PD IEC/TS 62746-3:2015

BSI Standards Publication

Systems interface between customer energy management system and the power management system

Part 3: Architecture

...making excellence a habit.™

National foreword

This Published Document is the UK implementation of IEC/TS 62746-3:2015.

The UK participation in its preparation was entrusted to Technical Committee PEL/57, Power systems management and associated information exchange.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2015

ISBN 978 0 580 86672 2
ICS 33.200

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 November 2015.

Amendments/corrigenda issued since publication

Date	Text affected

IEC TS 62746-3

Edition 1.0 2015-10

TECHNICAL SPECIFICATION

colour inside

Systems interface between customer energy management system and the power management system – Part 3: Architecture

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.200 ISBN 978-2-8322-2951-4

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

SYSTEMS INTERFACE BETWEEN CUSTOMER ENERGY MANAGEMENT SYSTEM AND THE POWER MANAGEMENT SYSTEM –

Part 3: Architecture

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62746-3, which is a technical specification, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
57/1527/DTS	57/1610/RVC

Full information on the voting for the approval of this technical specification 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.

A list of all parts in the IEC 62746 series, published under the general title *Systems interface between customer energy management system and the power management system*, can be found on the IEC website.

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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The purpose of this part of IEC 62746 is to define an architecture for IEC 62746 series of standards that can be leveraged for the management of customer energy resources and DER. These resources may be a combination of load, generation and storage 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 Technical Specification leverages existing IEC standards.The data model of IEC 62746 is based on the Common Information Model and IEC 61850. IEC 62746 is transport-independent.

Figure 1 shows the relationship of IEC 62746 to other IEC and ISO standards.

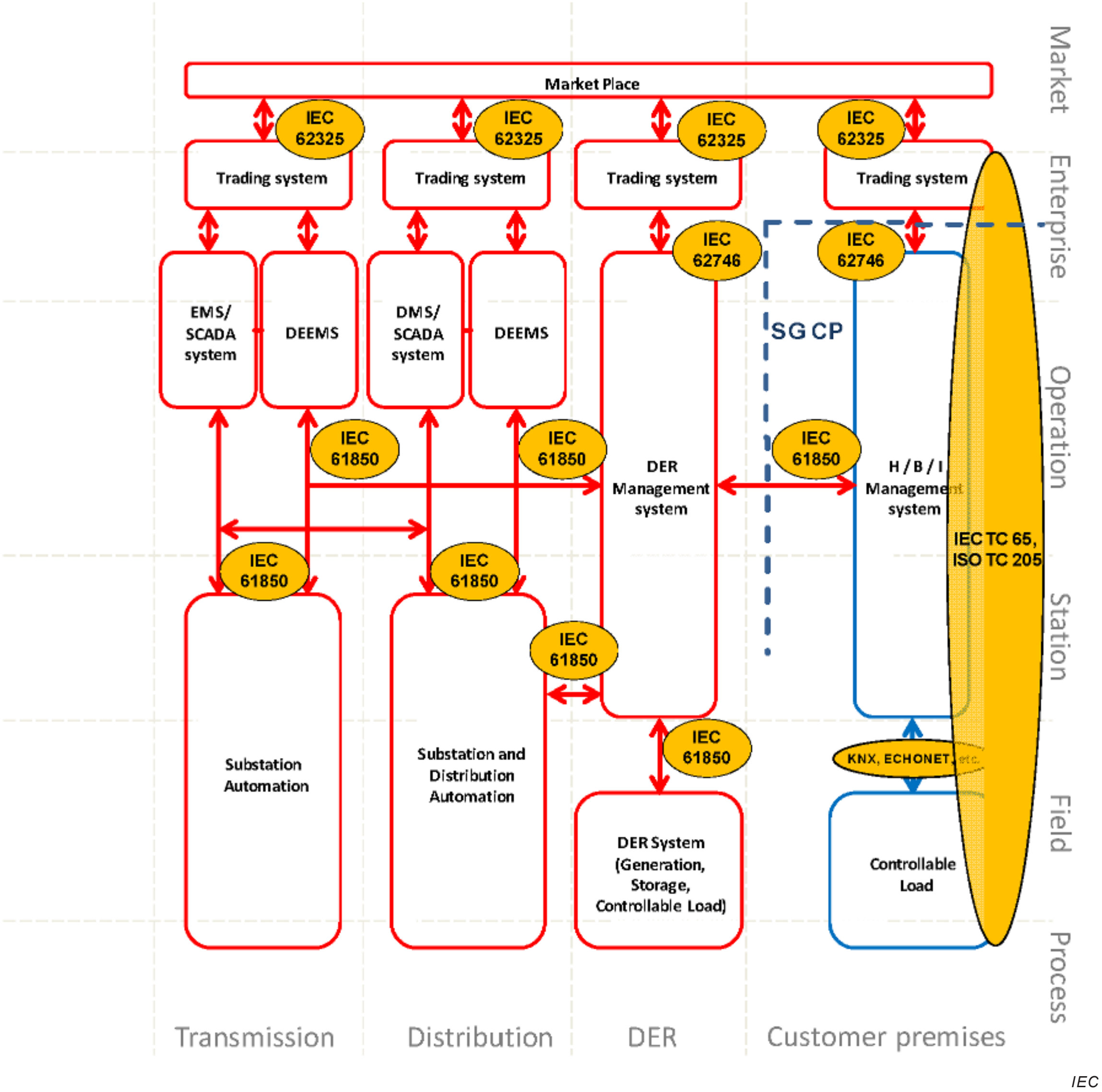

Figure 1 – Relationship of IEC 62746 to other standards

SYSTEMS INTERFACE BETWEEN CUSTOMER ENERGY MANAGEMENT SYSTEM AND THE POWER MANAGEMENT SYSTEM –

Part 3: Architecture

1 Scope

This part of IEC 62746, which is a Technical Specification, establishes an architecture that is supportive of interfaces between the Customer Energy Management System and the Power Management System.

A DER Management System can also be a Customer Energy Management System.

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 61968-9:2013, *Application integration at electric utilities – System interfaces for distribution management – Part 9: Interfaces for meter reading and control*

IEC 61968-100, *Application integration at electric utilities – System interfaces for distribution management – Part 100: Implementation profiles*

IEC 62351 (all parts), *Power systems management and associated information exchange – Data and communications security*

IEC TR 62746-2:2015, *Systems interface between customer energy management system and the power management system – Part 2: Use cases and requirements*

IEC 62443 (all parts), *Industrial communication networks – Network and system security*

3 Terms, definitions and abbreviations

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

3.1 Terms and definitions

3.1.1
aggregation
collection of the capabilities of multiple resources into a single virtual resource

Note 1 to entry: 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.

3.1.2
cascading
event which 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

3.1.3
communication domain
logical association of a VTN with a set of VENs supported by an underlying communication infrastructure

Note 1 to entry: 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.

Note 2 to entry: This term is defined by this technical specification.

3.1.4
customer energy manager
CEM
central managing function used by the customer to manage the flow of information between the grid and connected smart devices at the customer premises

Note 1 to entry: This is defined in more detail in IEC TR 62746-2.

3.1.5
demand response
DR
incentivizing of customers by costs, ecological information or others in order to initiate a change in their consumption or feed-in pattern (“bottom-up approach” = Customer decides, based on EURELECTRIC Views on Demand-Side Participation [1])

Note 1 to entry: Alternative definition: In IEC 60050-617:2009, 617-04-15 it is defined as: action resulting from management of the electricity demand in response to supply conditions.

3.1.6
distributed energy resource
specialized energy resource with a flexible load and/or supply generally at the distribution level

3.1.7
message
method of conveying information between parties in a communication network

Note 1 to entry: The information may reflect a description of an object and/or data related to the object.

3.1.8
node
logical destination address for messages that are published using a publish/subscribe communication infrastructure

Note 1 to entry: Depending upon the specific communication infrastructure this may also be called a ‘topic’ or ‘subject’.

3.1.9
publish/subscribe
communication pattern where a message sent from a source may be received by zero or more interested subscribers

SEE: IEC 61968-100

3.1.10
request/reply
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.

3.1.11
resource
provider or consumer of energy

Note 1 to entry: A VEN may be responsible for managing one or more energy resources.

Note 2 to entry: Resources may be physical or aggregated.

3.1.12
signal
message that is sent to indicate a condition or information of potential interest

3.1.13
smart grid connection point
SG CP
information access point from the grid to the customer premises

Note 1 to entry: This is a logical connection point but not the electrical connection point.

Note 2 to entry: This is described in more detail in IEC TR 62746-2.

3.1.14
technical role
role which identifies responsibilities associated with participation within information exchanges with other actors

Note 1 to entry: Actors defined by use cases have assigned roles with associated responsibilities. Technical roles are physically realized through software and associated systems integration infrastructure. This is a term defined here for the purposes of this Technical Specification.

