1 Introduction

Energy Interoperation describes an information and communication model to coordinate energy supply, transmission, distribution, and use, including power and ancillary services, between any two parties, such as energy suppliers and customers, markets and service providers, in any of the domains indicated in Figure 2.1 below. Energy Interoperation makes no assumptions about which entities will enter those markets, or as to what those market roles will be called in the future. Energy Interoperation supports each of the secure communications interfaces in Figure 1-1, but is not limited to those interfaces.

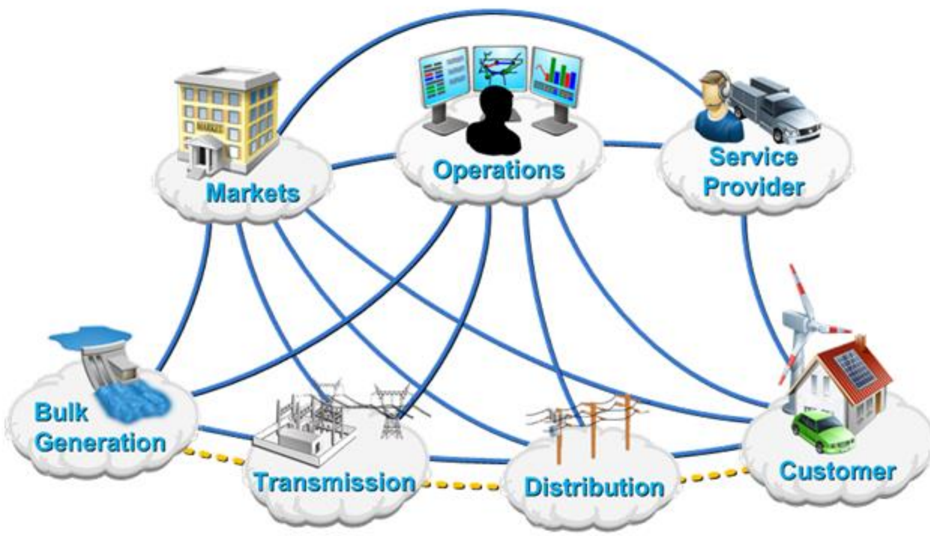

*Figure 1-1: Conceptual model for smart grid from **[NIST]** showing communications requirements*

Energy Interoperation defines messages to communicate price, reliability, and emergency conditions over communications interfaces. Energy Interoperation is agnostic as to the technology that a communications interface may use to carry these messages.

Energy Interoperation messages can concern real time interactions, forward projections, or historical reporting. Energy Interoperation is intended to support market-based balancing of energy supply and demand while increasing fluidity of transactions. Increased deployment of distributed and intermittent energy sources will require greater fluidity in both wholesale and retail markets. In retail markets, Energy Interoperation is meant to support greater consumer choice as to energy source.

Energy supplies are becoming more volatile due to the introduction of renewable energy sources. The introduction of distributed energy resources may create localized, volatile, surpluses and shortages. These changes will create more granular energy transactions, require more granularity in temporal price changes, and more granularity in service territory.

Balancing local energy resources brings more kinds of resources into the mix. Natural gas markets share many characteristics with electricity markets. Local thermal energy distribution systems can balance electricity markets while having their own surpluses and shortages. Nothing in Energy Interoperation restricts its use to electricity-based markets.

Energy consumers will need technologies to manage their local energy supply, including curtailment, storage, generation, and time-of-use load shaping and shifting. In particular, consumers will respond to Energy Interoperation messages for emergency and reliability events, or price messages to take advantage of lower energy costs by deferring or accelerating usage, and to trade curtailment, local generation and energy supply rights. Energy Interoperation does not specify which technologies consumers will use; rather it defines a technology agnostic interface to enable accelerated market development of such technologies.

To balance supply and demand energy suppliers must be able to schedule resources, manage aggregation, and communicate both the scarcity and surplus of energy supply over time. Suppliers will use Energy Interoperation to inform customers of emergency and reliability events, to trade curtailment and supply of energy, and to provide intermediation services including aggregation of provision, curtailment, and use.

