the United States government initiated a related, yet much broader scoped, project correlating the development of an industry agreement on smart grid interoperability standards. As documented in the Energy Independence and Security Act of 2007 (EISA), the National Institute of Standards and Technology (NIST) was given "primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems." By mid-2010, NIST had developed 15 Priority Action Plans (PAPs) related to different aspects of the smart grid with priority Action Plan #9 (PAP09) entitled "Standard DR and DER Signals" being the one most relevant to the demand response community.

To execute the mandate for PAP09, NIST enlisted the North American Energy Standards Board (NAESB) to facilitate discussions within the industry and document requirements for demand response communication protocols. NAESB is split into four quadrants, wholesale electricity (WEQ), retail electricity (REQ), wholesale gas (WGQ), and retail gas (RGQ) – with the first two quadrants being charged with action items on their annual plan to deliver DR communication protocol requirements.

2.2 Wholesale Demand Response Standards

While the wholesale and retail groups at NAESB did work very closely together, the starting points for the two standards came from very different perspectives. The WEQ standards were based in large part on work submitted by the ISO/RTO Council (IRC). From a Canadian perspective, the Ontario Independent Electricity System Operator (IESO), the Alberta Electric System Operator (AESO), and the New Brunswick System Operator (NBSO) were all contributors. The ratified standards are available at no charge to NAESB members or to interested parties for a fee.[1]

The ten ISOs and RTOs in North America utilize a variety of systems and technologies to communicate demand response signals, ranging from internet-based protocols to dedicated networks communicating via DNP3. The NAESB WEQ Standards contain requirements for all information flows from registration through to performance evaluation of demand resources and including deployment, with 33 exchanges in total. The IRC members developed a flexible framework that is intended to cover local variations in market rules, while still standardizing the information payloads in these exchanges over time.

[1] The draft version is available at http://www.naesb.org/pdf4/weq_2010_ap_6c_rec.doc

2.3 Retail Demand Response Standards

Similar to the WEQ process, members of the REQ contributed different ideas until ultimately a retail set of standards was ratified. Whereas the wholesale group chose to model the business process and identify interactions among "actors", the retail group chose to document use cases using the Unified Modeling Language (UML), broken down into five major categories:

1. Administrate DR Program
2. Administrate Customer for DR
3. Administrate DR Resource
4. Execute DR Event
5. Post DR Event Management

Again, the final standards are available free to members or to non-members for a fee.2

2.4 Wholesale & Retail Reconciliation

One key difference between the approaches of wholesale and retail is the "level" of the resources. Typically, wholesale market operators deal only with resources with minimum reduction capacities of 100 kW. However, retail protocols often focus on individual buildings, homes, or even devices behind the meter. From an abstract perspective, dealing with resources of any size can be treated similarly, e.g. call a resource to reduce to its offered amount; however the details of enrolling, qualifying, offering capability, and measuring performance can be very different. For this reason, an early accomplishment of the joint wholesale-retail group was to build an object model which could handle different levels of demand response. In particular there are **Resources** (which represent wholesale-level dispatchable entities most often in aggregate), **Service Locations** (which represent the physical buildings which perform the demand response – sometimes called Facilities), and **Service Delivery Points** (which represent any object within the Facility capable of reducing consumption – sometimes called End Devices). This common point of understanding, depicted as an entity-relationship diagram, is included as an appendix to every NAESB PAP09 document. (See Appendix A: DR Entity-Relationship Diagram)

In the most general implementations of demand response programs, the Entity-Relationship Diagram collapses into a smaller model, as illustrated in the following diagram:

[2] The draft version is available at http://www.naesb.org/pdf4/retail_2010_ap_9c_rec_101510.doc

