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Communication Protocol Mapping Guide 1.0, OpenADR 2.0 to ANSI/CTA-2045-A

Requirements for Exchanging Information Between OpenADR 2.0 Clients and ANSI/CTA-2045 Technologies

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Member Organizations	OpenADR Alliance Northwest Energy Efficiency Alliance (NEEA) Consortium of Energy Efficiency (CEE)
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ABSTRACT

The intent of this publication is to provide the industry with a standardized approach to exchanging information between two different open communication standards, OpenADR 2.0 and ANSI/CTA-2045-A. The document defines how a specific set of messages from one standard are mapped to the other (i.e. protocol map). The map included herein was implemented and field tested with behind-the-meter (BTM) loads in systems designed to provide services to the grid. The systems were comprised of the following actors (1) an OpenADR 2.0 certified demand response management system, (2) an ANSI/CTA-2045 communication module with an embedded certified OpenADR 2.0 client and (3) different types of BTM loads that were preconfigured to respond to information exchanged through a native ANSI/CTA-2045-A port The responses of each BTM load was made predictable by requiring manufacturers to support a specific set of ANSI/CTA-2045-A messages. The set of ANSI/CTA-2045-A messages that BTM loads were required to support (included in Section 4.0 of this report) was used to determine the core set of messages include in the map, The mapping requirements and other information included in this document are intended to enable (1) manufacturers to embed "grid service" functionality into off-the shelf products, (2) consumers to directly access or manage access (i.e. utility, aggregator or third-party service provider) to information or functions embedded into their own devices to manage energy or demand BTM or provide services to the grid across the meter and (3) utilities, aggregators or any third-party to design and deploy systems with components that could be interchanged with those produced by manufacturers other than the original.

Keywords

ANSI/CTA-2045
ANSI/CTA-2045-A
Behind-the-meter
BTM
Communication port
Demand response
EVSE
Functional requirements
Grid interactive water heater
Grid services
Load management
Modular interface
OpenADR 2.0
Pool pump
Smart grid
Water heater

GLOSSARY OF TERMS

Actor – Representative name assigned to each of the subcomponents of a system that contribute to the output of a system. Example actors are humans, machines, or applications.

Application – Software program designed to provide a specific service.

Behind-the-meter (BTM) – Term used to describe resources physically located within the customer's premises.

Compliance – Conformance to a specific set of rules or requirements. This term is typically used in reference to standards and is used to signify that a technology or service meets the rules or requirements defined in a specific standard.

CTA – Consumer Technology Association

CTA-2045 Communication Module or Universal Communication Module (UCM) – A communication module that complies with the ANSI/CTA-2045-A standard under the form factor classification of either AC or DC.

Demand Response Management Application (DRMA) – An application designed to manage the aggregate services provided by resources.

Demand Response Management System (DRMS) – A DRMA and components required to support aggregate demand response services.

DRMS Operator – Human that interfaces with the DRMS through a graphical user interface that enables the DRMS and Human to exchange information.

Functional Requirement – A requirement defines the contribution of an actor within a system or the system itself. Functional requirements define specific functions or behaviors of actors within a system or the system.

Grid Service – Functions or behaviors of a device that could provide a benefit to the public.

GUI (Graphical User Interface), HMI (Human-Machine Interface), or H2M (Human-to-Machine) – These acronyms are used to represent an interface that enables humans and machines to share information.

Interface – Communications interfaces represent a pathway by which information is exchanged between actors. The interface is a pathway that conforms to a specific set of rules that must be supported by all actors that are required to exchange information.

Interoperability – The capability of two or more actors or systems to be connected to one another and exchange and process information in a predictable way without having to make any modifications to the involved actors.

M2M (Machine-to-Machine) Interface – Pathway over which information is shared between two machines.

Machine – Device that consumes, generates, or stores energy.

Non-Functional Requirement – A requirement that defines the qualities of a system, such as security, maintainability, and scalability, that can be used to judge how well the system operates and evolves.

OpenADR 2.0 – Open Automated Demand Response, published by the OpenADR Alliance, is a communication specification that defines the rules for sharing information between a server and one or more clients on a shared network. The specification includes application-layer messages that exchange information to support energy and other services. The standard also requires that messages be secured in accordance with TLS 1.2 and transported using HTTP or XMPP.

Profile – A set of constraints or rules for applying a standard.

REQ – Requirement

Resource – Smart-Grid Device (SGD)

Requirement – (1) A condition or capability needed to achieve an objective. (2) A condition or capability that must be met or possessed by an actor or system.

Smart-Grid Device (SGD) – Used in the ANSI/CTA-2045-A standard to describe the end-use device.

Standard – A technical specification, usually produced by a Standards Development Organization (SDO). Standards define sets of rules that can be tested across products or services provided by any manufacturer.

Subsystem – one or more actors within a system that work together to perform a specific task. Typically, actors within a subsystem communicate to one another through proprietary interfaces supplied by one manufacturer.

System (Control) – A collection of components (actors) whose collective output (dependent variable) can be predicted by managing the inputs (independent variables).

System (Operational Procedures) – A set of procedures that describes how to operate the system.

Universal Communication Module (UCM) – Name used in the ANSI/CTA-2045-A standard to describe the module that plugs into a ANSI/CTA-2045-A port of an end-use device.

Use-case – A document that includes the rules, requirements, actors, and operational and technical objectives of a system.

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1
INTRODUCTION

This document defines the requirements for exchanging information between the application layers of OpenADR 2.0[1] and ANSI/CTA-2045-A[2]. The requirements included herein (i.e. protocol map) were implemented and field tested in a system comprised of the following actors (1) demand response management system that supports OpenADR 2.0, (2) an ANSI/CTA-2045-A communication module that supports OpenADR 2.0 and (3) end-use devices that support ANSI/CTA-2045-A that conform to publicly available device type specific functional requirements (overview included in Section 4.0 of this report). The research was carried out to demonstrate how loads with built-in demand responsive features, accessible through an open interface could respond directly to dispatch signals, eliminating the need for an intermediary cloud application to consume the dispatch signal and disseminating instructions to loads through a proprietary messaging protocol. The key actor in this system was the ANSI/CTA-2045-A communication module, that was tasked with exchanging information with an OpenADR 2.0 server, converting dispatch instructions into a process by which information is exchanged with the load in a sequential order to provide the instructed service to the grid.

1.1 Approach

OpenADR 2.0 and ANSI/CTA-2045-A were developed to facilitate the open exchange of information between actors participating in a load management system. Even though both protocols were designed to support actors in load management systems, they were designed to exchange information with specific actors. Since both protocols support load management systems, the information supported by the application-layers of both protocols are similar, but they are very different. OpenADR 2.0 for example, was designed to exchange secured information with one or more actors in the system over a shared network (i.e. internet), whereas ANSI/CTA-2045-A was designed to exchange information between two actors, the end-use device (i.e. BTM resource) and a communication module over a private serial communication port. OpenADR 2.0 and ANSI/CTA-2045-A were designed to coexist with one another within the same system. Since load management services are provided by resources at their point of connect to the grid, the systems are dependent on the load management functions supported by resources and the accessibility of their functions. The map between ANSI/CTA-2045-A and load management functions for different types of resources were used to determine the information set to include in this guideline. Specifications for mapping ANSI/CTA-2045-A to functions of different types of resources are included in Table 1-1. The set of ANSI/CTA-2045-A messages common across the specifications listed in Table 1-1 were used to determine the minimum set of OpenADR 2.0 messages to include in the map. Tables that summarize the functional specifications listed in Table 1-1 are included in Section 4.0.

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[1] OpenADR Alliance, OpenADR 2.0 Profile Specification B_v1.1, 11-17-2015.

[2] Consumer Technology Association, ANSI/CTA-2045-A Modular Communications Interface for Energy Management, March 2018.

Table 1-1
Functional Specifications for ANSI/CTA-2045-A Resources

Resource Types	EPRI Publication ID for Functional Requirements	Summary Tables (Map between ANSI/CTA-2045-A Messages and Functions)
Domestic Electric Water Heater	3002002710	Table 4-1
Heat Pump Water Heater	3002002719	Table 4-2
Thermostat	3002002711	Table 4-3
Variable Speed Pool Pump	3002008320	Table 4-4
Electric Vehicle Supply Equipment	3002002712	Table 4-5
Packaged Terminal Air Conditioners	3002006951	Table 4-6
Variable Capacity HVAC	AHRI P1380	Table 4-7

To ensure that the requirements defined herein could be applied in contemporary and near-future systems, a general assessment of the technologies available today was performed. Summary findings are included below.

- ***OpenADR 2.0 Virtual Top Nodes***, Applications and services are available through different service providers[3]. Open source OpenADR 2.0 server application (certified by the OpenADR Alliance) is available on GitHub (see Section 5.2).
- ***OpenADR 2.0 Virtual End Nodes,*** Applications and libraries that support different operating systems are available through a number of different service providers. Open source applications for a variety of OpenADR 2,0 clients are available on GitHub (see Section 5.2).
- ***ANSI/CTA-2045 Communication Modules,*** Hardware with one or more types of physical communication interfaces capable of transporting OpenADR 2.0 payloads are produced by different manufacturers.
- ***ANSI/CTA-2045 Resources (Power Consuming Devices),*** Multiple types of resources are available from different manufacturers. Section 4.0 include the recommended (and applied) functional specifications requirements for most of the device types available today.

1.2 Intended Use

This document is intended to enable (1) manufacturers to embed "grid service" functionality into off-the shelf products, (2) consumers to directly access or provide others access (i.e. utility, aggregator or third-party service provider) to the embedded functionality and (3) utilities, aggregators or any third-party to design and deploy systems with interchangeable components that rely on BTM resources to provide predictable services to the grid. The map is intended to be used in the design, development and deployment of systems that manage BTM resources. Before example applications of the requirements are introduced, it's important to be familiar with system architectures and how these systems are represented in this document. The graphic

[3] The OpenADR Alliance publishes a list of OpenADR 2.0 certified applications and technologies.

in Figure 1-1 is used to represent a simplified BTM system. The components of this system include (actors), the flow of information between actors (interface), decisions and actions (logic) that each actor must support to achieve the system's objective (output or grid service). For further reference, the symbols used in this diagram and subsequent figures are defined in Section 5.3.

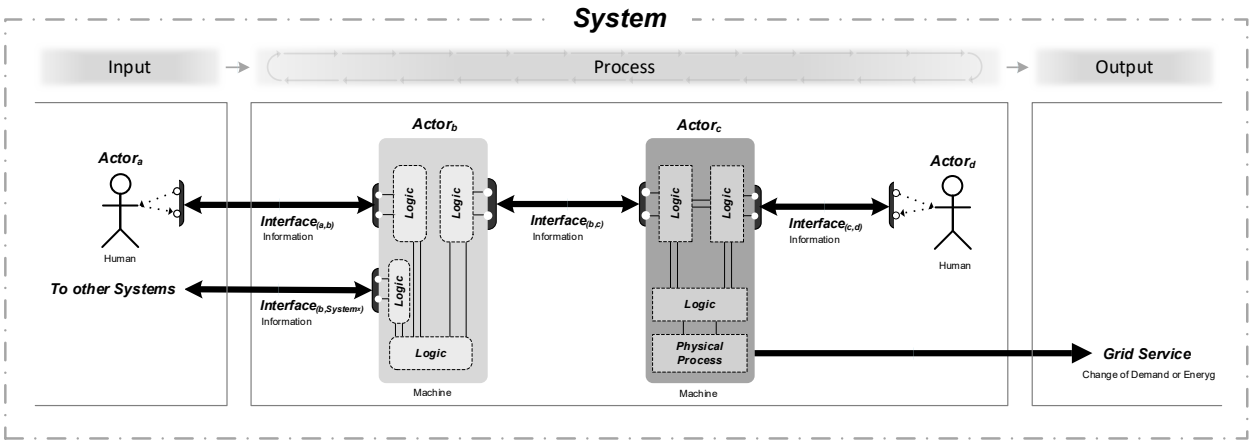

Figure 1-1
Reference BTM System Diagram

The following diagrams are intended to illustrate how the map could be deployed within systems designed to support the same use-case, but architected with different components. To help provide some insight into how the systems are intended to work, some general rules and requirements of the use-case are listed below.

- A Resource is any off-the-shelf energy consuming device that support a variety of different types and levels of grid services that can be accessed at the device through an ANSI/CTA-2045-A interface.
- Dispatch signals conform with the OpenADR 2.0 standard.
- Resources can be dispatched either manually by an operator or automatically by a secondary system.
- Information from the resources, such as Power, Energy Usage, Operational State and other information is available to the operator or to a secondary system.
- Dispatch signals can be sent to a single resource or groups of resources as determined by the operator or secondary system.
- The OpenADR 2.0 client resides within the premise.

In the system illustrated in Figure 1-2, an OpenADR 2.0 client embedded into an ANSI/CTA-2045-A communication module receives dispatch signals. The module uses the information contained in the dispatch signal to determine the sequence of information that must be exchanged with the resource to satisfy the dispatch.

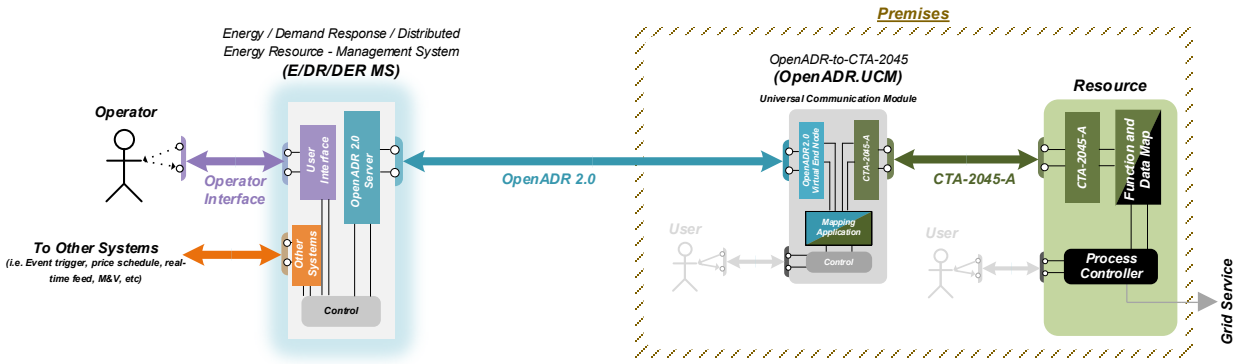

Figure 1-2
Example 1 – Architecture of a Load Management System

In the system illustrated in Figure 1-3, an OpenADR 2.0 client embedded into a Home Energy Management System (HEMS) receives dispatch signals. The HEMS uses the information contained in the dispatch signal to determine which resource to target and sequence of information that must be exchanged with the resource to satisfy the dispatch.