Energy Interoperation relies on standard format for communication of time and interval [WS-Calendar] and for energy price and product definition [EMIX]. This document assumes that there is a high degree of symmetry of interaction at any Energy Interoperation interface, i.e., that providers and customers may reverse roles during any period.

The OASIS Energy Interoperation Technical Committee is developing this specification in support of the National Institute of Standards and Technology (NIST) Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0 [Framework] in support of the US Department of Energy (DOE) as described in the Energy Independence and Security Act of 2007 [EISA2007].

Under the Framework and Roadmap, the North American Energy Standards Board (NAESB) surveyed the electricity industry and prepared a consensus statement of requirements and vocabulary. This work was submitted to the Energy Interoperation Committee in April 2010 and subsequently updated and delivered in January 2011.

All examples and all Appendices are non-normative.

1.1 Terminology

The key words “MUST”, “MUST NOT”, “REQUIRED”, “SHALL”, “SHALL NOT”, “SHOULD”, “SHOULD NOT”, “RECOMMENDED”, “MAY”, and “OPTIONAL” in this document are to be interpreted as described in **[RFC2119]**

1.2 Normative References

[EMIX] **EMIX OASIS Committee Specification Draft 04, *Energy Market Information Exchange 1.0*, September 2010. http://docs.oasis-open.org/emix/emix/v1.0/csd04/emix-v1.0-csd04.html**

[RFC2119] **S. Bradner, *Key words for use in RFCs to Indicate Requirement Levels*, http://www.ietf.org/rfc/rfc2119.txt, IETF RFC 2119, March 1997.**

[RFC2246] **T. Dierks, C. Allen *Transport Layer Security (TLS) Protocol Version 1.0*, http://www.ietf.org/rfc/rfc2246.txt, IETF RFC 2246, January 1999.**

[SOA-RAF] **OASIS Committee Specification, *Reference Architecture Foundation for Service Oriented Architecture Version 1.0*,** http://docs.oasis-open.org/soa-rm/soa-ra/v1.0/cs01/soa-ra-v1.0-cs01.pdf

[SOA-RM] **SOA-RM OASIS Standard, *OASIS Reference Model for Service Oriented Architecture 1.0*, October 2006 http://docs.oasis-open.org/soa-rm/v1.0/**

[Vavailability] **C. Daboo, B. Desruisseaux, Calendar Availability, http://tools.ietf.org/html/draft-daboo-calendar-availability-02, IETF Internet Draft, April 2011**

[WS-Calendar] **WS-Calendar OASIS Committee Specification 1.0, WS-Calendar, July 2011, http://docs.oasis-open.org/ws-calendar/ws-calendar-spec/v1.0/cs01/ws-calendar-spec-v1.0-cs01.pdf**

1.3 Non-Normative References

[BACnet/WS] **Addendum C to ANSI/ASHRAE Standard 135-2004, *BACnet Web Services Interface.***

[ebXML-MS] **OASIS Standard, *Electronic Business XML (ebXML) Message Service Specification v3.0: Part 1, Core Features*, October 2007. http://docs.oasis-open.org/ebxml-msg/ebms/v3.0/core/os/ebms_core-3.0-spec-os.pdf**

[EISA2007] **Energy Independence and Security Act of 2007, http://nist.gov/smartgrid/upload/EISA-Energy-bill-110-140-TITLE-XIII.pdf**

[EPRI] **Concepts to Enable Advancement of Distributed Energy Resources, February 2010, http://my.epri.com/portal/server.pt?Abstract_id=000000000001020432**

[Framework] **National Institute of Standards and Technology, *NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0*, January 2010, http://nist.gov/public_affairs/releases/upload/smartgrid_interoperability_final.pdf**

[Galvin] **Galvin Electricity Initiative, *Perfect Power*, http://www.galvinpower.org/perfect-power/what-is-perfect-power**

[ID-CLOUD] **OASIS Identity in the Cloud Technical Committee http://www.oasis-open.org/committees/id-cloud**