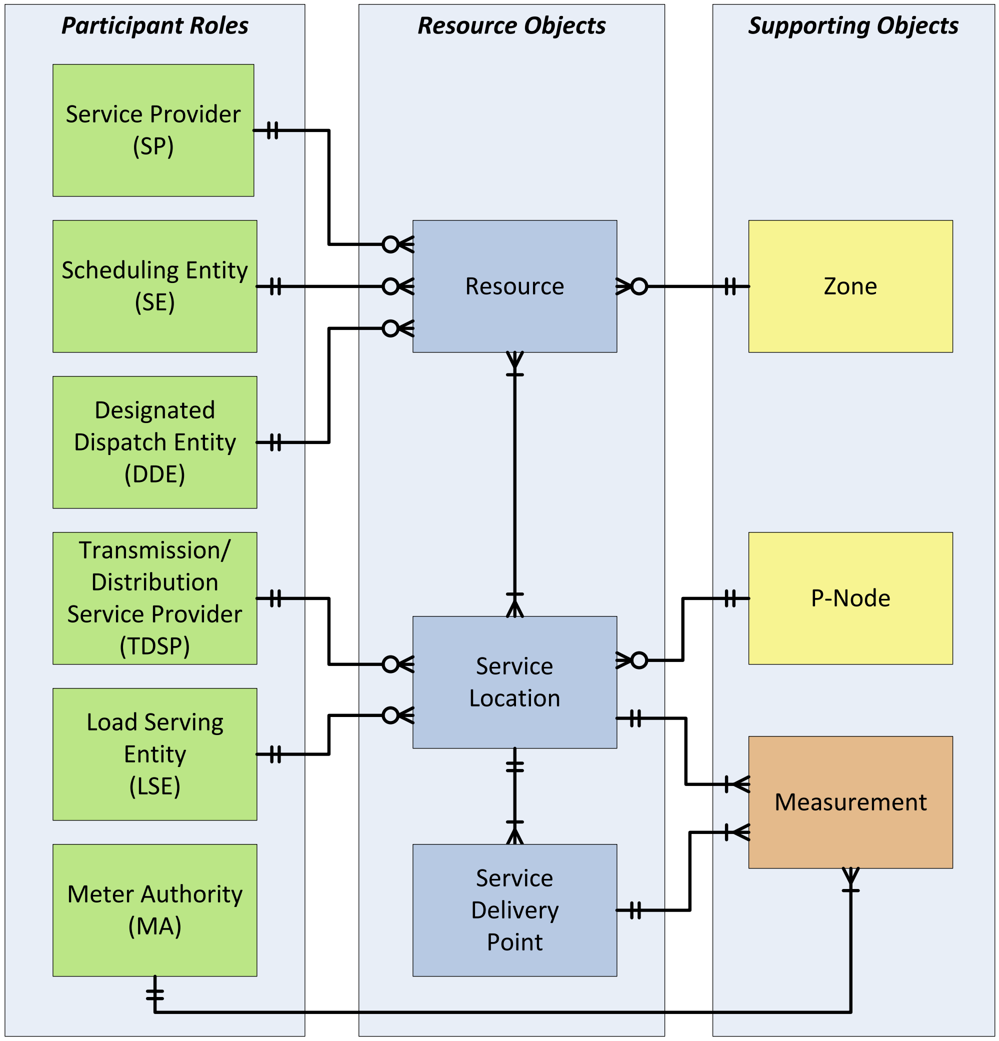

Figure 2: NAESB Entity-Relationship Model (Simple Case)

Following the ratification of both the WEQ and REQ requirements documents, the working group embarked on a more detailed data requirements phase. At this stage in the process, the wholesale and retail groups had reconciled the processes and aligned their models, and the team was able to deliver a common set of requirements. The final product is a document which covers the 290 data elements which are needed to build the 33 WEQ information flows and support the 31 REQ use cases, with indicators to applicability to wholesale and retail for each element.[3]

[3] The draft version is available at http://www.naesb.org/pdf4/weq_2010_ap6_rec_101510.doc

3 COMPARISON OF OPENADR & NAESB RETAIL

3.1 Introduction

For those utilities beginning a demand program who wish to adopt an industry-standard communication protocol, a key decision to make is the choice between the de-facto standard of OpenADR with a track record of multiple successful implementations and the NAESB REQ PAP09 standards with greater visibility but with no history of real-world implementations.

First it should be noted that the NAESB REQ PAP09 standards contain a set of business practices and requirements. As detailed as the documents are, the NAESB standards provide neither a complete information model nor message profiles which can be implemented in practice. This is also true of the WEQ case as well. For both REW and WEQ, the Organization for the Advancement of Structured Information Standards (OASIS) Energy Interoperation Technical Committee is building a model and associated profiles based on these requirements.

3.2 Event Handling

The key message in OpenADR for communicating the details of a demand response deployment is ***Get DR Event Information*** in the polling configuration (or the ***Send DR Event Information*** in the push configuration). The parallel concept in the NAESB requirements is the ***Execute/Update/Cancel DR Event.*** Within the NAESB requirements, four use cases are called out to be supported:

1. Advance Notification (for pre-event information transfers)
2. Dynamic Price-Based Deployment (called “DR Execution – Real Time Pricing (RTP)”)
3. Notification-Based Deployment (called “DR Execution – Notification Based”)
4. Direct Load Control (DLC)

Within OpenADR, confirmation from the DRAS client is communicated via the ***Set/Get DR Event Feedback*** function. The parallel within NAESB requirements are the ***Monitor DR Event (DR Asset)*** and ***Monitor DR Event (DR Resource)*** functions, depending on the “level” of demand resource involved.

