Interface Specification

LINKWARE IEC 61968

COMMON

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Contents

1 Overview

The purpose of this document is to describe common guidelines and messaging details in implementing integrations using Aidon Linkware IEC interfaces.

Linkware version

This document targets Linkware version 1.11.

References

Reference	Document
IEC 61968-100 ed.1 Implementation profiles	The document describes how message payloads defined by parts 3-9 of IEC 61968 are conveyed using web services and the Java Messaging System.
IEC 61968-9 ed.2 Interfaces for meter reading and control	The purpose of this document is to define a standard for the integration of metering systems (MS), which would include traditional (one or two-way) automated meter reading (AMR) systems, with other systems and business functions within the scope of IEC 61968.
Interface Specification - Linkware IEC 61968 Management v2 (draft).docx	Linkware IEC Management service specification
Interface Specification - Linkware IEC 61968 Event (draft).docx	Linkware IEC Event service specification
Linkware IEC 61968 Management schema	WSDL schemas of the IEC Management service

2 Services and interfaces

The Linkware IEC services are collection of Web Services for synchronous and asynchronous messaging between Aidon Gateware and any external systems.

The Linkware IEC services are meant to be IEC 61968 compliant interfaces to interact with Aidon Gateware. The IEC 61968 is a series of standards developed by Working Group 14 of Technical Committee 57 of the International Electrotechnical Commission (IEC TC 57 WG14). The schemas in these services are based on the Common Information Model TC57CIM subpackages IEC61968CIM11v13 and IEC61970CIM15v33. The payload schemas are mostly based on IEC 61968-9 standard which provides a base set of information transmitted within the service request and response payloads.

2.1 Available services

The Linkware IEC services are separated in logically independent services which are described in detail in the specification document of each service. Available services and operations are listed in the following table.

Service	Version	Interfaces
IEC Management	2.1	• CRUD and history operations for basic data (i.e. metering points, devices) • Management of metering points / devices
IEC Event	2.1	• Delivery of spontaneous events that are triggered from the Gateware or network • Notification events to notify about changes in the asset data
IEC AdHoc	2.1	• On-demand requests to metering devices

2.2 Technology

The web service interface is implemented in Gateware with SOAP and HTTPS using Microsoft WCF technologies. The interfaces use the strongly typed version of the web service as described in the IEC 61968-100 standard. Interfaces conform to Web Services Basic Profile 1.1.

3 Use Cases

TBD: descriptions how to use interfaces in different use cases and processes.

3.1 Messaging patterns

Following sequence diagrams describe different messaging patterns that are used to communicate with Linkware interfaces. These sequence diagrams are not supposed to describe any internal behavior of the Linkware services. Backend responsibility of fulfilling the functionality may be shared by other system components (Meteringware and Gateware).

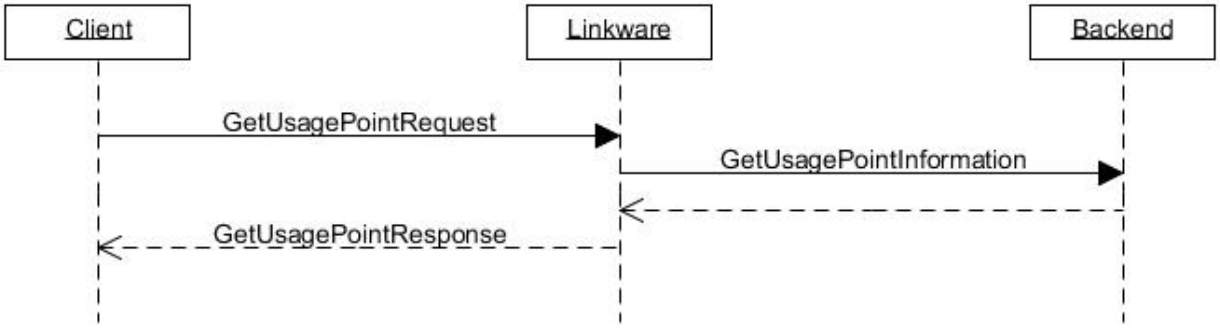
Messages for each messaging pattern are described chapter 4.

Pattern	Description	Endpoint configuration
Synchronous request-response	Basic Web Service / SOAP request that is responded immediately with the same network connection that was used to send the request	Synchronous requests are always sent from an external system to a predefined service endpoint that is published from the Linkware.
Asynchronous operation	Asynchronous operations consists of two or more requests that use request-response pattern, but only one request is inbound to Linkware and others are outbound to an external system (see sequence below)	Initial request is sent from an external system to a predefined service endpoint that is published from the Linkware. Subsequent asynchronous responses are sent to a reply address of an external system that is defined in the initial request with an element ReplyAddress (see message descriptions in chapter 4).
Spontaneous events and alarms	Events and alarms are triggered in systems behind Linkware which notifies Linkware for the events. Linkware forwards the events accordingly to external system(s).	Endpoints where external systems receive events and alarms sent by Linkware are preconfigured in the Linkware configuration.

3.1.1 Synchronous request-response

Synchronous request-response type of operation is usually operation that targets entities and data that is created and maintained within the system components (for example Gateware). Following diagram describes simple operation to retrieve metering point data (IEC-management interface, GetUsagePoint

operation).



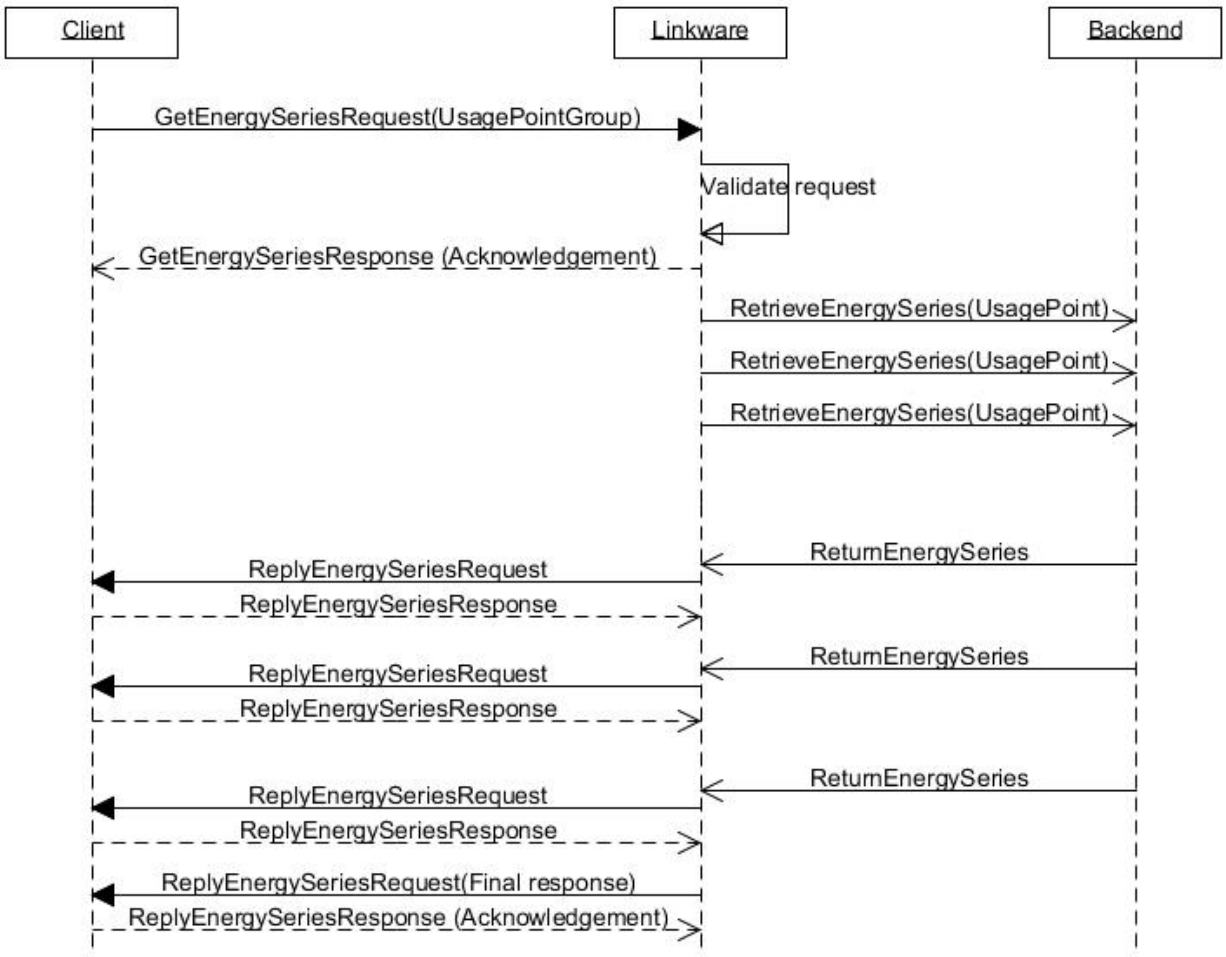
3.1.2 Asynchronous operation

Asynchronous operations are usually executed when a request results or potentially results in a request that is passed to a device in the network. For example reading register values or executing commands in the device results in an asynchronous operation.

Asynchronous responses are delivered by invoking a Web Service specified by the IEC interface specification from the client system. Therefore client systems must implement given Web Service to receive asynchronous responses. The client system end point address for asynchronous responses must be defined in the original request as specified in the chapter 4.