3.1.15
virtual end node
technical role assumed by an actor where the actor is a consumer and/or producer of messages that are defined by this Technical Specification

Note 1 to entry: 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.

Note 2 to entry: This term is defined by this Technical Specification 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 Technical Specification.

3.1.16
virtual resource
set of one or more physical resources that is represented as a single, aggregated resource

Note 1 to entry: This may be comprised of multiple entities that may be geographically distributed. Virtual Resources can be an aggregated model of many types of load, generation and storage, such as VPP, PV, factory, building, home, etc. Since the Virtual Resource can include both energy consumer and energy provider, the related "net load curve" can be positive (in this case the Virtual Resource acts as a consumer which consumes electrical power), or negative (in this case the Virtual Resource acts as generation assets to produce electrical power).

3.1.17
virtual top node
technical role assumed by an actor that is assuming responsibility for the coordination of VENs within a Communication Domain

Note 1 to entry: 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 which will typically implement a VTN interface.

Note 2 to entry: This term is defined by this Technical Specification 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 Technical Specification.

3.1.18
wire protocol
in a network, the mechanism transmitting data from a sender to a receiver

Note 1 to entry: 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.

Note 2 to entry: This is a widely used phrase without a specific normative definition, where a definition is provided here for the purposes of this technical specification.

3.2 Abbreviations

Abbreviation	Description
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
EV	Electric Vehicle
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
PV	Photovoltaic generator
SG CP	Smart Grid Connection Point
SM	Smart Meter
VEN	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 Architectural overview

4.1 Application area

Figure 2 shows a resource-level view of the area to be addressed by this Technical Specification, 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’ (SG CP).

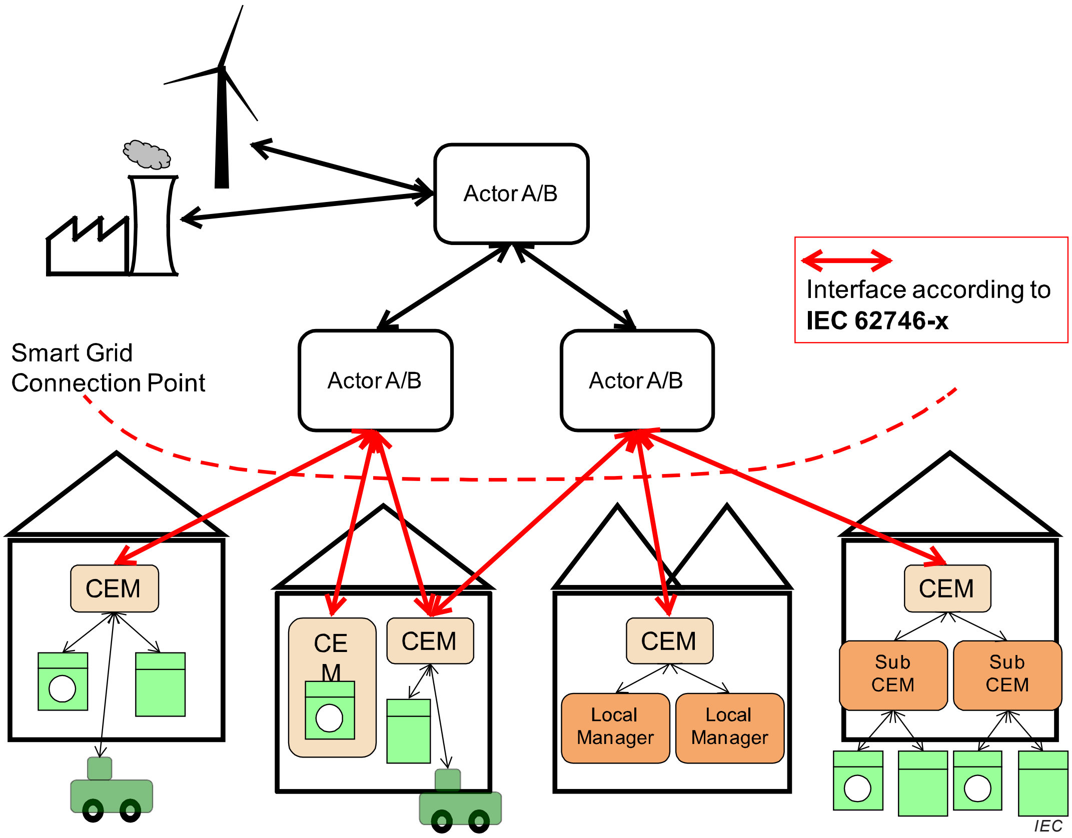

Figure 2 – Resource-level view

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 TR 62746-2.

4.2 Actors, roles and relationships

The purpose of this subclause 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 TR 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 TR 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 Technical Specification to provide examples of all actors defined by IEC TR 62746-2 or restate the definitions of those actors, and consequentially some higher-level categorization of actors will be used within this Technical Specification as opposed to specific actors in describing the use of this Technical Specification. 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 example diagram for wholesale and retail energy markets given in Figure 3:

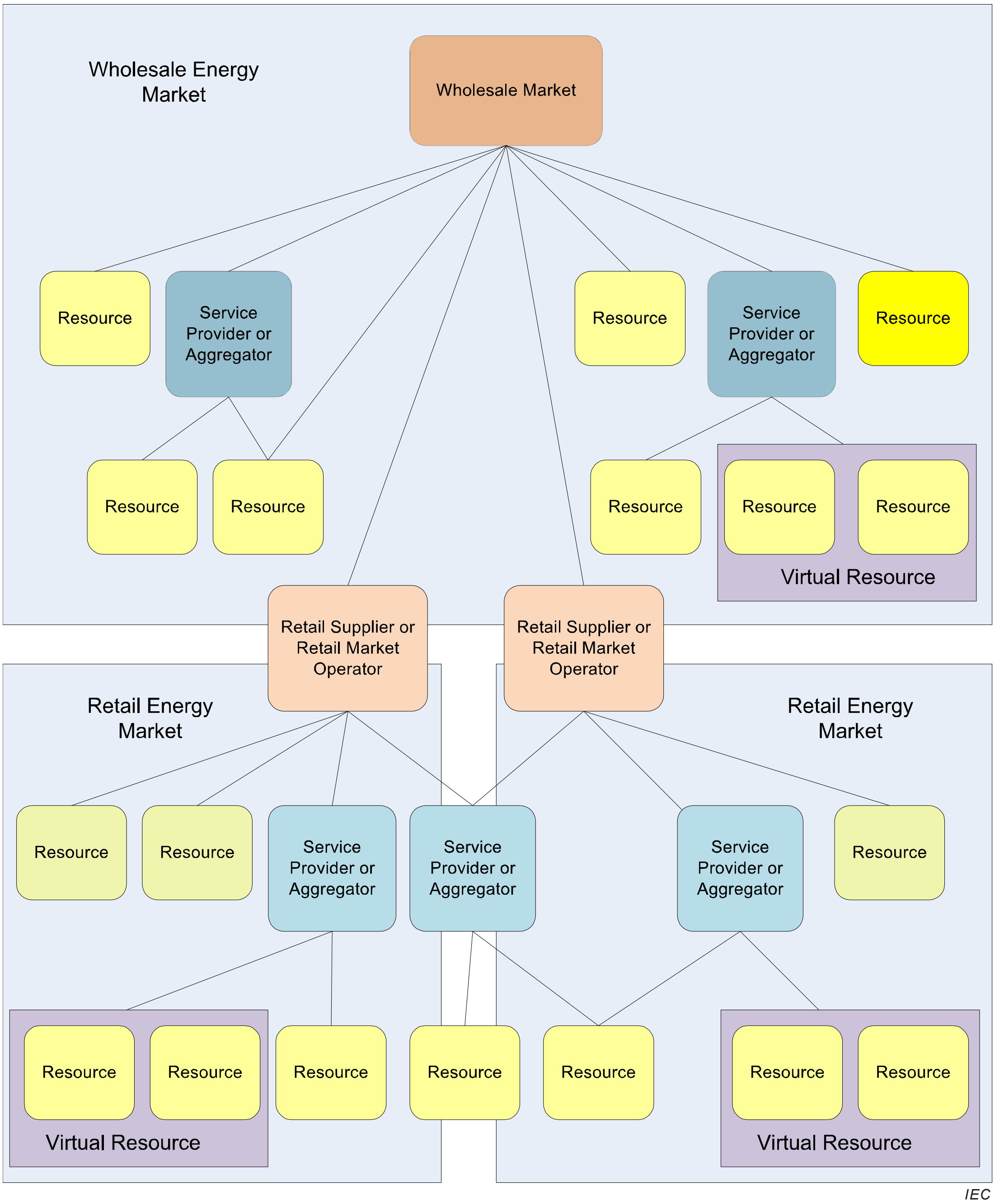

Figure 3 – High-level example of actors, roles and relationships

From 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.

