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Title:
IEC 62746-3:
Systems interface between customer energy management system and the power management system – Part 3: Architecture

(Titre) :

Introductory note

NOTE Attention is drawn to the fact that project 62746 is split into different parts.

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SYSTEM INTERFACES BETWEEN CUSTOMER ENERGY MANAGEMENT SYSTEM AND THE POWER MANAGEMENT SYSTEM –

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FOREWORD

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International Standard IEC 62747-3 has been prepared by subcommittee 21: Interfaces and protocol profiles relevant to systems connected to the electrical grid, of IEC technical committee 57

The text of this standard is based on the following documents:

FDIS	Report on voting
XX/XX/FDIS	XX/XX/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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Document history

Any person intervening in the present document is invited to complete the table below before sending the document elsewhere. The purpose is to allow all actors to see all changes introduced and the intervening persons.

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	From	**Date**		**To**	**Date**
Margareta Nöth	Scott Neumann	2014-03-26	CD document	CO	2014-04-08

This table will be removed by IEC editors before FDIS circulation (in case of IS) or before final publication (in case of TS or TR).

INTRODUCTION

The purpose of this standard is to define an architecture for IEC 62746 series of standards that can be leveraged for the management of customer energy resources. These resources may be a combination of load and generation resources that can be managed to respond to signals provided by grid and/or market operators. These resources may be identified and managed as individual resources with specific capabilities, or as virtual resources with an aggregated set of capabilities.

The focus of this architecture is to leverage the Internet for communications between grid operators, market operators, distribution system operators, electricity suppliers, aggregators, service providers and energy resources.

This standard leverages existing IEC TC57, IETF and W3C standards. IEC 62746 is transport independent.

SYSTEM INTERFACES AND COMMUNICATION PROFILE FOR SYSTEMS CONNECTED TO THE SMART GRID –

Part 3: Architecture

1 Scope

This International Standard establishes an architecture that is supportive of interfaces and protocol profiles relevant to systems connected to the electrical grid.

Figure 1 shows the relationship of IEC 62746 to other IEC TC57 standards and those of other IEC and ISO technical committees.

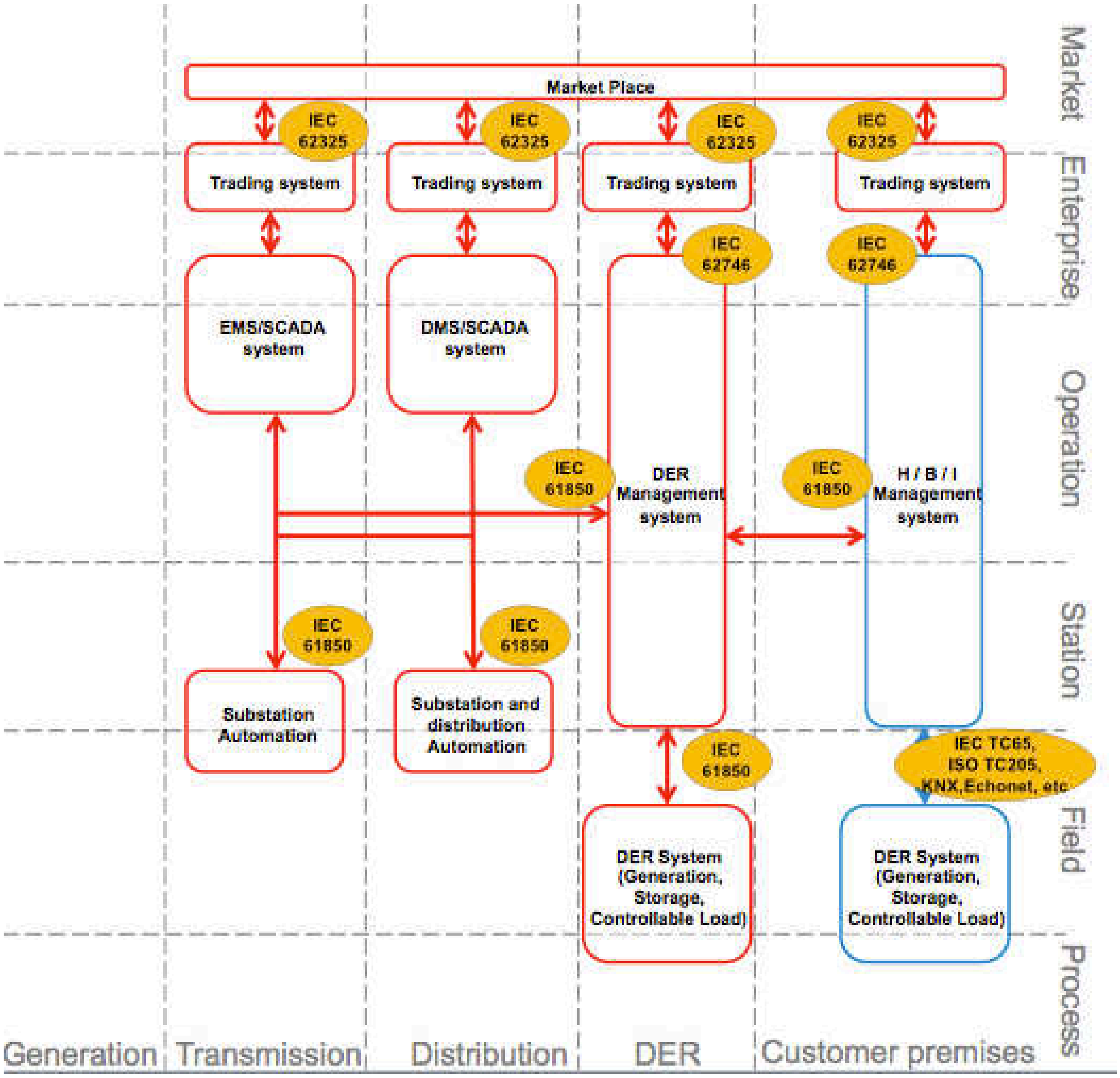

Figure 1 - Relationship of IEC 62746 to other standards

Figure 1 shows the scope of IEC 62746 relative to the scope of other related standards.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

- IEC 62746-2, Use Cases and Requirements
- IEC 61850-7-1 Ed 2, Communication networks and systems for Power Utility Automation
  – Part 7-1: Basic communication structure – Principles and models
- IEC 61850-7-2 Ed 2, Communication networks and systems for Power Utility Automation
  – Part 7-2: Basic communication structure – Abstract communication service interface (ACSI)
- IEC 61850-7-3 Ed 2, Communication networks and systems for Power Utility Automation
  – Part 7-3: Basic communication structure – Common data classes
- IEC 61850-7-4 Ed 2, Communication networks and systems for Power Utility Automation
  – Part 7-4: Basic communication structure – Compatible logical node classes and data object classes
- IEC 61850-7-420
- IEC 61850-90-7 Ed 1, IEC 61850 object models for photovoltaic, storage, and other DER inverters
- IEC 61968-9 Ed 2, Interfaces for Meter Reading and Control
- IEC 61968-100, Implementation Profiles for IEC 61968
- IEC 62361-101, Naming and design rules for CIM profiles to XML schema mapping
- IETF RFC 6120, XMPP Core
- IETF RFC 6121, XMPP Instant Messaging and Presence
- IETF RFC 6122, XMPP Address Format
- IETF RFC 5122, URI Scheme for XMPP
- IETF RFC 3923, End-to-end signing and object encryption for XMPP
- IETF RFC 5246, Transport Layer Security Protocol v1.2
- XMPP XEP-0060, Publish-Subscribe messaging extensions
- Extensible Markup Language (XML) 1.1, W3C
- XML Schema Definition Language (XSD) 1.1 Part 1: Structures, W3C
- XML Schema Definition Language (XSD) 1.1 Part 2: Datatypes, W3C
- IEC 62351 Security

3 Terms, definitions and abbreviations

[redacted]Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

[redacted]Aggregation

Aggregation is the collection of the capabilities of multiple resources into a single virtual resource. A common use of aggregation is to collect many small resources and offer their capabilities in the form of a single larger resource to a market.

[redacted]Cascading

Cascading occurs when a message published in one communication domain causes another message to be published in one or more other communication domains at a different level of a hierarchy.

[redacted]Communication Domain

A logical association of a VTN with a set of VENs supported by an underlying communication infrastructure. This provides for authentication of VENs and secure communication services. Since VTN and VEN are roles within a Communication Domain, it is possible for an actor to take a VTN role in one Communication Domain and potentially one or more VEN roles in other Communication Domains This term is defined by this standard.

[redacted]Customer Energy Manager

A central managing function (sometimes a gateway) used by the customer to manage the flow of information between the grid and connected smart devices at the customer premise. This is defined in more detail by IEC 62746-2.

[redacted]Demand Response

The management of customer energy consumption in response to supply conditions.

[redacted]

Distributed Energy Resource

A specialized energy resource with a flexible load and/or supply generally at the distribution level. This is defined in more detail by IEC 62746-2.

[redacted]

Message

A message is used to convey information between parties in a communication network. The information may reflect a description of an object and/or data related to the object.

[redacted]Node

A logical destination address for messages that are published using a publish/subscribe communication infrastructure. Depending upon the specific communication infrastructure this may also be called a ‘topic’ or ‘subject’.

[redacted]

Publish/Subscribe

A communication pattern where a message sent from a source may be received by zero or more interested subscribers. See IEC 61968-100.

[redacted]

Request/Reply

A communication pattern where a request message is sent from one process to another process, where there is that the expectation that a response message will be returned by the receiver of the request message. See IEC 61968-100.

[redacted]

Resource

A provider of energy in terms of generation or demand response capability. A VEN may be responsible for managing one or more energy resources. Resources may be physical or virtual. Resources may be controlled using smart devices which may then be connected to a Customer Energy Manager.

[redacted]
Signal
A message that is sent to indicate a condition or information of potential interest.

[redacted]**Smart Grid Connection Point**
The point where the energy grid is connected to the customer premise. As a consequence of the smart grid, this connection can be both in terms of energy and information exchanges. This is described in more detail by IEC 62746-2.

[redacted]
Technical Role
Actors defined by use cases have assigned roles with associated responsibilities. Technical roles are those roles that identify responsibilities associated with participation within information exchanges with other actors. Technical roles are physically realized through software and associated systems integration infrastructure. This is a term defined here for the purposes of this standard.

[redacted]
Virtual End Node
A technical role assumed by an actor where the actor is a consumer and/or producer of messages that are defined by this standard. A Virtual End Node (VEN) can be associated with zero or more resources. A VEN can receive messages pushed from a VTN or send requests or events to a VTN. A VEN may communicate with multiple VTNs, where each VTN is part of a different Communication Domain. This term is defined by this standard as a technical role, noting that there is a somewhat related definition for an ‘End Device’ as defined by IEC 61968-9. While the concept is generic, the specific term is borrowed from OpenADR 2.0 with the normative definition being provided by this standard.

[redacted]
Virtual Resource
A set of one or more physical resources that is represented as a single, aggregated resource. This may be comprised of multiple entities that may be geographically distributed. Virtual resource can be e.g. a VPP, industrial plant, building, home, etc . This is defined in more detail by IEC 62746-2.