Asynchronous processing ends always with final response that doesn't include a payload, but only a reply element with statistics of the asynchronous processing. In addition the final response communicates the end of the operation processing in the Linkware. Final response uses the same operation and schema as all other reply requests for the given operation.

Following diagram describes retrieval of energy series for a metering point group that contains three metering points. Asynchronous operations are always acknowledged with a response after the message has been validated in Linkware. After that asynchronous request(s) to backend systems / devices are made. When responses are received by Linkware, responses are passed back to the client system that executed the original request. Asynchronous response is actually a synchronous request-response from Linkware to the client system. The client system must acknowledge receival of the reply message.



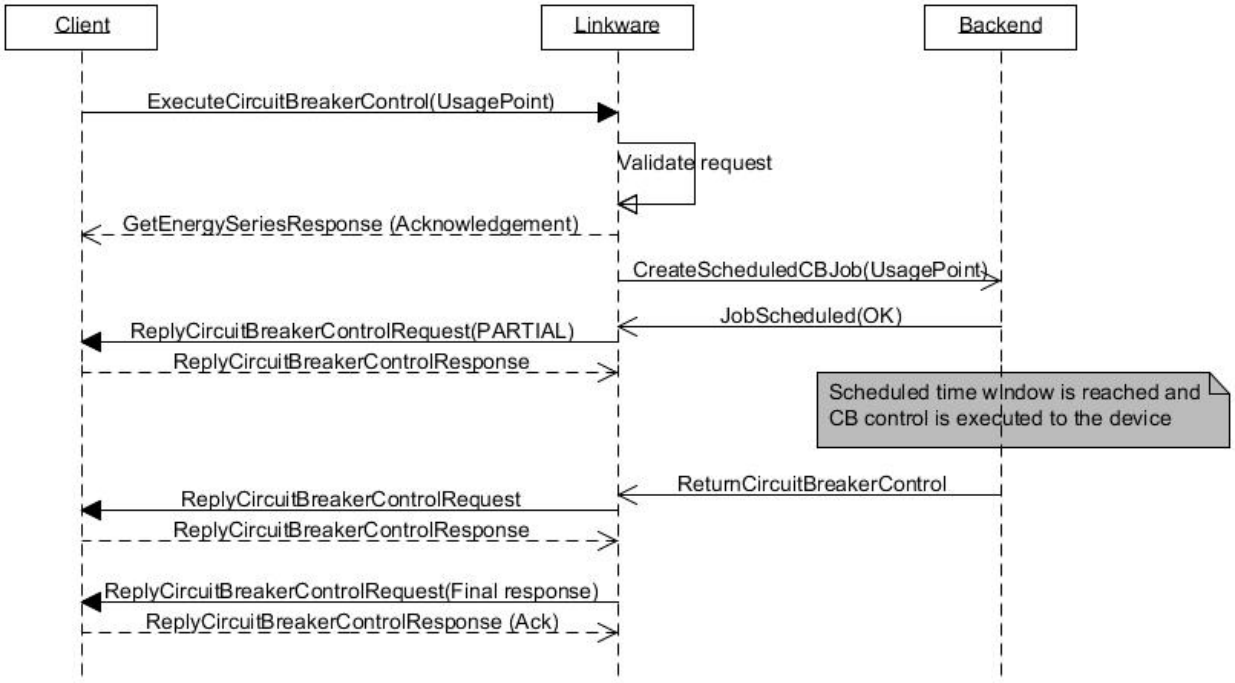
3.1.2.1 Scheduling asynchronous operations

Some IEC Ad Hoc operations allow scheduling commands that will be executed to the device when the specified time window is reached. When scheduling device controls, the execution of the operation is split in three phases:

1. Initial request to schedule the control
2. Asynchronous response to indicate if the scheduling was successful
3. Asynchronous response when the scheduled job is run (including regular final response).

It should be taken into account that the running the job may takes days or even weeks depending on the schedule. The completion of the scheduled job is responded with the specified payload (specific for each operation) and the CorrelationID is the same that was used in the original request.

Following sequence describes a successful asynchronous scheduling operation.



Errors are handled in two way:

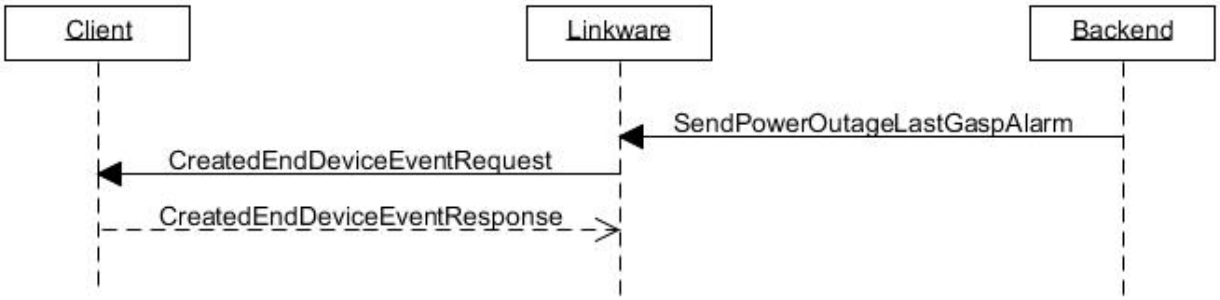
- First asynchronous response will return an error if the scheduling of the control wasn't successful. For example specified time window is in the past.
- Second asynchronous response will return a timeout error if the scheduled control couldn't be run successfully during the specified time window.

3.1.3 Spontaneous events and alarms

Spontaneus events and alarms are sent from Linkware to the client system when a notification or an event is triggered from the network or software systems. For example changes to the core asset data in Gateware may trigger a notification to indicate changed data in the system. Alarms and events sent from devices are also delivered to the client system by Linkware.

Events are delivered by invoking a Web Service specified by the IEC interface specification from the client system. Therefore client systems must implement given Web Service to receive events. Currently client systems that receive events are configured within Linkware, but in the future publish-subscribe scenario is supported.

Following diagram describes last gasp alarm sent from device. The client system must acknowledge the receival of the event in the response message.



4 Messages

All messages are divided into request messages (4.1.4) and response messages (4.3). A request message begins a communication with a service and a response message ends it.

4.1 Common Message Envelope

The common message envelope is the same for all IEC 61968 messages, but it is defined by operation which message parts are used within the operation. In the common message envelope there are optional fields available in the schema, but these are not used by the Linkware. These fields should be omitted from the requests and responses.

Common message envelope may contain following message parts:

Element	Data type	Remarks
Header	HeaderType	The message header contains control and descriptive information about the message. The header is mandatory for all messages.
Reply	ReplyType	Reply package is used to confirm success or report errors. The reply element is present only when replying to requests.
Request	RequestType	Request package is typically used to supply parameters for simple operations such as "get" and "delete". For some search operations the schema may be extended to contain other parameters.
Payload	*PayloadType	The payload and its type is determined by the operation and the noun field in the message header. The possible message payloads are defined in the separate interface specifications for each operation.

4.1.1 Header

The header can be found in all messages.

Element	Data type	Cardinality	Remarks
Verb	xs:string	1..1	Possible values are defined in each interface specification. This enumerated list of verbs that can be used to form message types in compliance with the IEC 61968 standard.
Noun	xs:string	1..1	Possible values are defined in each interface specification The Noun of the Control Area identifies the main subject of the message type, typically a real world object defined in the CIM
Timestamp	xs:dateTime	1..1	Application level relevant time and date for when this instance of the message type was produced. This is not intended to be used by middleware for message management. The time should be in UTC format yyyy-MM-ddTHH:mm:ssZ.

Source	xs:string	1..1	Source identifies the source system that is sending the request. For all messages sent from Linkware the sender is "Aidon Linkware". In the examples a string "Client System" is used for any external system that should identify itself in the Source element.
ReplyAddress	xs:string	0..1	Reply address describes service end point for asynchronous response replies. This element is mandatory for asynchronous operations and it must define the service end point address (not the WSDL).
MessageID	xs:string	1..1	Unique message ID to be used for tracking messages. Unique for each message.
CorrelationID	xs:string	1..1	ID to be used by applications for correlating replies. Unique for each operation.
AccessToken	xs:string	0..1	Access token issued by the system. Access token is used to identify and authorize the client. Access token is mandadory except for IEC Events.
OrganisationID	xs:string	0..1	Specifies organisation identifier in multi-organisation environments. Organisation identifier is globally unique identifier that is generated by Aidon system for an organisation in a given environment. The element is mandatory in multi-organisation environments and optional in single-organisation environments.
UseGuaranteedDelivery	xs:boolean	0..1	Used in asynchronous operations to indicate if the asynchronous response should be sent by using guaranteed delivery methods (retries). See chapter 7.2 for more information. If the parameter is not supplied in the request, the default "false" is used.

4.1.2 Request

Request element may contain following elements. Usage of the elements is described for each operation when applicable.

Element	Data type	Cardinality	Remarks
ID	xs:string	0..*	ID of an identified object. This may be used to query information or perform operations.
ID/@objectType	xs:string	0..1	Object type of an identified object the ID describes. This may be required when a request may contain different kind of IDs.

4.1.3 Reply

A response message contains a reply segment. The Verb in a response message header should be "reply".