[IEC 61968] **Application integration at electric utilities - System interfaces for distribution management - Part 9: Interfaces for meter reading and control**

[IEC 61970-301] **Energy management system application program interface (EMS-API) - Part 301: Common information model (CIM) base**

[KMIP] **OASIS Standard, *Key Management Interoperability Protocol Specification Version 1.0*, October 2010 http://docs.oasis-open.org/kmip/spec/v1.0/kmip-spec-1.0.pdf**

[OpenADR] **Mary Ann Piette, Girish Ghatikar, Sila Kiliccote, Ed Koch, Dan Hennage, Peter Palensky, and Charles McParland. 2009. Open Automated Demand Response Communications Specification (Version 1.0). California Energy Commission, PIER Program. CEC-500-2009-063.**

[NAESB-SG] **NAESB Smart Grid Subcommittee, http://www.naesb.org/smart_grid_standards_strategies_development.asp**

[OASIS SCA] **OASIS Service Component Architecture Member Section http://www.oasis-opencsa.org/sca**

[PMRM] **OASIS Privacy Management Reference Model (PMRM) Technical Committee**, **http://www.oasis-open.org/committees/pmrm**

[SAML] **OASIS Standard, *Security Assertion Markup Language 2.0*, March 2005. http://docs.oasis-open.org/security/saml/v2.0/saml-core-2.0-os.pdf**

~~[SOA-RA]~~ ~~**OASIS Public Review Draft 01, *Reference Architecture for Service Oriented Architecture Version 1.0,* April 2008 http://docs.oasis-open.org/soa-rm/soa-ra/v1.0/soa-ra-pr-01.pdf**~~

[SPML] **OASIS Standard, *Service Provisioning Markup Language (SPML) v2 - DSML v2 Profile*, April 2006. http://www.oasis-open.org/committees/download.php/17708/pstc-spml-2.0-os.zip** [TC57CIM] **IEC Technical Committee 57 Common Information Model (IEC 61968 and IEC 61970, various dates)**

[TeMIX] **TeMIX *Transactive Energy Market Information Exchange [TeMIX] an approved Note of the EMIX TC*. Ed Cazalet et al. http://www.oasis-open.org/committees/download.php/37954/TeMIX-20100523.pdf**

[UML] **Object Management Group, *Unified Modeling Language (UML), V2.4.1*, August 2011. http://www.omg.org/spec/UML/2.4.1/**

[Vavailability] **C. Daboo, B. Desruisseaux, Calendar Availability, http://tools.ietf.org/html/draft-daboo-calendar-availability-02, IETF Internet Draft, April 2011**

[WS-Addr] **Web Services Addressing (WS-Addressing) 1.0, W3C Recommendation, http://www.w3.org/2005/08/addressing.**

[WSFED] **OASIS Standard, *Web Services Federation Language (WS-Federation) Version 1.2*, 01 May 2009 http://docs.oasis-open.org/wsfed/federation/v1.2/os/ws-federation-1.2-spec-os.doc**

[WSI-Basic] **R Chumbley, J Durand, G Pilz, T Rutt , *Basic Profile Version 2.0,* http://ws-i.org/profiles/BasicProfile-2.0-2010-11-09.html, The Web Services-Interoperability Organization, November 2010**

[WSRM] **OASIS Standard, *WS-Reliable Messaging 1.1*, November 2004. http://docs.oasis-open.org/wsrm/ws-reliability/v1.1/wsrm-ws_reliability-1.1-spec-os.pdf**

[WS-SecureConversation] **OASIS Standard, *WS-SecureConversation 1.3,* March 2007. http://docs.oasis-open.org/ws-sx/ws-secureconversation/200512/ws-secureconversation-1.3-os.pdf**

[WS-Security] **OASIS Standard, *WS-Security 2004 1.1*, February 2006. http://www.oasis-open.org/committees/download.php/16790/wss-v1.1-spec-os-SOAPMessageSecurity.pdf**

[WS-SX] **OASIS Web Services Secure Exchange (WS-SX) Technical Committee http://www.oasis-open.org/committees/ws-sx**