[redacted]
Virtual Top Node

A technical role assumed by an actor that is assuming responsibility for the coordination of s within a Communication Domain. This is a special case of a VEN, where a Virtual Top Node (VTN) is effectively a parent of many VENs with the responsibility for coordination of those VENs. A VTN is responsible for pushing to or receiving message from many VENs. A market operator, grid operator or aggregator are examples of actors will typically implement a VTN interface. This term is defined by this standard as a technical role, noting that there is a related definition provided by IEC 61968-9. While the concept is generic, the specific term is borrowed from OpenADR 2.0 with the normative definition being provided by this standard.

[redacted]
Wire Protocol
In a network, the wire protocol is the mechanism transmitting data from a sender to a receiver. If the sender and receiver use the same wire protocol they are said to interoperate. This does not literally mean that signals are conveyed over a metal wire, as the term is also used in conjunction with wireless and fiber communication media. This is a widely used phrase without a specific normative definition, where a definition is provided here for the purposes of this standard.

[redacted]

[redacted] Abbreviated terms

Abbreviation	Description
API	Application Programming Interface
CEM	Customer Energy Manager
CIM	Common Information Model
DER	Distributed Energy Resources
DMZ	De-Militarized Zone, a perimeter network used to shield an internal trusted network from attacks from external networks such as the Internet
DoS	Denial of service
DR	Demand Response
ECP	Electrical Connection Point
HAN	Home area network
IEC	International Electrotechnical Commission
IETF	Internet Engineering Task Force
JMS	Java Message Service
LAN	Local area network
PAN	Premise area network, could be a LAN or HAN
PCC	Point of Common Coupling
SGCP	Smart Grid Connection Point
VEV	Virtual End Node
VPP	Virtual Power Plant
VTN	Virtual Top Node
XML	Extensible Markup Language
XMPP	Extensible Messaging and Presence Protocol
XSD	XML Schema
W3C	World-wide Web Consortium

4 Requirements (Informative)

The requirements made on the background of mainly commercial use cases. Additional requirements from operations may come.

[redacted] Principles

The following are key architectural principles to be followed for this standard, which are at least in part a distillation of the functional and non-functional requirements.

- Interfaces shall be based upon open technologies and standards
- Interfaces shall be based upon or permit the use of common software technologies
- Interfaces shall be inherently extensible, allowing for new application messages to be defined over time as well as the introduction of new elements into existing messages
- Interface development shall be agnostic with respect to programming languages and operating systems, but at the same time shall not preclude the use of Java, C++, C#, Python, Linux, Windows, Android, etc.
- Interface specifications shall be agnostic with respect to communication technology in order to allow for multiple protocol mappings
- Shall establish a low end technology threshold for end point devices and related software components in order to avoid limiting the capabilities and technical reach of the architecture in order to support ‘constrained’ devices that can not readily support Internet-based communications

It is the intent that these principles will provide an architecture that will be viable for decades into the future.

[redacted] Additional Communication Specific Functional Requirements

The functional requirements for IEC 62746-3 are to some extent defined within IEC 62746-2. The focus of this section is to describe additional functional requirements that are more focused on the functionality to be provided by the interfaces and functional responsibilities associated with the technical roles defined by this standard.

The architecture is intended to address a set of important functional requirements as related to communications directly to and indirectly in support of devices that may be connected to the electrical grid. The following are functional requirements:

- Virtual resources shall have a unique identity. This identity may be used as a logical address for communications.
- Virtual resources shall be configured with credentials that enable them to make authenticated connections to a trusted communication infrastructure.
- Communications over the Internet shall be encrypted.
- Virtual resources shall not be required to accept inbound connections, where there shall not be the need to open ports in firewalls to allow them to communicate over the Internet. Virtual resources will only make outbound connections to the communication infrastructure using their credentials.
- Virtual resources shall be able to receive messages asynchronously, without the need to poll a controller.
- Group communications shall be supported, where a controller can address a message to all members of a group. Virtual resources may have membership in zero or more groups. This means that each message shall have a single source, but potentially many destination addresses where a destination address may be a group address that is maintained and managed by the communication infrastructure.

- It shall be possible for a controller to readily determine the presence and state of a device.
- The order of messages shall be preserved. In this way a device will see all of the commands issued by a controller in the proper order, and a controller may see all of the events issued by a device in the proper order.
- There shall be mechanisms for time synchronization and timestamps on messages.
- Message content shall be extensible. If a message contains additional information not understood by a device, it can be ignored and the sender shall realize and accommodate for this fact.
- Virtual resources shall be configured with parameters that control aspects of their behavior and identify their capabilities. Some of these may be public and some may be private. Devices shall submit their public parameters to the communications infrastructure.
- Existing proven protocols shall be used as the basis of the communications infrastructure.
- Virtual resources or controllers shall support a role based security model which defines access down to parameter or message type level.
- There shall be a mechanism to update credentials, e.g. withdraw certificates.
- Devices or controllers shall be capable to simultaneously hold multiple connections to different communication partners with different trust levels.

The following are needed communication services, where application level services would be layered upon these basic communication services:

- Connection management
- Authentication
- Publish/Subscribe messaging
- Request/Reply messaging
- Event messaging
- Message encryption

Configuration services shall be supported.

Non-Functional Requirements

The architecture is also intended to address a set of important non-functional requirements as related to communications directly to and indirectly in support of devices that may be connected to the electrical grid. The following are non-functional requirements:

- Shall support connectivity over public networks, e.g. the Internet
- Preference should be given within IEC IP rules compliant solutions to solutions based on non proprietary software or free licensing for the development of VENs that use the interfaces
- Shall not be tied to a single programming language or operating system, and conversely shall allow for implementation using a variety of commonly used programming languages and operating systems, including those found on mobile devices
- Shall be scalable, where it is possible to support thousands of VENs with a single communication server, and allow for federation using many communication servers

- In case of single point of failure redundant solutions shall be possible (availability).
- Shall allow for authentication of trusted connections and encryption
- Shall have a scheme by which the identity of VEN devices can be trusted
- Shall support efficient ‘push’ communications mechanisms without the need to open ports in firewalls to enable communication the VENs and reverse.
- Shall allow for application-defined XML message payloads
- Shall support publish/subscribe mechanisms, including capabilities to address messages from Head Points to groups of VENs
- Shall support publish/subscribe mechanisms, including capabilities to address messages from VENs to groups of Head Points
- Shall support publish/subscribe mechanisms, including capabilities to address messages from VTN to groups of VENs
- Shall support introduction of new message types without breaking the wire protocol
- Shall be possible to determine the status of VENs (permanent life check)
- Shall comply with the IEC 62351 framework.
- Shall support intermittent communication, where delivery guarantees are provided
- Shall support mobile virtual resources, which includes electric vehicles and mobile storage devices and mobile generation..
- The ability to be externally/locally configured and managed as necessary to define identity, connection parameters and parameters that describe capabilities as needed for participation in DR programs

Shall support multi-level aggregation of virtual resources.

5 Architectural Overview

[redacted] Problem Overview

The diagram of figure 2 shows a resource-level view the problem space to be addressed by this standard, where examples of specific actors are provided as related to interactions between the smart grid and the customer premises at what is called the ‘smart grid connection point’ (SGCP).

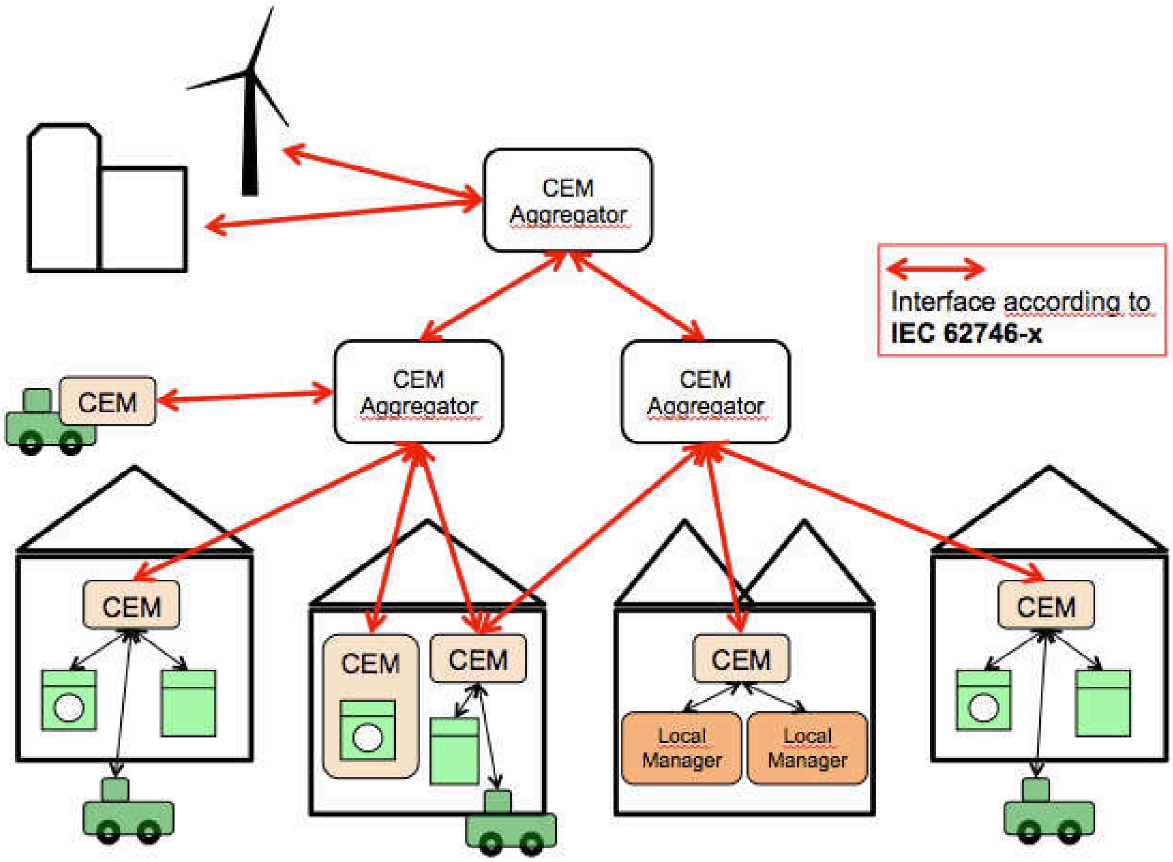

Figure 2 – Resource-level view

However, the problem space is extended upward to support coordination of these resources by actors representing markets, aggregators and operations. In order to support the coordination of these actors, there are a variety of information exchanges that are conveyed using IEC 62746. More examples are provided by the use cases of IEC 62746-2.

[redacted] Actors, Roles and Relationships

The purpose of this clause is to provide an architecture overview from the perspective of the identification of technical roles and associated communication standards that can be applied to a set of actors in support of their respective functional roles and relationships. The definitions of specific actors are provided by IEC 62746-2. The intent of the architecture is to enable communications (primarily using public wide area networks, such as Internet) between a wide variety of actors, including (but not limited to) utilities, market operators, service providers, aggregators and customers for the purposes of coordinating and operating distributed energy resources (DER) and demand response (DR).