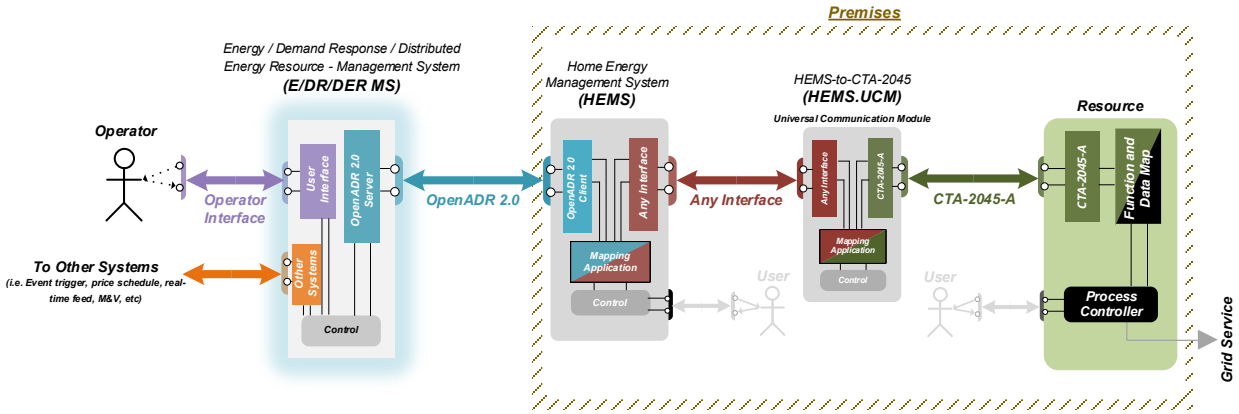

Figure 1-3
Example 2 – Architecture of a Load Management System

Table 1-2 shows how the contents of this document could be used by the components (actors) of both example systems. Included in this table are the names of the actors, their role in the system and how the contents of different sections of this document could be applied to support the system.

Table 1-2
Example Application of the Requirements (Filtered by Actor)

Actor	Description / Role	Dependent Actor(s)	Referenced Section	Example Use of the Requirements in Reference Section
Energy / Demand Response / Distributed Energy Resource - Management System ***(E/DR/DER MS)***	Application designed to manage resources located before or behind the meter to provide aggregation and other control services as determined by the requirements of the system the application is intended to support	***OpenADR.UCM*** ***HEMS*** ***Operator*** (not specified) **Other Systems** (not specified)	2.2	To specify the minimum set of OpenADR 2.0 event signals required to dispatch ANSI/CTA-2045-A resources. To specify, design and/or develop user interfaces configured to support each event signal identified in the minimum set.
			2.3	To determine the information that could be reported. To specify the information must be made available to support control or measurement and verification requirements of te program
			3.0	To setup groups and subgroups to enable dispatch signals to be sent to a single resource or multiple resources within a group.
			4.0	To determine what functions embedded in different types of resources could be leveraged to provide the most value to consumers and the grid.
Home Energy Management System ***(HEMS)*** Controller	Application running on a controller within a premises that's designed to manage energy usage or demand of one or more behind the meter resources. Interfaces: OpenADR 2.0 VEN Undefined	***E/DR/DER MS*** ***HEMS.UCM*** ***User or Consumer*** (not specified)	2.0	If programmatic rules require pending and active event notifications at the device, this section could be used to specify how to use issue notifications To specify the Link Layer messages and how to use the payload of the Outside Communication Status command
			2.2	To specify how OpenADR 2.0 dispatch signals must be processed by the controller
			2.3	To specify the information and frequency by which data from the device must be queried and presented to an OpenADR 2.0 VTN through the EiReport service
			3.0	To specify the naming conventions for the resources behind the VEN (ResourceID) To specify the use and format of GroupIDs for filtering and processing events To specify how EiEvents with one or more group IDs match those assigned to the HEMS's VEN
			4.0	To determine and specify the type and level of services that different resources could provide to the grid and how the ANSI/CTA-2045-A interface is used to access the services.
HEMS-to-CTA-2045 ***(HEMS.UCM)*** Communication Module	A device that meets the minimum requirements for a communication module as defined in ANSI/CTA-2045-A standard that also includes software and hardware required to connect to and communicate with the HEMS	***RESOURCE*** ***HEMS*** ***User or Consumer*** (not specified)	2.0	To specify the minimum set of ANSI/CTA-2045-A commands to communicate with the resource To specify commands required to support the HEMS or the system in which the HEMS is supporting.
			2.2	To specify how OpenADR 2.0 dispatch signals must be converted to ANSI/CTA-2045-A commands and the sequence by which the commands must be sent to the resource.

Actor	Description / Role	Dependent Actor(s)	Referenced Section	Example Use of the Requirements in Reference Section
			2.3	To specify the commands that must be sent to the resource to obtain information required to support the HEMS or the system in which the HEMS is supporting.
			3.0	To specify the naming convention for the attached resource (ResourceID).
			4.0	To determine and specify the type and level of services that different resources could provide to the grid and how the ANSI/CTA-2045-A interface is used to access the services
OpenADR-to-CTA-2045 ***(OpenADR.UCM)*** Communication Module	A device that meets the minimum requirements for a communication module as defined in ANSI/CTA-2045-A standard. The module also includes a certified OpenADR 2.0b VEN and the hardware required to connect to and communicate with an OpenADR 2.0b VTN located outside the premises.	***E/DR/DER MS*** ***RESOURCE*** ***User or Consumer*** (not specified)	2.0	To specify the minimum set of commands required to communicate with a ANSI/CTA-2045-A resource To specify commands required to support the system in which the module is intended to support.
			2.2	To specify how OpenADR 2.0 dispatch signals must be converted to ANSI/CTA-2045-A commands and the sequence by which the commands must be sent to the resource.
			2.3	To specify the commands that must be sent to the resource to obtain information required to support the HEMS or the system in which the HEMS is supporting.
			3.0	To specify the naming conventions for the resources behind the VEN To specify the use and format of GroupIDs for filtering and processing events To specify how EiEvents with one or more group IDs match those assigned to the VEN
			4.0	To determine and specify the type and level of services that different resources could provide to the grid and how the ANSI/CTA-2045-A interface is used to access the services
RESOURCE	Energy consuming resource with embedded grid services that can be accessed through a ANSI/CTA-2045-A interface	***HEMS.UCM*** ***OpenADR.UCM***	4.0	To specify the type and level of services that must be embedded into the resources and how they must be accessed through an ANSI/CTA-2045-A port.

2
MAPPING REQUIREMENTS

The requirements in this section define the rules by which information contained in the application-layer of one communication protocol is shared with the application-layer of another. The set of messages (i.e. information) contained in OpenADR 2.0 and ANSI/CTA-2045-A are similar, however the rules that govern how messages are exchanged between specific actors are quite different. OpenADR 2.0 is designed to exchange information over a network, shared by other devices. In the majority of contemporary systems where OpenADR 2.0 is deployed, the shared network is the public internet[4]. ANSI/CTA-2045-A is designed to exchange information between two devices (one being the BTM load and the other, a device physically attached to the load) over a private serial communication bus. Figure 2-1 is included to show where in a system these standards were intended to be deployed. In this system, ***Actor$_a$*** conforms to the rules of a OpenADR 2.0 server (i.e. Virtual Top Node) exchanges information with multiple clients over a shared network. ***Actor$_b$*** conforms to the rules for both an OpenADR 2.0 client (i.e. Virtual End Node) and ANSI/CTA-2045-A communication module. The module exchanges information with ***Actor$_c$*** which conforms to the functional specifications for ANSI/CTA-2045 resources (see Section 4.0).

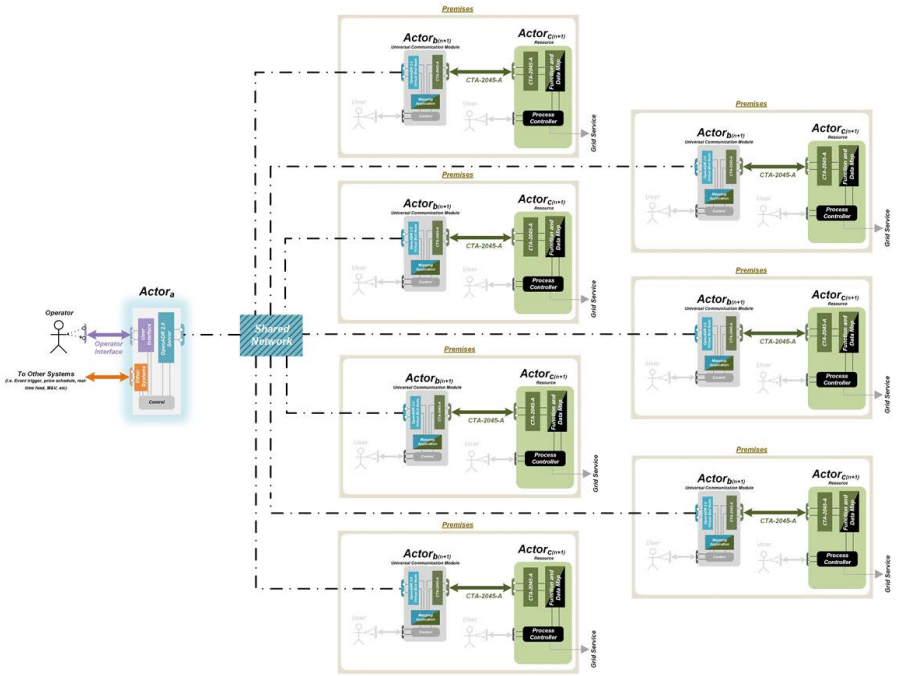

Figure 2-1
Example application of OpenADR 2.0 and ANSI/CTA-2045-A

[4] To deter security threats inherent to public networks, OpenADR 2.0 requires that the payloads be encrypted using transport-layer security (TLS 1.2).

Each standard defines the roles for each actor along with information each must support and the process for exchanging information between the actors. Each of these two standard define processes that are very different from one another that govern what and when information is exchanged. This process must be considered when applying the mapping requirements and when developing the requirements for the hardware and software to implement the map. For example, the information exchanged between OpenADR 2.0 actors are primarily triggered by events, even though there are some exchanges are scheduled, whereas ANSI/CTA-2045-A actors sequentially exchange information in real-time. The block diagram in Figure 2-2 is included to show the functional blocks of a conceptual mapping application (see ***Actor$_b$***) and that the sequence and time by which information is exchanged between ***Actor$_b$*** and ***Actor$_a$*** will not align with the sequence and time by which information is exchanged between ***Actor$_b$*** and ***Actor$_c$***.

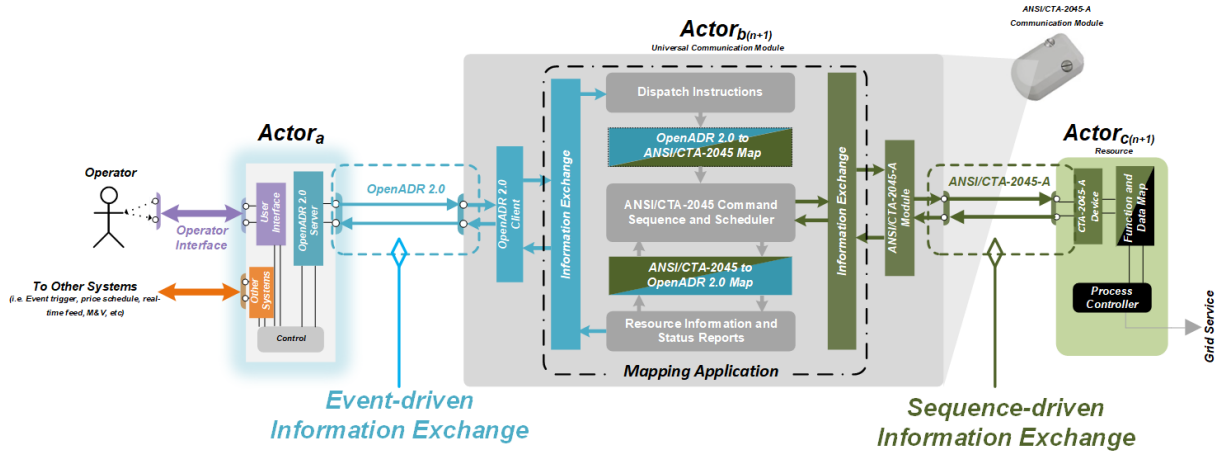

Figure 2-2
Conceptual mapping application and its functional blocks

2.1 Housekeeping Functions (Normative)

This section is titled "Housekeeping" because there are a few ANSI/CTA-2045-A commands that the standard requires all actors to support or are common across the functional specifications for all device types included in Section 4.0. These messages include the link-layer ACK/NAK, query capabilities (Message Types of Supported Query/Response, Max Payload Length, verify that the data contains the appropriate information (Basic Application ACK/NAK) and to inform the resource of its communication status (Outside Communication Status).

This section also includes messages that could be required to support a specific grid services use-case and other information obtained through the information exchange processes themselves. These additional commands include (Operational State Query/Response) used to query the resource for its operational state, (Pending Event Time) and (Pending Event Type) which could be used if the system requires the resource to be informed of the next event type and time (duration) till the next event. Requirements for how these commands must be applied are included in Table 2-1.

Table 2-1
Housekeeping Requirements

<table>
<tr><th rowspan="2">REQ.H#</th><th colspan="5">ANSI/CTA-2045-A Commands</th><th rowspan="2">Use</th></tr>
<tr><th>Message Type</th><th>Name</th><th>Opcode 1</th><th>Opcode 2</th><th>Payload</th></tr>
<tr><td>REQ.H1</td><td>Link Layer</td><td>ACK</td><td></td><td></td><td><table><tr><th>Type</th><th>Byte 1</th><th>Byte 2</th></tr><tr><td>ACK</td><td>0x06</td><td>0x00</td></tr></table>Refer to Section 6.1 in ANSI/CTA-2045-A</td><td>Link Layer ACK and NAK messages are used in response to all messages except other link layer ACKs and NAKs</td></tr>
<tr><td>REQ.H2</td><td>Link Layer</td><td>NAK</td><td></td><td></td><td><table><tr><th>Type</th><th>Byte 1</th><th>Byte 2</th></tr><tr><td>NAK</td><td>0x15</td><td>NAK Code</td></tr></table>Refer to Section 6.1 in ANSI/CTA-2045-A</td><td>Link Layer ACK and NAK messages are used in response to all messages except other link layer ACKs and NAKs