Element	Data type	Cardinality	Remarks
Result	string	1..1	Possible values: "OK" or "FAILED". "OK" if the request processing was successful and no errors exist in the Error list. "FAILED" if at least one error occurred and is reported in the Error list.
./Error	ErrorType	1	Possible error(s) for each error that occurred during the processing of the request. If Result is OK, the Error element is included with sub-element code = 0.0
./Error/code	string	1..1	Error code specific to the error that occurred. All possible error codes are described in 5.1. Possible error codes for each operation are listed in the separate interface specifications.
./Error/level	string	1..1	Severity level. Possible values: - WARNING: When the result of the operation is as expected even if the operation didn't execute as anticipated. For example, deleting a device that was already deleted. - FATAL: When the operation couldn't be performed due to an error in the processing or request parameters. - CATASTROPHIC: When the operation failed due to an error that is preventing application to work correctly. For example connectivity issues to the database could be counted as catastrophic failure.
./Error/reason	string	0..1	Description of the error as described in 5.1.
./Error/details	string	0..1	Possible details about the error if available.
./Error/stacktrace	string	0..1	Stack trace as generated by software upon exception

4.1.4 Payload

Payload types are always specified for each operation separately. Payloads may be specified exactly by IEC data model (related CIM model), thay may be extended from IEC model by Aidon or they may be Aidon specific data models. All elements in payload messages that have a cardinality "0..1" or "0..n" are excluded from the response when the value is empty or does not exist.

4.2 Request Message

A request message is sent to the service and a response is message is returned from the service. All requests should be answered by a response message.

In addition to Header a request message must contain either Request or Payload specified by the operation.

4.3 Response Message

A response may be any of the following:

- Synchronous response for the given request with actual response payload
- Synchronous acknowledgement to a request that results in an asynchronous response
- Asynchronous response for the request that was initiated by a separate request

A synchronous response message is returned by a service when it receives a request message. All requests are answered by a corresponding response message immediately after the request is processed.

A synchronous acknowledgement is returned by a service when it receives a request message that results in an asynchronous reply. The acknowledgement is returned immediately as soon as the request is received and validated, but before any processing starts. Validation may be checking the mandatory parameters, but also checking that used data is appropriate for the operation (for example checking that metering point with given ID exists).

An asynchronous response is returned when processing of an operation finishes.

In addition to Header a response message must contain the Reply element and possibly the Payload element.

4.3.1 Acknowledgement response in asynchronous requests

In asynchronous requests the IEC services responds synchronously to acknowledge the receival of the request. The request is validated and synchronous response is sent. Also the external system acknowledges the receival of the asynchronous response message. Both message payloads contain same elements and they use following message structure:

Element	Data type	Cardinality	Description and usage
Header/Verb	xs:string	1	Static "reply"
Header/Noun	xs:string	1	Noun of the request operation. Same that was sent in the request.
Reply		1	
Reply/Result		1	OK, PARTIAL, FAILED. If there are major problems with the request, query will fail immediately and response includes corresponding error message. This behaviour is defined by the error codes the operation may return. For example query for a metering point group with incorrect id may fail immediately. If part of the request can be handled, PARTIAL result is returned and error message can be found for each failed object.

Reply/Error		1	Return Error for each identified object. For example, when querying metering point groups for readings, return error element for each metering point.
./code	xs:string	1	Result code. Code 0.0 is returned for successful executions.
./level	xs:string	1	
./reason	xs:string	0..1	Description of the error

4.3.1.1 Example messages

Successful request acknowledged by Linkware

```
<soap:Envelope xmlns:soap="http://www.w3.org/2003/05/soap-envelope"
               xmlns:met="http://aidon.com/IEC/AdHoc/v1/MeterReadingMessage"
               xmlns:asy="http://aidon.com/IEC/AdHoc/v1/AsyncMessage"
               xmlns:mes="http://iec.ch/TC57/2011/schema/message">
   <soap:Header />
   <soap:Body>
      <met:GetEnergySeriesResponse>
         <asy:Header>
            <mes:Verb>reply</mes:Verb>
            <mes:Noun>MeterReading</mes:Noun>
            <mes:Timestamp>2014-01-01T12:15:00Z</mes:Timestamp>
            <mes:Source>Aidon Linkware</mes:Source>
            <mes:MessageID>795931F9-3DF3-4D2C-A743-AF139041E3FE</mes:MessageID>
            <mes:CorrelationID>6E4496DD-E2F8-4775-A332-
D3DE25B961E9</mes:CorrelationID>
         </asy:Header>
         <asy:Reply>
            <mes:Result>OK</mes:Result>
            <mes:Error>
               <mes:code>0.0</mes:code>
            </mes:Error>
         </asy:Reply>
      </met:GetEnergySeriesResponse>
   </soap:Body>
</soap:Envelope>
```

Successful response acknowledged by an external system

```
<soap:Envelope xmlns:soap="http://www.w3.org/2003/05/soap-envelope"
               xmlns:met="http://aidon.com/IEC/AdHoc/v1/MeterReadingMessage"
               xmlns:asy="http://aidon.com/IEC/AdHoc/v1/AsyncMessage"
               xmlns:mes="http://iec.ch/TC57/2011/schema/message">
   <soap:Header />
   <soap:Body>
      <met:ReplyEnergySeriesResponse>
         <asy:Header>
            <mes:Verb>reply</mes:Verb>
            <mes:Noun>MeterReading</mes:Noun>
            <mes:Timestamp>2014-01-01T12:15:00Z</mes:Timestamp>
            <mes:Source>Client System</mes:Source>
            <mes:MessageID>795931F9-3DF3-4D2C-A743-AF139041DDAF</mes:MessageID>
```

```
            <mes:CorrelationID>6E4496DD-E2F8-4775-A332-
D3DE25B961E9</mes:CorrelationID>
         </asy:Header>
         <asy:Reply>
            <mes:Result>OK</mes:Result>
            <mes:Error>
               <mes:code>0.0</mes:code>
            </mes:Error>
         </asy:Reply>
      </met:ReplyEnergySeriesResponse>
   </soap:Body>
</soap:Envelope>
```

Unsuccessful request an asynchronous service acknowledged by Linkware

```
<soap:Envelope xmlns:soap="http://www.w3.org/2003/05/soap-envelope"
               xmlns:met="http://aidon.com/IEC/AdHoc/v1/MeterReadingMessage"
               xmlns:asy="http://aidon.com/IEC/AdHoc/v1/AsyncMessage"
               xmlns:mes="http://iec.ch/TC57/2011/schema/message">
   <soap:Header />
   <soap:Body>
      <met:GetEnergySeriesResponse>
         <asy:Header>
            <mes:Verb>reply</mes:Verb>
            <mes:Noun>MeterReading</mes:Noun>
            <mes:Timestamp>2014-01-01T12:15:00Z</mes:Timestamp>
            <mes:Source>Aidon Linkware</mes:Source>
            <mes:MessageID>795931F9-3DF3-4D2C-A743-AF139041E3FE</mes:MessageID>
            <mes:CorrelationID>6E4496DD-E2F8-4775-A332-
D3DE25B961E9</mes:CorrelationID>
         </asy:Header>
         <asy:Reply>
            <mes:Result>FAILED</mes:Result>
            <mes:Error>
               <mes:code>2.1</mes:code>
               <mes:level>FATAL</mes:level>
               <mes:reason>Usage point not found</mes:reason>
            </mes:Error>
         </asy:Reply>
      </met:GetEnergySeriesResponse>
   </soap:Body>
</soap:Envelope>
```

4.3.2 Partial responses in asynchronous processing

In asynchronous operations reply messages are delivered to the client as they are processed in the Linkware. These reply messages contains the actual payload for each operation to each individual entity (for example one response message for a metering point that contains requested energy series). These partial responses are returned with a result code PARTIAL and their Error/code element contains 0.0 on success and other error code in erroneous execution. Possible error codes are defined for each operation in their specification documentation.

Element	Data type	Cardinality	Description and usage
Header/Verb	xs:string	1	Static “reply”
Header/Noun	xs:string	1	Noun of the request operation. Same that was sent in the request.

Reply		1	
./Result	xs:string	1	Static "PARTIAL". The result is fixed in partial responses and the Error/code returns a code to describe if the request for the given entity was successful.
./Error	ErrorType	1	Possible error that occurred during the processing of the request. If there were no errors the code is "0.0"
./Error/code	xs:string	1..1	Error code specific to the error that occurred. All possible error codes are described in 5.1. Possible error codes for each operation are listed in the separate interface specifications.
./ID	xs:string	1	Identifier for the entity in question
./ID/@objectType	xs:string	1	Object type of the entity, for example UsagePoint.

4.3.3 Final response in asynchronous processing

In asynchronous operations reply messages are delivered to the client as they are processed in the Linkware. After the all reply messages are processed and sent Linkware sends a final reply response without any payload to the client to indicate that the processing has finished and all the responses are delivered. The reply element in this case includes the number of processed messages.

Element	Data type	Cardinality	Description and usage
Header/Verb	xs:string	1	Static "reply"
Header/Noun	xs:string	1	Noun of the request operation. Same that was sent in the request.
Reply		1	
Reply/Result		1	OK, FAILED. If there were any partial responses with an error code different than 0.0, the final response contains result FAILED. Otherwise the result is OK.
Reply/sentResponses	xs:int	1	Number of partial reply responses sent with this operation (identified by CorrelationID). This usually corresponds for example the number of metering points that were included in the request.

4.4 Modifying data

Modifying data using Linkware IEC interfaces follows principles described in this chapter.

4.4.1 Create operations

Operations that create new entities into Aidon systems will usually contain same payload as get operations would produce. Following rules apply to the create payloads:

- When there is a mandatory element mRID, the operation expects predefined identifiers for the given entity. For example metering points and devices have predefined mRID identifiers.
- When there are optional elements in the schema, client may leave these out from the creation message. It is defined in each payload and/or operation if there are any default values used for optional elements.