IEC 62746-2 defines a large number of actors. It can be readily seen that there are many similarities in some of those actors as well as functional overlap in the roles of many of the actors. However, from the perspective of defining a supporting architecture it is important to define technical roles and responsibilities that can be taken on by those actors.

It is not the intent of this standard to provide examples of all actors defined by IEC 62746-2 or restate the definitions of those actors, and consequentially some higher-level categorization of actors will be used within this standard as opposed to specific actors in describing the use of this standard. Additionally it is the intent of this architecture to support specific actors who are yet unknown. The basic requirement is that an actor can assume (either directly or by proxy) the technical roles of 'VTN' and/or 'VEN' as defined by this architecture.

The focus of this architecture is the support of operations and markets as they interact with the customer at the smart grid connection point. As an example, within a market for DER/DR, there are typically a set of hierarchical relationships. Examples of these hierarchical relationships for different categories of actors include:

- Resource Provider to Market Operators
- Resource Provider to Aggregators/Service Providers
- Aggregators/Service Providers to Market Operators

At the same time it is important to recognize that resources may be grouped into virtual resources, where virtual resources are typically grouped, managed and coordinated by aggregators. These example relationships are shown in the following example diagram for wholesale and retail energy markets:

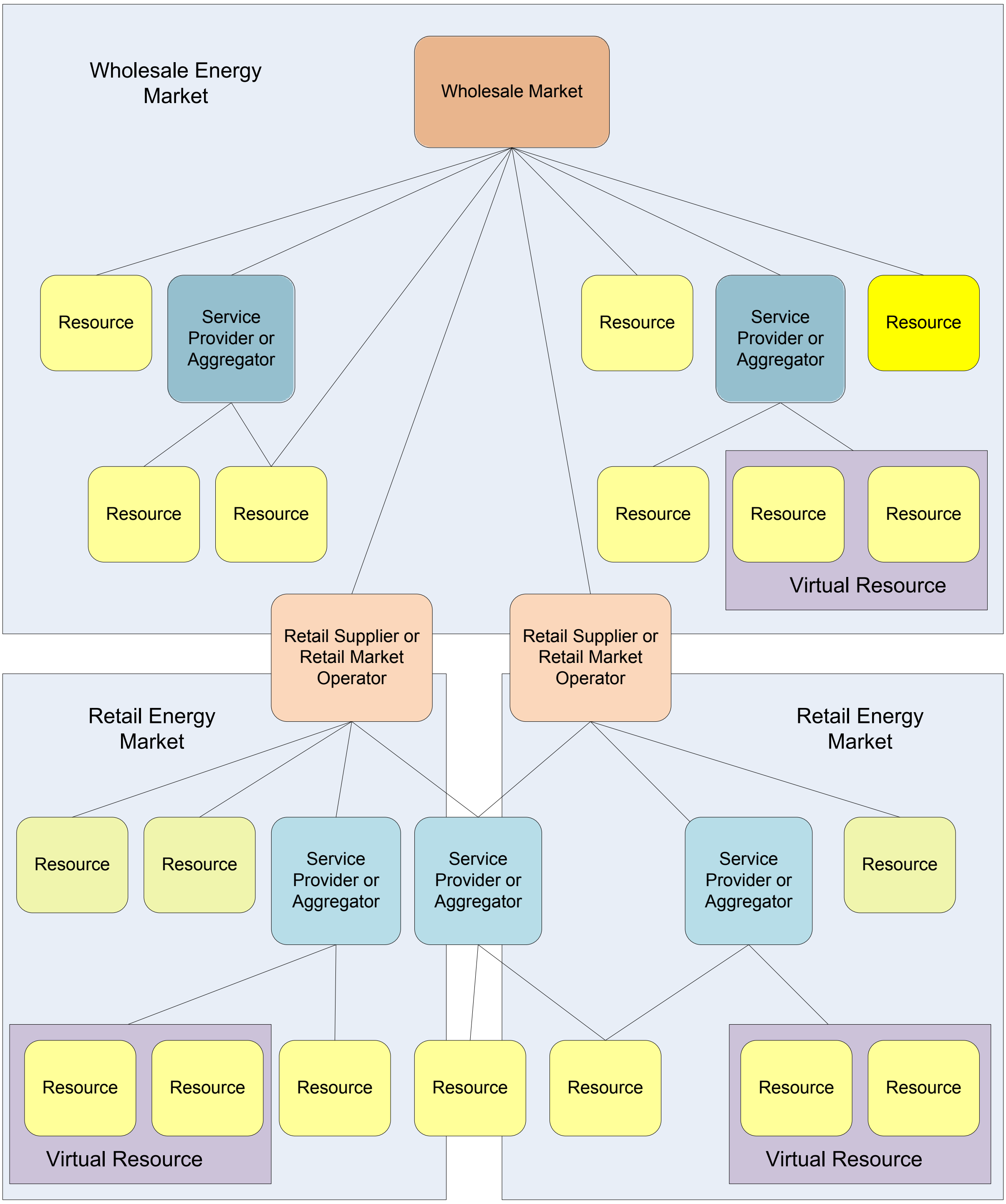

Figure 3 – High-Level Example of Actors, Roles and Relationships

From the diagram of figure 3, it can be seen that the relationships are typically (but not always) hierarchical. Examples of non-hierarchical relationships could exist in the case of a resource that may participate in multiple markets or where some capabilities of a resource may be managed by different parties. It is also possible to have a service provider gather usage information after the fact for resources that are managed by one or more aggregators. It is also possible that an aggregator or virtual resource could participate in both wholesale and retail markets. The restrictions upon this are left to the rules imposed by the market, but are not technical restrictions per se.

However, the key point of figure 3 is to show that the relationships are typically ‘upstream’ or ‘downstream’. There is not an explicit requirement for direct peer-to-peer communication between actors when the actors are at a common level. Typically the fan out is downsteam, where for example a market operator will communicate with large numbers of resources, service providers or aggregators. That is also to say that a resource, service provider or aggregator will only interact with a small number of upstream entities.

It is important to note that resources may also have IEC 61850-based communications for the purpose of grid operations. The architecture supports the communication with distribution management systems. This communication infrastructure can also be used for grid operations and potentially to transport IEC 61850 messages. The use of IEC 61850 is otherwise outside of the scope of this document.

█ Concepts

The purpose of this clause is to introduce key architectural concepts as needed for the definition of this technical standard in support of the use cases and requirements. These key architectural concepts include the following:

- Communication Domain
- VTN Interface
- VEN Interface
- Customer Energy Manager
- Resource
- Cascading
- Aggregation

It can also be seen that resources may be leveraged in more than one market, provided that there are controls (technical or contractual) that prohibit a resource from unfairly making commitments for the same energy at the same time in more than one market.

The hierarchical relationships can be represented as different communication domains. Resources can be registered within a market or virtualized through an aggregator, and therefore associated with a communication domain accordingly

The example diagram of figure 4 provides a ‘communication domain’ perspective, where there can be many actors of different types within each communication domain. Some actors (most commonly aggregators and service providers) can exist in more than one communication domain.

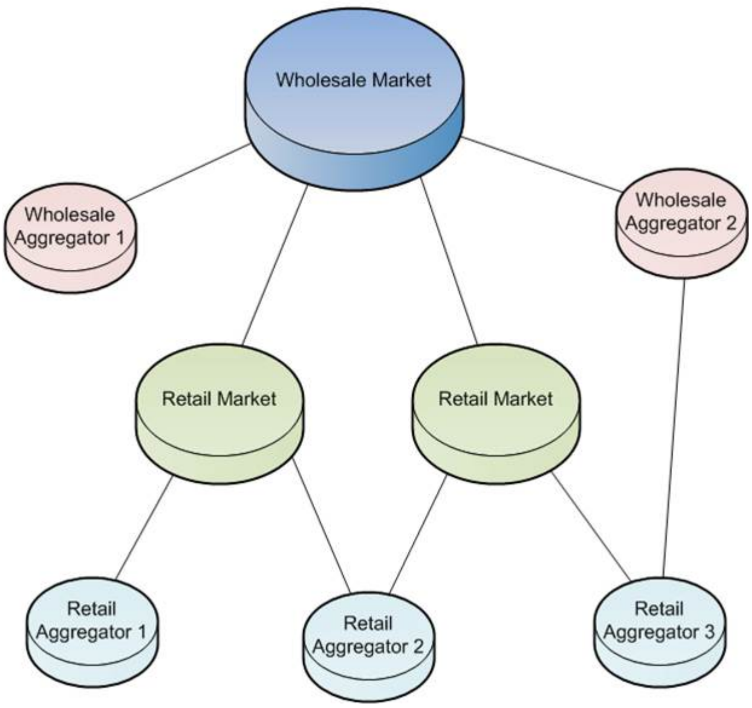

Figure 4 - Example Communication Domain Hierarchy

Given the hierarchical relationships between communication domains, there will typically be cascading of information flows from one communication domain to another. An example of this might be a price signal issued within a wholesale market that causes a related signal (e.g. price or control signal) to be issued within a retail market, which may then cause specific actions to be taken by a retail aggregator. At the lowest levels customer energy managers would receive IEC 62746 messages and decide upon actions to be taken locally by smart devices to appropriately manage resources.

With respect to cascading, information flows are cascaded between communication domains when:

- An actor is a VEN in one communication domain and a VTN in another communication domain, and
- The actor decides that a message received in one domain should result in a message be propagated to another communication domain (it need not be identically the same message)

Another related aspect is that of aggregation, where a set of resources in a lower level domain may be projected as a virtual resource in a higher level domain. This is the commonly the case where an aggregator may manage resources and offer there aggregate capabilities (either all or in part) to a retail or wholesale market. Aggregation of resources is key to scalability enabling multi-level architectures. Aggregation may occur within a CEM or by actors such as those for aggregators, service providers, retail markets, retail suppliers or distribution system operators.

The example shown in figure 4 shows example paths for commercial communications, where there may be other communication domains added. The market designs for different regions of the world would dictate specific designs for IEC 62746 communication domains.

The diagram of figure 5 shows an expanded example, where communication domains are added for a grid operator and retail suppliers. There are nearly an infinite number of combinations possible when specific types of actors are assigned to different communication domains which are then hierarchically organized as appropriate to meet regional needs.