NAK Codes<table><tr><th>Link NAK Error Code</th><th>Priority</th><th>Description</th><th>Usage</th></tr><tr><td>0x00</td><td></td><td>No Reason</td><td>Not used.</td></tr><tr><td>0x01</td><td>1</td><td>Invalid Byte</td><td>Indicates that a byte framing or other invalid byte error has occurred (e.g., missing stop-bit on the AC RS-485 interface).</td></tr><tr><td>0x02</td><td>2</td><td>Invalid Length</td><td>Used to indicate that the length indicated in the PDU length field is out of range.</td></tr><tr><td>0x03</td><td>3</td><td>Checksum Error</td><td>The bytes in the checksum field at the end of the message did not agree with the computed checksum.</td></tr><tr><td>0x04</td><td>4</td><td>Reserved</td><td>NA</td></tr><tr><td>0x05</td><td>5</td><td>Message Timeout</td><td>Indicates that more than t_{ML} (defined in Error! Reference source not found.) elapsed between receipt of the first byte and receipt of the last byte in a message transmission. t_{ML} was selected to allow any combination of data rate and payload. As additional speeds and payloads are added some combinations may be invalid.
This error code is not used by the DC Form Factor as noted in Appendix A.</td></tr><tr><td>0x06</td><td>6</td><td>Unsupported Message Type</td><td>Indicates that the “Message Type” is not supported.</td></tr><tr><td>0x07</td><td>7</td><td>Request Not Supported</td><td>Indicates that the requested setting is not supported (e.g., a requested Power Mode or Bit Rate is not supported).
This error code is used only in regards to link layer requests, not in regards to lack of support for application layer requests.</td></tr></table></td></tr>
<tr><td>REQ.H3</td><td>Link Layer</td><td>Message Type Supported Query</td><td></td><td></td><td><table><tr><th>Message Type MS Byte</th><th>Message Type LS Byte</th><th>Description</th></tr><tr><td>0x00 to 0x05</td><td>0x00 to 0xFF</td><td>Reserved for vendor proprietary use</td></tr><tr><td>0x06</td><td>0x00 to 0xFF</td><td>Reserved to avoid confusion with link layer ACK</td></tr><tr><td>0x07</td><td>0x00 to 0xFF</td><td>For Future Assignment</td></tr><tr><td>0x08</td><td>0x01</td><td>Basic DR Application (at least partially supported by all devices)</td></tr><tr><td>0x08</td><td>0x02</td><td>Intermediate DR Application</td></tr><tr><td>0x08</td><td>0x03</td><td>Data-Link Messages</td></tr><tr><td>0x08</td><td>0x04</td><td>Commissioning and Network Support Messages</td></tr><tr><td>0x08</td><td>0x05 to 0xFF</td><td>For Future Assignment</td></tr><tr><td>0x09</td><td>0x01</td><td>USNAP 1.0, Pass-Through</td></tr><tr><td>0x09</td><td>0x02</td><td>ClimateTalk, Pass-Through</td></tr><tr><td>0x09</td><td>0x03</td><td>Smart Energy Profile 1.0, Pass-Through</td></tr></table></td><td>Message type supported query is mandatory. After power-up, communications modules and end devices shall begin communication assuming only that the mandatory functions of the Basic DR application are supported.<table><tr><th rowspan="2">Byte 1</th><th rowspan="2">Byte 2</th><th>Byte 3</th><th>Byte 4</th><th rowspan="2">Byte 5</th><th rowspan="2">Byte 6</th></tr><tr><th>Reserved</th><th>Payload Length</th></tr><tr><td colspan="2">Desired Message Type</td><td>0x00</td><td>0x00</td><td colspan="2">Checksum</td></tr></table></td></tr>
</table>

<table>
<tr><th rowspan="2">REQ.H#</th><th colspan="5">ANSI/CTA-2045-A Commands</th><th rowspan="2">Use</th></tr>
<tr><th>Message Type</th><th>Name</th><th>Opcode 1</th><th>Opcode 2</th><th>Payload</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>
<table>
<tr><td>0x09</td><td>0x04</td><td>Smart Energy Profile 2.0 over IP, Pass-Through</td></tr>
<tr><td>0x09</td><td>0x05</td><td>OpenADR1.0 over IP, Pass-Through</td></tr>
<tr><td>0x09</td><td>0x06</td><td>OpenADR2.0 over IP, Pass-Through</td></tr>
<tr><td>0x09</td><td>0x07</td><td>Generic IP Pass-Through (IP packets self-identify version so both IPV4 and IPV6 are covered)</td></tr>
<tr><td>0x09</td><td>0x08</td><td>ECHONET Lite Pass-Through</td></tr>
<tr><td>0x09</td><td>0x09</td><td>KNX Pass-Through</td></tr>
<tr><td>0x09</td><td>0x0A</td><td>LonTalk Pass-Through</td></tr>
<tr><td>0x09</td><td>0x0B</td><td>Sunspec Modbus Pass-Through</td></tr>
<tr><td>0x09</td><td>0x0C</td><td>BACnet Pass-Through</td></tr>
<tr><td>0x09</td><td>0x0D to 0xFF</td><td>For Future Assignment</td></tr>
<tr><td>0x0A to 0x14</td><td>0x00 to 0xFF</td><td>For Future Assignment</td></tr>
<tr><td>0x15</td><td>0x00 to 0xFF</td><td>Reserved to avoid confusion with link layer NAK</td></tr>
<tr><td>0x16 to 0xEF</td><td>0x00 to 0xFF</td><td>For Future Assignment</td></tr>
<tr><td>0xF0 to 0xFF</td><td>0x00 to 0xFF</td><td>Reserved for vendor proprietary use</td></tr>
</table>
</td><td></td></tr>
<tr><td>REQ.H4</td><td>Basic</td><td>Application ACK</td><td>0x03</td><td>Opcode 1 of last message received</td><td>Any except for 0x03</td><td>Acknowledge successful receipt and support of previous command.

Verification that the last message was received by responding or receiving a response with Opcode 1 of the previous message</td></tr>
<tr><td>REQ.H5</td><td>Basic</td><td>Application NAK</td><td>0x04</td><td>Reason</td><td>Reason
0x00 = No reason given
0x01 = Opcode1 not supported
0x02 = Opcode2 invalid
0x03 = Busy
0x04 = Length Invalid
0x05 = Customer Override is in effect
0x06 to 0xFF Reserved</td><td>If SGD responds with either;
0x00 = No reason given
0x03 = Busy
Then retry every 1-min until the duration specified in the Time Interval has timed out.

If SGD responds with;
0x05 = Customer Override is in effect
Then record in x-CTA2045_STATUS report</td></tr>
<tr><td>REQ.H6</td><td>Basic</td><td>Outside Comm Connection Status</td><td>0x0E</td><td>Connect Status Code</td><td>Connect Status Code
0x00 = No / Lost Connection
0x01 = Found / Good Connection
0x02 = Poor / Unreliable Connection
0x03 to 0xFF = Reserved</td><td>The “Connection” refers to the connection between the communication module and the application it depends on for control.

0x00 = Over the Time Interval, connection could not be established
0x01 = Successful connection
0x02 = Two-thirds of the attempts to connect with the DRMA over the Time Interval fail.
0x03 to 0xFF = Reserved

REQ.H3.1, Time Interval = 15-min (non-overlapping)</td></tr>
<tr><td>REQ.H7</td><td>Link Layer</td><td>ACK</td><td></td><td></td><td>
<table>
<tr><th>Type</th><th>Byte 1</th><th>Byte 2</th></tr>
<tr><td>ACK</td><td>0x06</td><td>0x00</td></tr>
</table>
Refer to Section 6.1 in ANSI/CTA-2045-A</td><td>Link Layer ACK and NAK messages are used in response to all messages except other link layer ACKs and NAKs</td></tr>
</table>

<table>
<tr><th rowspan="2">REQ.H#</th><th colspan="5">ANSI/CTA-2045-A Commands</th><th rowspan="2">Use</th></tr>
<tr><th>Message Type</th><th>Name</th><th>Opcode 1</th><th>Opcode 2</th><th>Payload</th></tr>
<tr><td>REQ.H8</td><td>Link Layer</td><td>NAK</td><td></td><td></td><td>
<table>
<tr><th>Type</th><th>Byte 1</th><th>Byte 2</th></tr>
<tr><td>NAK</td><td>0x15</td><td>NAK Code</td></tr>
</table>
Refer to Section 6.1 in ANSI/CTA-2045-A
</td><td>
Link Layer ACK and NAK messages are used in response to all messages except other link layer ACKs and NAKs

NAK Codes
<table>
<tr><th>Link NAK Error Code</th><th>Priority</th><th>Description</th><th>Usage</th></tr>
<tr><td>0x00</td><td></td><td>No Reason</td><td>Not used.</td></tr>
<tr><td>0x01</td><td>1</td><td>Invalid Byte</td><td>Indicates that a byte framing or other invalid byte error has occurred (e.g., missing stop-bit on the AC RS-485 interface).</td></tr>
<tr><td>0x02</td><td>2</td><td>Invalid Length</td><td>Used to indicate that the length indicated in the PDU length field is out of range.</td></tr>
<tr><td>0x03</td><td>3</td><td>Checksum Error</td><td>The bytes in the checksum field at the end of the message did not agree with the computed checksum.</td></tr>
<tr><td>0x04</td><td>4</td><td>Reserved</td><td>NA</td></tr>
<tr><td>0x05</td><td>5</td><td>Message Timeout</td><td>Indicates that more than t_{ML} (defined in Error! Reference source not found.) elapsed between receipt of the first byte and receipt of the last byte in a message transmission. t_{ML} was selected to allow any combination of data rate and payload. As additional speeds and payloads are added some combinations may be invalid.
This error code is not used by the DC Form Factor as noted in Appendix A.</td></tr>
<tr><td>0x06</td><td>6</td><td>Unsupported Message Type</td><td>Indicates that the “Message Type” is not supported.</td></tr>
<tr><td>0x07</td><td>7</td><td>Request Not Supported</td><td>Indicates that the requested setting is not supported (e.g., a requested Power Mode or Bit Rate is not supported).
This error code is used only in regards to link layer requests, not in regards to lack of support for application layer requests.</td></tr>
</table>
</td></tr>
<tr><td>REQ.H9</td><td>Link Layer</td><td>Message Type Supported Query</td><td></td><td></td><td>
<table>
<tr><th>Message Type MS Byte</th><th>Message Type LS Byte</th><th>Description</th></tr>
<tr><td>0x00 to 0x05</td><td>0x00 to 0xFF</td><td>Reserved for vendor proprietary use</td></tr>
<tr><td>0x06</td><td>0x00 to 0xFF</td><td>Reserved to avoid confusion with link layer ACK</td></tr>
<tr><td>0x07</td><td>0x00 to 0xFF</td><td>For Future Assignment</td></tr>
<tr><td>0x08</td><td>0x01</td><td>Basic DR Application (at least partially supported by all devices)</td></tr>
<tr><td>0x08</td><td>0x02</td><td>Intermediate DR Application</td></tr>
<tr><td>0x08</td><td>0x03</td><td>Data-Link Messages</td></tr>
<tr><td>0x08</td><td>0x04</td><td>Commissioning and Network Support Messages</td></tr>
<tr><td>0x08</td><td>0x05 to 0xFF</td><td>For Future Assignment</td></tr>
<tr><td>0x09</td><td>0x01</td><td>USNAP 1.0, Pass-Through</td></tr>
<tr><td>0x09</td><td>0x02</td><td>ClimateTalk, Pass-Through</td></tr>
<tr><td>0x09</td><td>0x03</td><td>Smart Energy Profile 1.0, Pass-Through</td></tr>
<tr><td>0x09</td><td>0x04</td><td>Smart Energy Profile 2.0 over IP, Pass-Through</td></tr>
<tr><td>0x09</td><td>0x05</td><td>OpenADR1.0 over IP, Pass-Through</td></tr>
<tr><td>0x09</td><td>0x06</td><td>OpenADR2.0 over IP, Pass-Through</td></tr>
<tr><td>0x09</td><td>0x07</td><td>Generic IP Pass-Through (IP packets self-identify version so both IPV4 and IPV6 are covered)</td></tr>
<tr><td>0x09</td><td>0x08</td><td>ECHONET Lite Pass-Through</td></tr>
<tr><td>0x09</td><td>0x09</td><td>KNX Pass-Through</td></tr>
<tr><td>0x09</td><td>0x0A</td><td>LonTalk Pass-Through</td></tr>
<tr><td>0x09</td><td>0x0B</td><td>Sunspec Modbus Pass-Through</td></tr>
<tr><td>0x09</td><td>0x0C</td><td>BACnet Pass-Through</td></tr>
<tr><td>0x09</td><td>0x0D to 0xFF</td><td>For Future Assignment</td></tr>
<tr><td>0x0A to 0x14</td><td>0x00 to 0xFF</td><td>For Future Assignment</td></tr>
</table>
</td><td>
Support of the message type supported query is mandatory. After power-up, communications modules and end devices shall begin communication assuming only that the mandatory functions of the Basic DR application are supported.
<table>
<tr><th rowspan="2">Byte 1</th><th rowspan="2">Byte 2</th><th>Byte 3</th><th>Byte 4</th><th rowspan="2">Byte 5</th><th rowspan="2">Byte 6</th></tr>
<tr><th>Reserved</th><th>Payload Length</th></tr>
<tr><td colspan="2">Desired Message Type</td><td>0x00</td><td>0x00</td><td colspan="2">Checksum</td></tr>
</table>
</td></tr>
</table>

REQ.H#	ANSI/CTA-2045-A Commands					Use
	Message Type	Name	Opcode 1	Opcode 2	Payload	
					0x15 | 0x00 to 0xFF | Reserved to avoid confusion with link layer NAK 0x16 to 0xEF | 0x00 to 0xFF | For Future Assignment 0xF0 to 0xFF | 0x00 to 0xFF | Reserved for vendor proprietary use	
REQ. H10	Basic	Pending Event Time	0x18	Time Until Event	Used to inform the resource (and possibly the user) that a Grid Service event will occur in the near future. Time Until Event See Section 8.1.2 for format	For all events that are within 4-hours from their start time, the UCM shall inform the resource of the remaining time at intervals of 15-min.
REQ. H11	Basic	Pending Event Type	0x19	Opcode 1 of the Pending Event	Applies to Basic commands Opcode2 set to 0x02 (End Shed/Run Normal) informs the resource that the pending event has been canceled,	For all events that are within 4-hours from their start time, the UCM shall inform the resource of the Basic command that's mapped to the upcoming EiEvent signals.

2.2 Load Management Functions (Normative)

The purpose of this section is to define the relationship between the application-layer messages of OpenADR 2.0 and ANSI/CTA-2045-A and how to exchange information between the two protocols. The messages included in this section are those targeted at influencing the behavior of different types of ANSI/CTA-2045-A loads (see Section 4.0).