[XACML] **OASIS Standard, *eXtensible Access Control Markup Language 2.0*, February 2005. http://docs.oasis-open.org/xacml/2.0/access_control-xacml-2.0-core-spec-os.pdf**

1.4 Contributions

The NIST Roadmap for Smart Grid Interoperability Standards described in the **[Framework]** requested that many standards development organizations (SDOs) and trade associations work together closely in unprecedented ways. An extraordinary number of groups came together and contributed effort, time, requirements, and documents. Each of these groups further gathered together, repeatedly, to review the work products of this committee and submit detailed comments. These groups contributed large numbers of documents to the Technical Committee. These efforts intersected with this specification in ways almost impossible to unravel, and the committee acknowledges the invaluable works below which are essential to understanding the North American Grid and its operation today, as well as its potential futures.

NAESB Smart Grid Standards Development Subcommittee [NAESB-SG]:

The following documents are password protected. For information about obtaining access to these documents, please visit www.naesb.org or contact the NAESB office at (713) 356 0060.

[NAESB EUI] NAESB REQ Energy Usage Information Model: **http://www.naesb.org/member_login_check.asp?doc=req_rat102910_req_2010_ap_9d_rec.doc**

[NAESB EUI] NAESB WEQ Energy Usage Information Model: **http://www.naesb.org/member_login_check.asp?doc=weq_rat102910_weq_2010_ap_6d_rec.doc**

The following documents are under development and subject to change.

[NAESB PAP 09] Phase Two Requirements Specification for Wholesale Standard DR Signals – for NIST PAP09: **http://www.naesb.org/member_login_check.asp?doc=fa_2010_weq_api_6_c_ii.doc**

[NAESB PAP 09] Phase Two Requirements Specification for Retail Standard DR Signals – for NIST PAP09: **http://www.naesb.org/member_login_check.asp?doc=fa_2010_retail_api_9_c.doc**

The NAESB Measurement and Verification of Demand Response (WEQ-015) and Measurement and Verification of Energy Efficiency Products (WEQ-021) standards were adopted by the US Federal Energy Regulatory Commission (FERC) on February 21, 2013 and have been incorporated by reference as federal regulation. The complementary standards developed to support the retail markets (REQ.13 and REQ.19, respectively) were adopted by NAESB and are available for consideration by state regulatory agencies. The NAESB Demand Side Management and Energy Efficiency Subcommittee is currently developing a certification program for energy efficiency and demand response measurement and verification products that comply with the NAESB standards.

The ISO / RTO Council Smart Grid Standards Project:

Information Model – HTML: **http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-InformationModel-HTML-Condensed_Rev1_20101014.zip**

Information Model – EAP: **http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-InformationModel-EAP-Condensed_Rev1_20101014.zip**

XML Schemas: **http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-XML_Schemas_Rev1_20101014.zip**

Eclipse CIMTool Project: **http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-CIMTool-Project-Workspace_Rev1_20101014.zip**

Interactions - Enrollment and Qualification: **http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Interactions-HTML_Enrollment_And_Qualification_Rev1_20101014.zip**

Interactions - Scheduling and Award Notification: **http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Interactions-HTML_Scheduling_And_Award_Notification_Rev1_20101014.zip**

Interactions - Deployment and Real Time Notifications: **http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Interactions-HTML_Deployment_And_RealTime_Communications_Rev1_20101014.zip**

Interactions - Measurement and Performance: **http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Interactions-HTML_Measurement_And_Performance_Rev1_20101014.zip**

Interactions Non-Functional Requirements: **http://www.isorto.org/atf/cf/%7B5B4E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC-DR-Non-Functional_Requirements_Rev1_20100930.pdf**

UCAIug OpenSG OpenADR Task Force:

OpenADR 1.0 System Requirements Specification v1.0
http://osgug.ucaiug.org/sgsystems/OpenADR/Shared%20Documents/SRS/OpenSG%20OpenADR%201.0%20SRS%20v1.0.pdf

OpenADR 1.0 Service Definition - Common Version :R0.91
http://osgug.ucaiug.org/sgsystems/OpenADR/Shared%20Documents/Services/OpenSG%20OpenADR%20SD%20-%20Common%20r0.91.doc