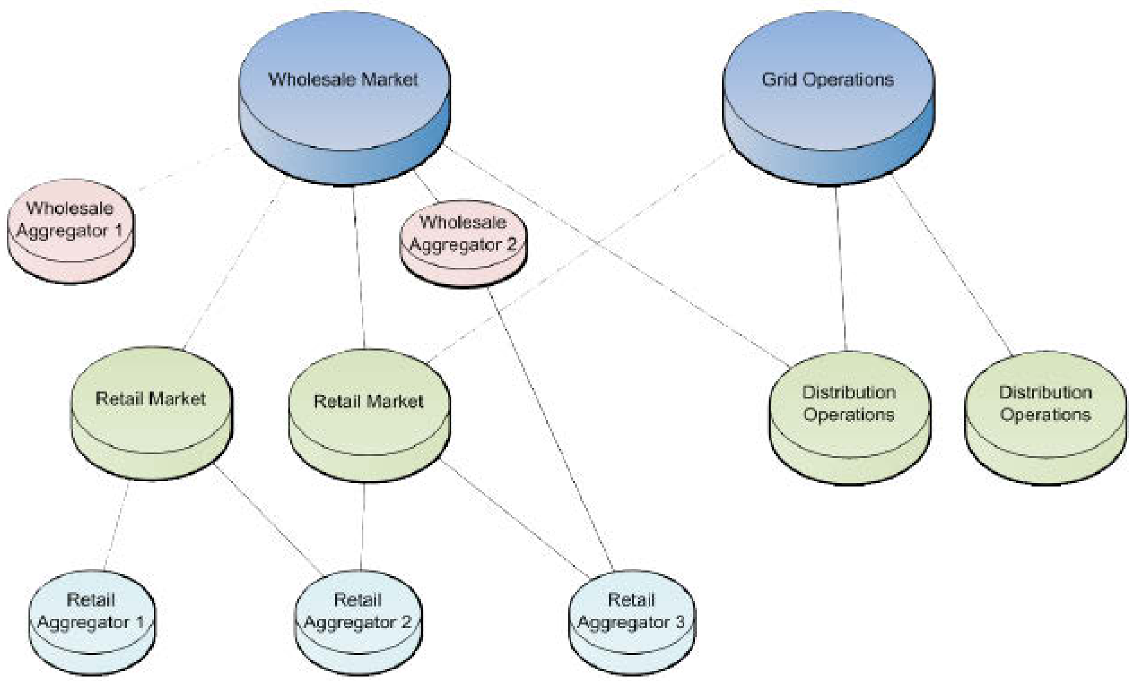

Figure 5 - Expanded Communication Domain Example Including Operations

In figure 5 it can be more readily seen that actors within one communication domain may participate in other communication domains. One example of this is where the VTN for a retain market may be a VEN in both Wholesale Market and Grid Operations communication domains.

█ Components/Entities

Within a communication domain, the communication needs of each actor are served by either a VTN or VEN interface as realized through some software component deployed on a device or server. Figure 6 describes logical communication relationships within a communication domain between VENs and VTNs.

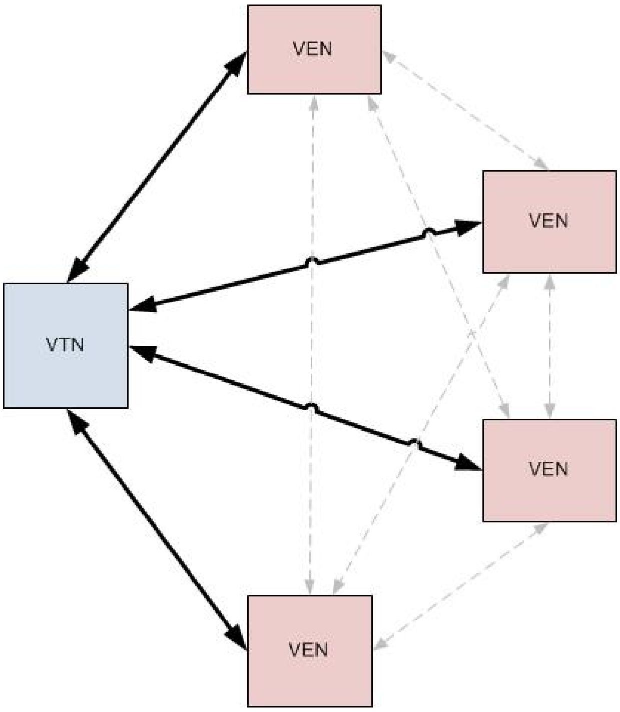

Figure 6 – Communication Domain

As can be seen from the diagram, VENs communicate with VTNs and not with each other as peers (if they do so, it is outside the scope of this standard). The following communication rules apply within a communication domain:

- All components are not equal, one of the components within a Communication Domain is classified as a 'VTN' (which is representative of the hierarchical roles and relationships within a domain) and all others are classified as 'VENs'
- The VTN will communicate with all VENs
- VENs do not have any requirement for direct interaction between themselves within DR/DER markets
- VENs within a communication domain may be assigned roles and have privileges

As indicated earlier, since it is possible for a resource, service provider or aggregator to participate in multiple markets, it shall be possible for a VEN to communicate in more than one communication domain (e.g. with more than one VTN). This is shown in figure 8, where there are three VTNs that each manage a different communication domain.

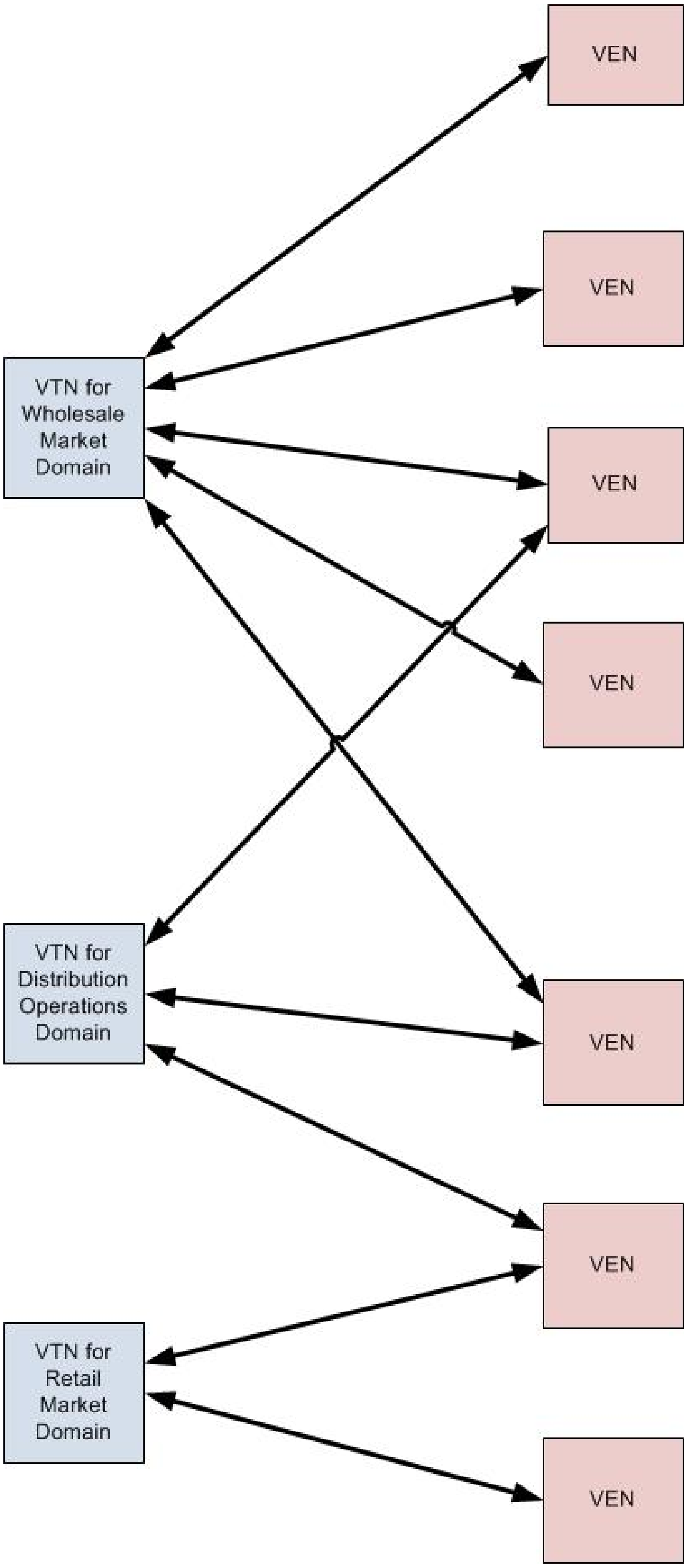

Figure 7 – Example Realization of VTNs and VENs in Multiple Communication Domains

The IEC 62746 interface standard can then be logically represented by the diagram of figure 8 when representing a single communication domain:

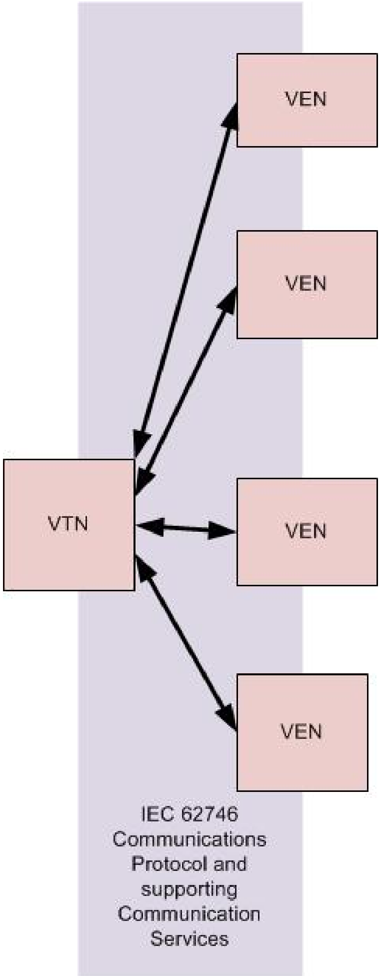

Figure 8 - Technical Space of a single communication domain in IEC 62746

The communications between VTNs and VENs will require the use of a communication server to manage access and interactions. This is largely a consequence of the communication and security requirements, where it would be better to leverage a commercial communication product as opposed to implementing the required functionality specifically for IEC 62746.Support of publish/subscribe is one example of a requirement that is typically complex to implement in conjunction with the other requirements. Two examples of communication technologies that involve servers include JMS and XMPP.

The example of figure 9 shows this interface being used by the VTN of a market operator or aggregator to communicate with a set of resources.