Table 2-2
Load Management Mapping Requirements

REQ.LM#	OpenADR 2.0 EiEvent Signal					ANSI/CTA-2045-A Message				Use
	Signal Name	Signal Type	Value	Units	Duration	Message Type	Name	Opcode 1	Opcode 2	
REQ.LM1	Simple	Level	0	None	Any	Basic	End Shed/Run Normal	0x02	Event Duration	At start of the event, the same Duration provided in the EiEvent must be sent to the SGD. If the UCM sends subsequent curtailment requests to the resource during the active period of the OpenADR 2.0 event, the Duration sent to the resource must be the actual time remaining in the event and not the original Duration included in the original OpenADR 2.0 signal.
REQ.LM2	Simple	Level	1	None	Any	Basic	Shed	0x01	Event Duration	
REQ.LM3	Simple	Level	2	None	Any	Basic	Critical Peak Event	0x0A	Event Duration	
REQ.LM4	Simple	Level	3	None	Any	Basic	Grid Emergency	0xB	Event Duration	
REQ.LM5	Custom	x-CTA-2045	0	None	Any	Basic	End Shed/Run Normal	0x02	Not Used	The custom signals are similar to that of the SIMPLE LEVEL, except there are (5) five choices (0-4) instead of (4) four. For this custom signal, the “load up” request is assigned to the value of 4..
REQ.LM6	Custom	x-CTA-2045	1	None	Any	Basic	Shed	0x01	Event Duration	
REQ.LM7	Custom	x-CTA-2045	2	None	Any	Basic	Critical Peak Event	0x0A	Event Duration	
REQ.LM8	Custom	x-CTA-2045	3	None	Any	Basic	Grid Emergency	0xB	Event Duration	
REQ.LM9	Custom	x-CTA-2045	4	None	Any	Basic	Load Up	0x17	Event Duration	
REQ.LM10	ELECTRICITY_PRICE	pricemultiplier	any	None	Any	Basic	Present Relative Price	0x07	Relative Price Indicator	ANSI/CTA-2045-A use of Relative Price: Relative price = Relative_Price_Indicator = Present_Price / Average_Price. See standard for details on Average Price.
REQ.LM11	LOAD_DISPATCH	level	-10 to 10	powerXXX	Any	Basic	Request for Power Level	0x06	Percent Setting MSbit = 0 = Power Absorbed	Percent setting 0x00 to 0x7F = 0 to 100% = LOAD_DISPATCH,level(value must be between 0 to -10) At the conclusion of the LOAD_DISPATCH event, the UCM must send the SGD an End Shed/Run Normal Opcode 1 (0x02)

<table>
<tr><th rowspan="2">REQ.LM#</th><th colspan="5">OpenADR 2.0 EiEvent Signal</th><th colspan="4">ANSI/CTA-2045-A Message</th><th rowspan="2">Use</th></tr>
<tr><th>Signal Name</th><th>Signal Type</th><th>Value</th><th>Units</th><th>Duration</th><th>Message Type</th><th>Name</th><th>Opcode 1</th><th>Opcode 2</th></tr>
<tr><td>REQ.LM12</td><td>LOAD_CONTROL</td><td>x-LoadControlLevelOffset</td><td>Integer</td><td>None</td><td>Any</td><td>Intermediate</td><td>Set Temperature Offset</td><td>0x03</td><td>0x02</td><td>
<table>
<tr><th>Payload Byte</th><th>Description</th><th>Map to OpenADR 2.0 Signal</th></tr>
<tr><td>1</td><td>Opcode1</td><td></td></tr>
<tr><td>2</td><td>Opcode2</td><td></td></tr>
<tr><td>3</td><td>Current Offset</td><td>Value</td></tr>
<tr><td>4</td><td>Units</td><td>See Note1</td></tr>
</table>
Note1: OpenADR 2.0 does not require that the LoadControlOffset signal be used solely for temperature offset.
</td></tr>
<tr><td>REQ.LM13</td><td>LOAD_CONTROL</td><td>x-LoadControlSetpoint</td><td>any</td><td>None</td><td>Any</td><td>Intermediate</td><td>Set Setpoint</td><td>0x03</td><td>0x02</td><td>
LOAD_CONTROL x-LoadControlSetpoint = SetSetpoint(Set Point 1)
<table>
<tr><th>Payload Byte</th><th>Payload</th><th>Map to OpenADR 2.0 Signal</th></tr>
<tr><td>1</td><td>Opcode1</td><td></td></tr>
<tr><td>2</td><td>Opcode2</td><td></td></tr>
<tr><td>S</td><td>Device Type**</td><td>See Note1</td></tr>
<tr><td>5</td><td>Units</td><td>Unit</td></tr>
<tr><td>6-7</td><td>Set Point 1</td><td>Value</td></tr>
<tr><td>8-9</td><td>Set Point 2</td><td></td></tr>
</table>
Note1: This command requires the Device Type of the DER to be included in the payload. Device type must be known or acquired by Get Information command.
</td></tr>
<tr><td>REQ.LM14</td><td>ELECTRICITY_PRICE</td><td>price</td><td>any</td><td>currency/kWh</td><td>Any</td><td>Intermediate</td><td>Set Energy Price</td><td>0x03</td><td>0x00</td><td>
<table>
<tr><th>Payload Byte</th><th>Payload</th><th>Map to OpenADR 2.0 Signal</th></tr>
<tr><td>1</td><td>Opcode1</td><td></td></tr>
<tr><td>2</td><td>Opcode2</td><td></td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th rowspan="2">REQ.LM#</th><th colspan="5">OpenADR 2.0 EiEvent Signal</th><th colspan="4">ANSI/CTA-2045-A Message</th><th rowspan="2">Use</th></tr>
<tr><th>Signal Name</th><th>Signal Type</th><th>Value</th><th>Units</th><th>Duration</th><th>Message Type</th><th>Name</th><th>Opcode 1</th><th>Opcode 2</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>
<table>
<tr><td>3-6</td><td>Current Price</td><td>Value</td></tr>
<tr><td>7-8</td><td>Currency Code</td><td>Unit</td></tr>
<tr><td>9</td><td>Digits After Decimal Point</td><td>Note 1</td></tr>
<tr><td>10-13</td><td>Expiration Time/Date in UTC seconds</td><td></td></tr>
<tr><td>14-117</td><td>Next Price</td><td></td></tr>
</table>
Note 1: Since OpenADR does not specify the number of digits after the decimal points, this will need to be determined before this message can be sent.
</td></tr>
</table>

2.3 Monitoring and Reporting Functions (Normative)

This section includes requirements for transferring operational state type information from the device and making it available to an OpenADR 2.0B server through an OpenADR 2.0b client. OpenADR 2.0B. The information included in this section align with the commands defined in the "monitoring/feedback" sections of each of the functional specification documents, see Section 4.0. Table 2-3 includes the ANSI/CTA-2045-A command and information that could be obtained from the BTM load and how to package the information into a report for the OpenADR 2.0B client to make available to an OpenADR 2.0 server.

Table 2-3
Measurement and Reporting Mapping Requirements

<table>
<tr><th rowspan="2">REQ.M#</th><th colspan="5">ANSI/CTA-2045-A Commands</th><th rowspan="2">OpenADR 2.0b EiReport Service</th></tr>
<tr><th>Message Type</th><th>Name</th><th>Opcode 1</th><th>Opcode 2</th><th>Payload</th></tr>
<tr><td rowspan="2">REQ.M1</td><td rowspan="2">Basic</td><td rowspan="2">Operational State Query and Response</td><td>0x12</td><td>0x00 Not User</td><td></td><td>N/A</td></tr>
<tr><td>0x13</td><td>Operational state code</td><td>
<table>
<tr><th>Op State Code</th><th>Name</th></tr>
<tr><td>0</td><td>Idle Normal</td></tr>
<tr><td>1</td><td>Running Normal</td></tr>
<tr><td>2</td><td>Running Curtailed</td></tr>
<tr><td>3</td><td>Running Heightened</td></tr>
<tr><td>4</td><td>Idle Curtailed</td></tr>
<tr><td>5</td><td>SGD Error Condition</td></tr>
<tr><td>6</td><td>Idle Heightened</td></tr>
<tr><td>7</td><td>Cycling On</td></tr>
<tr><td>8</td><td>Cycling Off</td></tr>
<tr><td>9</td><td>Variable Following</td></tr>
<tr><td>10</td><td>Variable Not Following</td></tr>
<tr><td>11</td><td>Idle, Opted Out</td></tr>
<tr><td>12</td><td>Running, Opted Out</td></tr>
<tr><td>13-125</td><td>Not Used</td></tr>
<tr><td>126-255</td><td>Reserved</td></tr>
</table>
</td><td>
<table>
<tr><th colspan="4">OpenADR 2.0b EiReport Service</th></tr>
<tr><td>REQ</td><td>Report Name</td><td colspan="2">x-CTA2045_Status</td></tr>
<tr><td rowspan="5">M1.1</td><td>Report Structure</td><td>Status</td><td>Interval</td></tr>
<tr><td>rID</td><td>OperationalState</td><td rowspan="4">1-min</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><th colspan="4">ANSI/CTA-2045-A Message</th></tr>
<tr><td colspan="2">Message</td><td colspan="2">Operational State Query Response</td></tr>
<tr><td colspan="2">Element Mapped to rID</td><td colspan="2">Opcode 2 of Basic 0x13</td></tr>
</table>
</td></tr>
<tr><td>REQ.M2</td><td>Intermediate</td><td>Info Request</td><td>0x01</td><td>Request 0x01
Response 0x81</td><td>
<table>
<tr><th>Payload Byte</th><th>Description</th></tr>
<tr><td>1</td><td>Opcode1</td></tr>
<tr><td>2</td><td>Opcode2 (Reply always has bit 7 high)</td></tr>
<tr><td>3</td><td>Response Code</td></tr>
<tr><td>4-5</td><td>CTA-2045 Version – ASCII*</td></tr>
<tr><td>6-7</td><td>Vendor ID</td></tr>
<tr><td>8-9</td><td>Device Type</td></tr>
</table>
</td><td>
<table>
<tr><th colspan="4">OpenADR 2.0b EiReport Service</th></tr>
<tr><td>REQ</td><td>Report Name</td><td colspan="2">x-CTA2045_Metadata</td></tr>
<tr><td rowspan="5">R2.1</td><td>Report Structure</td><td colspan="2">Value</td></tr>
<tr><td>rID</td><td colspan="2">CTA-2045_Version*</td></tr>
<tr><td>Report Type</td><td colspan="2">Reading</td></tr>
<tr><td>Reading Type</td><td colspan="2">Direct Read</td></tr>
<tr><td>Units</td><td colspan="2">customUnit</td></tr>
<tr><th colspan="4">ANSI/CTA-2045-A Message</th></tr>
<tr><td colspan="2">Message</td><td colspan="2">Info Request</td></tr>
<tr><td colspan="2">Element Mapped to rID</td><td colspan="2">Response 0x01,0x81, Payload Byte 4-5</td></tr>
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<table>
<tr><th rowspan="2">REQ.M#</th><th colspan="5">ANSI/CTA-2045-A Commands</th><th rowspan="2">OpenADR 2.0b EiReport Service</th></tr>
<tr><th>Message Type</th><th>Name</th><th>Opcode 1</th><th>Opcode 2</th><th>Payload</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>
<table>
<tr><td>10-11</td><td>Device Revision</td></tr>
<tr><td>12-15</td><td>Capability Bitmap</td></tr>
<tr><td>16</td><td>Reserved</td></tr>
<tr><td>17-32</td><td>Model Number – ASCII</td></tr>
<tr><td>33-48</td><td>Serial Number – ASCII</td></tr>
<tr><td>49</td><td>Firmware Year – 20YY</td></tr>
<tr><td>50</td><td>Firmware Month</td></tr>
<tr><td>51</td><td>Firmware Day</td></tr>
<tr><td>52</td><td>Firmware Major</td></tr>
<tr><td>53</td><td>Firmware Minor</td></tr>
</table>
Capability Bitmap Matric
<table>
<tr><th>Bit (2^n)</th><th>Description</th></tr>
<tr><td>0</td><td>Cycling supported</td></tr>
<tr><td>1</td><td>Tier mode supported</td></tr>
<tr><td>2</td><td>Price mode supported</td></tr>
<tr><td>3</td><td>Temperature Offset supported</td></tr>
<tr><td>4</td><td>Continuously variable power</td></tr>
<tr><td>5</td><td>Discreetly variable power</td></tr>
<tr><td>6-31</td><td>Reserved</td></tr>
</table>
See section 9.1.1 Info Request for device types.
</td><td>
<table>
<tr><th colspan="3">OpenADR 2.0b EiReport Service</th></tr>
<tr><td>REQ</td><td>Report Name</td><td>x-CTA2045_Metadata</td></tr>
<tr><td rowspan="5">M2.2</td><td>Report Structure</td><td>Value</td></tr>
<tr><td>rID</td><td>Vendor_ID</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><th colspan="3">ANSI/CTA-2045-A Message</th></tr>
<tr><td colspan="2">Intermediate Message</td><td>Info Request</td></tr>
<tr><td colspan="2">Element mapped to rID</td><td>Response 0x01,0x81, Payload Byte 6-7</td></tr>
</table>
<table>
<tr><th colspan="3">OpenADR 2.0b EiReport Service</th></tr>
<tr><td>REQ</td><td>Report Name</td><td>x-CTA2045_Metadata</td></tr>
<tr><td rowspan="5">M2.3</td><td>Report Structure</td><td>Value</td></tr>
<tr><td>rID</td><td>Device_Type</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><th colspan="3">ANSI/CTA-2045-A Message</th></tr>
<tr><td colspan="2">Intermediate Message</td><td>Info Request</td></tr>
<tr><td colspan="2">Element mapped to rID</td><td>Response 0x01,0x81, Payload Byte 8-9</td></tr>
</table>
<table>
<tr><th colspan="3">OpenADR 2.0b EiReport Service</th></tr>
<tr><td>REQ</td><td>Report Name</td><td>x-CTA2045_Metadata</td></tr>
<tr><td rowspan="5">M2.4</td><td>Report Structure</td><td>Value</td></tr>
<tr><td>rID</td><td>Device_Revision</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><th colspan="3">ANSI/CTA-2045-A Message</th></tr>
<tr><td colspan="2">Intermediate Message</td><td>Info Request</td></tr>
<tr><td colspan="2">Element mapped to rID</td><td>Response 0x01,0x81, Payload Byte 10-11</td></tr>
</table>
<table>
<tr><th colspan="3">OpenADR 2.0b EiReport Service</th></tr>
<tr><td>REQ</td><td>Report Name</td><td>x-CTA2045_Metadata</td></tr>
<tr><td rowspan="3">M2.5</td><td>Report Structure</td><td>Value</td></tr>
<tr><td>rID</td><td>Capability_Bitmap</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
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<table>
<tr><th rowspan="2">REQ.M#</th><th colspan="5">ANSI/CTA-2045-A Commands</th><th rowspan="2">OpenADR 2.0b EiReport Service</th></tr>
<tr><th>Message Type</th><th>Name</th><th>Opcode 1</th><th>Opcode 2</th><th>Payload</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>
<table>
<tr><td></td><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td></td><td>Units</td><td>customUnit</td></tr>
<tr><td colspan="3">ANSI/CTA-2045-A Message</td></tr>
<tr><td colspan="2">Intermediate Message</td><td>Info Request</td></tr>
<tr><td colspan="2">Element mapped to rID</td><td>Response 0x01,0x81, Payload Byte 12-15</td></tr>
</table>
<table>
<tr><td colspan="3">OpenADR 2.0b EiReport Service</td></tr>
<tr><td>REQ</td><td>Report Name</td><td>x-CTA2045_Metadata</td></tr>
<tr><td rowspan="5">M2.6</td><td>Report Structure</td><td>Value</td></tr>
<tr><td>rID</td><td>Model_Number-ASCII</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Unitsz</td><td>customUnit</td></tr>
<tr><td colspan="3">ANSI/CTA-2045-A Message</td></tr>
<tr><td colspan="2">Intermediate Message</td><td>Info Request</td></tr>
<tr><td colspan="2">Element mapped to rID</td><td>Response 0x01,0x81, Payload Byte 17-32</td></tr>
</table>
<table>
<tr><td colspan="3">OpenADR 2.0b EiReport Service</td></tr>
<tr><td>REQ</td><td>Report Name</td><td>x-CTA2045_Metadata</td></tr>
<tr><td rowspan="5">M2.7</td><td>Report Structure</td><td>Value</td></tr>
<tr><td>rID</td><td>Serial_Number– ASCII</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><td colspan="3">ANSI/CTA-2045-A Message</td></tr>
<tr><td colspan="2">Intermediate Message</td><td>Info Request</td></tr>
<tr><td colspan="2">Element mapped to rID</td><td>Response 0x01,0x81, Payload Byte 33-48</td></tr>
</table>
<table>
<tr><td colspan="3">OpenADR 2.0b EiReport Service</td></tr>
<tr><td>REQ</td><td>Report Name</td><td>x-CTA2045_Metadata</td></tr>
<tr><td rowspan="5">M2.8</td><td>Report Structure</td><td>Value</td></tr>
<tr><td>rID</td><td>Firmware_Year_20YY</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><td colspan="3">ANSI/CTA-2045-A Message</td></tr>
<tr><td colspan="2">Intermediate Message</td><td>Info Request</td></tr>
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<tr><th rowspan="2">REQ.M#</th><th colspan="5">ANSI/CTA-2045-A Commands</th><th rowspan="2">OpenADR 2.0b EiReport Service</th></tr>
<tr><th>Message Type</th><th>Name</th><th>Opcode 1</th><th>Opcode 2</th><th>Payload</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>
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<tr><td colspan="2">Element mapped to rID</td><td>Response 0x01,0x81, Payload Byte 49</td></tr>
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<tr><td colspan="3">OpenADR 2.0b EiReport Service</td></tr>
<tr><td>REQ</td><td>Report Name</td><td>x-CTA2045_Metadata</td></tr>
<tr><td rowspan="5">M2.9</td><td>Report Structure</td><td>Value</td></tr>
<tr><td>rID</td><td>Firmware_Month</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><td colspan="3">ANSI/CTA-2045-A Message</td></tr>
<tr><td colspan="2">Intermediate Message</td><td>Info Request</td></tr>
<tr><td colspan="2">Element mapped to rID</td><td>Response 0x01,0x81, Payload Byte 50</td></tr>
</table>
<table>
<tr><td colspan="3">OpenADR 2.0b EiReport Service</td></tr>
<tr><td>REQ</td><td>Report Name</td><td>x-CTA2045_Metadata</td></tr>
<tr><td rowspan="5">M2.10</td><td>Report Structure</td><td>Value</td></tr>
<tr><td>rID</td><td>Firmware_Day</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><td colspan="3">ANSI/CTA-2045-A Message</td></tr>
<tr><td colspan="2">Intermediate Message</td><td>Info Request</td></tr>
<tr><td colspan="2">Element mapped to rID</td><td>Response 0x01,0x81, Payload Byte 51</td></tr>
</table>
<table>
<tr><td colspan="3">OpenADR 2.0 EiReport Service</td></tr>
<tr><td>REQ</td><td>Report Name</td><td>x-CTA2045_Metadata</td></tr>
<tr><td rowspan="5">M2.11</td><td>Report Structure</td><td>Value</td></tr>
<tr><td>rID</td><td>Firmware_Major</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><td colspan="3">ANSI/CTA-2045-A Message</td></tr>
<tr><td colspan="2">Intermediate Message</td><td>Info Request</td></tr>
<tr><td colspan="2">Element mapped to rID</td><td>Response 0x01,0x81, Payload Byte 52</td></tr>
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<tr><th rowspan="2">REQ.M#</th><th colspan="5">ANSI/CTA-2045-A Commands</th><th rowspan="2">OpenADR 2.0b EiReport Service</th></tr>
<tr><th>Message Type</th><th>Name</th><th>Opcode 1</th><th>Opcode 2</th><th>Payload</th></tr>
<tr><td>REQ.M3</td><td>Basic</td><td>Customer Override</td><td>0x11</td><td>0x00 or 0x01</td><td>0 = No Override,
1 = Override</td><td>
<table>
<tr><th colspan="4">OpenADR 2.0b EiReport Service</th></tr>
<tr><td>REQ</td><td>Report Name</td><td colspan="2">x-CTA2045_Status</td></tr>
<tr><td rowspan="5">M3.1</td><td>Report Structure</td><td>Status</td><td>Interval</td></tr>
<tr><td>rID</td><td>OverrideStatus</td><td rowspan="4">1-min</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><th colspan="4">ANSI/CTA-2045-A Message</th></tr>
<tr><td colspan="2">Message</td><td colspan="2">Customer Override</td></tr>
<tr><td colspan="2">Element Mapped to rID</td><td colspan="2">Opcode 2 of Basic 0x11</td></tr>
</table>