OpenADR 1.0 Service Definition – Web Services Implementation Profile Version: v0.91
http://osgug.ucaiug.org/sgsystems/OpenADR/Shared%20Documents/Services/OpenSG%20OpenADR%20SD%20-%20WS%20r0.91.doc

1.5 Namespace

The XML namespace [XML-ns] URI that MUST be used by implementations of this specification is:

```
http://docs.oasis-open.org/ns/energyinterop
```

Dereferencing the above URI will produce the Resource Directory Description Language [RDDL 2.0] document that describes this namespace.

Table 1 lists the XML namespaces that are used in this specification. The choice of any namespace prefix is arbitrary and not semantically significant.

Table 1-1: Namespaces Used in this Specification

Prefix	Namespace
xs	http://www.w3.org/2001/XMLSchema
gml	http://www.opengis.net/gml/3.2
xcal	urn:ietf:params:xml:ns:icalendar-2.0
strm	urn:ietf:params:xml:ns:icalendar-2.0:stream
emix	http://docs.oasis-open.org/ns/emix/2011/06
power	http://docs.oasis-open.org/ns/emix/2011/06/power
resource	http://docs.oasis-open.org/ns/emix/2011/06/power/resource
ei	http://docs.oasis-open.org/ns/energyinterop/201110

enrl	http://docs.oasis-open.org/ns/energyinterop/201110/enroll
pyld	http://docs.oasis-open.org/ns/energyinterop/201110/payloads
wsdl	http://docs.oasis-open.org/ns/energyinterop/201110/wsdl

The normative schemas for EMIX can be found linked from the namespace document that is located at the namespace URI specified above.

1.6 Naming Conventions

This specification follows some naming conventions for artifacts defined by the specification, as follows:

For the names of elements and the names of attributes within XSD files, the names follow the lowerCamelCase convention, with all names starting with a lower case letter. For example,

```
<element name="componentType" type="ei:ComponentType"/>
```

For the names of types within XSD files, the names follow the UpperCamelCase convention with all names starting with a lower case letter prefixed by “type-“. For example,

```
<complexType name="ComponentServiceType">
```

For the names of intents, the names follow the lowerCamelCase convention, with all names starting with a lower case letter, EXCEPT for cases where the intent represents an established acronym, in which case the entire name is in upper case.

An example of an intent that is an acronym is the "SOAP" intent.

1.7 Editing Conventions

For readability, element names in tables appear as separate words. The actual names are lowerCamelCase, as specified above, and as they appear in the XML schemas.

All elements in the tables not marked as “optional” are mandatory.

Information in the “Specification” column of the tables is normative. Information appearing in the note column is explanatory and non-normative.

All sections explicitly noted as examples are informational and are not to be considered normative.

1.8 Architectural Background

Energy Interoperability defines a service-oriented approach to energy interactions. Accordingly, it assumes a certain amount of definitions of roles, names, and interaction patterns. This document relies heavily on roles and interactions as defined in the OASIS Standard *Reference Model for Service Oriented Architecture* **[SOA-RM]** and the related technical specification *Reference Architecture Foundation for Service Oriented Architecture* **[SOA-RAF]**.

Service orientation focuses on the desired results rather than the requested processes. Service orientation complements loose integration. Service orientation organizes distributed capabilities that may be in different ownership domains.

The SOA paradigm concerns itself with visibility, interaction, and effect. Visibility refers to the capacity for those with needs and those with capabilities to be able to see each other. Interaction is the activity of using a capability. A service provides a decision point for any policies and transactions without delving into the process on either side of the interface

Services are concerned with the public actions of each interoperating system. Service interactions consider private actions, e.g., those on either side of the interface, to be inherently unknowable by other parties. A service is used without needing to know all the details of its implementation. Services are generally paid for results, not effort.