Also, dependent on the individual realization, the SG CP can be at different locations in the diagram. Resources or Virtual Resources correspond to to either CEM or CEM Aggregator in IEC TR 62746-2.

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 downstream, 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.

4.3 Concepts

The purpose of this subclause is to introduce key architectural concepts as needed for the definition of this Technical Specification 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.

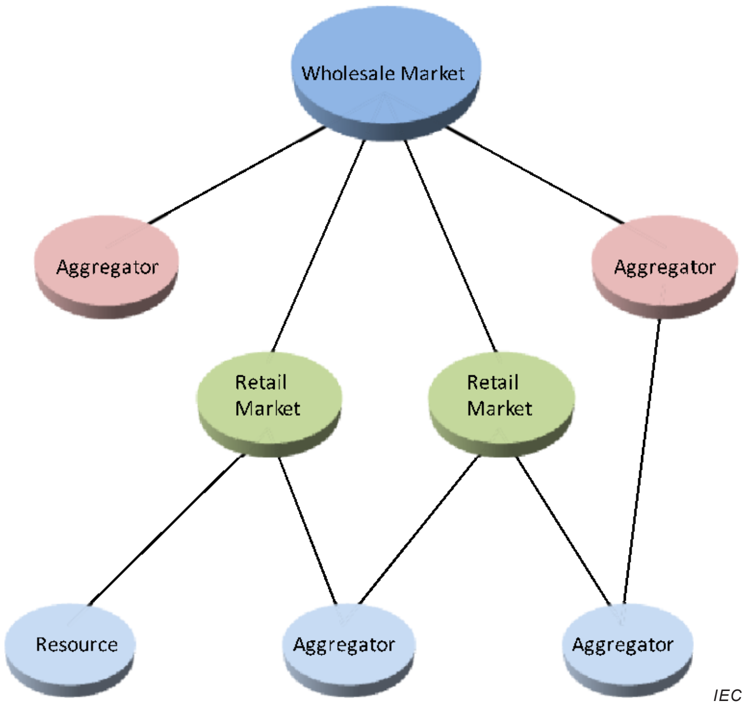

Figure 4 – Example Communication Domain hierarchy

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.

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.

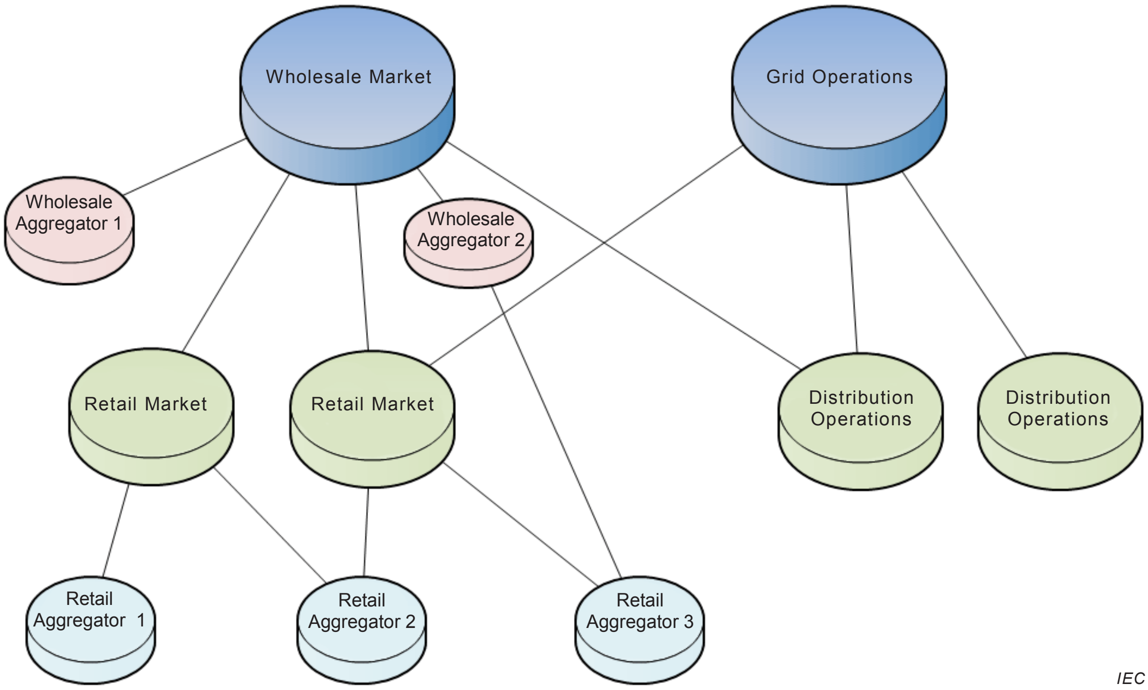

Figure 5 – Expanded communication domain example including operations

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 retail market may be a VEN in both Wholesale Market and Grid Operations communication domains.

4.4 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.

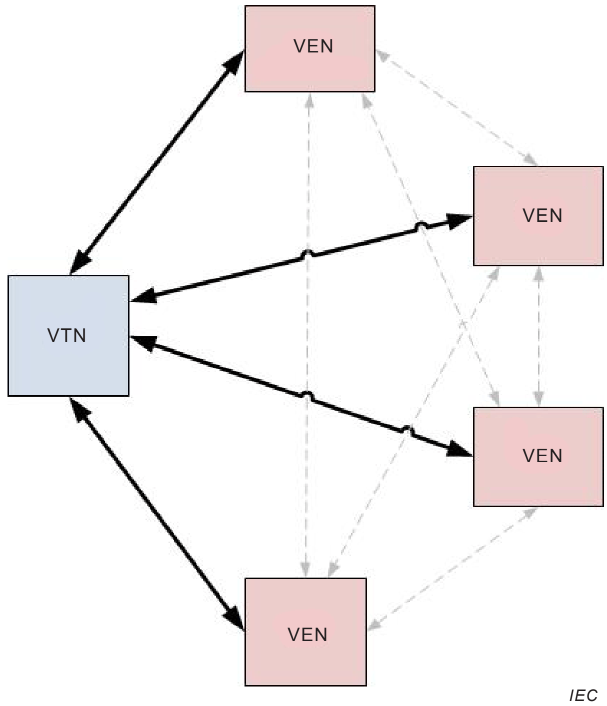

Figure 6 – Communication domain

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 technical specification). 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 7, where there are three VTNs which each manage a different communication domain.

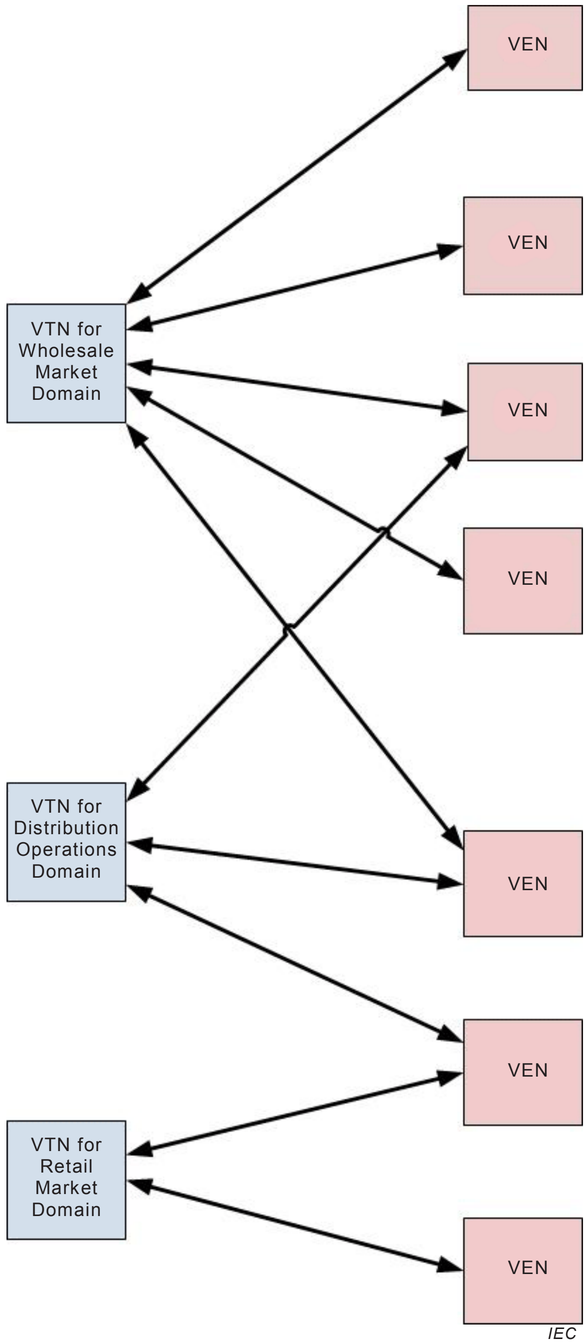

Figure 7 – Example realization of VTNs and VENs in multiple communication domains

In this context a VEN may represent a complete industrial facility or a commercial building or even a single load. In Figure 8 a practical example is shown. All consumers (in this case VENs and the VTN for the industrial facility) are connected to the grid which is managed by one grid operator. But the places where they buy their energy are different. The large consumers buy the electrical energy directly from the wholesale market whereas the smaller consumers buy from an energy service provider.