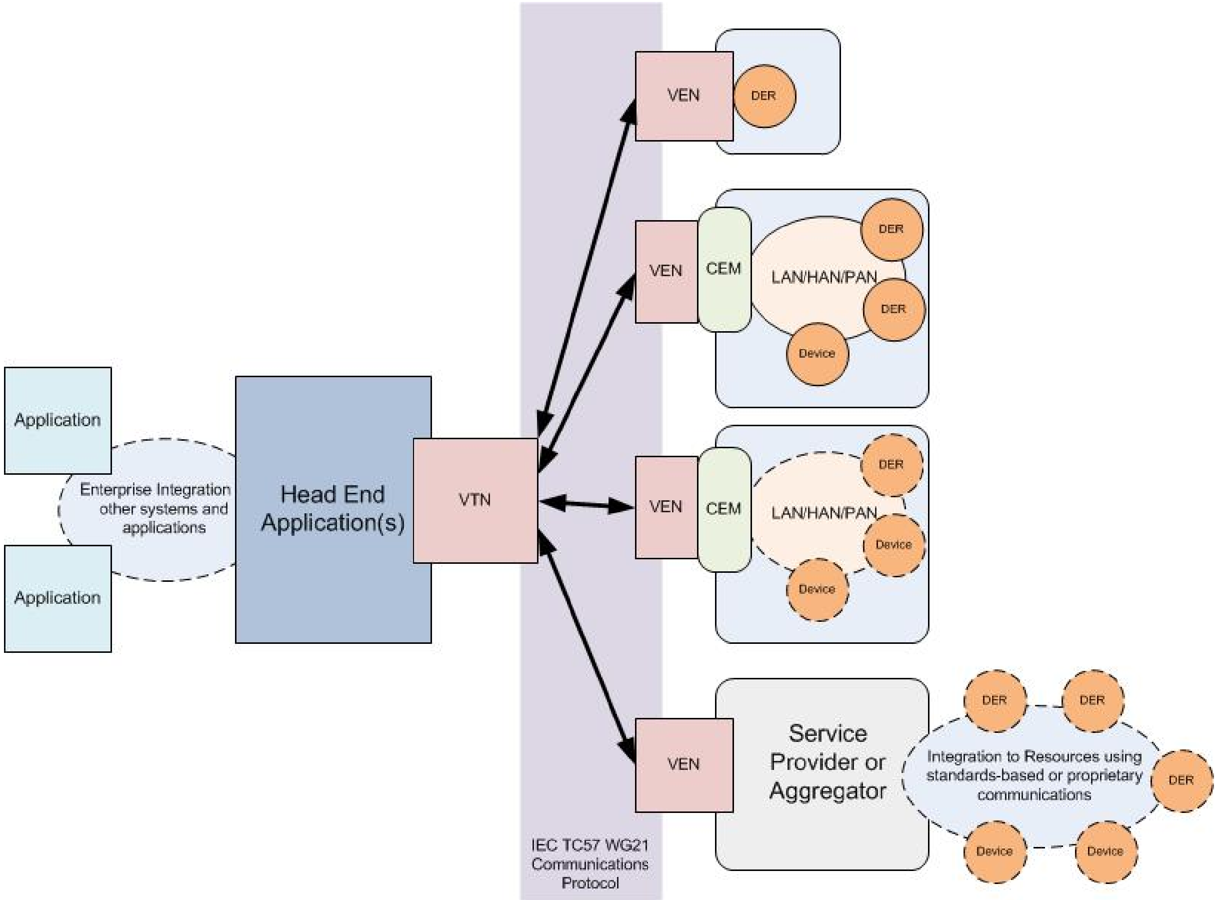

Figure 9 – Example Application of IEC 62746

In the application of the VEN interface, there are a variety of options possible:

- A DER/DR device directly implements the IEC 62746 interface for communication with one or more VTNs
- A device or application program (such as a CEM) implements the IEC 62746 interface for communication with one or more VTNs, where it then acts as a proxy for potentially many local devices using an appropriate integration technology. In this case the individual physical resources and their individual capabilities may be known to the VTN.
- A device or application program (such as a CEM) implements the IEC 62746 interface for communication with one or more VTNs, where it then coordinates and communicates with potentially many local devices using an appropriate integration technology. However in this case the VTN may see only virtualized resources as opposed to the individual resources.
- An aggregator or service provider program implements the IEC 62746 interface for communication with one or more VTNs, where in turn it may manage a portfolio of resources using a variety of integration mechanisms. In this case the VTN may see one or more virtualized resources.

As a result, from the perspective of a VTN it may see a set of VENs, each seen as managing:

- A single physical resource
- More than one physical resource
- One or more virtualized resources

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- A combination of physical and virtualized resources

The management of the resources and IEC 62746 VEN interface will commonly be realized using a CEM. The CEM may implement other interfaces, such as those needed using for metering or for control and monitoring of the specific type of resource. Where non-IEC 62746 interfaces are used to integrate resources the CEM performs any necessary mapping and local management of the resources.

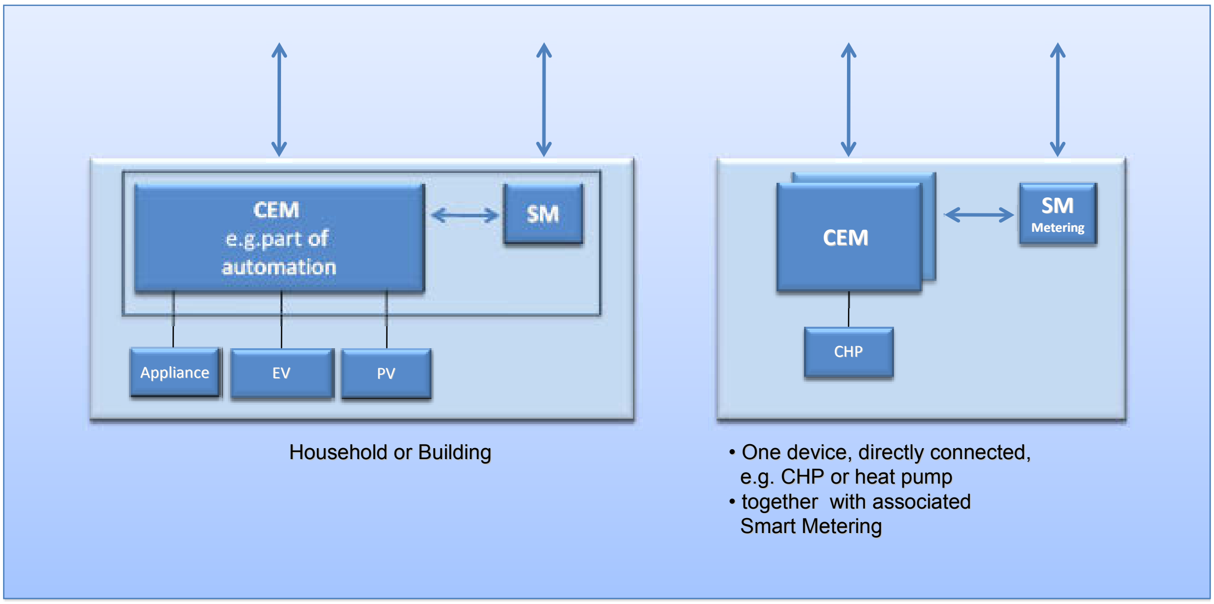

Figure 2 - CEM and Resource Relationships

Where the CEM manages a set of resources, it may make those know as individual resources with individual capabilities or more commonly as an aggregated resource where the capabilities are aggregated to project a view of a single resource.

However, there is no explicit requirement that a CEM be used, as a resource could be managed using a smart device that directly implements the IEC 62746 VEN interface. There could also be a ‘gateway’ device that implements the IEC 62746 interface and passes messages to resources using other protocols. The diagram of Figure 10 provides an example of resource management using a CEM.

6 Message transport and services

[redacted]Transport Requirements

The IEC 62746 transport shall support real time transport in the magnitude of few seconds. Therefore message queuing concept like store and forward, e.g. e-mail is not allowed. Forwarding between communication servers is allowed, but limited to one hop.

The transport shall be optimized for small messages with low overhead. This does not exclude long messages.

[redacted]Supporting Messaging Standards

The IEC 62746 is transport neutral, but to permit realization later parts will describe the mappings to XMPP as an initial transport. This is mentioned as to provide foreshadowing of the basic capabilities that are needed by a message transport and associated services. It is intended that additional transports could be defined in the future based upon industry needs.

[redacted]Message Payloads

There are a variety of message payloads that can be conveyed using IEC 62746. As an example, message payloads related to DR/DER market communications will typically be derived from the IEC CIM as contextual profiles. Message payloads are realized as XML Schemas (XSDs) according to the rules of IEC 62361-100. Figure 11 provides an example schema diagram that was derived from the IEC CIM. This payload would be encoded within the message container that is used for the given transport. When information within payloads is derived from different information models such as IEC 61850, different namespaces will be used.

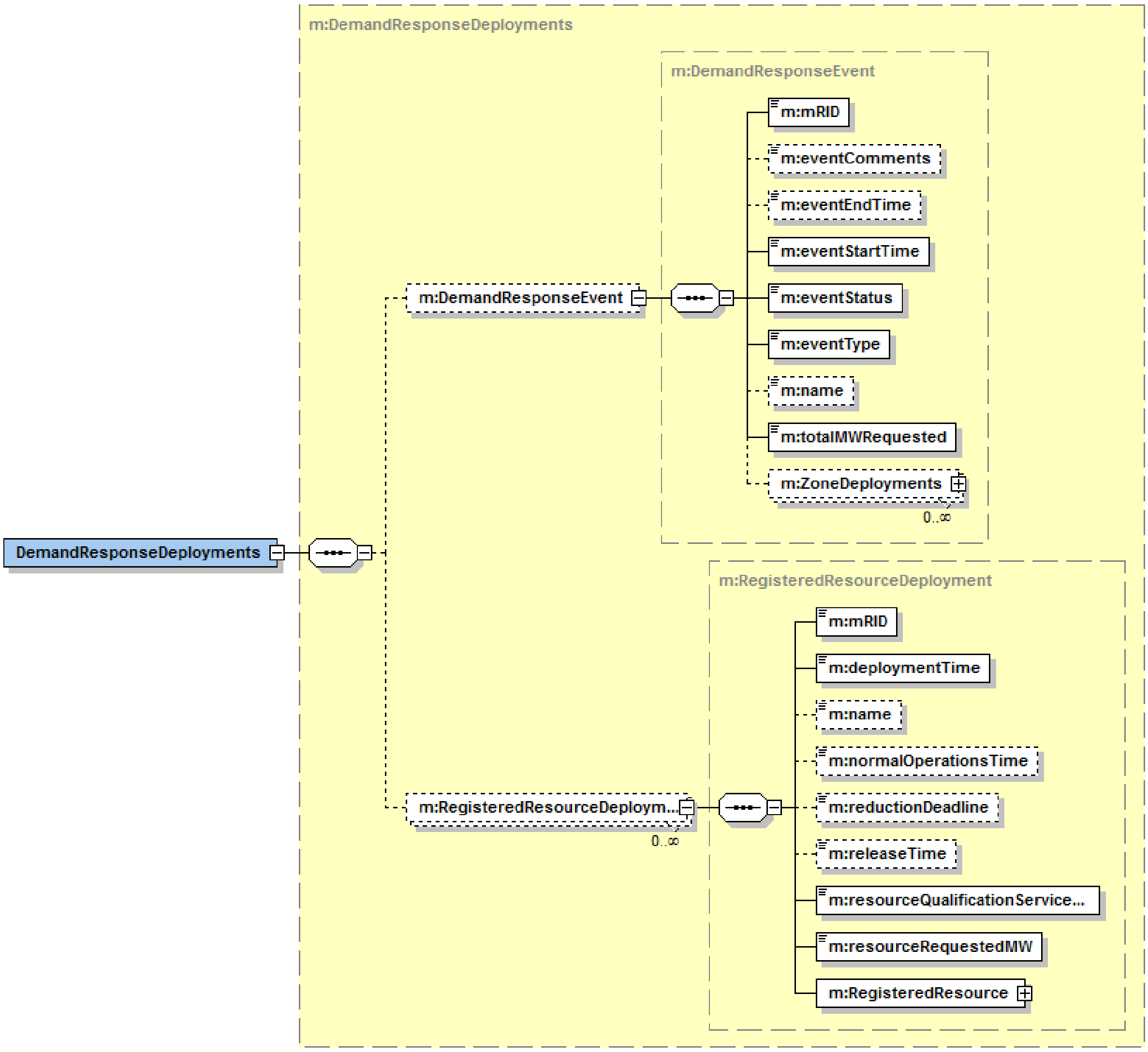

Figure 11 - Example Payload

The full set of message payloads and detailed descriptions are outside the scope of this document and are left to other parts of IEC 62746.