The mapping application shall record the Customer Override state of the DER and send to the OpenADR 2.0b VTN via the VEN’s EiReport Service

Depending on the ANSI/CTA-2045 version implemented by the DER, the override status could be provided by two other messages.

Operational State Response (Code 11 and 12)
NAK (Reason 0x05 = Customer Override is in effect)</td></tr>
<tr><td>REQ.M4</td><td>Intermediate</td><td>GetTemperatureOffset

Request and Reply</td><td>0x03</td><td>0x02

Reply 0x82</td><td>DER Reply

<table>
<tr><th>Payload Byte</th><th>Comments</th></tr>
<tr><td>1</td><td>Opcode1</td></tr>
<tr><td>2</td><td>Opcode2 (Reply always has bit 7 high)</td></tr>
<tr><td>3</td><td>Response Code</td></tr>
<tr><td>4</td><td>Current Offset</td></tr>
<tr><td>5</td><td>Units</td></tr>
</table>
</td><td>
<table>
<tr><th colspan="4">OpenADR 2.0b EiReport Service</th></tr>
<tr><td>REQ</td><td>Report Name</td><td colspan="2">x-CTA2045_Status</td></tr>
<tr><td rowspan="5">M4.1</td><td>Report Structure</td><td>Status</td><td>Interval</td></tr>
<tr><td>rID</td><td>TemperatureOffset</td><td rowspan="4">1-min</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><th colspan="4">ANSI/CTA-2045-A Message</th></tr>
<tr><td colspan="2">Message</td><td colspan="2">Get Temperature Offset</td></tr>
<tr><td colspan="2">Element Mapped to rID</td><td colspan="2">Reply 0x03,0x82 Byte 4</td></tr>
</table>

<table>
<tr><th colspan="4">OpenADR 2.0b EiReport Service</th></tr>
<tr><td>REQ</td><td>Report Name</td><td colspan="2">x-CTA2045_Status</td></tr>
<tr><td rowspan="4">M4.2</td><td>Report Structure</td><td>Status</td><td>Interval</td></tr>
<tr><td>rID</td><td>TemperatureOffsetUnits</td><td rowspan="3">1-min</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
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<table>
<tr><th rowspan="2">REQ.M#</th><th colspan="5">ANSI/CTA-2045-A Commands</th><th rowspan="2">OpenADR 2.0b EiReport Service</th></tr>
<tr><th>Message Type</th><th>Name</th><th>Opcode 1</th><th>Opcode 2</th><th>Payload</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>
<table>
<tr><td></td><td>Units</td><td>customUnit</td><td></td></tr>
<tr><td colspan="4">ANSI/CTA-2045-A Message</td></tr>
<tr><td colspan="2">Message</td><td colspan="2">Get Temperature Offset</td></tr>
<tr><td colspan="2">Element Mapped to rID</td><td colspan="2">Reply 0x03,0x82 Byte 5</td></tr>
</table>

The UCM shall record the Temperature Offset of the DER and send to the OpenADR 2.0 VTN via the VEN’s EiReport Service
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<tr><td>REQ.M5</td><td>Intermediate</td><td>GetSetPoint</td><td>0x03</td><td>0x03

Reply 0x83</td><td>
<table>
<tr><th>Payload Byte</th><th>Comments</th></tr>
<tr><td>1</td><td>Opcode1</td></tr>
<tr><td>2</td><td>Opcode2 (Reply always has bit 7 high)</td></tr>
<tr><td>3</td><td>Response Code</td></tr>
<tr><td>4-5</td><td>Device Type</td></tr>
<tr><td>6</td><td>Units</td></tr>
<tr><td>7-8</td><td>Set Point 1</td></tr>
<tr><td>9-10</td><td>Set Point 2</td></tr>
</table>
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<table>
<tr><td colspan="4">OpenADR 2.0b EiReport Service</td></tr>
<tr><td>REQ</td><td>Report Name</td><td colspan="2">x-CTA2045_Status</td></tr>
<tr><td rowspan="5">R.5.1</td><td>Report Structure</td><td>Status</td><td>Interval</td></tr>
<tr><td>rID</td><td>SetPointDeviceType</td><td rowspan="4">1-min</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><td colspan="4">ANSI/CTA-2945-A Message</td></tr>
<tr><td colspan="2">Message</td><td colspan="2">Get Set Point (Get Reply)</td></tr>
<tr><td colspan="2">Element Mapped to rID</td><td colspan="2">Reply 0x03,0x83 Byte 4-5</td></tr>
</table>

<table>
<tr><td colspan="4">OpenADR 2.0b EiReport Service</td></tr>
<tr><td>REQ</td><td>Report Name</td><td colspan="2">x-CTA2045_Status</td></tr>
<tr><td rowspan="5">M5.2</td><td>Report Structure</td><td>Status</td><td>Interval</td></tr>
<tr><td>rID</td><td>SetPointUnits</td><td rowspan="4">1-min</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><td colspan="4">ANSI/CTA-2945-A Message</td></tr>
<tr><td colspan="2">Message</td><td colspan="2">Get Set Point (Get Reply)</td></tr>
<tr><td colspan="2">Element Mapped to rID</td><td colspan="2">Reply 0x03,0x83 Byte 6</td></tr>
</table>

<table>
<tr><td colspan="4">OpenADR 2.0b EiReport Service</td></tr>
<tr><td>REQ</td><td>Report Name</td><td colspan="2">x-CTA2045_Status</td></tr>
<tr><td rowspan="5">M5.3</td><td>Report Structure</td><td>Status</td><td>Interval</td></tr>
<tr><td>rID</td><td>SetPoint1</td><td rowspan="4">1-min</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><td colspan="4">ANSI/CTA-2945-A Message</td></tr>
</table>
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<table>
<tr><th rowspan="2">REQ.M#</th><th colspan="5">ANSI/CTA-2045-A Commands</th><th rowspan="2">OpenADR 2.0b EiReport Service</th></tr>
<tr><th>Message Type</th><th>Name</th><th>Opcode 1</th><th>Opcode 2</th><th>Payload</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>
<table>
<tr><td>Message</td><td>Get Set Point (Get Reply)</td></tr>
<tr><td>Element Mapped to rID</td><td>Reply 0x03,0x83 Byte 7-8</td></tr>
</table>
<table>
<tr><td colspan="4">OpenADR 2.0b EiReport Service</td></tr>
<tr><td>RFQ</td><td>Report Name</td><td colspan="2">x-CTA2045_Status</td></tr>
<tr><td rowspan="6">M5.4</td><td>Report Structure</td><td>Status</td><td>Interval</td></tr>
<tr><td>rID</td><td>SetPoint2</td><td rowspan="4">1-min</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><td colspan="4">ANSI/CTA-2945-A Message</td></tr>
<tr><td colspan="2">Message</td><td colspan="2">Get Set Point (Get Reply)</td></tr>
<tr><td colspan="2">Element Mapped to rID</td><td colspan="2">Reply 0x03,0x83 Byte 9-10</td></tr>
</table>
The UCM shall Get the Set Point and other data provided in the reply payload from of the DER and send to the OpenADR 2.0b VTN via the Report Name specified in the tables above using the EiReport Service
</td></tr>
<tr><td>REQ.M6</td><td>Intermediate</td><td>GetPresentTemperature</td><td>0x03</td><td>0x04

Reply 0x84</td><td>
<table>
<tr><th>Payload Byte</th><th>Comments</th></tr>
<tr><td>1</td><td>Opcode1</td></tr>
<tr><td>2</td><td>Opcode2 (Reply always has bit 7 high)</td></tr>
<tr><td>3</td><td>Response Code</td></tr>
<tr><td>4-5</td><td>Device Type</td></tr>
<tr><td>6</td><td>Units</td></tr>
<tr><td>7-8</td><td>Present Temperature</td></tr>
</table>
</td><td>
<table>
<tr><td colspan="4">OpenADR 2.0b EiReport Service</td></tr>
<tr><td>REQ</td><td>Report Name</td><td colspan="2">x-CTA2045_Status</td></tr>
<tr><td rowspan="6">M6.1</td><td>Report Structure</td><td>Status</td><td>Interval</td></tr>
<tr><td>rID</td><td>PresentTempDeviceType</td><td rowspan="4">1-min</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><td colspan="4">ANSI/CTA-2945-A Message</td></tr>
<tr><td colspan="2">Message</td><td colspan="2">Reply to Get Present Temperature</td></tr>
<tr><td colspan="2">Element Mapped to rID</td><td colspan="2">Reply 0x03,0x84 Byte 4-5</td></tr>
</table>
<table>
<tr><td colspan="4">OpenADR 2.0b EiReport Service</td></tr>
<tr><td>REQ</td><td>Report Name</td><td colspan="2">x-CTA2045_Status</td></tr>
<tr><td rowspan="6">M6.2</td><td>Report Structure</td><td>Status</td><td>Interval</td></tr>
<tr><td>rID</td><td>PresentTempUnits</td><td rowspan="4">1-min</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><td colspan="4">ANSI/CTA-2945-A Message</td></tr>
<tr><td colspan="2">Message</td><td colspan="2">Reply to Get Present Temperature</td></tr>
<tr><td colspan="2">Element Mapped to rID</td><td colspan="2">Reply 0x03,0x84 Byte 6</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th rowspan="2">REQ.M#</th><th colspan="5">ANSI/CTA-2045-A Commands</th><th rowspan="2">OpenADR 2.0b EiReport Service</th></tr>
<tr><th>Message Type</th><th>Name</th><th>Opcode 1</th><th>Opcode 2</th><th>Payload</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>
<table>
<tr><th colspan="4">OpenADR 2.0b EiReport Service</th></tr>
<tr><td>REQ</td><td colspan="3">Report Name: x-CTA2045_Status</td></tr>
<tr><td rowspan="6">M6.3</td><td>Report Structure</td><td>Status</td><td>Interval</td></tr>
<tr><td>rID</td><td>PresentTemp</td><td rowspan="4">1-min</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><th colspan="4">ANSI/CTA-2945-A Message</th></tr>
<tr><td colspan="2">Message</td><td colspan="2">Reply to Get Present Temperature</td></tr>
<tr><td colspan="2">Element Mapped to rID</td><td colspan="2">Reply 0x03,0x84 Byte 7-8</td></tr>
</table>

The UCM shall Get the Present Temperature and other data provided in the reply payload from of the DER and send to the OpenADR 2.0b VTN via the Report Name specified in the tables above using the EiReport Service</td></tr>
<tr><td>REQ M7</td><td>Intermediate</td><td>Commodity Read</td><td>0x06</td><td>Request 0x00

Reply 0x80</td><td>Request

<table>
<tr><th>Payload Byte</th><th>Comments</th></tr>
<tr><td>1</td><td>Opcode1</td></tr>
<tr><td>2</td><td>Opcode2</td></tr>
<tr><td>3</td><td>Requested Commodity Code</td></tr>
</table>

Commodity Codes
<table>
<tr><th>*Lower 7-bits</th><th>Description</th><th>Units</th></tr>
<tr><td>0</td><td>Electricity Consumed</td><td>W & W-hr</td></tr>
<tr><td>1</td><td>Electricity Produced</td><td>W & W-hr</td></tr>
<tr><td>2</td><td>Natural gas</td><td>cu-ft/hr & cu-ft</td></tr>
<tr><td>3</td><td>Water</td><td>Gal/hr & Gallons</td></tr>
<tr><td>4</td><td>Natural gas</td><td>cubic meters/hour (m^3) & cubic meters (m^3)</td></tr>
<tr><td>5</td><td>Water</td><td>liters/hr & liters</td></tr>
<tr><td>6</td><td>Total Energy Storage/Take Capacity</td><td>W-hr
Note: Instantaneous field in CommodityRead is not used.</td></tr>
</table>
</td><td>
<table>
<tr><th colspan="4">OpenADR 2.0b EiReport Service</th></tr>
<tr><td>REQ</td><td colspan="3">Report Name: x-CTA2045_Status</td></tr>
<tr><td rowspan="6">M7.1</td><td>Report Structure</td><td>Status</td><td>Interval</td></tr>
<tr><td>rID</td><td>DataSource</td><td rowspan="4">1-min</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>customUnit</td></tr>
<tr><th colspan="4">ANSI/CTA-2945-A Message</th></tr>
<tr><td colspan="2">Message</td><td colspan="2">Get Commodity
(0x06,0x00 Byte 3) = Any</td></tr>
<tr><td colspan="2">Element Mapped to rID</td><td colspan="2">If Reply
(0x06,0x80 Byte 4) = 0x0X
Then DataSource = 1 = Measured