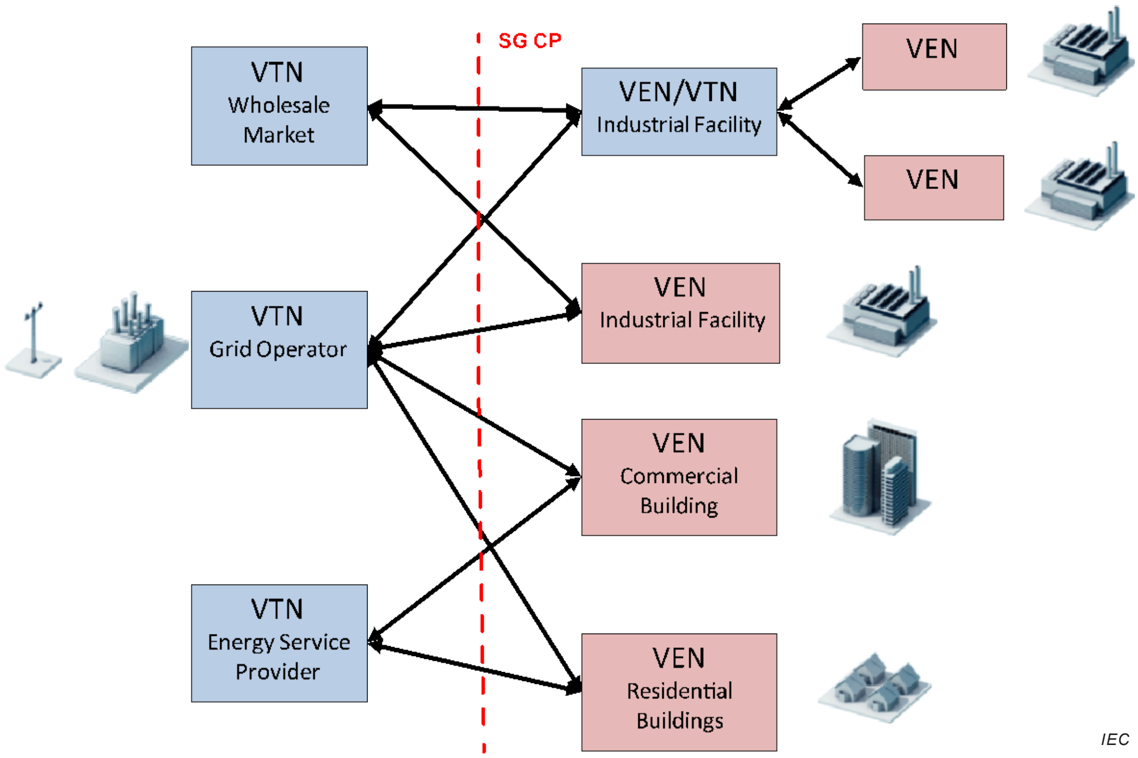

Figure 8 – Example for multiple communication domains

The IEC 62746 interface standard can then be logically represented by Figure 9 when representing a single communication domain:

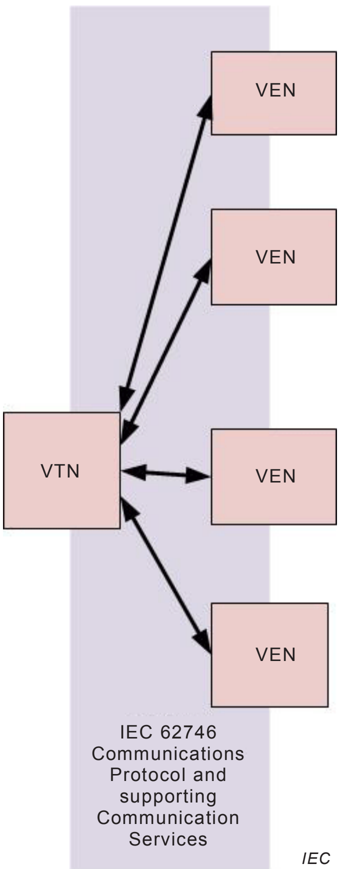

Figure 9 – Technical space of a single communication domain in IEC 62746

The communications between VTNs and VENs shall allow 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.

Figure 10 shows an example of this interface being used by the VTN of a market operator or aggregator to communicate with a set of resources.

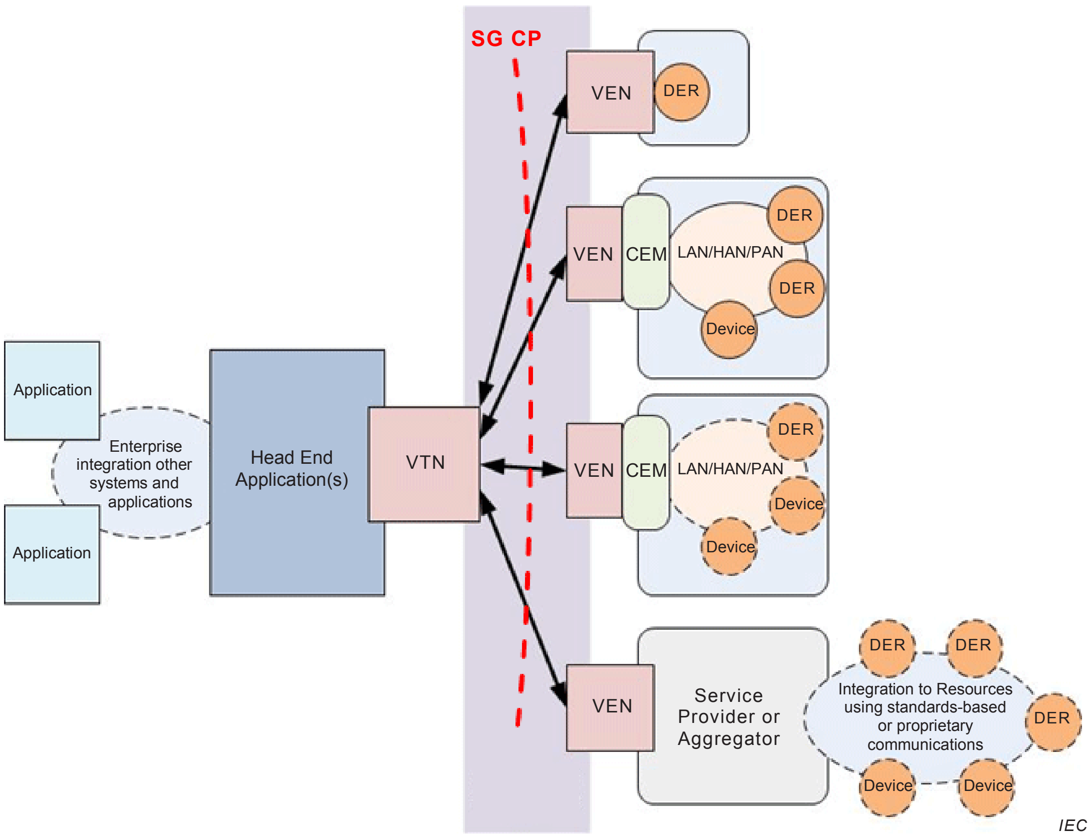

Figure 10 – Example application of IEC 62746

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 VEN therefore may represent multiple local devices.
- 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
- 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.

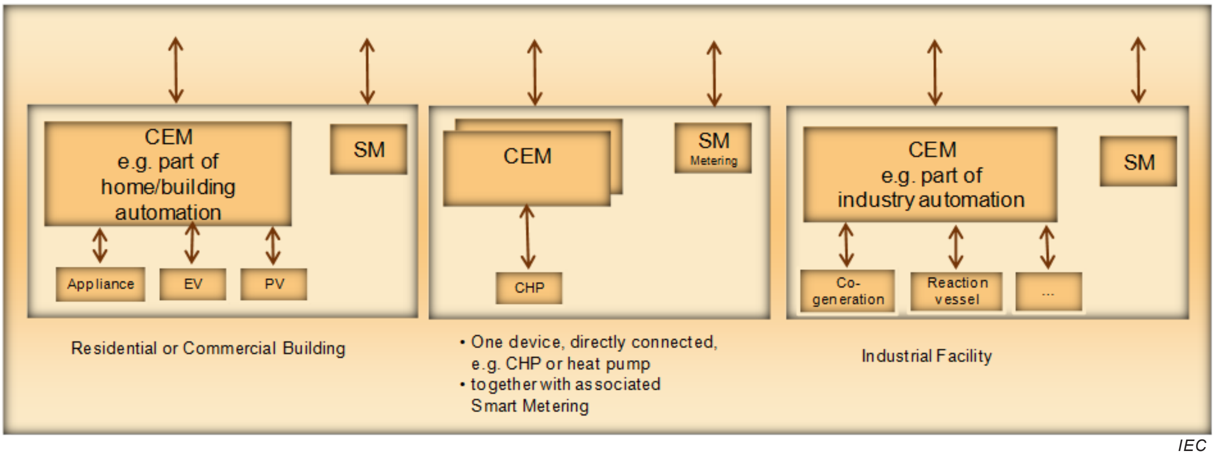

Figure 11 – CEM and resource relationships

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. Figure 11 provides an example of resource management using a CEM.