[redacted] Message Construction

The structure of a message may be dependent upon the message container defined for use by a specific messaging pattern in conjunction with a specific transport. For example, the structures used for a request/reply message pattern may have subtle variations from the structure used to convey messages using a publish/subscribe pattern. At the same time, the message structures defined for use by a specific transport may be completely generic and pattern independent.

In all cases, the message structure shall minimally convey in a generic sense:

- Message source
- Message destination(s)
- Unique message identifier
- Type of action (e.g. an IEC 61968 verb)
- Application-specific message payload, where the payload has a type and appropriate namespaces are used

A standard, generic message container definition is defined by IEC 61968-100. However, some transports such as XMPP may already have a sufficient message container defined and not need an IEC 61968-100 message container.

[redacted] Messaging Patterns

Central to IEC 62746 are several messaging patterns that are supported by the messaging infrastructure. Within each pattern there may be differences in the following:

- The initiator and target(s), where multiple targets require the use of publish/subscribe messaging
- Preconditions, such as subscriptions for publish/subscribe messaging
- The structure of the message container
- The placement and usage of payloads within message containers

The specific patterns leveraged by this standard include:

- Transactional request/reply, which can be initiated by the VTN to a specific individual VEN, or by the VEN to the VTN.
- Query request/reply, which can be initiated by the VTN to a specific VEN, or by a VEN to the VTN.
- Events published by the VTN to zero or more VENs. A common use of this would be to publish market signals, such as real time price signals or demand response events. Note that there are cases where there may be zero VENs interested in a specific event type at a given point in time, such as when a new event type is added but no existing VENs yet have a need for it as an example.
- Events published by a VEN to the VTN. A common use of this would be to report state changes, measurements and events.
- Presence, which is published by the VTN and all VENs to the communication server. A common use of this would be to track the availability of resources. A presence message may indicate a status change event, or may be a non-event that just provides a heartbeat to the communication infrastructure with current status.

It is important to note that communications between VENs, while supported by many communication transports, is currently outside the scope of this standard.

[redacted] Transactional Request/Reply Message Patterns

Transaction request reply messages involve the use of a message container to send transactional requests, where the initiator expects a response from the target. In terms of IEC 61968-100, this involves the use of the ‘create’, ‘change’, ‘delete’ or ‘cancel’ verbs within the IEC 61968-100 message envelope and a corresponding payload that identifies the information to be created, changed, deleted or canceled.

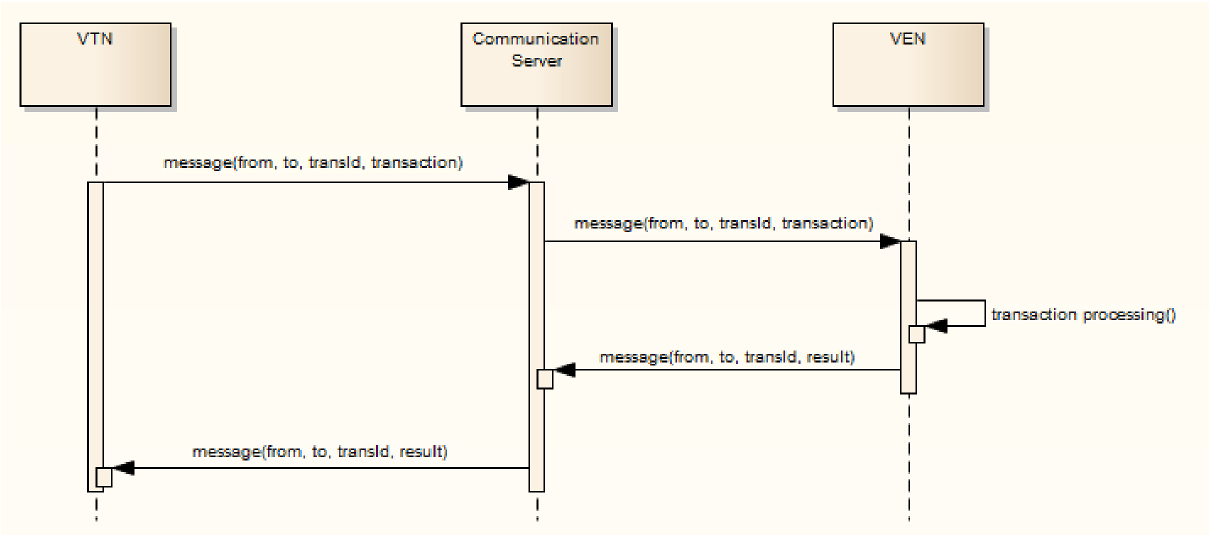

Figure 12 - Transactional Request/Reply Initiated by VTN

Where figure 12 described the transaction being initiated by the VTN, figure 13 shows a similar pattern where the transaction is initiated by the VEN.

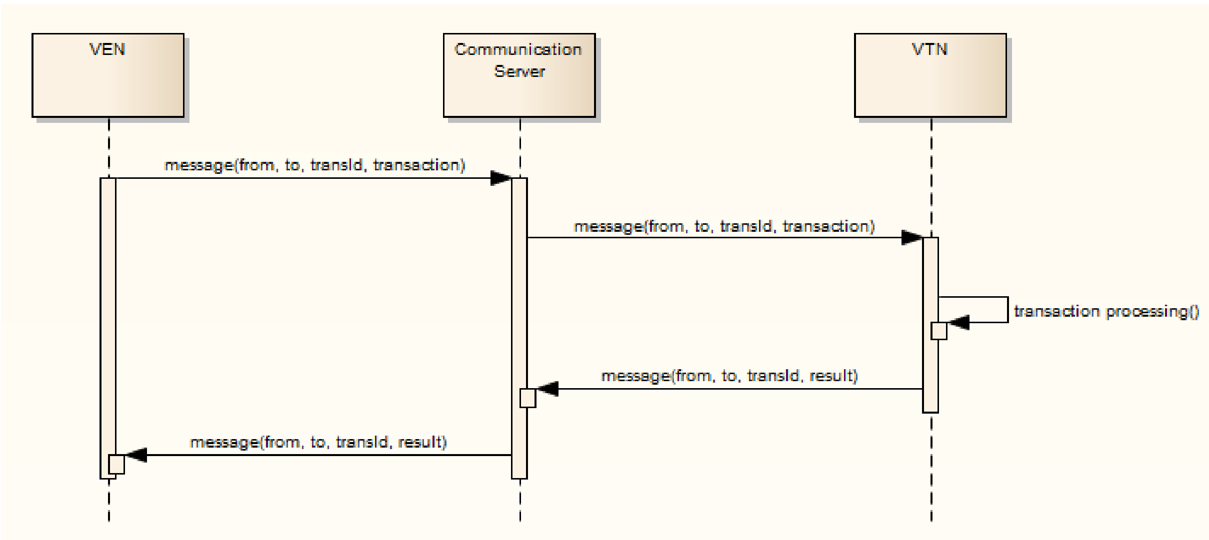

Figure 13 - Transaction Request/Reply Initiated by VEN

[redacted] Query Request/Reply Messages

Query request/reply message patterns are used where the initiator is requesting that specific information be returned by the target. In terms of IEC 61968-100, this involves the use of the 'get' verb within the IEC 61968-100 message envelope. Figure 14 describes the interactions where the query is initiated by the VTN to a VEN.

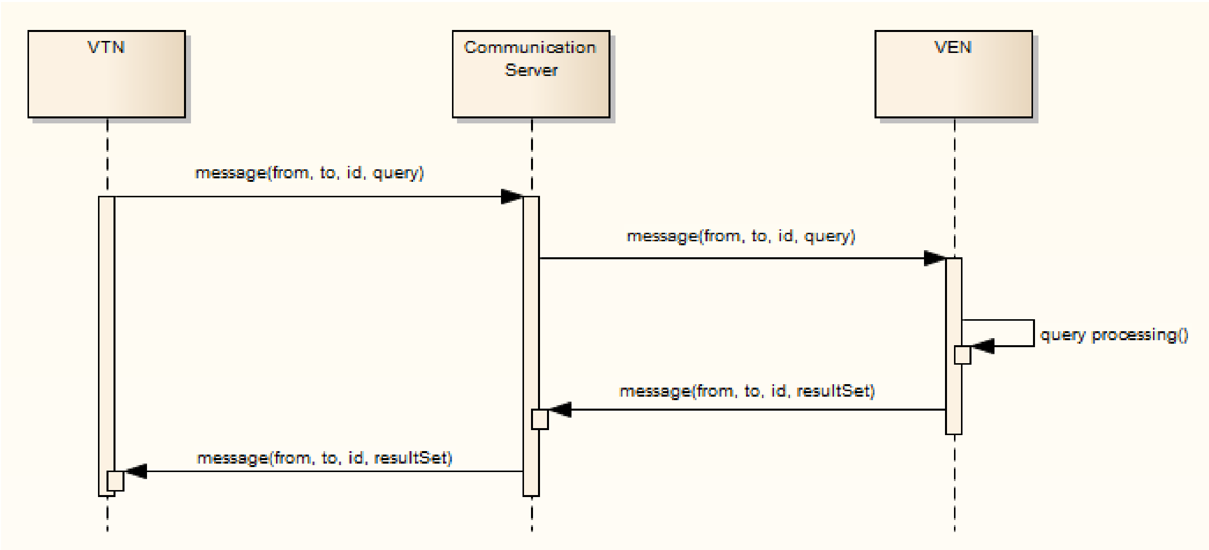

Figure 14 - Query Request Initiated by VTN

Figure 15 describes the interactions where the query is initiated by a VEN to the VTN.