If Reply
(0x06,0x80 Byte 4) = 0x8X
Then DataSource = 2 = Estimated

Where X = any Commodity Codes</td></tr>
</table>

The above data point is designed to record the origin of the commodity value provided by the DER.
1, Measured, (Instrumentation is used to derive commodity values)
0, Estimated, (Calculated based on Operating States or other data, Instrumentation is NOT used to derive commodity values)</td></tr>
</table>

<table>
<tr><th rowspan="2">REQ.M#</th><th colspan="5">ANSI/CTA-2045-A Commands</th><th rowspan="2">OpenADR 2.0b EiReport Service</th></tr>
<tr><th>Message Type</th><th>Name</th><th>Opcode 1</th><th>Opcode 2</th><th>Payload</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>
<table>
<tr><td></td><td>(see Figure 1)</td><td></td></tr>
<tr><td>7</td><td>Present Energy Storage/Take Capacity</td><td>W-hr
Note: Instantaneous field in CommodityRead is not used.</td></tr>
<tr><td>8</td><td>Rated Max Consumption Level Electricity</td><td>W
Note: Cumulative field in CommodityRead is not used.</td></tr>
<tr><td>9</td><td>Rated Max Production Level Electricity</td><td>W
Note: Cumulative field in CommodityRead is not used.</td></tr>
<tr><td>10-127</td><td>Reserved</td><td></td></tr>
</table>
<u>*MSBit</u>
MSBit = 1, Measured, (Instrumentation is used to derive commodity values)
MSBit = 0, Estimated, (Calculated based on Operating States or other data, Instrumentation is NOT used to derive commodity values)

Get Commodity Reply
<table>
<tr><th>Payload Byte</th><th>Comments</th></tr>
<tr><td>1</td><td>Opcode1</td></tr>
<tr><td>2</td><td>Opcode2
(Response has 1st bit set)</td></tr>
<tr><td>3</td><td>Response Code</td></tr>
<tr><td>4</td><td>Commodity Code</td></tr>
<tr><td>5-10</td><td>Instantaneous Rate</td></tr>
<tr><td>11-16</td><td>Cumulative Amount</td></tr>
</table>
</td><td>
<table>
<tr><th colspan="4">OpenADR 2.0b EiReport Service</th></tr>
<tr><td>Point</td><td>Report Name</td><td colspan="2">x-CTA2045_Status</td></tr>
<tr><td rowspan="5">M7.2</td><td>Report Structure</td><td>Status</td><td>Interval</td></tr>
<tr><td>rID</td><td>ElectricPowerUsage</td><td rowspan="4">1-min</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>Watts</td></tr>
<tr><th colspan="4">ANSI/CTA-2945-A Message</th></tr>
<tr><td colspan="2">Message</td><td colspan="2">Get Commodity
0x06,0x00 (Byte 3 = 0x00)</td></tr>
<tr><td colspan="2">Element Mapped to rID</td><td colspan="2">Reply 0x06,0x80 Bytes 5-10</td></tr>
</table>
<table>
<tr><th colspan="4">OpenADR 2.0b EiReport Service</th></tr>
<tr><td>REQ</td><td>Report Name</td><td colspan="2">x-CTA2045_Status</td></tr>
<tr><td rowspan="5">M7.3</td><td>Report Structure</td><td>Status</td><td>Interval</td></tr>
<tr><td>rID</td><td>ElectricPowerUsage</td><td rowspan="4">1-min</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>Watts</td></tr>
<tr><th colspan="4">ANSI/CTA-2945-A Message</th></tr>
<tr><td colspan="2">Message</td><td colspan="2">Get Commodity
0x06,0x00 (Byte 3 = 0x00)</td></tr>
<tr><td colspan="2">Element Mapped to rID</td><td colspan="2">Get Commodity
Reply 0x06,0x80, Bytes 11-16</td></tr>
</table>
Note: The cumulative number provided by the DER could be reset to 0 at any time.
<table>
<tr><th colspan="4">OpenADR 2.0b EiReport Service</th></tr>
<tr><td>REQ</td><td>Report Name</td><td colspan="2">x-CTA2045_Status</td></tr>
<tr><td rowspan="5">M7.4</td><td>Report Structure</td><td>Status</td><td>Interval</td></tr>
<tr><td>rID</td><td>TotalEnergyCapacity</td><td rowspan="4">1-min</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>W-h</td></tr>
<tr><th colspan="4">ANSI/CTA-2945-A Message</th></tr>
<tr><td colspan="2">Message</td><td colspan="2">Get Commodity
0x06,0x00 (Byte 3 = 0x06)</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th rowspan="2">REQ.M#</th><th colspan="5">ANSI/CTA-2045-A Commands</th><th rowspan="2">OpenADR 2.0b EiReport Service</th></tr>
<tr><th>Message Type</th><th>Name</th><th>Opcode 1</th><th>Opcode 2</th><th>Payload</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>
<table>
<tr><td>Element Mapped to rID</td><td>Get Commodity, Reply
0x06,0x80 Bytes 11-16</td></tr>
</table>
<table>
<tr><th colspan="4">OpenADR 2.0b EiReport Service</th></tr>
<tr><td>REQ</td><td>Report Name</td><td colspan="2">x-CTA2045_Status</td></tr>
<tr><td rowspan="5">M7.5</td><td>Report Structure</td><td>Status</td><td>Interval</td></tr>
<tr><td>rID</td><td>PresentEnergyCapacity</td><td rowspan="4">1-min</td></tr>
<tr><td>Report Type</td><td>Reading</td></tr>
<tr><td>Reading Type</td><td>Direct Read</td></tr>
<tr><td>Units</td><td>W-h</td></tr>
<tr><th colspan="4">ANSI/CTA-2945-A Message</th></tr>
<tr><td colspan="2">Message</td><td colspan="2">Get Commodity
0x06,0x00 (Byte 3 = 0x07)</td></tr>
<tr><td colspan="2">Element Mapped to rID</td><td colspan="2">Get Commodity, Reply
0x06,0x80 Bytes 11-16</td></tr>
</table>
</td></tr>
</table>

3
GROUPING / TARGETING BEHIND-THE-METER RESOURCES

The purpose of this section is to establish a common method for targeting groups or individual BTM resources that reside behind a common client. In OpenADR 2.0, dispatch signal information (i.e. dispatch instructions) are communicated through the EiEvent service. A component of the dispatch signal are messages that are intended to be used to target individual or groups of resources. An excerpt from Section 8.2.1 of the OpenADR 2.0B 2015 OpenADR Alliance specification, included below, provides some insight into how these messages are intended to be used.

Section 8.2.1 Event Targets and Resources (OpenADR 2.0, 2015)
While the A Profile supported event targets (EiTarget), the B Profile includes several more target types, and also allows device class targeting to be applied at the signal level. A VEN is a communication endpoint that represents one or more logical resources (individual shedable loads, endpoint equipment, meters, etc.). Event targets select which specific VEN resources the event applies to. If an event target is not specified, the VEN should assume that it applies to all of its resources. ***How resources are assigned properties (location, pnode associations, resourceIDs, groupIDs, etc.) is outside the scope of the specification and is up to deployment configurations in the VTN and VEN. However, if a VEN receives an event target that it is not configured for, it should reject the message with the appropriate error code described in section 8.7.*** [emphasis added]

This excerpt was included to highlight the last two sentences, which state that the application of these targets is beyond the scope of the OpenADR 2.0b specification. To provide some guidance on the use of Targets in different DR programs, the OpenADR Alliance published the OpenADR 2.0 Demand Response Program Implementation Guide, Revision 1.1, Document Number 20140701. The purpose of this document is to provide guidance to those implementing DR programs that utilize OpenADR 2.0 to dispatch resources. With regards to event targeting, the above referenced guide includes informative examples of how different DR programs use event targeting. Included in Table 3-1 is a summary of how targets could be used to support the requirements of different programs. It's important to note that the guide does not specify how resources must be targeted within a specific program. Instead, it only provides guidance on how they could be targeted.

Table 3-1
Uses of Targeting in the OpenADR 2.0 Demand Response Program Implementation Guide, Revision 1.1, Document Number 20140701. (Informative)

Program Type	Target Loads	Event Targets
Critical Peak Pricing Program (CPP)	Any	venID or resourceIDs (Typical)
Capacity Bidding	Any	venID or resourceID representative of the aggregated load associated with a VEN
Thermostat	HVAC	resourceIDs or venID with event signal device class target set to Thermostat
Fast DR Dispatch	Those which can respond to real-time dispatches	venID or a resourceID representative of the aggregated load associated with a VEN
Residential EV TOU Programs	EV Chargers	No advanced targeting required but targeting can be used to send prices to specific transformers, feeders, or geographic areas.
Public Station Electric Vehicle (EV) Real-Time Pricing Program	Public EV Chargers	No advanced targeting required but targeting can be used to send prices to specific transformers, feeders, or geographic areas.
Distributed Energy Resources (DER)	Any	venID. No other advanced targeting required
The Universal Smart Energy Framework (USEF) Incentive-based	HVAC, Industrial loads	venID or resourceIDs (Typical)
The Universal Smart Energy Framework (USEF) Transaction based Program	Any	venID or a resourceID representative of the aggregated load associated with a VEN
The Universal Smart Energy Framework (USEF) Override based Program	Those which can respond to real-time dispatches	venID or a resourceID representative of the aggregated load associated with a VEN

3.1 Targeting Requirements (Normative)

The purpose of this section is to define a standardized set of rules for targeting BTM resources in systems with architectures similar to those shown in Figure 1-2 and Figure 1-3. The reason for defining these rules is to improve the interchangeability between the components of one system and the components of another system. The groups listed in Table 3-2 are some of the mechanisms that the OpenADR 2.0 supports to facilitate the targeted distribution of dispatches.

Table 3-2
Five grouping levels supported by and defined in OpenADR 2.0a and 2.0b

Group	XML Element	Definition	Intended use
MarketContext	eventDescriptorType	Identifies a particular program or application defined grouping that pertains to an event.	Used to send an event to a group of VENs with the same MarketContext.
ei:venID	eiTarget:eiTargetType	A VEN is a communication endpoint that represents one or more logical resources (individual shedable loads, endpoint equipment, meters, etc.). venID must be a unique number.	Used to send an event to a specific VEN
ei:partyID	eiTarget:eiTargetType	No definition	Undefined
ei:groupID	eiTarget:eiTargetType	No definition	Undefined
ei:resourceID	eiTarget:eiTargetType	Unique ID assigned to a single logical resource- (individual shedable loads, endpoint equipment, meters, etc.).	Used to send an event to an individual DER

OpenADR 2.0 defines rules for how clients accept or reject dispatches based on MarketContext and eiTarget. Besides the venID and resourceID, the protocol does not include rules or provide guidance on what the other eiTargets (such as partyID and groupID) should be used to represent. If eiTargets (besides venID and resourceID) are used in deployments without rules or guidelines that govern their use, each deployment could be unique. This means that a client that interoperates within one deployment is not likely to interoperate in other deployments, even if that client has been certified. To reduce variability between deployments, rules that define the use of partyID and groupID, along with logic for how VENs use targets to determine if events should be accepted (i.e. logic), are included in Table 3-3.

Table 3-3
Target Level Filtering

REQ.T#	Target Level	Group	Use	Target Filtering Logic (VEN Application)[5]
REQ.T1	1	MarketContext	Unique name of a DER program	If eventDescriptorType:MarketContext and the MarketContext of the VEN match, then process event
REQ.T2	2	ei:venID	Unique ID assigned to a VEN	If eventDescriptorType:MarketContext and the MarketContext of the VEN match, AND If eiTarget:ei:venID and ei:venID of the VEN match, then process event
REQ.T3	3	ei:partyID	Electric network location (Substation / Transformer)	If eventDescriptorType:MarketContext and the MarketContext of the VEN match, AND If eiTarget:ei:venID and ei:venID of the VEN match, AND If eiTarget:ei:PartyID and the eiTarget:ei:PartyID of the VEN match, then process event
REQ.T4	4	ei:groupID	Device Type (see Table 3-4 for groupID definitions)	If eventDescriptorType:MarketContext and the MarketContext of the VEN match, AND If eiTarget:ei:venID and ei:venID of the VEN match, AND If eiTarget:ei:PartyID and the eiTarget:ei:PartyID of the VEN match, then process event AND If eiTarget:ei:groupID and the eiTarget:ei:groupID of the VEN match, then process event
REQ.T5	5	ei:resourceID	Unique ID assigned to a single logical resource	If eventDescriptorType:MarketContext and the MarketContext of the VEN match, AND If eiTarget:ei:resourceID and ei:resourceID of the VEN match, then process event

[5] The filtering logic for level 1,2 and 5 are defined in the OpenADR 2.0 specification.

3.1.1 ResourceID Format (Normative)

The resourceID must be in the following format:

resourceID = partyID:groupID:UniqueIDassignedtoresource

A graphical representation of the targeting filter logic is illustrated in Figure 3-1. For example, to targeted resources at a specific location, the EiEvent must include the MarketContext, vanID, partyID.

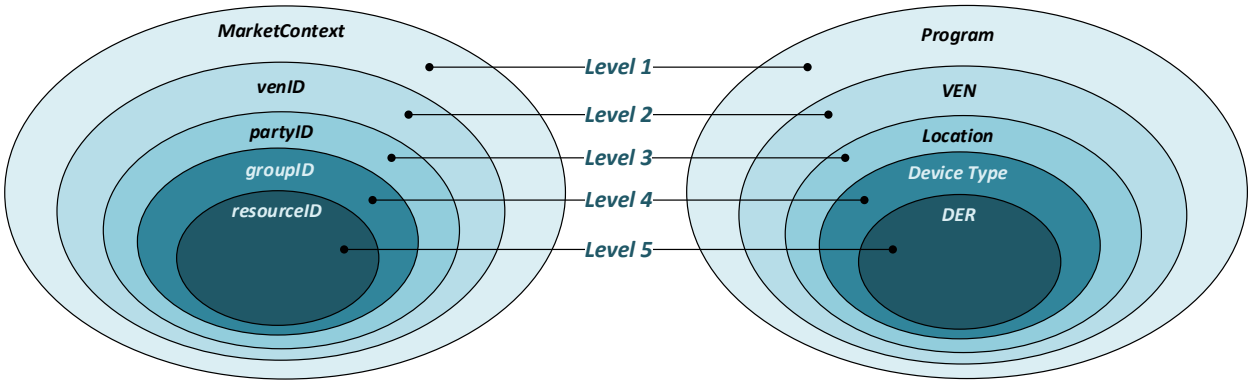


Figure 3-1
Use of groups and their assigned level of filtering

The Info Request message of the ANSI/CTA-2045-A standard includes a list of Device Types that must be included in the payload in response to a GetInfo query. This message enables the ANSI/CTA-2045-A communication module application to obtain the device type directly from the end-use device. Once obtained, the OpenADR 2.0 client shall use as the groupID. This mapping between GetInfo Device Type and groupID demonstrates how OpenADR 2.0 and ANSI/CTA-2045-A complement one another. The Device Types that must be used for groupID are listed in Table 3-4.

3.1.2 GroupID Format (Normative)

The groupID must include one of the device types listed in Table 3-4.