4.4.2 Change operations

Operations that change data in Aidon systems will usually contain same payload as get operation would produce. Following rules apply to the change payloads:

- Only those elements are updated which are sent in the request payload of a change operation
- For update operations there usually are no mandatory elements in the schema.
- Deleting single pieces of information is done by using nil="true" attribute in the element. Nillable elements are described by XML Schema attribute "nillable=true".

4.4.3 Delete operations

Delete operations change entity statuses as archived in Aidon systems and those entities will not be available in most interface operations except for those that retrieve data from timeperiod that the entity was still active.

4.5 Commonly used values

4.5.1 Meter reading types

The measurement values ("Readings") returned in the ad hoc commands contain ReadingType field which can be mapped to the measured register. The possible ReadingTypes are listed below and further explained in IEC 61968-9 ed 2.0 annex C.

ReadingType	Description	Unit
0.0.0.1.1.1.12.0.0.0.0.0.0.0.3.72.0	Active positive (forward) register (A+).	kWh
0.0.0.1.19.1.12.0.0.0.0.0.0.0.3.72.0	Active negative (reverse) register (A-).	kWh
0.0.0.1.1.1.12.0.0.0.0.0.0.0.3.73.0	Reactive positive (forward) register (R+).	kVArh
0.0.0.1.19.1.12.0.0.0.0.0.0.0.3.73.0	Reactive negative (reverse) register (R-).	kVArh
0.0.0.1.1.1.12.0.0.0.0.1.0.0.0.3.72.0	Tariff register 1 (T1), A+.	kWh
0.0.0.1.1.1.12.0.0.0.0.2.0.0.0.3.72.0	Tariff register 2 (T2), A+.	kWh
0.0.0.1.1.1.12.0.0.0.0.3.0.0.0.3.72.0	Tariff register 3 (T3), A+.	kWh
0.0.0.1.1.1.12.0.0.0.0.4.0.0.0.3.72.0	Tariff register 4 (T4), A+.	kWh

0.0.0.6.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 momentary voltage.	V
0.0.0.6.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 momentary voltage.	V
0.0.0.6.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 momentary voltage.	V
0.0.0.6.0.1.4.0.0.0.0.0.0.0.128.0.5.0	Phase L1 momentary current.	A
0.0.0.6.0.1.4.0.0.0.0.0.0.0.64.0.5.0	Phase L2 momentary current.	A
0.0.0.6.0.1.4.0.0.0.0.0.0.0.32.0.5.0	Phase L3 momentary current.	A
0.0.0.6.0.1.54.0.0.0.0.0.0.0.129.0.29.0	Voltage level L1-N	V
0.0.0.6.0.1.54.0.0.0.0.0.0.0.65.0.29.0	Voltage level L2-N	V
0.0.0.6.0.1.54.0.0.0.0.0.0.0.33.0.29.0	Voltage level L3-N	V
0.0.0.6.0.1.54.0.0.0.0.0.0.0.132.0.29.0	Voltage level L1-L2	V
0.0.0.6.0.1.54.0.0.0.0.0.0.0.66.0.29.0	Voltage level L2-L3	V
0.0.0.6.0.1.54.0.0.0.0.0.0.0.40.0.29.0	Voltage level L3-L1	V
0.2.1.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 10 minute average voltage.	V
0.2.1.9.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 10 minute average voltage.	V
0.2.1.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 10 minute average voltage.	V
0.0.0.6.0.1.4.0.0.0.0.0.0.0.17.0.5.0	Momentary earth fault current.	A
0.9.0.6.0.1.41.0.0.0.0.0.0.0.128.0.29.0	Phase L1 dip	V
0.9.0.6.0.1.41.0.0.0.0.0.0.0.64.0.29.0	Phase L2 dip	V
0.9.0.6.0.1.41.0.0.0.0.0.0.0.32.0.29.0	Phase L3 dip	V
0.8.0.6.0.1.42.0.0.0.0.0.0.0.128.0.29.0	Phase L1 swell	V
0.8.0.6.0.1.42.0.0.0.0.0.0.0.64.0.29.0	Phase L2 swell	V
0.8.0.6.0.1.42.0.0.0.0.0.0.0.32.0.29.0	Phase L3 swell	V
0.0.0.6.0.1.38.0.0.0.0.0.0.0.128.0.0.0	Momentary power factor L1	N/A
0.0.0.6.0.1.38.0.0.0.0.0.0.0.64.0.0.0	Momentary power factor L2	N/A
0.0.0.6.0.1.38.0.0.0.0.0.0.0.32.0.0.0	Momentary power factor L3	N/A
0.0.0.6.0.1.47.0.0.0.0.0.0.0.128.0.0.0	Momentary phase L1 THD%	%
0.0.0.6.0.1.47.0.0.0.0.0.0.0.64.0.0.0	Momentary phase L2 THD%	%
0.0.0.6.0.1.47.0.0.0.0.0.0.0.32.0.0.0	Momentary phase L3 THD%	%
0.0.0.1.15.1.12.0.0.0.0.0.0.0.3.73.0	Reactive energy Q1	kVArh
0.0.0.1.16.1.12.0.0.0.0.0.0.0.3.73.0	Reactive energy Q2	kVArh
0.0.0.1.17.1.12.0.0.0.0.0.0.0.3.73.0	Reactive energy Q3	kVArh
0.0.0.1.18.1.12.0.0.0.0.0.0.0.3.73.0	Reactive energy Q4	kVArh
0.0.0.6.0.1.37.0.0.0.0.0.0.0.224.0.61.0	Apparent total power L1+L2+L3	VA
0.0.0.6.0.1.37.0.0.0.0.0.0.0.128.3.38.0	Phase L1 active power	kW
0.0.0.6.0.1.37.0.0.0.0.0.0.0.64.3.38.0	Phase L2 active power	kW
0.0.0.6.0.1.37.0.0.0.0.0.0.0.32.3.38.0	Phase L3 active power	kW
0.0.0.6.0.1.37.0.0.0.0.0.0.0.128.3.63.0	Phase L1 reactive power	kVAr
0.0.0.6.0.1.37.0.0.0.0.0.0.0.64.3.63.0	Phase L2 reactive power	kVAr

0.0.0.6.0.1.37.0.0.0.0.0.0.0.32.3.63.0	Phase L3 reactive power	kVAr
0.0.0.6.1.1.37.0.0.0.0.0.0.0.224.3.38.0	A+ total power L1+L2+L3	kW
0.0.0.6.1.1.37.0.0.0.0.0.0.0.224.3.63.0	R+ total power L1+L2+L3	kVAr
0.0.0.6.19.1.37.0.0.0.0.0.0.0.224.3.38.0	A- total power L1+L2+L3	kW
0.0.0.6.19.1.37.0.0.0.0.0.0.0.224.3.63.0	R- total power L1+L2+L3	kVAr
0.0.0.6.0.1.15.0.0.0.0.0.0.0.0.33.0	Frequency	Hz
0.0.0.1.0.7.58.0.0.0.0.0.0.0.0.42.0	Volume (Gas)	m^3
0.0.0.1.0.9.58.0.0.0.0.0.0.0.0.42.0	Volume (Potable water)	m^3
0.0.0.6.0.9.155.0.0.0.0.0.0.0.0.125.0	Flow (Potable water)	m^3/h
0.0.0.1.0.12.12.0.0.0.0.0.0.0.6.72.0	Thermal Energy E1 (heating)	Wh
0.0.0.1.0.12.58.0.0.0.0.0.0.0.0.42.0	Volume (heating)	m^3
0.0.0.6.1.12.46.0.0.0.0.0.0.0.0.23.0	Temperature in (heating)	°C
0.0.0.6.19.12.46.0.0.0.0.0.0.0.0.23.0	Temperature out (heating)	°C
0.0.0.4.0.12.46.0.0.0.0.0.0.0.0.23.0	Temperature delta (heating)	°C
0.0.0.6.0.12.155.0.0.0.0.0.0.0.0.125.0	Flow (heating)	m^3/h
0.0.0.1.0.13.12.0.0.0.0.0.0.0.6.72.0	Thermal Energy E1 (cooling)	Wh
0.0.0.1.0.13.58.0.0.0.0.0.0.0.0.42.0	Volume (cooling)	m^3
0.0.0.6.1.13.46.0.0.0.0.0.0.0.0.23.0	Temperature in (cooling)	°C
0.0.0.6.19.13.46.0.0.0.0.0.0.0.0.23.0	Temperature out (cooling)	°C
0.0.0.4.0.13.46.0.0.0.0.0.0.0.0.23.0	Temperature delta (cooling)	°C
0.0.0.6.0.13.155.0.0.0.0.0.0.0.0.125.0	Flow (cooling)	m^3/h
0.0.0.1.0.41.11.0.0.0.0.0.0.0.0.27.0	Operational time of the device	s
0.0.0.6.0.41.123.0.0.0.0.0.0.0.0.0.0	Device information	N/A