5 Message transport and services

5.1 Transport requirements

The IEC 62746 transport shall support real time transport. Therefore message queuing concepts like store and forward, e.g. e-mail are not allowed. Forwarding between communication servers is allowed under the condition that the applicable real time communication requirements are satisfied. Nevertheless limitation to one hop is recommended.

Real time shall mean:

- Transport of an event message for one event from a VTN to all its (direct) VENs shall be done within less than 30 seconds.
- The transport connection shall be open permanently.

- Connection establishment including complete authorization and key exchange shall be done within less than 60 seconds.

The selected transport protocol shall be optimized for small messages with low overhead. This does not exclude long messages. The real time requirements above shall be met with small messages.

A message is defined as small, if it fits in one transmission packet. The maximum path transmission unit is network dependent.

NOTE For IPv6 the maximum path transmission unit size is at least 1 280 including headers.

5.2 Supporting messaging standards

IEC 62746 is transport-neutral, but to permit realization later parts will describe the mappings to XMPP as an initial transport. This is mentioned in order 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. This includes peer to peer communication solutions.

5.3 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 12 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.

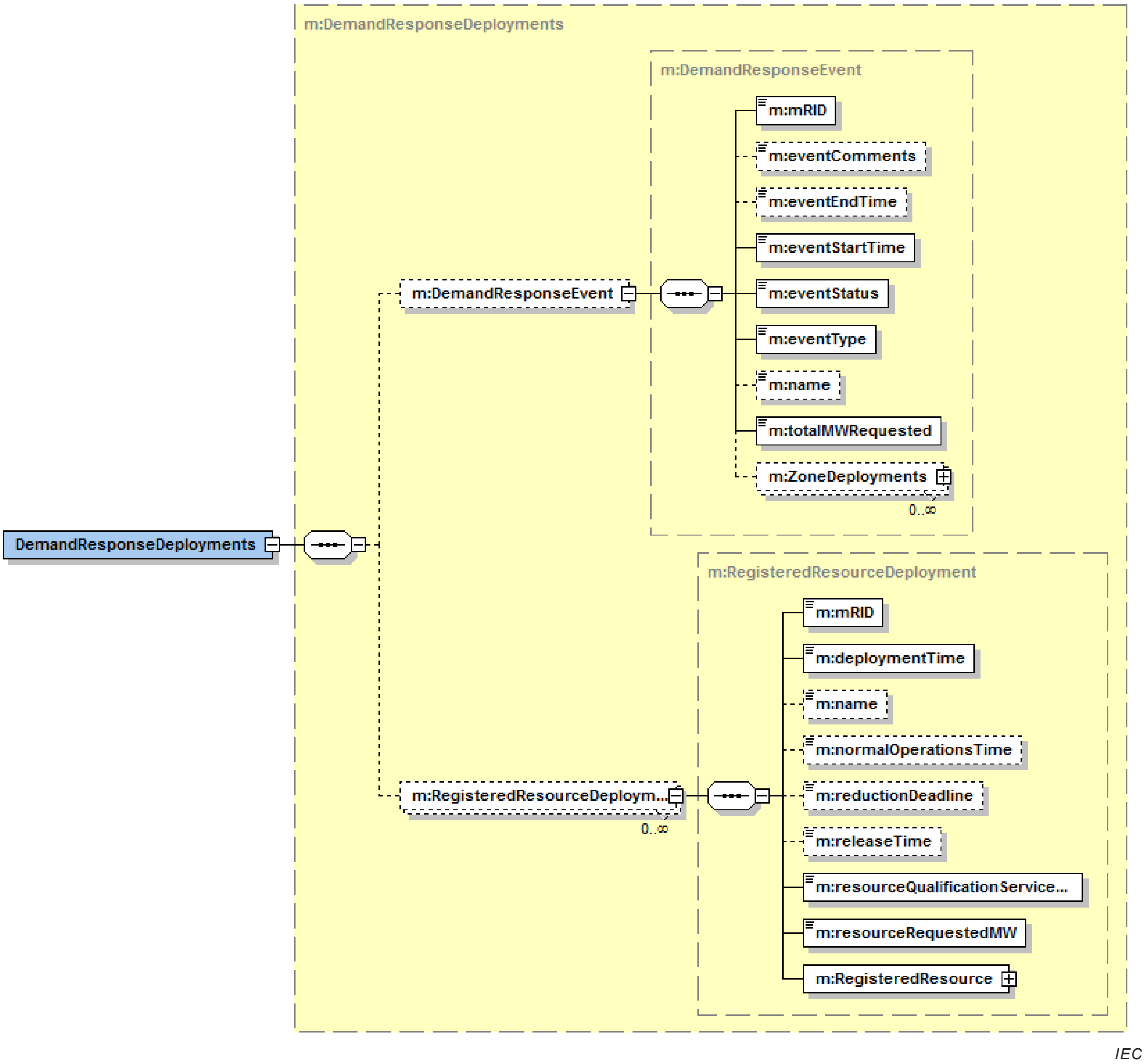

Figure 12 – Example payload

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

5.4 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.

5.5 Messaging patterns

5.5.1 General

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 Technical Specification 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 or from the VENs to the VTN. 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, are currently outside the scope of this Technical Specification.

5.5.2 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.

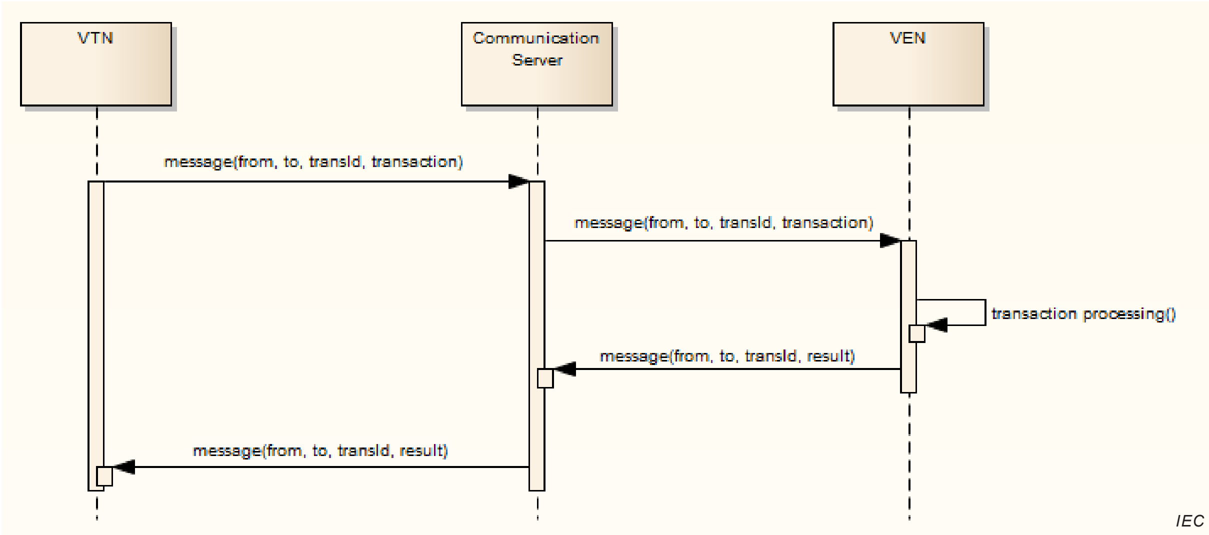

Figure 13 – Transactional request/reply initiated by VTN

Where Figure 13 describes the transaction being initiated by the VTN, Figure 14 shows a similar pattern where the transaction is initiated by the VEN.