GetInfo Response (Device Type) = eiTarget:groupID.

Table 3-4
Resource Device Types for eiTarget:groupID

eiTarget:groupID	ANSI/CTA-2045-A Get/Set Info Request (Device Types)
Device Type (String)	**Device Type (HEX)**
Unspecified_Type	0x0000
Water_Heater_Gas	0x0001
Water_Heater_Electric	0x0002
Water_Heater_Heat_Pump	0x0003
Central_AC_Heat_Pump	0x0004
Central_AC_Fossil_Fuel_Heat	0x0005
Central_AC-Resistance_Heat	0x0006
Central_AC_(only)	0x0007

eiTarget:groupID	ANSI/CTA-2045-A Get/Set Info Request (Device Types)
Device Type (String)	**Device Type (HEX)**
Evaporative_Cooler	0x0008
Baseboard_Electric_Heat	0x0009
Window_AC	0x000A
Portable_Electric_Heater	0x000B
Clothes_Washer	0x000C
Clothes_Dryer_Gas	0x000D
Clothes_Dryer_Electric	0x000E
Refrigerator/Freezer	0x000F
Freezer	0x0010
Dishwasher	0x0011
Microwave Oven	0x0012
Oven_Electric	0x0013
Oven_Gas	0x0014
Cook_Top_Electric	0x0015
Cook_Top_Gas	0x0016
Stove_Electric	0x0017
Stove_Gas	0x0018
Dehumidifier	0x0019
Central_AC_Heat_Pump_Variable_Capacity	0x001A
Fan	0x0020
Pool_Pump_Single_Speed	0x0030
Pool_Pump_Variable_Speed	0x0031
Electric_Hot_Tub	0x0032
Irrigation_Pump	0x0040
Clothes_Dryer_Heat_Pump	0x0041
Electric_Vehicle	0x1000
Hybrid_Vehicle	0x1001
Electric_Vehicle_Supply_Equipment_general(SAE_J1772)	0x1100
Electric_Vehicle_Supply_Equipment_Level_1(SAE_J1772)	0x1101
Electric_Vehicle_Supply_Equipment_Level_2(SAE J1772)	0x1102
Electric_Vehicle_Supply_Equipment_Level_3(SAE J1772)	0x1103
In_Premises_Display	0x2000
Energy_Manager	0x5000
Gateway_Device	0x6000
Distributed_Energy_Resources	0x7000
Solar_Inverter	0x7001
Battery_Storage	0x7002
x-(user_defined)	0x8000 – 0xFFFF

3.2 Example Targeting Application (Informative)

The architectural diagram in Figure 2-1 is provided as an example application of the targeting requirements. In this example, the Operator targets all resources classified as Device Type A and connected to Substation X. Upon the receipt of the dispatch signal, the OpenADR 2.0 client would filter the eiTarget field and determine which resources are being targeted. After the

resources have been identified, the information would be passed to the subroutine that maps the converts the information into ANSI/CTA-2045-A commands and used to manage resources to automatically provide the requested grid service.

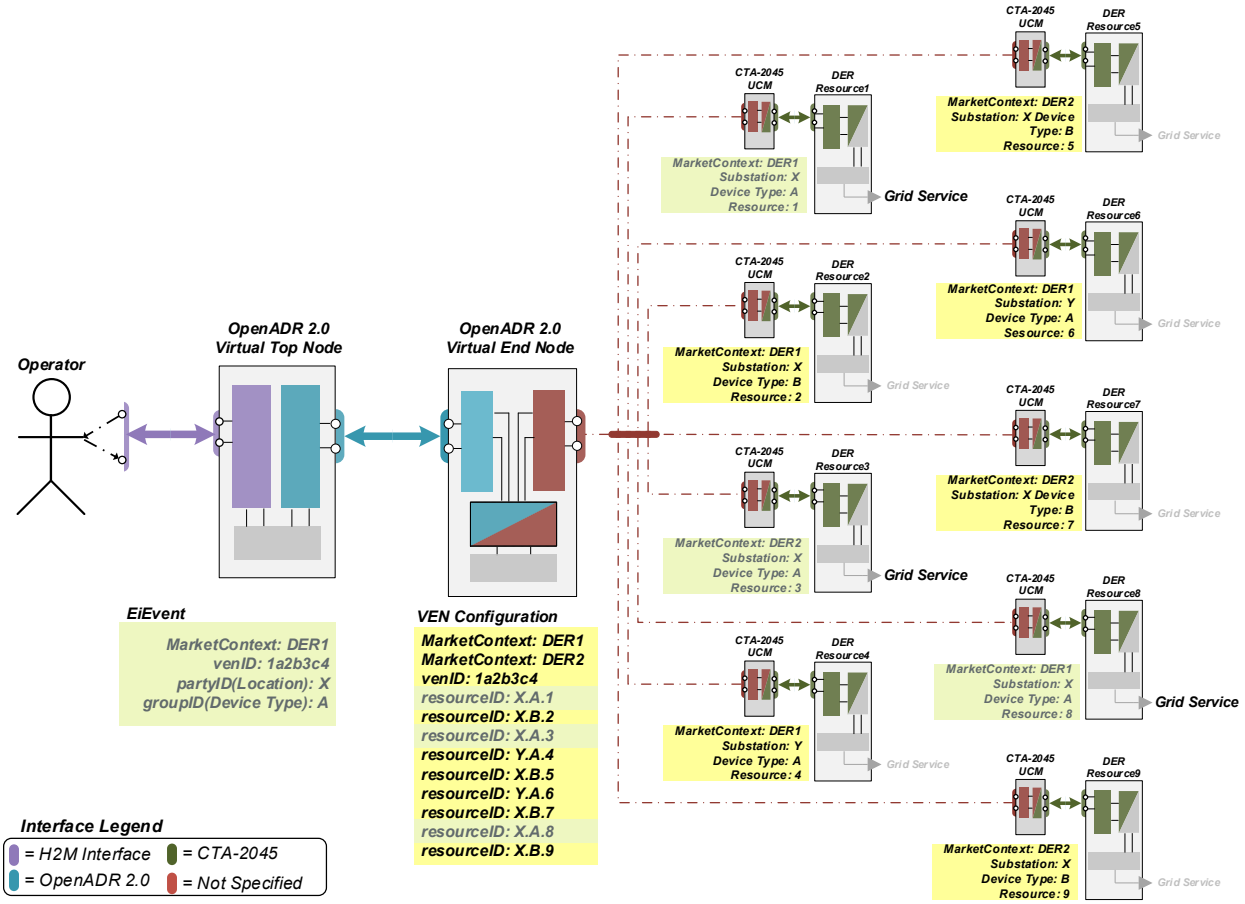


Figure 3-2
Example Use of Targeting Requirements

4
FUNCTIONAL REQUIREMENTS FOR ANSI/CTA-2045 RESOURCES (INFORMATIVE)

The tables in this section are included to show the relationship between load management functions of different types of resources and how ANSI/CTA-2045 is used to access these functions. For the full set of requirements, references are included in the captions of each table.

Domestic Water Heaters

Table 4-1
Demand Response-Ready Domestic Water Heater Specification: Preliminary Requirements for CEA-2045 Field Demonstration. EPRI, Palo Alto, CA: 2014. 3002002710

ANSI/CTA-2045 Messages	Domestic Water Heater Functional Responses
Link Layer	Link ACK, NAK, Max Payload Length Query/Response and Message Type Supported
****Shed***	Moderately reduce energy usage while maintaining customer comfort at a level determined by the OEM. OEM determines the level of comfort on the estimated average frequency of this request (Estimated AVG Frequency = 1/day)
End Shed/Run Normal	Return to normal operation
****Critical Peak Event***	Aggressively reduce energy usage while maintaining customer comfort at a level determined by the OEM. OEM determines the level of comfort on the estimated average frequency of this request (Estimated AVG Frequency = 20/year)
****Grid Emergency***	Immediately stop using energy and do not use energy for the duration of this event (If the duration of the event is longer than 1-hr, energy can be added to maintain a minimum customer comfort level, as determined by the OEM)
Outside Comm Connection Status	If a curtailment event is active and this message is not communicated, unit will return to normal operating mode
Customer Override	Device is required to have a local interface by which the user can override curtailment events. The Customer Override message is used to report the override state of the device. If override occurs when any curtailment event is in effect, ignore all curtailment requests for the next 4-hours. If override occurs when an event is not in effect, ignore all curtailment requests for the next 24-hours.
Operational state Query and Response	Operational states: Idle, Running, Idle Grid, Running Grid, Heightened Grid and Fault
****Load Up***	Unit will go to max set point (as determined by the user)
Get/Set Info Request	Vendor ID, Device Type, Model #, SN and Firmware revision
Get/Set Temperature Offset	Not supported
Get/Set Set Point	Not supported
Get/Set Commodity Read	Instantaneous power (W), cumulative energy (W-h), Energy Storage Capacity (W-h), Present Energy Storage Level (W-h). Commodities can be estimated
GetPresent Temperature	Not supported

Note (*): Referred to as “curtailment events” in ANSI/CTA-2045-A

Heat Pump Water Heater

Table 4-2
Demand Response-Ready Heat Pump Water Heater Specification: Preliminary Requirements for CEA-2045 Field Demonstration. EPRI, Palo Alto, CA: 2014. 3002002719.

ANSI/CTA-2045 Messages	Heat Pump Water Heater Responses
Link Layer	Link ACK, NAK, Max Payload Length Query/Response and Message Type Supported
****Shed***	Moderately reduce energy usage while maintaining customer comfort at a level determined by the OEM. OEM determines the level of comfort on the estimated average frequency of this request (Estimated AVG Frequency = 1/day) If the stored energy drops below the min comfort level, only the heat pump unit should engage to heat water as long as the curtailment event is in effect.
End Shed/Run Normal	Return to normal operation
****Critical Peak Event***	Aggressively reduce energy usage while maintaining customer comfort at a level determined by the OEM. OEM determines the level of comfort on the estimated average frequency of this request (Estimated AVG Frequency = 20/year) If the stored energy drops below the min comfort level, only the heat pump unit should engage to heat water as long as the curtailment event is in effect.
****Grid Emergency***	Immediately stop using energy and do not use energy for the duration of this event (If the duration of the event is longer than 1-hr, energy can be added to maintain a minimum customer comfort level, as determined by the OEM)
Outside Comm Connection Status	If a curtailment event is active and this message is not communicated, unit will return to normal operating mode
Customer Override	Device is required to have a local interface by which the user can override curtailment events. The Customer Override message is used to report the override state of the device. If override occurs when any curtailment event is in effect, ignore all curtailment requests for the next 4-hours. If override occurs when an event is not in effect, ignore all curtailment requests for the next 24-hours.
Operational state Query and Response	Operational states: Idle, Running, Idle Grid, Running Grid, Heightened Grid and Fault
****Load Up***	Unit will go to max set point (as determined by the user)
Get/Set Info Request	Vendor ID, Device Type, Model #, SN and Firmware revision
Get/Set Temperature Offset	Not supported
Get/Set Set Point	Not supported
Get/Set Commodity Read	Instantaneous power (W), cumulative energy (W-h), Energy Storage Capacity (W-h), Present Energy Storage Level (W-h). Commodities can be estimated
GetPresent Temperature	Not supported

Programmable Thermostat

Table 4-3
DR-Ready Programmable Thermostat Specification: Preliminary Requirements for CEA-2045 Field Demonstration. EPRI, Palo Alto, CA: 2014. 3002002711

ANSI/CTA-2045 Messages	Thermostat Responses
Link Layer	Link ACK, NAK, Max Payload Length Query/Response and Message Type Supported
Shed	Initiate a 4-degree offset for the duration of the event. Display text notification on thermostat's user interface for the duration of the event.
End Shed/Run Normal	Used to clear text notification field and to return to user defined set points
Critical Peak Event	Initiate a 8 degree offset for the duration of the event. Display text notification on thermostat's user interface for the duration of the event.
Grid Emergency	Immediately stop using energy and do not use energy for the duration of this event.
Outside Communication Status	If a curtailment event is active and this message is not communicated, thermostat will stop processing event and return to user-defined set points. In conjunction with an indicator, this message is used to convey the connectivity status between the communication module and its supervisory controller.
Customer Override	Device is required to have a local interface by which the user can override curtailment events. The Customer Override message is used to report the override state of the device. If override occurs when any curtailment event is in effect, ignore all curtailment requests for the next 4-hours. If override occurs when an event is not in effect, ignore all curtailment requests for the next 24-hours.
Query operational state	Idle, Running, Idle Grid, Running Grid and Heightened Grid supported
Load Up	If unit is in Cool mode, set point will be decreased by 1 degree. If in Heat mode, set point will be incremented by 1 degree.
Info Request	Vendor ID, Device Type, Model #, SN and Firmware revision
Get/Set Temperature Offset	Current offset can be read and set. "Conservation Event" displayed in text box until an End Shed is received.
Get/Set Setpoint	Cool and Heat mode setpoints can be read and set
Get/Set Commodity Read	Thermostat assumes HVAC system draws 2200W. Instantaneous power and cumulative energy are estimated based on this assumption and provided to the communication module.
GetPresent Temperature	The current temperature of the controlled zone can be read

Variable-Speed Pool Pump

Table 4-4
Demand Response-Ready Variable-Speed Pool Pump Specification: Preliminary Requirements for CEA-2045 Field Demonstration. EPRI, Palo Alto, CA: 2016. 3002008320

ANSI/CTA-2045 Messages	Pool Pump Responses
Link Layer	Link ACK, NAK, Max Payload Length Query/Response and Message Type Supported
Shed	If running, pump will decrease speed to 2X the min setpoint as determined by the operator or limited by the pump.
End Shed/Run Normal	Return to normal operation. Normal operation is the mode that the unit would running if the curtailment event were not processed.
Critical Peak Event	If running, pump will decrease speed to the min setpoint as determined by the operator or limited by the pump
Grid Emergency	Pump will stop pumping and remain off until midnight of the day the event is received
Outside Communication Status	The pool pump must monitor for this “heartbeat” signal which is sent from the communication module. If the pool pump is processing a curtailment request and the heartbeat is not received within 15 minutes, the pool pump will return to normal operation.
Customer Override	User can override curtailment events through a user interface
Query operational state	Idle, Running, Idle Grid, Running Grid, Heightened Grid, Opt Out Idle, Opt Out Running supported
Load Up	Unit will run at max speed (default is 3000 RPM). Total daily circulation will not be exceeded in a 24hr period
Power Level	Command will variably set speed of pump between min and max RPM (0-100%, where max RPM = 100%)
Info Request	Vendor ID, Device Type, Model #, SN and Firmware revision
Get/Set Commodity Read	Instantaneous power and cumulative energy are supported

Electric Vehicle Supply Equipment

Table 4-5
DR-Ready Electric Vehicle Supply Equipment Specification: Preliminary Requirements for CEA-2045 Field Demonstration. EPRI, Palo Alto, CA: 2014 3002002712