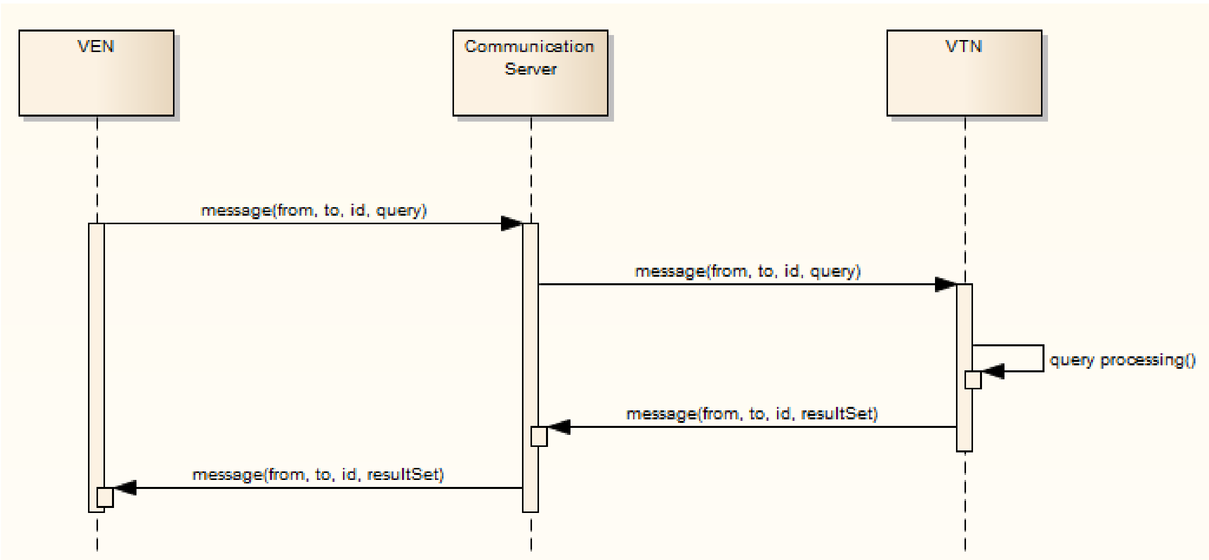

Figure 15 - Query Request Initiated by VEN

[redacted]Event Messages

Within IEC 62746 there are two categories of event messages. The first case is where VENs subscribe to content of interest and corresponding events are then published by the VTN. Figure 16 provides an example where a set of interested VENs subscribe to information that might be published to a defined 'node', which then enables a copy of related events to be sent to the VEN when published. VENs that do not subscribe will not get a copy of the event.

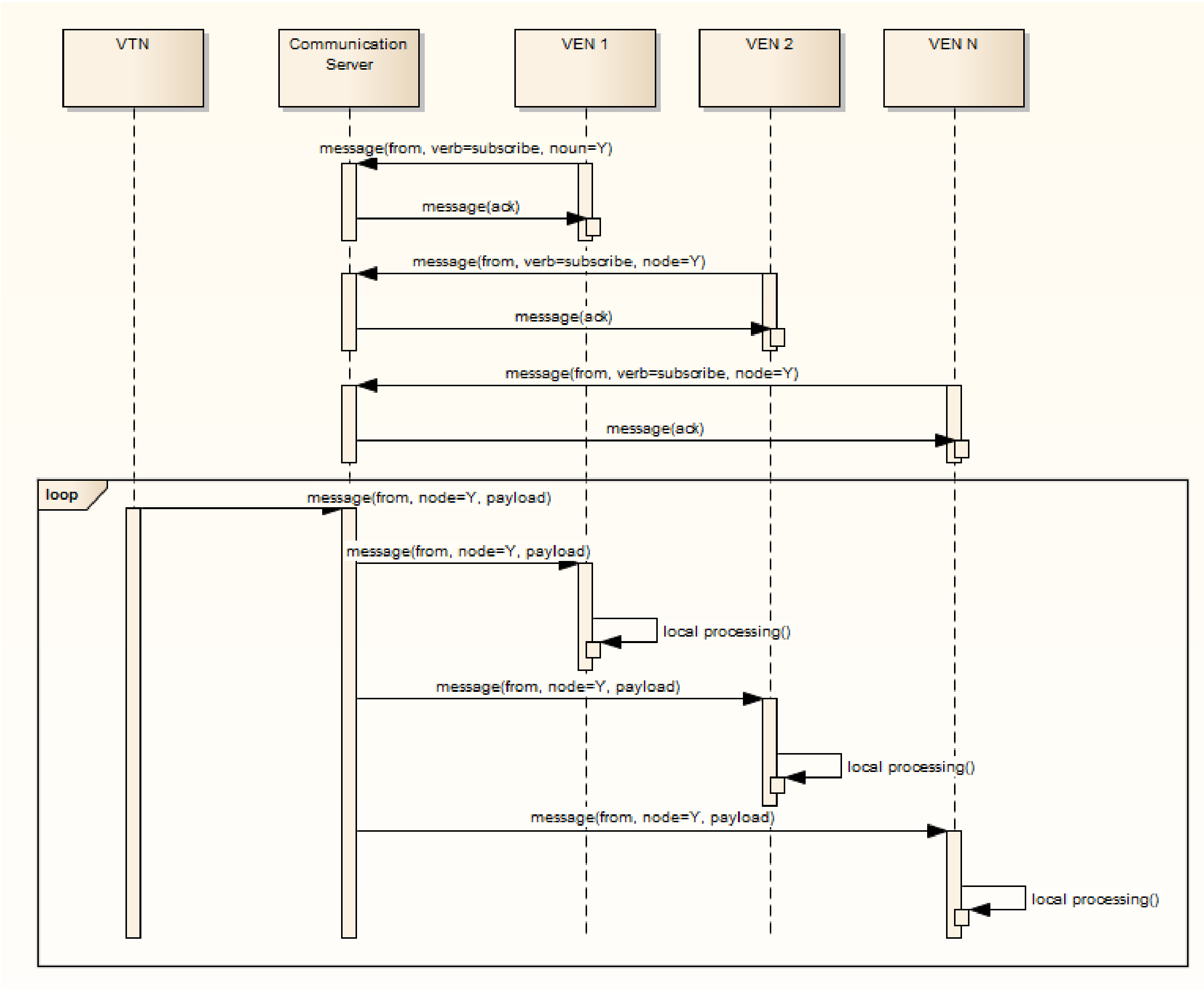

Figure 16 - VTN Initiated Events

The second category are events that are initiated by a VEN use a simpler pattern, as they are simply a message from the VEN directly to the VTN and do not require the use of a multi-casted publish/subscribe. This is described by figure 17.

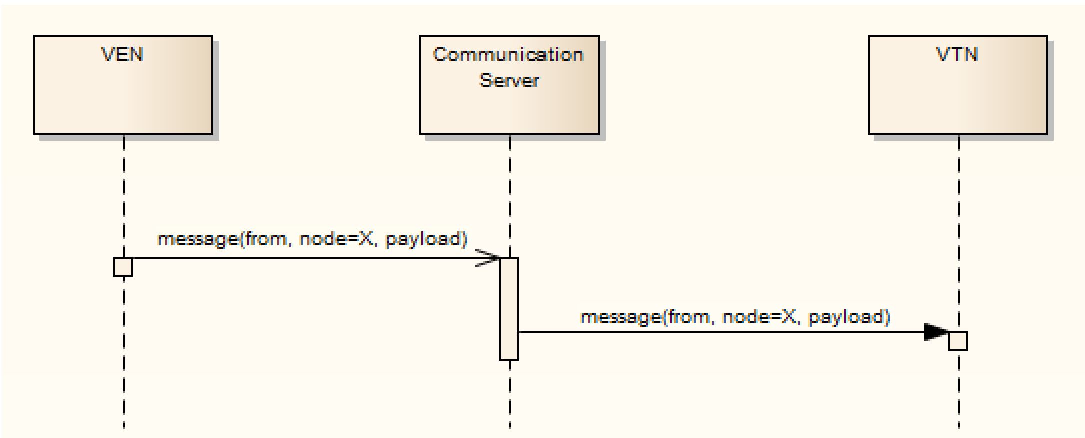

Figure 17 - VEN Initiated Events

[redacted] Presence

Presence messages are used to report the state of a VEN. These are published by a VEN to the communication infrastructure. These may represent a change in state of the VEN, or simply be reflective of a periodic heartbeat to the communication infrastructure.

[redacted]Publish/Subscribe Messaging

Event messages may be initiated from a VTN to many VENs. Because the message has more than one destination, publish/subscribe messaging is needed. The logical address of a publish/subscribe message is specified using a logically named 'node', which is equivalent to a JMS topic. In this pattern, VENs subscribe to one or more well known 'nodes'.

When using publish/subscribe messaging, the messages are addressed to defined nodes. Once these nodes are defined, the VENs may subscribe to them. Nodes may be organized hierarchically. An example is provided in the figure 18.

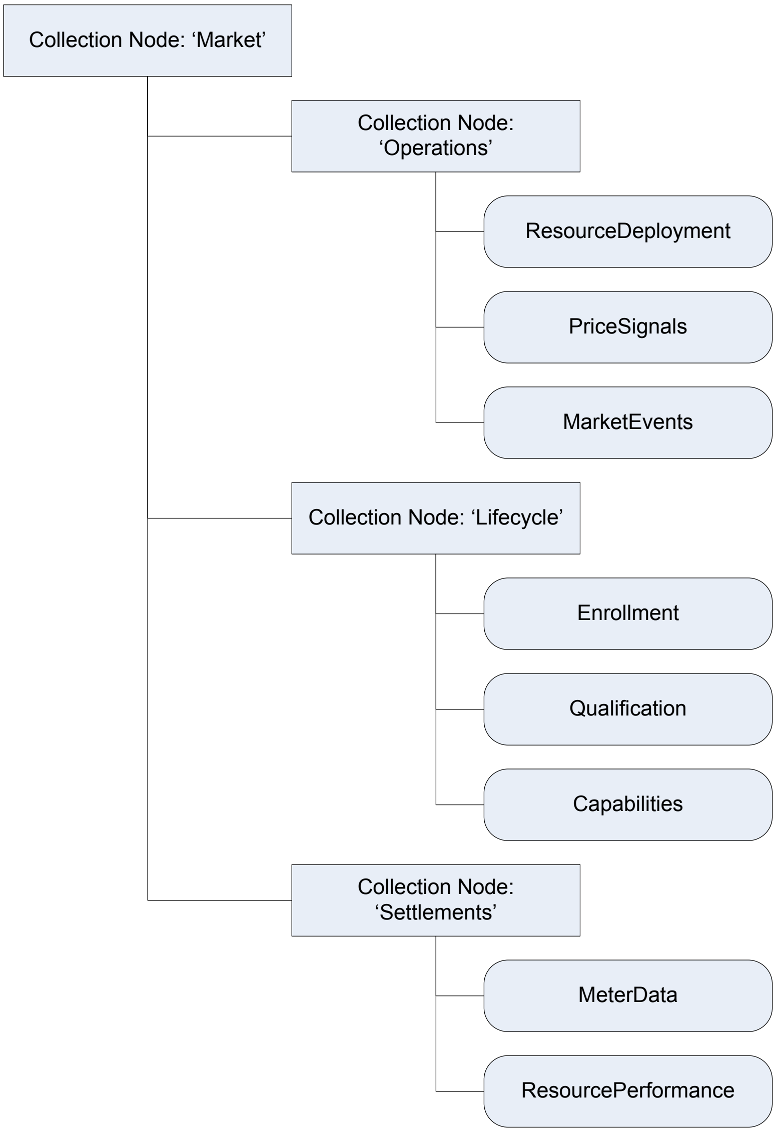

Figure 18 - Example of Publish/Subscribe Nodes

7 Security

Cyber security is a key issue for this standard, especially given the need for many parties to interact over the Internet. Physical security is outside the scope of this standard.

For VENs to accept inbound connections, ports would need to be opened in firewalls creating many points of vulnerabilities. However, this problem is avoided if all connections are made out bound to a communications server in a DMZ or cloud. The communications server is then responsible for authentication, protecting against DoS, etc.

The diagram of figure 19 describes the relationships between VTNs, VENs, a communication server and network infrastructure.