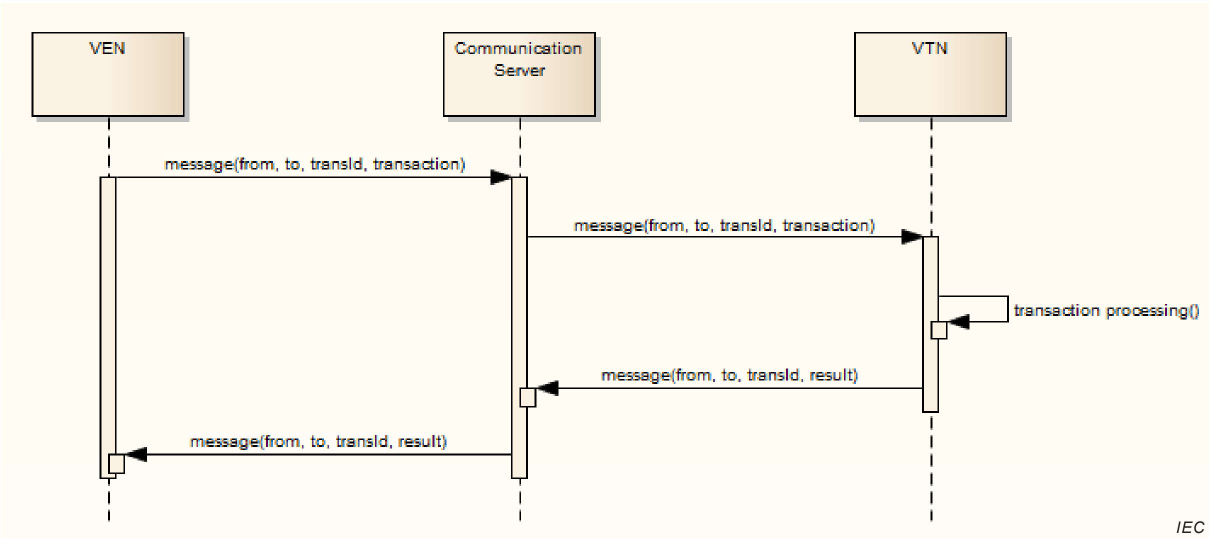

Figure 14 – Transaction request/reply initiated by VEN

5.5.3 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 15 describes the interactions where the query is initiated by the VTN to a VEN.

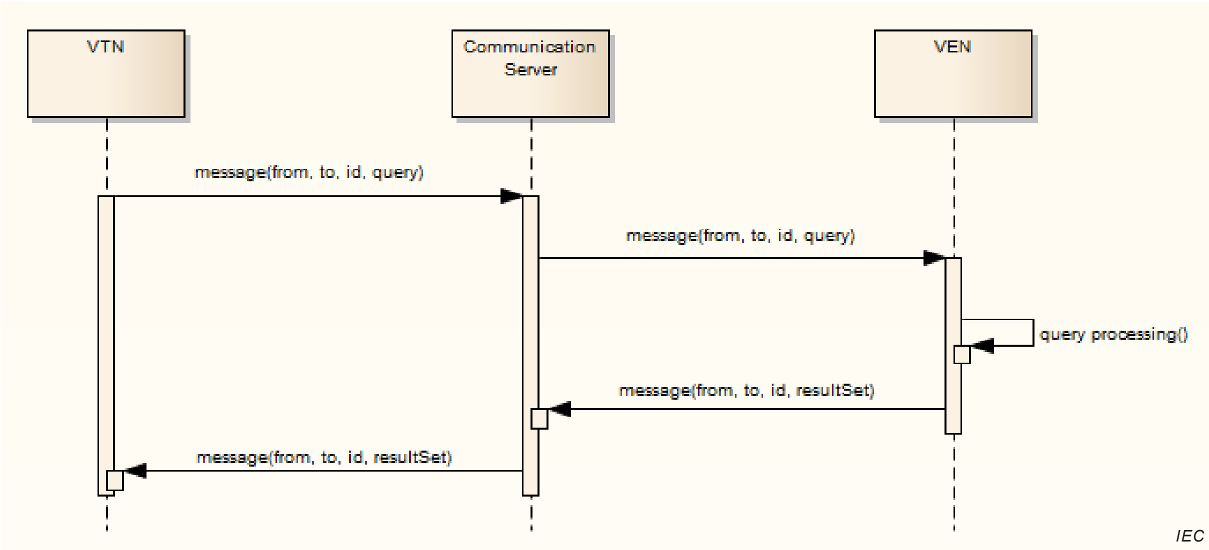

Figure 15 – Query request initiated by VTN

Figure 16 describes the interactions where the query is initiated by a VEN to the VTN.

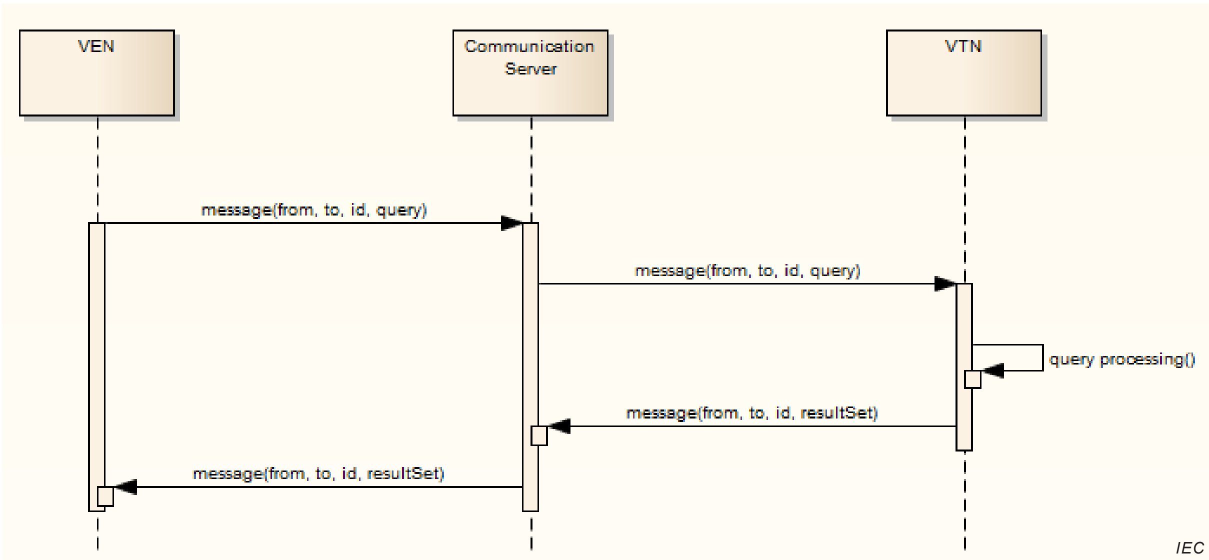

Figure 16 – Query request initiated by VEN

5.5.4 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 17 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.