ANSI/CTA-2045 Messages	EVSE Responses
Link Layer	Link ACK, NAK, Max Payload Length Query/Response and Message Type Supported
Shed	Upon receipt of this message, the maximum EV charging current will be set to 50% of max rated current, as determined by the EVSE user
End Shed/Run Normal	Return to normal operation. Normal operation is the mode that the unit would running if the curtailment event were not processed.
Critical Peak Event	The EVSE will set the maximum allowable EV charging current to the min setting as determined by J1772 standard (6A at 240V)
Grid Emergency	EVSE will open contactor and stop charging EV. The pilot is still active and the car will continue to request power from the EVSE. At the end of the event, the EV will return to charging
Outside Communication Status	The EVSE must monitor for this “heartbeat” signal which is sent from the communication module in intervals less than 5-minutes. If the EVSE is processing a curtailment request and the heartbeat is not received within 15 minutes, the EVSE will return to normal operation.
Customer Override	Device is required to have a local interface by which the user can override curtailment events. The Customer Override message is used to report the override state of the device. If override occurs when either Shed or Critical Peak Event is in effect, ignore all curtailment requests for the next 4-hours. During a Grid Emergency event, the device will ignore the Customer Override and all curtailment requests during the first hour of this event. After the Grid Emergency has been in effect for 1-hour, the customer overrides and curtailment requests will be processed. If override occurs when an event is not in effect, ignore all curtailment requests for the next 24-hours.
Query operational state	Idle, Running, Idle Grid, Running Grid, Opt Out Idle, Opt Out Running supported
Power Level	Command will variably set max EV charging level between min (6A) and max as set by user. 0-100%, where 100% = Max rated current. Resolution is 1%
Info Request	Vendor ID, Device Type, Model #, SN and Firmware revision
Get/Set Commodity Read	Instantaneous power and cumulative energy are supported

Packaged Terminal Air Conditioner

Table 4-6
Demand Response-Ready Programmable Packaged Terminal Air Conditioner Specification: Preliminary Requirements for CEA-2045 Field Demonstration EPRI, Palo Alto, CA: 2015 3002006951

ANSI/CTA-2045 Messages	Packaged Terminal Air Conditioner Responses
Link Layer	Link ACK, NAK, Max Payload Length Query/Response and Message Type Supported
Shed	4 deg offset is applied for the event duration
End Shed/Run Normal	Used to clear text notification field and to return to user defined set points
Critical Peak Event	8 deg offset is applied for the event duration
Grid Emergency	Fan and compressor are turned off for the event duration
Outside Comm Connection Status	The PTAC must monitor for this “heartbeat” signal which is sent from the communication module in intervals less than 5-minutes. If the PTAC is processing a curtailment request and the heartbeat is not received within 15 minutes, the PTAC will return to normal operation.
Customer Override	Device is required to have a local interface by which the user can override curtailment events. The Customer Override message is used to report the override state of the device. If override occurs when any curtailment is in effect, ignore all curtailment requests for the next 4-hours. If override occurs when an event is not in effect, ignore all curtailment requests for the next 24-hours.
Query operational state	Idle, Running, Idle Grid, Running Grid and Heightened Grid supported
Load Up	If unit is in Cool mode, set point will be decreased by 2 deg. If in Heat mode, set point will be incremented by 2 degree
Info Request	Vendor ID, Device Type, Model #, SN and Firmware revision
Get/Set Temperature Offset	Current offset can be read and set.
Get/Set Set Point	Cool and Heat mode set points can be read and set
Get/Set Commodity Read	Instantaneous power and cumulative energy.
GetPresent Temperature	The current temperature of the controlled zone can be read

Variable Capacity Heat Pumps

Table 4-7
Requirements for Variable Capacity Heat Pumps (Air Conditioning, Heating and Refrigeration Institute (AHRI) Standard P1380.

ANSI/CTA-2045 Messages	Variable Capacity HVAC Responses
Shed	Limit input power to a maximum of 70% of the Benchmark Power, do not exceed if set
End Shed/Run Normal	Informs HVAC equipment that any curtailment or price events that may be presently in effect are terminated.
Critical Peak Event	Limit input power to a maximum of 40% of the Benchmark Power
Grid Emergency	Directs HVAC equipment to turn off, reducing input power to near zero
Outside Communication Status	Used as a “heartbeat” signal which is sent from the communication module in intervals less than 5-minutes.
Info Request	Vendor ID, Device Type, Model #, SN and Firmware revision
Get/Set Temperature Offset	Shall be used as the “Maximum Indoor Temperature Offset” for HVAC equipment during a load control or price event unless locally modified by the consumer.
Get/Set Commodity Read	N/A
Customer Override	User can override curtailment events by manually changing set point or by changing the mode to manual
Query operational state	Idle, Running, Idle Grid, Running Grid, Heightened Grid, Idle Heightened, Idle, Opted Out, Running Opted Out
Pending Event Warning and Pending Event	Equipment manufacturers may optionally use this information to take proactive action ahead of the event such as precooling or preheating
Pending Event Type	Pending event type or notice of cancellation

5
REFERENCES AND RESOURCES (INFORMATIVE)

5.1 Reference Standards

The requirements included herein apply to the version of the standards listed in Table 5-1.

Table 5-1
Referenced Communication Standards

Reference Number	Source	Name	Revision	Release Date
[1]	OpenADR Alliance	OpenADR 2.0 Profile Specification B Profile	1.1	11-17-2015
[2]	Consumer Technology Association	ANSI/CTA-2045-A Modular Communications Interface for Energy Management	A	March 2018

5.2 Open Source Code Repositories

The applications and source code listed in Table 5-2 were developed and published to advance research and the adoption of open communication standards.

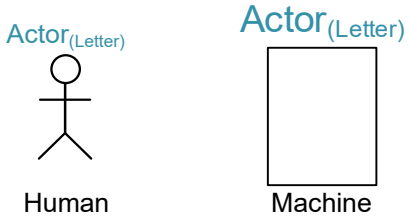
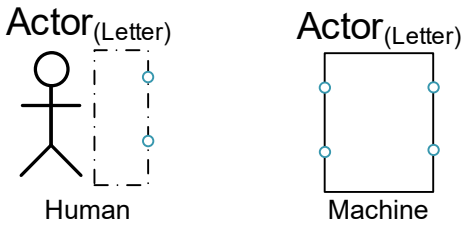
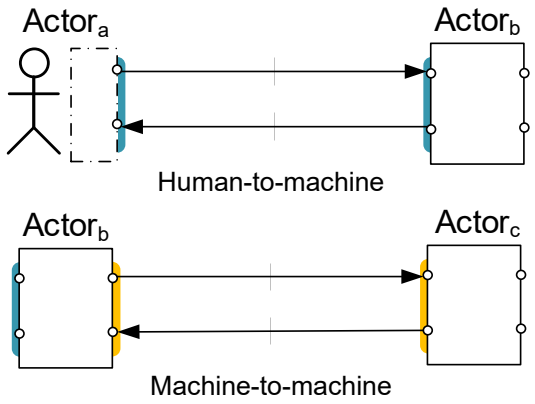
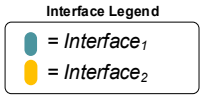
Table 5-2
Open Source Code Repositories for OpenADR 2.0 and ANSI/CTA-2045 Applications

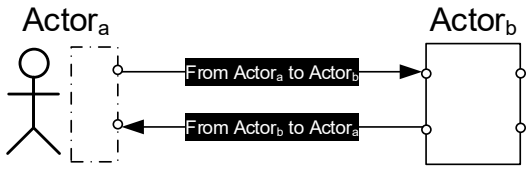
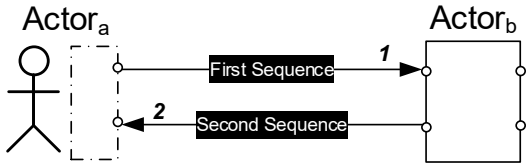
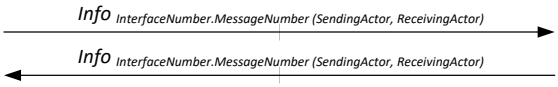
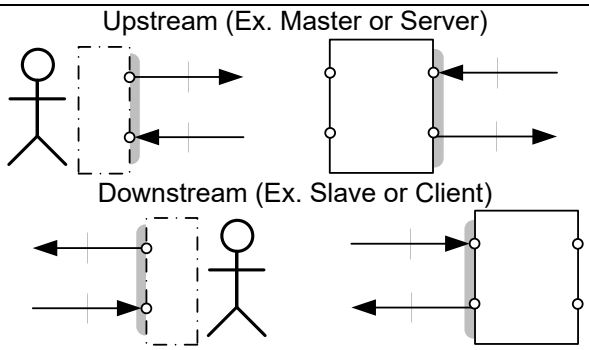
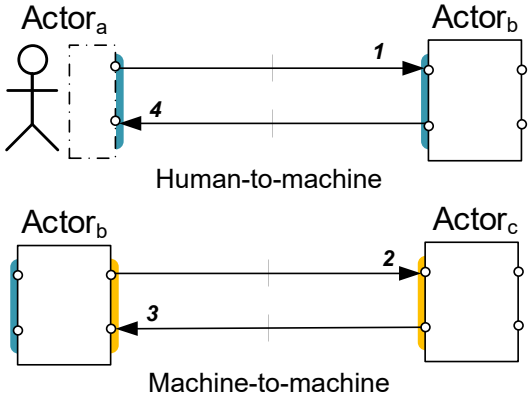
Name and Link	Description	Programming Language
OpenADR 2.0 Virtual Top Node (VTN)	This application is an implementation of a virtual top node (VTN) as defined in the OpenADR Alliance's OpenADR 2.0 Profile Specification.	Ruby
OpenADR 2.0b Virtual End Node (HTTP Poll)	This application is an implementation of a virtual end node (VEN) as defined in the OpenADR Alliance's OpenADR 2.0 Profile B Specification (HTTP pull)	C#
OpenADR 2.0b Virtual End Node (HTTP Poll) C++ Library	This library was developed to support the requirements of an OpenADR 2.0b HTTP Poll VEN client.	C++
CTA-2045 Desktop Simulator	This application is designed to aid in the develop and test of ANSI/CTA-2045 communication ports. This repository also includes hardware designs for the physical test harnesses (AC and DC form factors).	Visual Basic
CTA-2045 C++ Library (Communication Module Role)	This software is a C++ library developed and released to support companies in the marketplace who are developing or planning to develop ANSI/CTA-2045 communication modules	C++

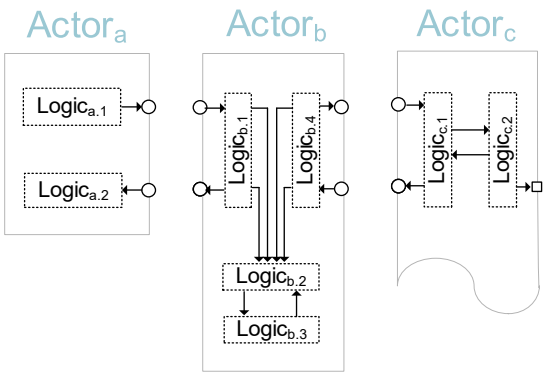
5.3 System Diagrams (Symbols – Definition, Nomenclature, Use)

Table 5-3 includes definitions for symbols used to compile the system diagrams included in Section 1.2. Another example use of these symbols in a system that leverages OpenADR 2.0 and ANSI/CTA-2045-A to automatically dispatch BTM resources is shown in Figure 5-1.

Table 5-3
System Diagram Symbol Definitions

Representative Element	Definition, Nomenclature, Use	Symbol
Actor	Actors are any human or machine whose interaction with the system contributes to the system's output. Actor$_{(letter)}$	
Information Exchange Point	A point at which data is exchanged with an actor. This point is represented by a circle located on one or more sides of an actor.	
Interface	A specific format and rules that one or more actors use to exchange information. The colors in the symbol represent a specific format and rules (protocol). *Suggested Naming Convention* Interface$_{(number)}$	
Interface Legend	An Interface Legend is used to map the colors used to differentiate one interface to another to the name of the interface.	

Representative Element	Definition, Nomenclature, Use	Symbol
Information Flow (Direction)	Direction by which information is sent from one actor to another.	
Information Exchange Sequence	The sequence by which information is shared between actors across a system.	
Information	Information (i.e. data, messages, instructions, commands, requests, etc.) shared between actors. *Example Naming Convention* *Info* *InterfaceNumber.MessageNumber (SendingActorLetter, ReceivingActorLetter)*	
Hierarchical Role (Upstream or Downstream)	Term used to describe the role of an actor with reference to another within the system. Note: For example, this concept is analogous to the roles for Masters and Slaves or Servers and Clients.	
Interface	The Colors behind the Actor's Information Exchange point are used to represent a common interface. *Suggested Naming Convention* Interface(number)	

Representative Element	Definition, Nomenclature, Use	Symbol
	A legend is used to map names to the colors selected to represent the interfaces **Interface Legend** = *Interface*$_1$ = *Interface*$_2$	
Logic	The Logic block represents decisions or actions that each actor must execute to fulfill the system's objective Arrows between the logic blocks can be used to represent interactions between one or more logic blocks within the same actor. *Example Naming Convention* Logic$_{(ActorLetter).(BlockNumber)}$ *Application Note:* For Actors representing Machines, logic blocks could represent subroutines such as mapping information to other subroutines that process and execute their functional role in the system. *Application Note:* For Actors representing Humans, the logic blocks are used to represent thought processes and actions.	

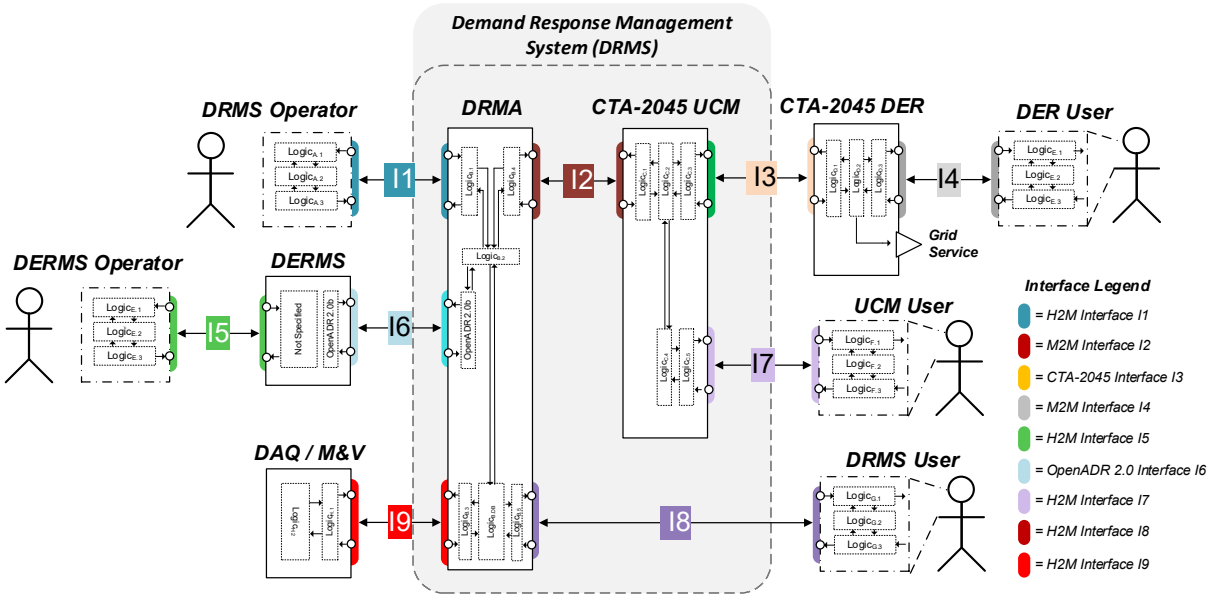


Figure 5-1
Example use of symbols in a system that relies on OpenADR 2.0 and ANSI/CTA-2045-A to dispatch BTM resources

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