4.5.2 Voltage quality reading types

ReadingType	Description	Unit
0.8.4.6.0.1.4.0.0.0.0.0.0.0.17.0.5.0	Daily maximum earth fault current	A
0.2.1.6.0.1.4.0.0.0.0.0.0.0.17.0.5.0	10 minute average earth fault current	A
0.2.2.6.0.1.4.0.0.0.0.0.0.0.17.0.5.0	15 minute average earth fault current	A
0.2.5.6.0.1.4.0.0.0.0.0.0.0.17.0.5.0	30 minute average earth fault current	A
0.2.7.6.0.1.4.0.0.0.0.0.0.0.17.0.5.0	60 minute average earth fault current	A
0.8.1.6.0.1.4.0.0.0.0.0.0.0.17.0.5.0	Maximum earth fault current on 10 minute period	A
0.8.2.6.0.1.4.0.0.0.0.0.0.0.17.0.5.0	Maximum earth fault current on 15 minute period	A
0.8.5.6.0.1.4.0.0.0.0.0.0.0.17.0.5.0	Maximum earth fault current on 30 minute period	A
0.8.7.6.0.1.4.0.0.0.0.0.0.0.17.0.5.0	Maximum earth fault current on 60 minute period	A

9011.9002.3.9.1.1.8.0.0.0.0.0.0.0.224.3.38.0	1 min peak active demand on 1h period	kW
9012.9002.3.9.1.1.8.0.0.0.0.0.0.0.224.3.38.0	1 min peak active demand on 2h period	kW
9013.9002.3.9.1.1.8.0.0.0.0.0.0.0.224.3.38.0	1 min peak active demand on 3h period	kW
9014.9002.3.9.1.1.8.0.0.0.0.0.0.0.224.3.38.0	1 min peak active demand on 4h period	kW
0.26.7.9.0.1.9003.0.0.0.0.0.0.0.128.0.111.0	Phase L1 samples over 115%	pcs
0.26.7.9.0.1.9004.0.0.0.0.0.0.0.128.0.111.0	Phase L1 samples 110-115%	pcs
0.26.7.9.0.1.9005.0.0.0.0.0.0.0.128.0.111.0	Phase L1 samples 105-110%	pcs
0.26.7.9.0.1.9006.0.0.0.0.0.0.0.128.0.111.0	Phase L1 samples Un-105%	pcs
0.26.7.9.0.1.9007.0.0.0.0.0.0.0.128.0.111.0	Phase L1 samples 95%-Un	pcs
0.26.7.9.0.1.9008.0.0.0.0.0.0.0.128.0.111.0	Phase L1 samples 90-95%	pcs
0.26.7.9.0.1.9009.0.0.0.0.0.0.0.128.0.111.0	Phase L1 samples 85-90%	pcs
0.26.7.9.0.1.9010.0.0.0.0.0.0.0.128.0.111.0	Phase L1 samples phase missing limit - 85%	pcs
0.2.7.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 voltage over period (1h)	V
0.2.79.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 voltage over period (2h)	V
0.2.83.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 voltage over period (3h)	V
0.2.80.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 voltage over period (4h)	V
9011.9001.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 minimum 1 minute average voltage on 1h period	V
9012.9001.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 minimum 1 minute average voltage on 2h period	V
9013.9001.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 minimum 1 minute average voltage on 3h period	V
9014.9001.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 minimum 1 minute average voltage on 4h period	V
9011.9002.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 maximum 1 minute average voltage on 1h period	V
9012.9002.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 maximum 1 minute average voltage on 2h period	V
9013.9002.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 maximum 1 minute average voltage on 3h period	V
9014.9002.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 maximum 1 minute average voltage on 4h period	V
0.26.7.9.0.1.9003.0.0.0.0.0.0.0.64.0.111.0	Phase L2 samples over 115%	pcs
0.26.7.9.0.1.9004.0.0.0.0.0.0.0.64.0.111.0	Phase L2 samples 110-115%	pcs

0.26.7.9.0.1.9005.0.0.0.0.0.0.64.0.111.0	Phase L2 samples 105-110%	pcs
0.26.7.9.0.1.9006.0.0.0.0.0.0.64.0.111.0	Phase L2 samples Un-105%	pcs
0.26.7.9.0.1.9007.0.0.0.0.0.0.64.0.111.0	Phase L2 samples 95%-Un	pcs
0.26.7.9.0.1.9008.0.0.0.0.0.0.64.0.111.0	Phase L2 samples 90-95%	pcs
0.26.7.9.0.1.9009.0.0.0.0.0.0.64.0.111.0	Phase L2 samples 85-90%	pcs
0.26.7.9.0.1.9010.0.0.0.0.0.0.64.0.111.0	Phase L2 samples phase missing limit - 85%	pcs
0.2.7.9.0.1.54.0.0.0.0.0.0.64.0.29.0	Phase L2 voltage over period (1h)	V
0.2.79.9.0.1.54.0.0.0.0.0.0.64.0.29.0	Phase L2 voltage over period (2h)	V
0.2.83.9.0.1.54.0.0.0.0.0.0.64.0.29.0	Phase L2 voltage over period (3h)	V
0.2.80.9.0.1.54.0.0.0.0.0.0.64.0.29.0	Phase L2 voltage over period (4h)	V
9011.9001.3.9.0.1.54.0.0.0.0.0.0.64.0.29.0	Phase L2 minimum 1 minute average voltage on 1h period	V
9012.9001.3.9.0.1.54.0.0.0.0.0.0.64.0.29.0	Phase L2 minimum 1 minute average voltage on 2h period	V
9013.9001.3.9.0.1.54.0.0.0.0.0.0.64.0.29.0	Phase L2 minimum 1 minute average voltage on 3h period	V
9014.9001.3.9.0.1.54.0.0.0.0.0.0.64.0.29.0	Phase L2 minimum 1 minute average voltage on 4h period	V
9011.9002.3.9.0.1.54.0.0.0.0.0.0.64.0.29.0	Phase L2 maximum 1 minute average voltage on 1h period	V
9012.9002.3.9.0.1.54.0.0.0.0.0.0.64.0.29.0	Phase L2 maximum 1 minute average voltage on 2h period	V
9013.9002.3.9.0.1.54.0.0.0.0.0.0.64.0.29.0	Phase L2 maximum 1 minute average voltage on 3h period	V
9014.9002.3.9.0.1.54.0.0.0.0.0.0.64.0.29.0	Phase L2 maximum 1 minute average voltage on 4h period	V
0.26.7.9.0.1.9003.0.0.0.0.0.0.32.0.111.0	Phase L3 samples over 115%	pcs
0.26.7.9.0.1.9004.0.0.0.0.0.0.32.0.111.0	Phase L3 samples 110-115%	pcs
0.26.7.9.0.1.9005.0.0.0.0.0.0.32.0.111.0	Phase L3 samples 105-110%	pcs
0.26.7.9.0.1.9006.0.0.0.0.0.0.32.0.111.0	Phase L3 samples Un-105%	pcs
0.26.7.9.0.1.9007.0.0.0.0.0.0.32.0.111.0	Phase L3 samples 95%-Un	pcs
0.26.7.9.0.1.9008.0.0.0.0.0.0.32.0.111.0	Phase L3 samples 90-95%	pcs
0.26.7.9.0.1.9009.0.0.0.0.0.0.32.0.111.0	Phase L3 samples 85-90%	pcs
0.26.7.9.0.1.9010.0.0.0.0.0.0.32.0.111.0	Phase L3 samples phase missing limit - 85%	pcs
0.2.7.9.0.1.54.0.0.0.0.0.0.32.0.29.0	Phase L3 voltage over period (1h)	V
0.2.79.9.0.1.54.0.0.0.0.0.0.32.0.29.0	Phase L3 voltage over period (2h)	V
0.2.83.9.0.1.54.0.0.0.0.0.0.32.0.29.0	Phase L3 voltage over period (3h)	V
0.2.80.9.0.1.54.0.0.0.0.0.0.32.0.29.0	Phase L3 voltage over period (4h)	V
9011.9001.3.9.0.1.54.0.0.0.0.0.0.32.0.29.0	Phase L3 minimum 1 minute average voltage on 1h period	V
9012.9001.3.9.0.1.54.0.0.0.0.0.0.32.0.29.0	Phase L3 minimum 1 minute average voltage on 2h period	V

9013.9001.3.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 minimum 1 minute average voltage on 3h period	V
9014.9001.3.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 minimum 1 minute average voltage on 4h period	V
9011.9002.3.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 maximum 1 minute average voltage on 1h period	V
9012.9002.3.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 maximum 1 minute average voltage on 2h period	V
9013.9002.3.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 maximum 1 minute average voltage on 3h period	V
9014.9002.3.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 maximum 1 minute average voltage on 4h period	V
0.2.1.0.1.1.8.0.0.0.0.0.0.0.224.3.38.0	10 minute average active demand (total)	kW
0.2.1.0.1.1.8.0.0.0.0.0.0.0.224.3.63.0	10 minute average reactive (inductive) demand (total)	kVAr
0.2.1.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 10 minute average voltage	V
0.2.1.9.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 10 minute average voltage	V
0.2.1.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 10 minute average voltage	V
0.2.2.0.1.1.8.0.0.0.0.0.0.0.224.3.38.0	15 minute average active demand (total)	kW
0.2.2.0.1.1.8.0.0.0.0.0.0.0.224.3.63.0	15 minute average reactive (inductive) demand (total)	kVAr
0.2.2.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 15 minute average voltage	V
0.2.2.9.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 15 minute average voltage	V
0.2.2.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 15 minute average voltage	V
0.2.5.0.1.1.8.0.0.0.0.0.0.0.224.3.38.0	30 minute average active demand (total)	kW
0.2.5.0.1.1.8.0.0.0.0.0.0.0.224.3.63.0	30 minute average reactive (inductive) demand (total)	kVAr
0.2.5.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 30 minute average voltage	V
0.2.5.9.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 30 minute average voltage	V
0.2.5.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 30 minute average voltage	V
0.2.7.0.1.1.8.0.0.0.0.0.0.0.224.3.38.0	60 minute average active demand (total)	kW
0.2.7.0.1.1.8.0.0.0.0.0.0.0.224.3.63.0	60 minute average reactive (inductive) demand (total)	kVAr
0.2.7.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 60 minute average voltage	V
0.2.7.9.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 60 minute average voltage	V
0.2.7.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 60 minute average voltage	V
9015.9001.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 minimum 1 minute average voltage on 10min period	V
9015.9001.3.9.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 minimum 1 minute average voltage on 10min period	V
9015.9001.3.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 minimum 1 minute average voltage on 10min period	V