3.3 Managing Clients

Before an event can be communicated, however, the client itself must be registered. In OpenADR this is achieved via the ***Create/Get/Modify/Delete DRAS*** Client functions. The parallel within the NAESB requirements are the ***Register/Update/Remove DR Asset*** and ***Register/Update/Remove DR Resource*** functions, again depending on the “level” of demand resource involved.

OpenADR also provides for the registration of participants via the ***Get/Modify Participant Accounts***, considered outside the scope of the NAESB working group.

A common feature used in OpenADR is the ***Create/Get/Delete Opt-Out State*** function which is used by the participant to temporarily remove a client from demand response participation. While not explicitly supported with the NAESB requirements as a stand-alone function, the Offer Commit Status variable within the registration functions may be toggled to achieve the same effect.

3.4 Bidding

Automated bidding is a key component of OpenADR. The ***Submit/Get Bid*** functions are used to dynamically set the level at which a DRAS client becomes economic. Standing bids may also be employed using the ***Submit/Get/Delete Standing Bid*** functions.

The NAESB requirements also utilize bids, but in a somewhat different formalism aligned more with an auction-type market, as opposed to the "client set threshold price" concept within OpenADR. There are two functions, one to supply demand response services ***(DR Bid To Supply)*** and one to procure demand response services ***(DR Bid To Buy)***. It is the supply side of the auction that most closely corresponds to OpenADR, albeit without the standing bid concept.

3.5 Higher-Level OpenADR Functions

Another feature of OpenADR is an ability to capture program constraints, such as maximum event durations, black-out dates and/or times, and the maximum consecutive over which events may run. The constraints are particular to a given program and may be set for individual DRAS clients or at the participant level, i.e. across all DRAS clients for that participant. The following related functions are not included in the NAESB requirements:

Managing Program Constraints

- **Set/Get/Delete Participant Program Constraints**
- **Set/Get/Delete DRAS Client Program Constraints**

OpenADR supports the ability to manage response schedules. Response schedules are collections of conditions which can be used to affect a given DRAS client, i.e. change its response state based on simple variables such as a dynamic price relative a bid/offer value. Each operational state must be defined in the program, e.g. High Shed / Moderate Shed / Normal, and may be found by polling the DRAS for program information. The following related functions are not included in the NAESB requirements:

Managing Response Schedules

- **Get Program Information**
- **Create/Get/Delete Response Schedule**

The DRAS, via OpenADR, can query any client for its status, log files, and alarms. The following related functions are not included in the NAESB requirements:

Monitoring of DRAS Activities

- **Get DRAS Client Comms Status**
- **Get DRAS Transactions**
- **Get DRAS Client Alarms**

OpenADR also allows for testing of the DRAS client. A test mode function is first used to toggle the DRAS client into the correct mode, and then a separate function may be used to force the client into a specific response state. While in test mode, normal demand response commands are ignored. The following related functions are not included in the NAESB requirements:

Installation & Testing

- **Set Test Mode**
- **Set/Get Test Mode State**

3.6 Measurement & Verification

Measurement & Verification, the process of analyzing meter data collected during an event to either levels before the event or to historical usage patterns, is covered in the NAESB requirements. From a communications perspective, the functions include the submittal of metering information and the receipt of payment information.

No post-event data processing is included within OpenADR, however the NAESB requirements include use cases defined, one for the traditional utility/client interaction (labelled “No Retail Competition”) and another with retail competition (labelled “Retail Competition”). The logical difference is the insertion of a load-serving entity in between the participant and the utility in the retail competition case.

3.7 Participant / Client Operations Summary

The following table summarizes the mapping between OpenADR and NAESB REQ PAP09 functions related to operations on the participant/client interface:

PARTICIPANT / CLIENT OPERATIONS

Function	OpenADR	NAESB REQ PAP09
Event Handling	Get/Send DR Event Information	Execute/Update/Cancel DR Event
	Set/Get DR Event Feedback	Monitor DR Event (DR Asset/Resource)
Managing Clients	Create/Get/Modify/Delete DRAS Client	Register/Update/Remove DR Asset/Resource
	Create/Get/Delete Opt-Out State	
	Get/Modify Participant Accounts	
Bidding	Submit/Get Bid	DR Bid To Supply
		DR Bid To Buy
	Submit/Get/Delete Standing Bid	
Managing Constraints	Set/Get/Delete Participant Program Constraints	
	Set/Get/Delete DRAS Client Program Constraints	
Response Schedules	Get Program Information	
	Create/Get/Delete Response Schedule	
Monitoring Clients	Get DRAS Client Comms Status/Transactions/Alarms	
Installation & Testing	Set Test Mode	
	Set/Get Test Mode State	
M & V		DR Event M&V / Settlement (Yes/No Open Retail)

3.8 Utility/ISO Interface

The focus of the NAESB working group was on uniform communication outside enterprise communications, therefore the entire utility/ISO side of the DRAS is considered out of scope within the NAESB requirements.