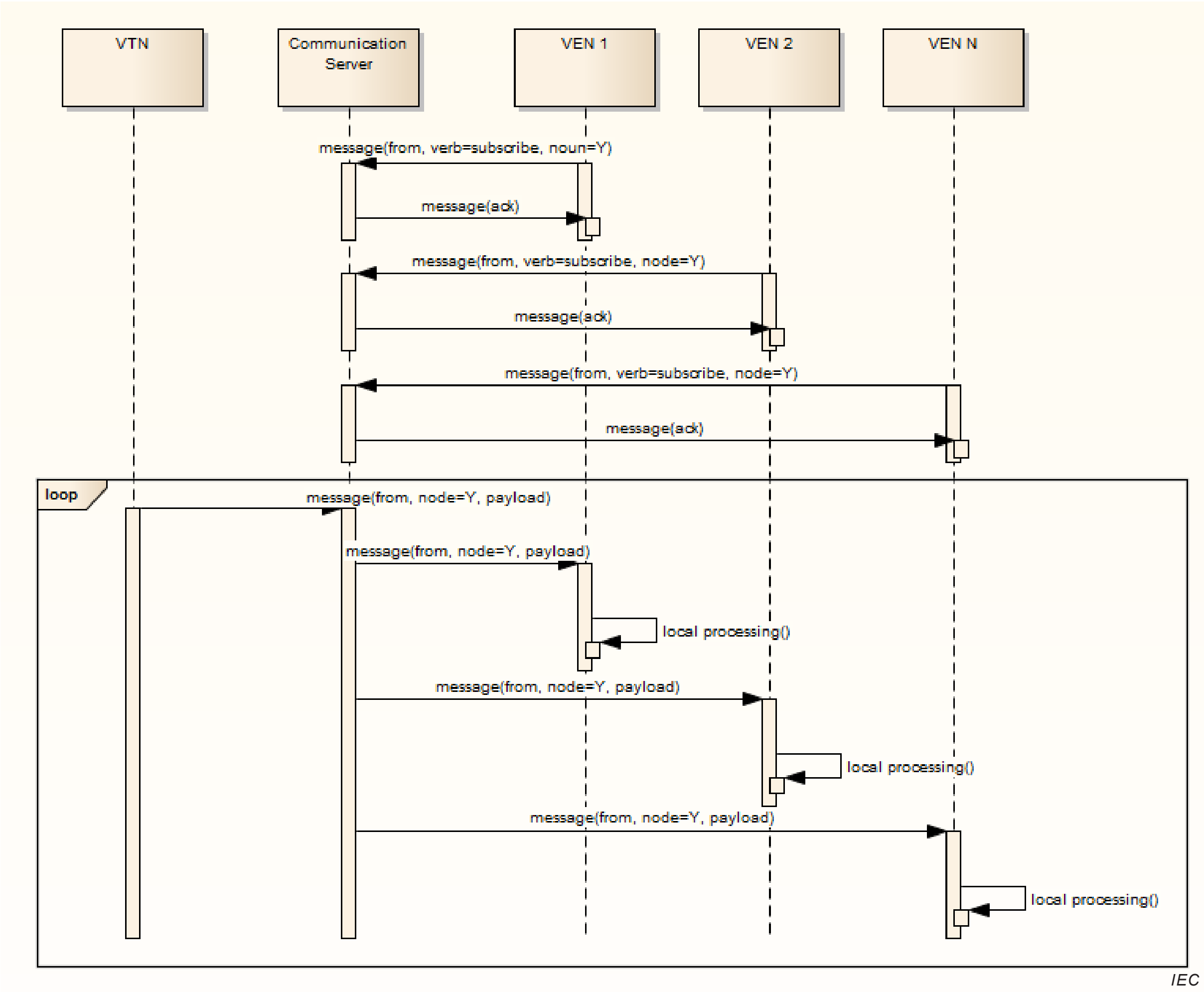

Figure 17 – Example of VTN initiated events

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 in Figure 18.

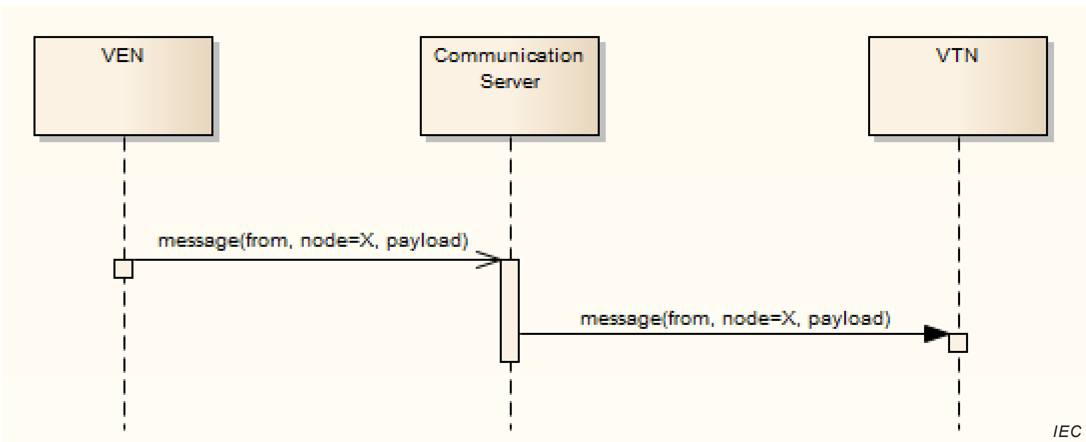

Figure 18 – VEN initiated events

5.5.5 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.

5.6 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 Figure 19.

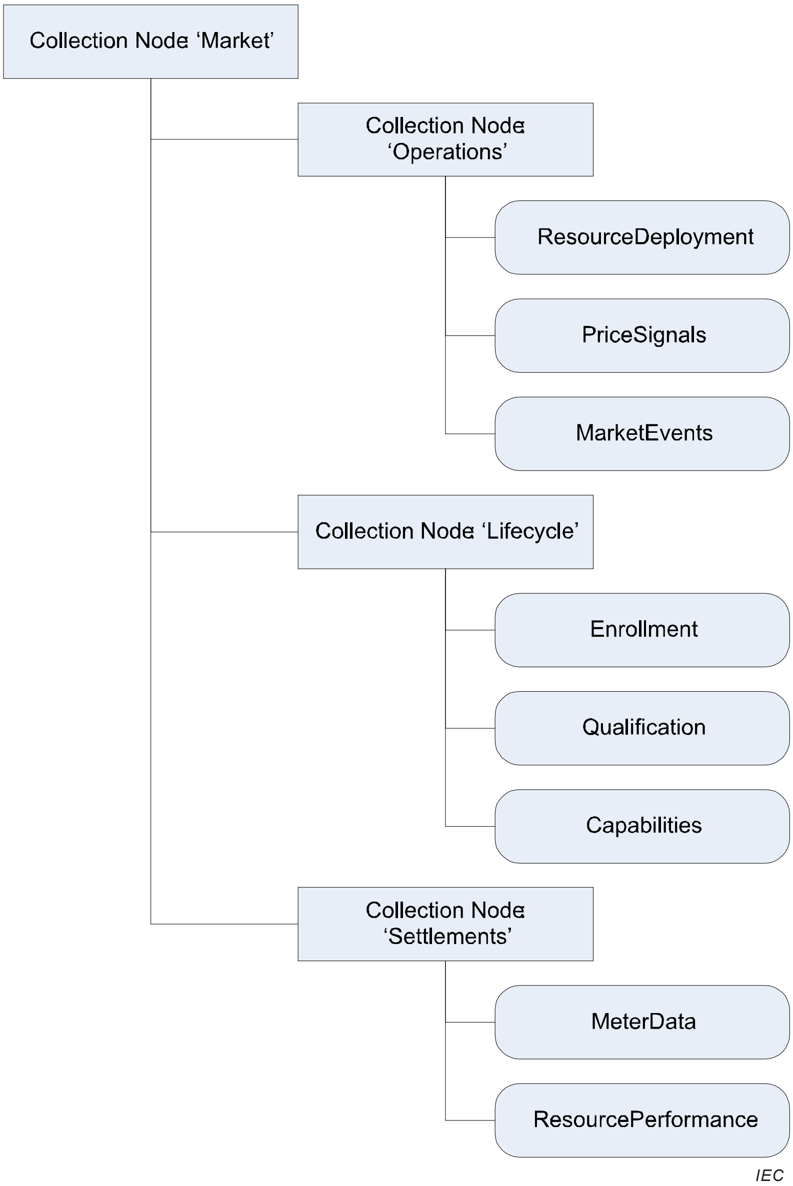

Figure 19 – Example of publish/subscribe nodes

6 Security

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

The communication server functionality described in this clause may be implemented in the VTN.

Special attention shall be given to IEC 62351 and IEC 62443. The security requirements for private networks have to be examined on a case by case basis.

For VENs to accept inbound connections, ports would need to be opened in firewalls creating many points of vulnerabilities. However, this problem may be 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.

Figure 20 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 or other suitable means. A VTN may include the communication server functionality.

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. VTNs and VENs shall allow the assignment of individual properties of virtual resources to one or more roles.

The communication between the communication server and the VTNs and the VENs is secured using mechanisms such as mutually authenticated 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 objective of the design shall be to minimize the security burden for the VEN's and VTNs as much as possible, however the security requirements for VTNs and VENs connected to the Internet remain significant. If a VTN includes communication server functionality it inherits the corresponding security requirements.

The main burden of security is on the communication server side. This includes protection against attacks from the internet like port scans, denial of service or similar attacks which is very resource consuming.

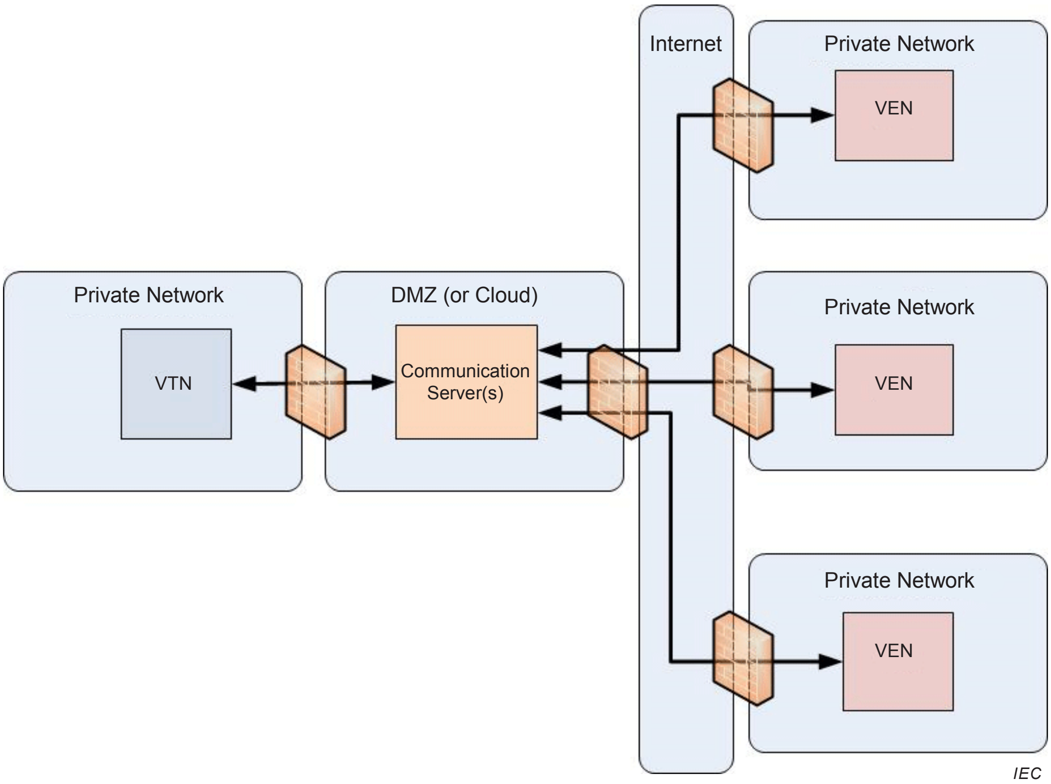

Figure 20 – Security overview

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 unsecure 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.