While loosely coupled, it is important to understand some typical message exchange patterns to understand how business processes are tied together through an SOA. [SOA-RAF] Section 4.3.3~~2.1~~ describes how message exchange patterns (MEP) are leveraged for this purpose. While [SOA-RAF] describes two types of MEPs, event notification and request response it also notes that, "This is by no means a complete list of all possible MEPs used for inter- or intra-enterprise messaging".

Three types of MEPs can inform the discussion on Energy Interoperation integration; a one way MEP, which differs somewhat from an event notification MEP in that no response is required or expected from the service provider, although the service consumer may receive appropriate http messages, e.g. 404 error.

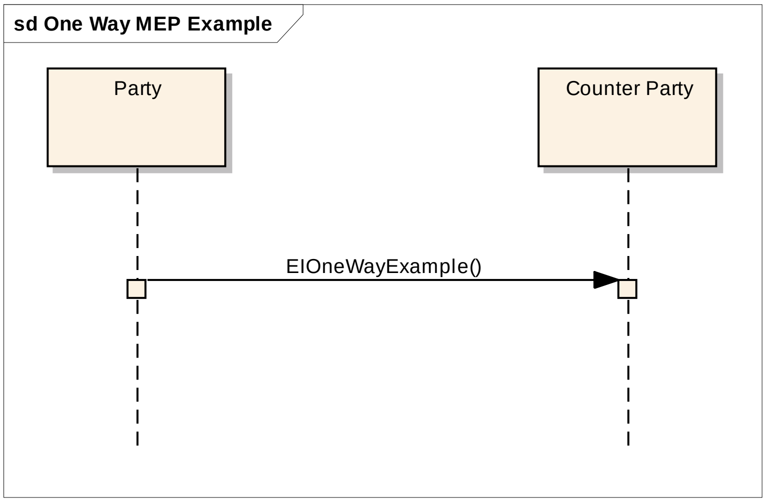

Figure 1-2: One-way MEP where no return is expected

Additionally a two-way MEP and a callback MEP are specific types of request/response MEPs described in [SOA-RAF] that are used in Energy Interoperation. A two way MEP exchange pattern assumes that after a service is consumed an acknowledgement is sent. This acknowledgement is made up of the message header of the returning service, and may include a standardized acknowledgement payload, i.e., for capturing errors, (or no errors if the service was called successfully).

The callback MEP is similar to the request/response pattern described in [SOA-RAF] except that it is more specific. In a callback MEP the service provider will send an acknowledgement upon receiving a request. However, once the service provider completes the corresponding business process, it will become a service consumer, by calling a service of the previous consumer, where it turn it will receive its own acknowledgement.

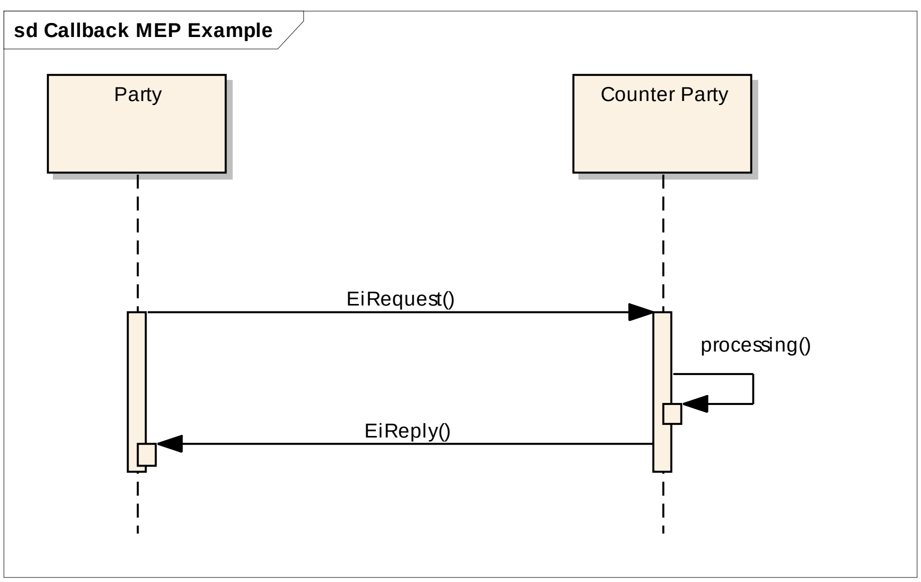

Figure 1-3: Callback MEP where a service provider sends an acknowledgement to the service consumer, performs a corresponding activity to act on the service request, then in turn makes a service request to the original initiating service consumer and receiving an acknowledgement in return.