9015.9002.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 maximum 1 minute average voltage on 10min period	V
9015.9002.3.9.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 maximum 1 minute average voltage on 10min period	V
9015.9002.3.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 maximum 1 minute average voltage on 10min period	V
9016.9001.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 minimum 1 minute average voltage on 15min period	V
9016.9001.3.9.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 minimum 1 minute average voltage on 15min period	V
9016.9001.3.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 minimum 1 minute average voltage on 15min period	V
9016.9002.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 maximum 1 minute average voltage on 15min period	V
9016.9002.3.9.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 maximum 1 minute average voltage on 15min period	V
9016.9002.3.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 maximum 1 minute average voltage on 15min period	V
9017.9001.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 minimum 1 minute average voltage on 30min period	V
9017.9001.3.9.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 minimum 1 minute average voltage on 30min period	V
9017.9001.3.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 minimum 1 minute average voltage on 30min period	V
9017.9002.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 maximum 1 minute average voltage on 30min period	V
9017.9002.3.9.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 maximum 1 minute average voltage on 30min period	V
9017.9002.3.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 maximum 1 minute average voltage on 30min period	V
9011.9001.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 minimum 1 minute average voltage on 1h period	V
9011.9001.3.9.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 minimum 1 minute average voltage on 1h period	V
9011.9001.3.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 minimum 1 minute average voltage on 1h period	V
9011.9002.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 maximum 1 minute average voltage on 1h period	V
9011.9002.3.9.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 maximum 1 minute average voltage on 1h period	V
9011.9002.3.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 maximum 1 minute average voltage on 1h period	V
0.0.3.1.1.1.8.0.0.0.0.0.0.0.224.3.38.0	1 minute active demand (total)	kW
0.0.3.1.1.1.8.0.0.0.0.0.0.0.224.3.63.0	1 minute reactive (inductive) demand (total)	kVAr
0.2.3.9.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 1 minute average voltage	V
0.2.3.9.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 1 minute average voltage	V

0.2.3.9.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 1 minute average voltage	V
0.9.3.12.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 voltage sample min	V
0.9.3.12.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 voltage sample min	V
0.9.3.12.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 voltage sample min	V
0.8.3.12.0.1.54.0.0.0.0.0.0.0.128.0.29.0	Phase L1 voltage sample max	V
0.8.3.12.0.1.54.0.0.0.0.0.0.0.64.0.29.0	Phase L2 voltage sample max	V
0.8.3.12.0.1.54.0.0.0.0.0.0.0.32.0.29.0	Phase L3 voltage sample max	V
0.2.1.9.0.1.47.0.0.0.0.0.0.0.128.0.0.0	Phase L1 10 minute average THD%	%
0.2.1.9.0.1.47.0.0.0.0.0.0.0.64.0.0.0	Phase L2 10 minute average THD%	%
0.2.1.9.0.1.47.0.0.0.0.0.0.0.32.0.0.0	Phase L3 10 minute average THD%	%
0.2.1.9.0.1.47.3.1.0.0.0.0.0.128.0.29.0	Phase L1 3. harmonics 10 minutes voltage average	V
0.2.1.9.0.1.47.5.1.0.0.0.0.0.128.0.29.0	Phase L1 5. harmonics 10 minutes voltage average	V
0.2.1.9.0.1.47.7.1.0.0.0.0.0.128.0.29.0	Phase L1 7. harmonics 10 minutes voltage average	V
0.2.1.9.0.1.47.3.1.0.0.0.0.0.64.0.29.0	Phase L2 3. harmonics 10 minutes voltage average	V
0.2.1.9.0.1.47.5.1.0.0.0.0.0.64.0.29.0	Phase L2 5. harmonics 10 minutes voltage average	V
0.2.1.9.0.1.47.7.1.0.0.0.0.0.64.0.29.0	Phase L2 7. harmonics 10 minutes voltage average	V
0.2.1.9.0.1.47.3.1.0.0.0.0.0.32.0.29.0	Phase L3 3. harmonics 10 minutes voltage average	V
0.2.1.9.0.1.47.5.1.0.0.0.0.0.32.0.29.0	Phase L3 5. harmonics 10 minutes voltage average	V
0.2.1.9.0.1.47.7.1.0.0.0.0.0.32.0.29.0	Phase L3 7. harmonics 10 minutes voltage average	V
0.2.1.9.0.1.15.0.0.0.0.0.0.0.0.33.0	10 minute frequency average	Hz
0.2.4.9.0.1.47.0.0.0.0.0.0.0.128.0.0.0	Phase L1 average THD%	%
11.9.54.9.0.1.47.0.0.0.0.0.0.0.128.0.0.0	Phase L1 minimum 10 minute average THD%	%
11.8.54.9.0.1.47.0.0.0.0.0.0.0.128.0.0.0	Phase L1 maximum 10 minute average THD%	%
11.9.54.9.0.1.47.3.1.0.0.0.0.0.128.0.29.0	Phase L1 minimum 3. harmonics 10 minutes voltage average	V
11.9.54.9.0.1.47.5.1.0.0.0.0.0.128.0.29.0	Phase L1 minimum 5. harmonics 10 minutes voltage average	V
11.9.54.9.0.1.47.7.1.0.0.0.0.0.128.0.29.0	Phase L1 minimum 7. harmonics 10 minutes voltage average	V
11.8.54.9.0.1.47.3.1.0.0.0.0.0.128.0.29.0	Phase L1 maximum 3. harmonics 10 minutes voltage average	V
11.8.54.9.0.1.47.5.1.0.0.0.0.0.128.0.29.0	Phase L1 maximum 5. harmonics 10 minutes voltage average	V
11.8.54.9.0.1.47.7.1.0.0.0.0.0.128.0.29.0	Phase L1 maximum 7. harmonics 10 minutes voltage average	V

0.2.4.9.0.1.47.0.0.0.0.0.0.0.64.0.0.0	Phase L2 average THD%	%
11.9.54.9.0.1.47.0.0.0.0.0.0.0.64.0.0.0	Phase L2 minimum 10 minute average THD%	%
11.8.54.9.0.1.47.0.0.0.0.0.0.0.64.0.0.0	Phase L2 maximum 10 minute average THD%	%
11.9.54.9.0.1.47.3.1.0.0.0.0.0.64.0.29.0	Phase L2 minimum 3. harmonics 10 minutes voltage average	V
11.9.54.9.0.1.47.5.1.0.0.0.0.0.64.0.29.0	Phase L2 minimum 5. harmonics 10 minutes voltage average	V
11.9.54.9.0.1.47.7.1.0.0.0.0.0.64.0.29.0	Phase L2 minimum 7. harmonics 10 minutes voltage average	V
11.8.54.9.0.1.47.3.1.0.0.0.0.0.64.0.29.0	Phase L2 maximum 3. harmonics 10 minutes voltage average	V
11.8.54.9.0.1.47.5.1.0.0.0.0.0.64.0.29.0	Phase L2 maximum 5. harmonics 10 minutes voltage average	V
11.8.54.9.0.1.47.7.1.0.0.0.0.0.64.0.29.0	Phase L2 maximum 7. harmonics 10 minutes voltage average	V
0.2.4.9.0.1.47.0.0.0.0.0.0.0.32.0.0.0	Phase L3 average THD%	%
11.9.54.9.0.1.47.0.0.0.0.0.0.0.32.0.0.0	Phase L3 minimum 10 minute average THD%	%
11.8.54.9.0.1.47.0.0.0.0.0.0.0.32.0.0.0	Phase L3 maximum 10 minute average THD%	%
11.9.54.9.0.1.47.3.1.0.0.0.0.0.32.0.29.0	Phase L3 minimum 3. harmonics 10 minutes voltage average	V
11.9.54.9.0.1.47.5.1.0.0.0.0.0.32.0.29.0	Phase L3 minimum 5. harmonics 10 minutes voltage average	V
11.9.54.9.0.1.47.7.1.0.0.0.0.0.32.0.29.0	Phase L3 minimum 7. harmonics 10 minutes voltage average	V
11.8.54.9.0.1.47.3.1.0.0.0.0.0.32.0.29.0	Phase L3 maximum 3. harmonics 10 minutes voltage average	V
11.8.54.9.0.1.47.5.1.0.0.0.0.0.32.0.29.0	Phase L3 maximum 5. harmonics 10 minutes voltage average	V
11.8.54.9.0.1.47.7.1.0.0.0.0.0.32.0.29.0	Phase L3 maximum 7. harmonics 10 minutes voltage average	V
11.9.54.9.0.1.47.0.0.0.0.0.0.0.128.0.33.0	Minimum 10 minute frequency average	Hz
11.8.54.9.0.1.47.0.0.0.0.0.0.0.128.0.33.0	Maximum 10 minute frequency average	Hz
0.2.1.0.1.1.8.0.0.0.0.0.0.0.224.3.38.0	10 minute average active demand (total)	kW
0.2.2.0.1.1.8.0.0.0.0.0.0.0.224.3.38.0	15 minute average active demand (total)	kW
0.2.5.0.1.1.8.0.0.0.0.0.0.0.224.3.38.0	30 minute average active demand (total)	kW
0.2.7.0.1.1.8.0.0.0.0.0.0.0.224.3.38.0	60 minute average active demand (total)	kW
9015.9002.3.9.1.1.8.0.0.0.0.0.0.0.224.3.38.0	Maximum 1 minute average active demand (total) on 10 min period	kW
9016.9002.3.9.1.1.8.0.0.0.0.0.0.0.224.3.38.0	Maximum 1 minute average active demand (total) on 15 min period	kW
9017.9002.3.9.1.1.8.0.0.0.0.0.0.0.224.3.38.0	Maximum 1 minute average active demand (total) on 30 min period	kW
9011.9002.3.9.1.1.8.0.0.0.0.0.0.0.224.3.38.0	Maximum 1 minute average active demand (total) on 60 min period	kW