7 Scalability and availability

The communication server functionality described in this clause may be implemented in the VTN.

Scalability and availability are largely accomplished by the additiona 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 as in server cluster.

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 cluster.

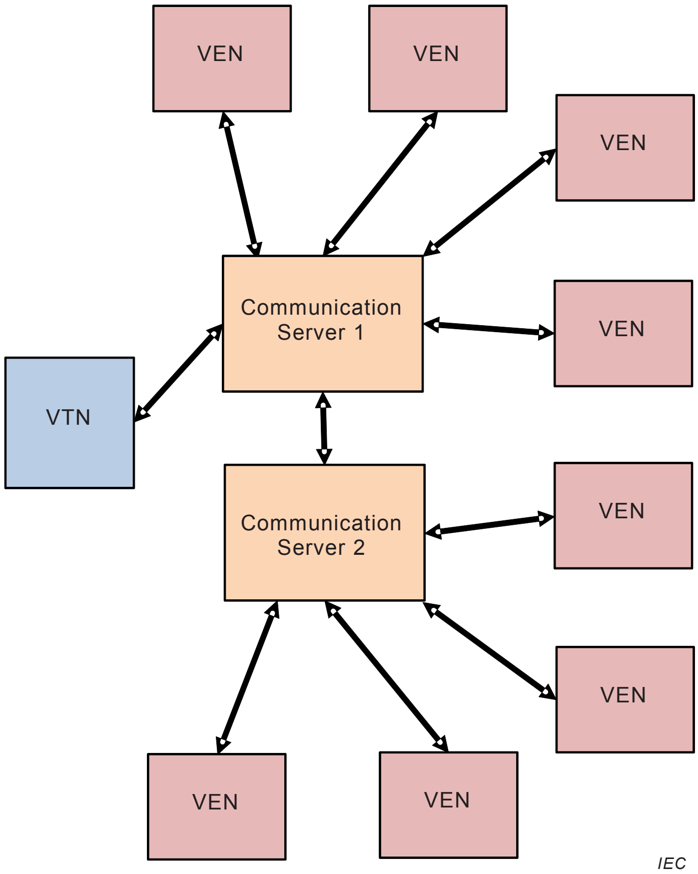

Figure 21 – Configuration for scalability and availability

Availability of VTNs has to be addressed by the VTNs themselves, e.g. by redundancy.

Annex A
(informative)

Requirements

A.1 General

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

A.2 Principles

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

- Possibilities of cyber attacks crossing the interfaces are to be prevented
- 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.

A.3 Additional communication-specific functional requirements

The functional requirements for IEC TS 62746-3 are to some extent defined within IEC TR 62746-2. The focus of this subclause 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 Technical Specification.

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:

- Resources/virtual resources shall have a unique identity. This identity may be used as a logical address for communications.
- Resources/virtual resources shall be configured with credentials that enable them to make authenticated connections to a trusted communication infrastructure.
- Adequate security measures shall be included to ensure the protection of information carried over the internet. E.g. communications over the Internet shall be encrypted.
- Resources/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.

- Resources/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.
- Resources/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.
- Resources/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
- Integrity protection
- Publish/Subscribe messaging
- Request/Reply messaging
- Event messaging
- Message encryption

Configuration services shall be supported.

A.4 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 intellectual property 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 VTNs to groups of VENs
- Shall support publish/subscribe mechanisms, including capabilities to address messages from VENs to groups of VTNs
- 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 by VTNs (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 cascading aggregation of virtual resources

Annex B
(informative)

Message payload profiles

Figure B.1 describes the possible structure of profiles used for messages. This is provided here for convenience purposes.

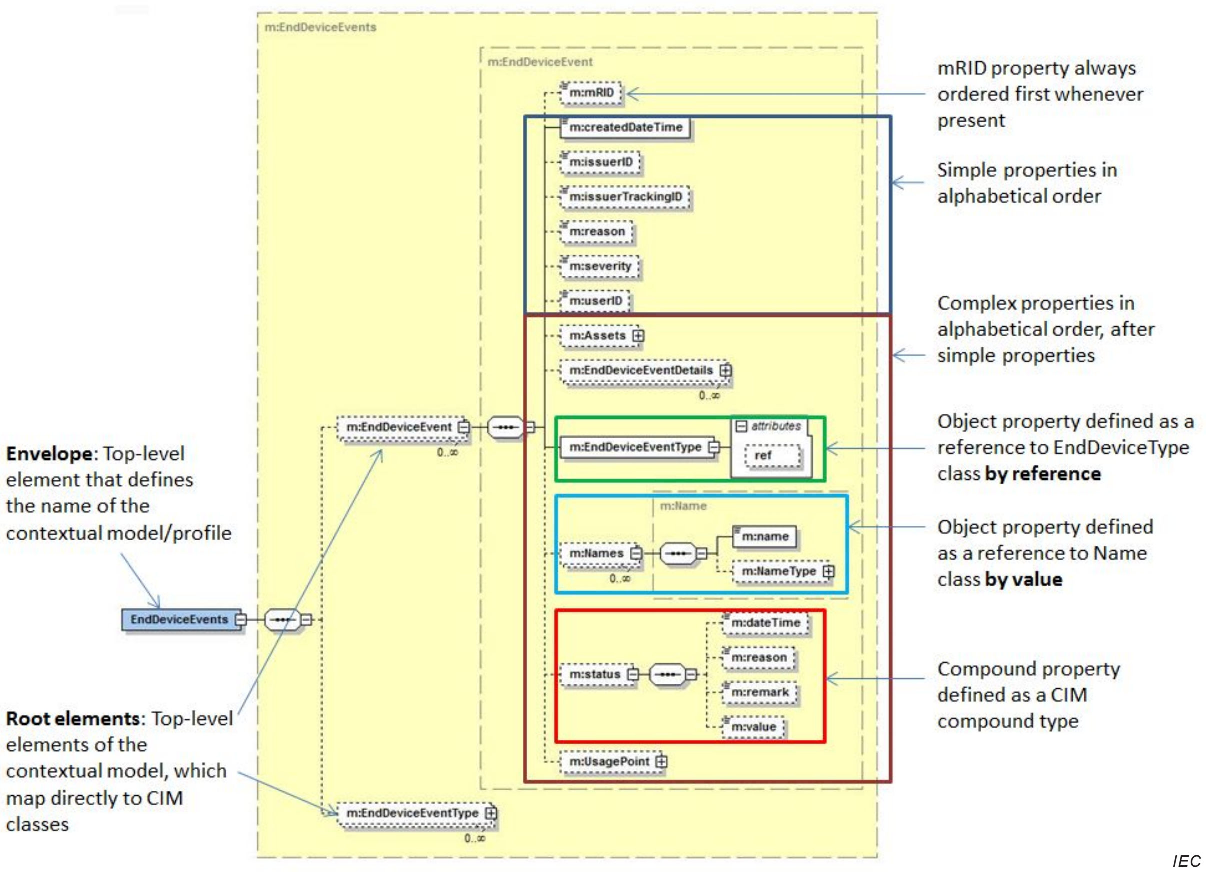

Figure B.1 – Profile structure

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] XMPP XEP-0060, *Publish-Subscribe messaging extensions*, July 2010

[3] IEC PAS 62746-10-1, *Systems interface between customer energy management system and the power management system – Part 10-1: Open Automated Demand Response (OpenADR 2.0b Profile Specification)*

[4] The Smart Grid Coordination Group reports http://www.cencenelec.eu/standards/Sectors/SustainableEnergy/SmartGrids/Pages/default.aspx

[5] IEC PAS 62559:2008, *IntelliGrid methodology for developing requirements for energy systems*

____

This page deliberately left blank

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

bsi.

...making excellence a habit.™