Each VTN and each VEN shall have an account on a communication server. In the case where a VEN belongs to more than one communication domain it may have a separate account for each domain. The communication server and the VTNs and the VENs are authenticated by certificates.

Role-based access control shall be used to manage the privileges to access and manage the virtual resource. An account can be assigned one or more roles. The roles may dictate which specific information or actions are permitted. As an example, access to specific publish/subscribe nodes is controlled by role.

The communication between the communication server and the VTNs and the VENs is encrypted using mechanisms such as TLS. Non-repudiation shall be supported. The details of the security implementation are defined as a part of the transport-specific mappings.

The communication server is a trusted entity for all other parties to forward messages including information on groups for communication, generate event notification, and store pub/sub information. The implications of key management shall also be addressed as a part of the transport-specific mappings.

The main burden of security is on the communication server side. This relieves the VTNs and the VENs as much as possible from security overhead.

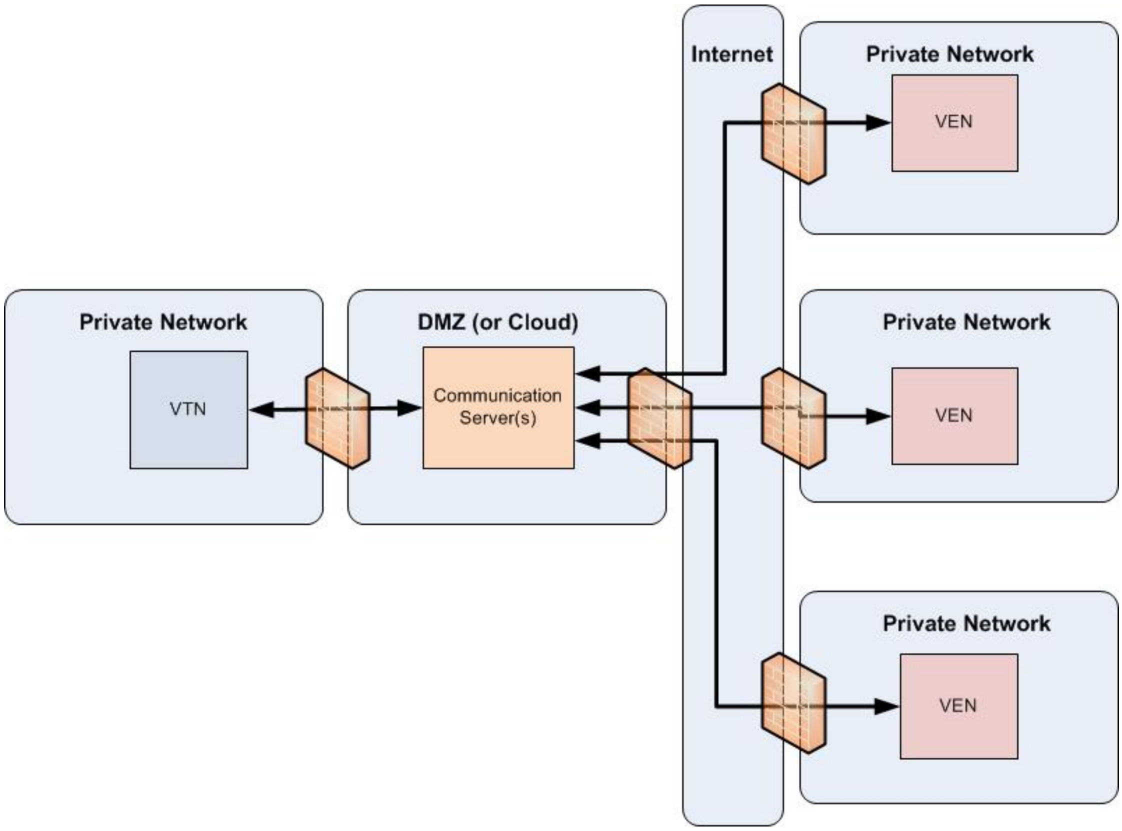

Figure 19 - Security Overview

The diagram shows three types of network segments:

- Private networks, which may be networks provided by a customer or market operator and shall remain protected from inbound connections.
- Internet, which is viewed as an untrusted communication infrastructure.
- A DMZ or cloud used for the deployment of a supporting communications server. This will allow inbound connections on designated communications ports using secure

authentication mechanisms. Firewall capabilities may be leveraged to further protect the communication server from denial of service attacks.

8 Scalability and Availability

Scalability and availability are largely accomplished by the additional of communication servers, where the communication to VENs is federated among the communication servers.

The communication server shall provide availability by redundancy of the servers themselves and associated databases or other means. An example of this is shown in figure 20.

For scalability the distribution of messages is done by the communication server.
Requests for pub/sub data or meta data are handled by the communication server. E.g. if a VTN provides a real time price then this price is forwarded by the communication server to all addresses VENs.

The communication server may be realized as a server farm.

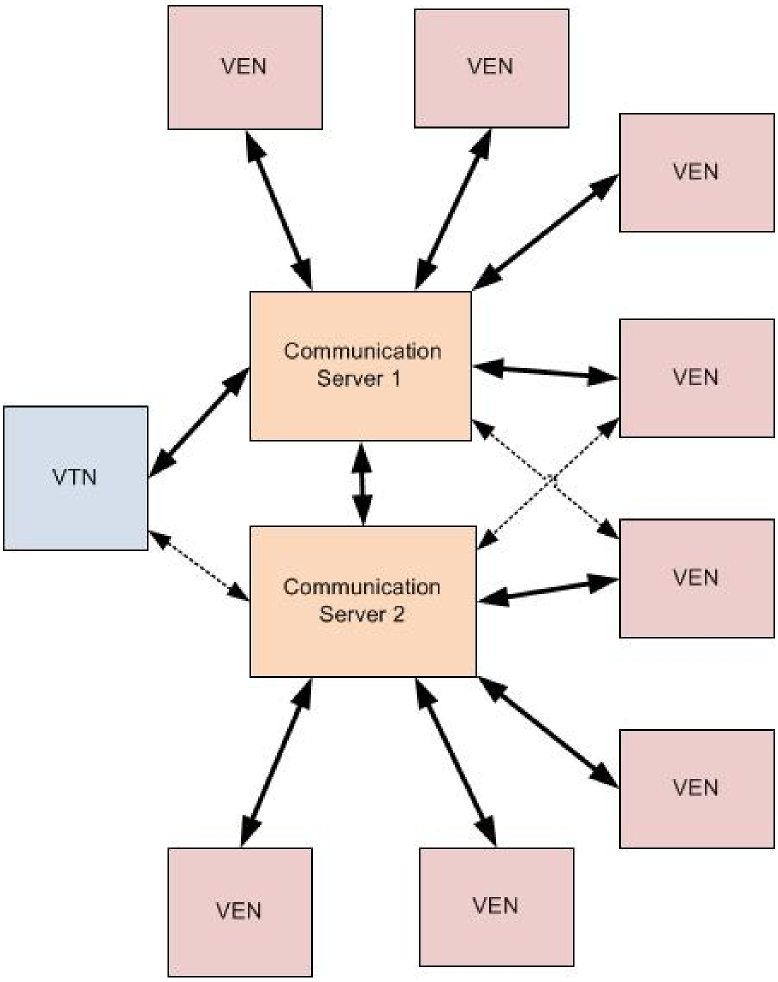

Figure 20 - Configuration for Scalability and Availability

Annex A
(Informative)
Message Payload Profiles

The following diagram describes the structure of profiles used for message payloads as defined by IEC 62361-101. This is provided here for convenience purposes.

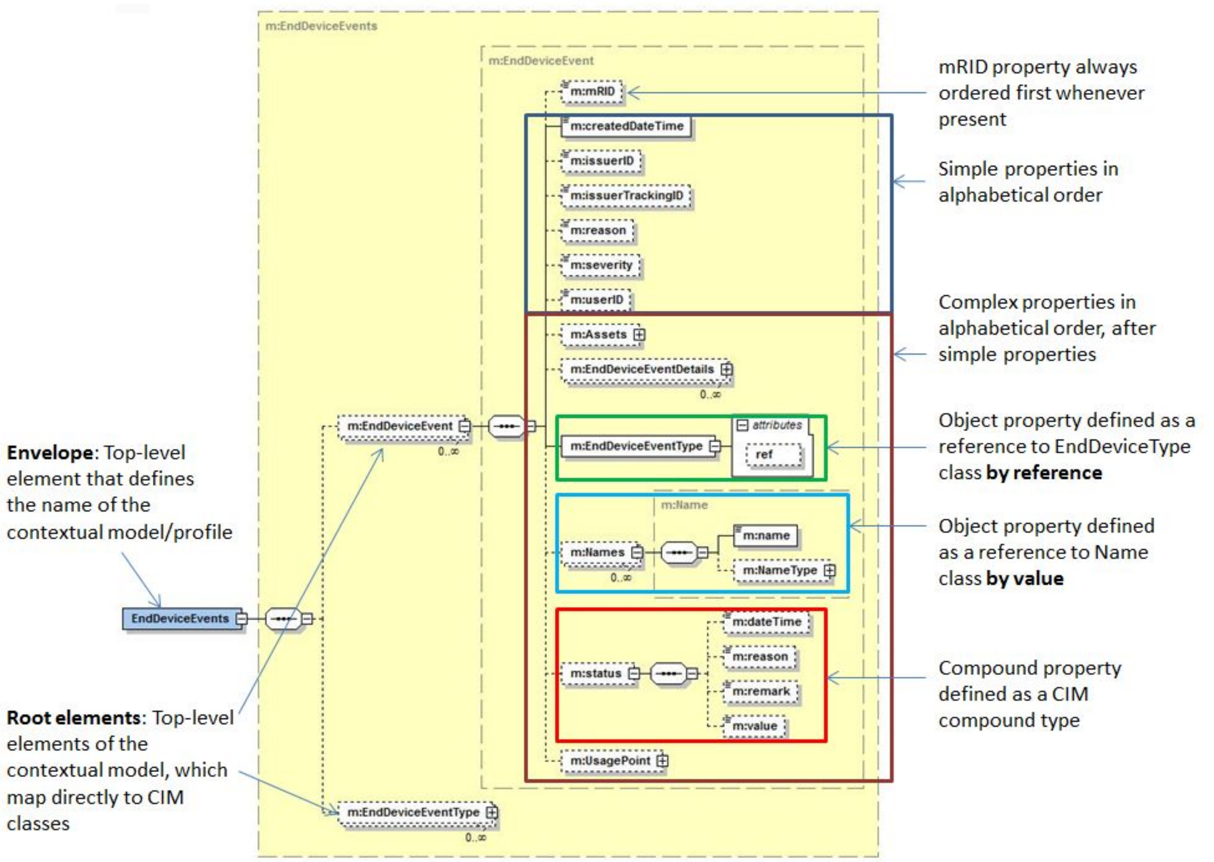

Figure A.1 – Profile Structure

Payloads are to be realized using XML, where payload structures are defined using XML schemas.

Bibliography

[1] IETF RFC 6272, Internet Protocols for the Smart Grid, June 2011

[2] Bibliographical reference 2

[3] Bibliographical reference 3

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