9015.9001.3.9.1.1.8.0.0.0.0.0.0.224.3.38.0	Minimum 1 minute average active demand (total) on 10 min period	kW
9016.9001.3.9.1.1.8.0.0.0.0.0.0.224.3.38.0	Minimum 1 minute average active demand (total) on 15 min period	kW
9017.9001.3.9.1.1.8.0.0.0.0.0.0.224.3.38.0	Minimum 1 minute average active demand (total) on 30 min period	kW
9011.9001.3.9.1.1.8.0.0.0.0.0.0.224.3.38.0	Minimum 1 minute average active demand (total) on 60 min period	kW
9015.9001.3.9.0.1.4.0.0.0.0.0.0.128.0.5.0	Phase L1 minimum 1 minute average current on 10 min period	A
9016.9001.3.9.0.1.4.0.0.0.0.0.0.128.0.5.0	Phase L1 minimum 1 minute average current on 15 min period	A
9017.9001.3.9.0.1.4.0.0.0.0.0.0.128.0.5.0	Phase L1 minimum 1 minute average current on 30 min period	A
9011.9001.3.9.0.1.4.0.0.0.0.0.0.128.0.5.0	Phase L1 minimum 1 minute average current on 60 min period	A
9015.9001.3.9.0.1.4.0.0.0.0.0.0.64.0.5.0	Phase L2 minimum 1 minute average current on 10 min period	A
9016.9001.3.9.0.1.4.0.0.0.0.0.0.64.0.5.0	Phase L2 minimum 1 minute average current on 15 min period	A
9017.9001.3.9.0.1.4.0.0.0.0.0.0.64.0.5.0	Phase L2 minimum 1 minute average current on 30 min period	A
9011.9001.3.9.0.1.4.0.0.0.0.0.0.64.0.5.0	Phase L2 minimum 1 minute average current on 60 min period	A
9015.9001.3.9.0.1.4.0.0.0.0.0.0.32.0.5.0	Phase L3 minimum 1 minute average current on 10 min period	A
9016.9001.3.9.0.1.4.0.0.0.0.0.0.32.0.5.0	Phase L3 minimum 1 minute average current on 15 min period	A
9017.9001.3.9.0.1.4.0.0.0.0.0.0.32.0.5.0	Phase L3 minimum 1 minute average current on 30 min period	A
9011.9001.3.9.0.1.4.0.0.0.0.0.0.32.0.5.0	Phase L3 minimum 1 minute average current on 60 min period	A
9015.9002.3.9.0.1.4.0.0.0.0.0.0.128.0.5.0	Phase L1 maximum 1 minute average current on 10 min period	A
9016.9002.3.9.0.1.4.0.0.0.0.0.0.128.0.5.0	Phase L1 maximum 1 minute average current on 15 min period	A
9017.9002.3.9.0.1.4.0.0.0.0.0.0.128.0.5.0	Phase L1 maximum 1 minute average current on 30 min period	A
9011.9002.3.9.0.1.4.0.0.0.0.0.0.128.0.5.0	Phase L1 maximum 1 minute average current on 60 min period	A
9015.9002.3.9.0.1.4.0.0.0.0.0.0.64.0.5.0	Phase L2 maximum 1 minute average current on 10 min period	A
9016.9002.3.9.0.1.4.0.0.0.0.0.0.64.0.5.0	Phase L2 maximum 1 minute average current on 15 min period	A
9017.9002.3.9.0.1.4.0.0.0.0.0.0.64.0.5.0	Phase L2 maximum 1 minute average current on 30 min period	A

9011.9002.3.9.0.1.4.0.0.0.0.0.0.0.64.0.5.0	Phase L2 maximum 1 minute average current on 60 min period	A
9015.9002.3.9.0.1.4.0.0.0.0.0.0.0.32.0.5.0	Phase L3 maximum 1 minute average current on 10 min period	A
9016.9002.3.9.0.1.4.0.0.0.0.0.0.0.32.0.5.0	Phase L3 maximum 1 minute average current on 15 min period	A
9017.9002.3.9.0.1.4.0.0.0.0.0.0.0.32.0.5.0	Phase L3 maximum 1 minute average current on 30 min period	A
9011.9002.3.9.0.1.4.0.0.0.0.0.0.0.32.0.5.0	Phase L3 maximum 1 minute average current on 60 min period	A
0.2.3.9.0.1.4.0.0.0.0.0.0.0.128.0.5.0	Phase L1 1 minute average current (when maximum active demand)	A
0.2.3.9.0.1.4.0.0.0.0.0.0.0.64.0.5.0	Phase L2 1 minute average current (when maximum active demand)	A
0.2.3.9.0.1.4.0.0.0.0.0.0.0.32.0.5.0	Phase L3 1 minute average current (when maximum active demand)	A
0.0.0.12.0.1.47.X.1.0.0.0.0.0.128.0.0.0	Phase L1 X. momentary harmonics, where X is 2-40	%
0.0.0.12.0.1.47.X.1.0.0.0.0.0.64.0.0.0	Phase L2 X. momentary harmonics, where X is 2-40	%
0.0.0.12.0.1.47.X.1.0.0.0.0.0.32.0.0.0	Phase L3 X. momentary harmonics, where X is 2-40	%
9012.9002.3.9.1.1.4.0.0.0.0.0.0.0.224.3.38.0	One minute maximum active demand total on 2h period	kW
9013.9002.3.9.1.1.4.0.0.0.0.0.0.0.224.3.38.0	One minute maximum active demand total on 3h period	kW
9014.9002.3.9.1.1.4.0.0.0.0.0.0.0.224.3.38.0	One minute maximum active demand total on 4h period	kW

4.5.3 Communication network diagnostics reading types

ReadingType	Description	Unit
0.0.0.12.0.3.9018.0.0.0.0.0.0.0.0.-1.113.0	Transmission power with the current cluster head	dBm
0.0.0.12.0.3.9019.0.0.0.0.0.0.0.0.0.114.0	Route cost	None
0.0.0.12.0.3.9028.0.0.0.0.0.0.0.0.0.0.0	Communication channel with the current cluster head	None
0.0.0.12.0.3.9030.0.0.0.0.0.0.0.0.0.0.0	Antenna type (internal or external)	None
0.0.0.12.0.3.9029.0.0.0.0.0.0.0.0.0.0.0	Channel with the cluster members at the end of the statistical period	None
11.26.0.9.0.3.9022.0.0.0.0.0.0.0.0.0.111.0	Number of channel changes	pcs
11.2.0.9.0.3.115.0.0.0.0.0.0.0.0.-1.113.0	Average signal strength with cluster heads on the period	dBm

11.9.0.9.0.3.115.0.0.0.0.0.0.0.0.-1.113.0	Minimum signal strength with cluster head on the period	dBm
11.8.0.9.0.3.115.0.0.0.0.0.0.0.0.-1.113.0	Maximum signal strength with cluster head on the period	dBm
0.2.0.9.0.3.9020.0.0.0.0.0.0.0.0.-1.113.0	Average signal strength with the current cluster head	dBm
0.9.0.9.0.3.9020.0.0.0.0.0.0.0.0.-1.113.0	Minimum signal strength with the current cluster head	dBm
0.8.0.9.0.3.9020.0.0.0.0.0.0.0.0.-1.113.0	Maximum signal strength with the current cluster head	dBm
11.2.0.9.0.3.9019.0.0.0.0.0.0.0.0.114.0	Average route cost	None
11.9.0.9.0.3.9019.0.0.0.0.0.0.0.0.114.0	Minimum route cost	None
11.8.0.9.0.3.9019.0.0.0.0.0.0.0.0.114.0	Maximum route cost	None
11.26.0.9.0.3.9021.0.0.0.0.0.0.0.0.111.0	Number of route changes	pcs
0.26.0.9.0.3.9023.0.0.0.0.0.0.0.0.111.0	Number of neighbours at the end of the statistical period	pcs
11.2.0.9.0.3.9023.0.0.0.0.0.0.0.0.111.0	Average number of neighbours	pcs
11.9.0.9.0.3.9023.0.0.0.0.0.0.0.0.111.0	Minimum number of neighbours	pcs
11.8.0.9.0.3.9023.0.0.0.0.0.0.0.0.111.0	Maximum number of neighbours	pcs
11.26.0.9.0.3.9024.0.0.0.0.0.0.0.0.0.0	Duration of no route	%
11.26.0.9.0.3.9025.0.0.0.0.0.0.0.0.0.0	Duration of no neighbours	%
11.8.0.9.0.3.9026.0.0.0.0.0.0.0.0.0.0	Maximum duty cycle	%
11.26.0.9.0.3.9027.0.0.0.0.0.0.0.0.111.0	Duty cycle alarm count	pcs
11.26.0.9.0.3.9031.0.0.0.0.0.0.0.0.0.0	Duration of participating in NAN	%