The following table summarizes the mapping between OpenADR and NAESB REQ PAP09 functions related to operations on the utility interface:

UTILITY OPERATIONS

Function	OpenADR	NAESB REQ PAP09
Event Handling	Initiate/Modify DR Event	
	Get Participant Feedback	
	Adjust DR Event Participants	
	Get DR Event Information	
	Set/Get Event Constraint	
Bidding	Set/Get Current Bids	
	Close Bidding	
	Set Bid Status	
Managing Programs & Accounts	Create/Get/Modify/Delete Program	
	Create/Get/Modify/Delete Participant Accounts	
	Adjust Program Participants	
	Set Groups	
Monitoring Clients	Get DRAS Client Comms Status/Transactions/Alarms	

4 OVERVIEW OF THE OTHER ACTORS IN DR SIGNALING

4.1 Oasis Energy Interoperation

The Organization for the Advancement of Structured Information Standards (OASIS) formed the Energy Interoperation Technical Committee[4] in 2010 to extend the requirements provided by NAESB into a fully-developed information model to supply to NIST to finalize the PAP09 deliverable set. As illustrated in the previous section, several components of the OpenADR specification are not incorporated into the NAESB PAP09 requirements.

The OASIS Technical Committee, however, goes beyond the NAESB requirements, extending the functions to more closely align with OpenADR. In addition to extending the scope of the model, the group also incorporated several logical models into it work. The first model was used to describe the relationship among multiple levels of demand resources using, recasting EPRI's Resource Energy Controller (REC) - Virtual End Node (VEN) concept.[5] The second model was the Energy Market Information Exchange[6] which layers financial trading over top of fundamental demand response concepts.

IT should be noted that the OASIS Technical Committee is still working on its specification, so information reported at this time should be considered draft.

The following table illustrates the high-level mapped between the concepts in OpenADR and the Energy Interoperation specification:

[4] http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=energyinterop
[5] http://my.epri.com/portal/server.pt?Abstract_id=000000000001020432
[6] http://docs.oasis-open.org/emix/emix/v1.0/csprd01/emix-v1.0-csprd01.doc

OpenADR - OASIS EI Mapping

OpenADR	OASIS Energy Interoperation
Participant	EI Party
DRAS Client	EI Registration
DR Event	EI Event
Opt Out State	EI Opt Out
DR Event Feedback	EI Feedback
	EI Quote
Bid	EI Tender
	EI Contract
Program	EI Program
Program Constraints	EI Constraint
	EI Usage

4.2 The OpenADR Alliance

In late 2010, a group of industry members, with the support of Lawrence Berkeley Laboratory, created the OpenADR Alliance. The OpenADR Alliance intends to foster "development, adoption, and compliance of the Open Automated Demand Response (OpenADR) standard through collaboration, education, training, testing, and certification."[7] The OpenADR alliance states that they will work with NAESB and OASIS, as well as group with related mandates, including the Utilities Communications Architecture International User's Group (UCAIug), the Wi-Fi Alliance™, and the Zigbee Alliance™.

[7] http://openadr.org/getattachment/Home/OpenADR-Alliance-Launch-102710.pdf

5 CONCLUSIONS

The NAESB Requirements Specification for Retail Standard DR Signals has fewer functions relative to OpenADR. However, many OpenADR implementations utilize only a small fraction of the complete OpenADR capability – aligned with what is included in the NAESB documents. And implementable standards should be arriving from the OASIS Energy Interoperation working group. Since individuals interested in OpenADR are participating in that forum, there is a good chance that the OASIS output will be easily mapped to the forthcoming OpenADR 2 specification.

In any case, for the first time the major players in demand response, including the wholesale market operators, utility program designers, demand response providers, and software developers, are all communicating. Common terminology is emerging and this should lead to convergence in the long-term.

The specifications from NAESB are intended to be applicable across all of North America. The NAESB Smart Grid working group has had participation from a number of companies involved in both the wholesale and retail ends of demand response; however, participation from Canadian companies – in general - has been very minimal. Given the impact these standards may have on the industry, it would be beneficial to Canadian electricity customers for their electric utilities and service providers to become more active in the process. We hope this report provides are good summary to those who have been or now may be considering such as step.

APPENDIX A

DR ENTITY-RELATIONSHIP DIAGRAM

APPENDIX A: DR ENTITY-RELATIONSHIP DIAGRAM