Note: Acknowledgements are normally shown as a dashed arrow return but have been omitted from the figures of this specification for brevity. Appropriate returns should be assumed.

While most figures that illustrate a service interaction assume a PUSH paradigm, that is not a requirement. A PULL paradigm may also be employed using Energy Interoperation services. However, the PULL pattern differs slightly. A request is made, responded to, and then once the requestor has the information required, then it acts using a final operation as shown in the following figure.

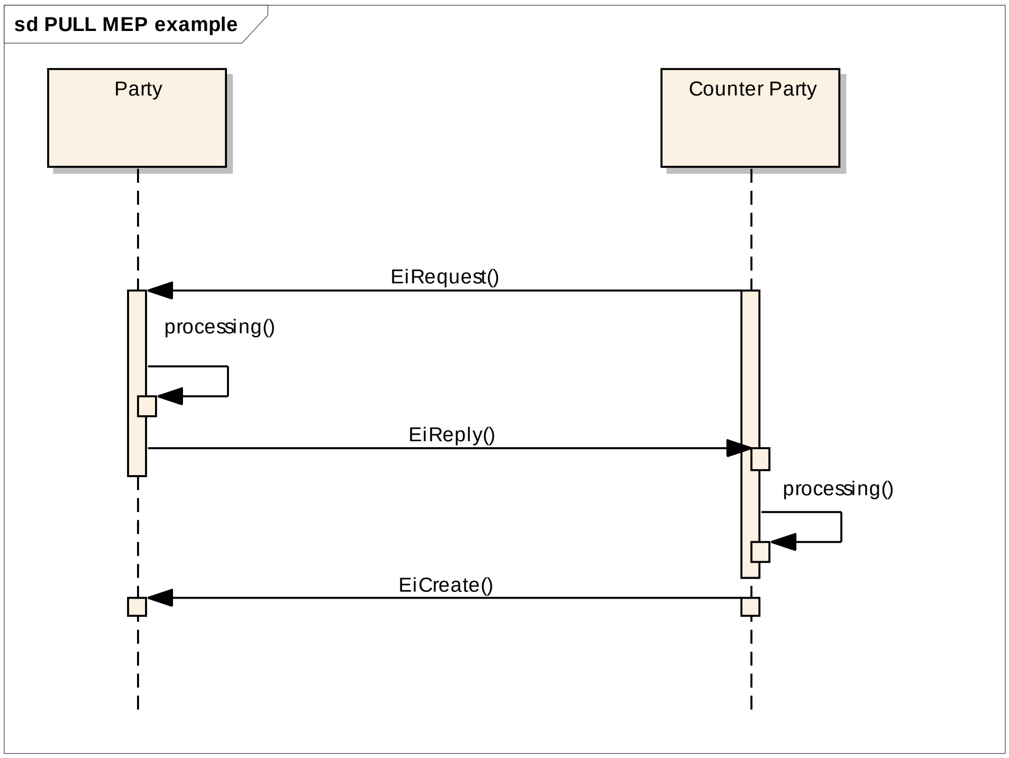

Figure 1-4: PULL MEP where a request is made, responded to, processed and then acted upon. Nominally this could be considered a combination of a callback MEP, followed by a two-way MEP

Loose integration using the SOA style assumes careful definition of security requirements between partners. Size of transactions, costs of failure to perform, confidentiality agreements, information stewardship, and even changing regulatory requirements can require similar transactions be expressed within quite different security contexts. It is a feature of the SOA approach that security is composed in to meet the specific and evolving needs of different markets and transactions. Security implementation must be free to evolve over time and to support different needs. Energy Interoperation allows for this composition, without prescribing any particular security implementation.