4.5.4 Other reading types

ReadingType	Description	Unit
0.0.0.0.0.3.9003.0.0.0.0.0.0.0.0.-3.27.0	Round-trip time in milliseconds reported when diagnosing communications to a device. Measurement kind 9003 is Aidon specific extension which means *round-trip time*.	ms
0.0.0.6.0.0.94.0.0.0.0.0.0.0.0.29.0	Momentary battery voltage. Used in substation monitoring where a battery can be attached to a device input for voltage monitoring.	V
0.0.0.6.0.0.94.0.0.0.0.0.0.0.0.23.0	Momentary temperature. Used in substation monitoring where a temperature sensor or a device reporting temperature can be attached to a device input for temperature monitoring.	C
0.0.0.6.0.1.54.0.0.0.0.0.0.0.17.0.29.0	Momentary earth fault voltage. Used in substation monitoring where earth fault is monitored externally through device inputs.	V

4.5.5 Meter reading quality attributes

Following meter reading value attributes are possible to use with Linkware interfaces.

Quality attribute	Name	Description
0	Ok	A valid measured value. No other flags may be set.
1	Uncertain	An uncertain or a missing reading. This flag is used always when there is uncertainty in the value. Usually this is set with another quality flags.
2	MissingValueDataNotSupported	A missing reading. The device does not support the requested data, or the register is not configured on the device.
4	MajorTimeChange	An uncertain reading. The time has been changed more (+/-) than the configured limit. Marked on all of the historical readings after the last time change.
8	PowerOutage	A power outage has extended over a configured saving moment (for example, with hourly series, over an hour). The readings that are marked because of a power outage are valid, except in situations where the power outage has lasted longer than the real time clock's backup time.
16	Reset	An uncertain reading. The device has reset on the time of a configured saving moment, and it has lasted over the allowed time deviation.
32	MissingValueDeviceError	A missing value. The reading could not be saved due to a device error.
64	SelfVerification	An uncertain reading. The device has validated the reading and decided to use previous valid value.
256	NotValid	An uncertain value. Reading has been determined to be invalid by the reading system only.
512	MissingValueNoAccess	A missing value, no access to device. This flag may be set by the reading system only.
1024	MajorTimeDifference	A value with major time difference compared to system time. This flag may be set by the reading system only.

4.6 Aidon – IEC/CIM translations

Following table translates terminology between Aidon data models and IEC/CIM data models. Some entities don't have exact counterpart in the IEC/CIM model, but these are listed in the table and they may have some related IEC/CIM element referenced.

Aidon name	IEC/CIM model
Configuration	*N/A*. Configuration can be seen as *customer agreement*, but it is more technical agreement about the provided services.
Configuration event	*Configuration event*
Circuit breaker status	*Connection state*
Contract	N/A. Contract can be seen as *customer agreement*, but it is more technical agreement about the provided services.
Device, metering device	*End device*
Device communication information	*N/A.* Communication information is expressed as *end device function* in the interfaces.

Energy series	*Meter readings*. Energy series contains series of measurements (meter readings) from a metering device.
Fuse size	*Rated Current*
Metering point	*Usage point*
Metering point group	*Usage point group*
Network	*N/A*
Product	*N/A*
Software fuse	*Current limit*
Spontaneous event	*End device event*
Utility type	*Service category*

4.7 Time handling

IEC interfaces support only timestamps in UTC (Zulu time) format requiring indicating "Z" at the end of the dateTime string. For example "2016-03-09T15:30:00Z". If a request message doesn't conform to this requirement an error with result code "1.1" is returned.

5 Error handling

Linkware IEC interfaces handle all possible errors internally and in case of any errors or failures in the processing of the request Linkware returns corresponding response with "Reply.Error" element as described in 4.1.2. Only if there is a catastrophic failure that prevents Linkware to run normally, the error may be returned as HTTP statuscode 500.

All possible error codes within the Linkware IEC interfaces are described in the next chapter, but non of the interfaces may return all of these error codes. In the separate interface specifications it is described which error codes each operation may return.

Descriptions, details and stack traces that may be attached with the "Error" element are there to give more information for diagnostic purposes and should never be tried to interpreted in automated fashion.

Errors are returned the same way independent if the request/response operation is synchronous or asynchronous. If there are errors with eventing or notifications, they are not transmitted to any receiving system, but Linkware handles them internally.

When operation parameters target multiple entities at the same request each entity is handled separately and data maybe partially updated. Erroneous entities are listed in Reply/Error elements and successfully handled are included in the payload (if any) or they may be omitted from the reply indicating successful operation.

5.1 Result codes

Result codes are categorized based on IEC 61968 standards, but they have been extended to fit better in the Linkware operations. The goal with the error codes is that the external system participating in the integration may coherently handle exceptional situations different ways:

- Return understandable error description to the end user using the external system
- Take alternative path in business logic on any service bus-like implementation
- Retry operation if error code somehow warrants that

Error categories are defined as follows:

- 0: no errors or partial response
- 1: invalid, missing or incomplete element or message
- 2: invalid parameter
- 5: application errors
- 7: authentication and autorisation

Code	Description
0.0	Ok
1.0	Request message is invalid or incomplete. This code is used when the request is invalid i.e. some required element is missing or invalid. For example when ChangeEndDevices message header's verb is not change or header's correlation id is missing.
1.1	The message contains incorrect time specification. Only UTC times are supported.
2.0	Invalid request. For example when the specified request would result in an configuration that is not allowed. For example setting a parent device that has a type that does not allow child devices.
2.1	Usage point not found
2.2	Device not found

2.3	Customer agreement not found
2.4	Network not found
2.5	Usage point already exists
2.6	Device already exists
2.7	Product not found
2.8	Contract not found
2.9	Configuration not found
2.10	Group not found
2.11	Invalid object type
2.12	Invalid reading type
2.13	Usage point not linked to a device
2.14	Usage point does not belong to a group.
2.15	Service category can not be updated, because usage point has a linked device
2.16	Failed to remove the usage point, because it is still linked with a device
2.17	Failed to remove the device, because it is still linked with a usage point
2.18	Failed to link device with the usage point, because the usage point already has a device linked to it
2.19	Failed to link device with the usage point, because the device is already linked to another usage point
2.20	A specified service category is not compatible with the specified usage point type
2.21	Given contract must be a standard contract
2.22	Given configuration must be a standard configuration
2.23	The product is already part of the usage point configuration
2.24	The usage point does not have the specified product configured
2.25	Incorrect product specified. Only configuration product changes are supported.
2.26	A specified service category is not compatible with the specified usage point type
2.27	Group is not empty.
2.28	Group already exists.
2.29	Given standard contract must be preconfigured.
2.30	The usage point does not have a suitable product configured
2.31	Usage point not linked to the specified device
2.34	The contract is not compatible with the usage point type
2.35	The fuse cannot be defined for the usage point type
2.36	The device is not linked to a usage point
2.37	Event subscription not found
2.38	Work order already exists
2.39	Scheduled job not found
2.40	Scheduled job cannot be cancelled, because it is already executed, currently being executed or allowed running time has passed

2.41	Component not found
2.42	Failed to link component with the device, because the component is already linked to another device
2.43	Device not linked to the specified component.
2.44	Event subscription already exists
2.45	Invalid category. Only specific categories or all categories (*.*.*.*) are allowed values for end device event category
2.46	Scheduling the specified command is not allowed
2.47	Incompatible product
2.48	Failed to remove network, because it is still linked to usage point
2.49	Load name not found
2.50	Device linked to metering point is not mapped to load name
2.51	The configuration is not compatible with the usage point type
5.0	Operation failed. This code is used when the request cannot be completed because an exception has occurred.
5.1	Failed to connect the device
5.3	Circuit breaker status couldn’t be changed
5.4	The scheduled command couldn’t be executed successfully within the specified time window
6.1	The scheduled command was cancelled
7.0	Authentication failed
7.1	Authentication required. Provide a valid AccessToken in the request.
7.5	Action not authorized for user

The table is to describe all error codes that are unique to the Linkware system. Error codes are listed per operation in the separate interface specification documents. Any new error codes should be added to this table and in corresponding operation(s).

6 Synchronous and asynchronous processing

All operations in IEC interfaces are either synchronous or asynchronous, but both methods are not supported. Operations are synchronous by default and asynchronicity in the operation is specified for each asynchronous operation in their specification. Therefore IEC specified Header/AsyncReplyFlag may not be used and it will be ignored by Linkware sent in the request message.

Asynchronous operation specification always contains following message descriptions:

- Request message
- Synchronous response acknowledgement
- Asynchronous response message

When using asynchronous operations, using ReplyAddress element in the Header is mandatory. When asynchronous processing completes the response is sent by invoking given Receive service from the reply address.

Asynchronous operations related to multiple entities will result in multiple response messages. For example retrieving energy series for metering point group will result in as many responses as there are metering points in the group. If retrieval is unsuccessful for some metering points, then response with an error is returned for these metering points. In addition there is a configured timeout in Linkware that will cause an error response when the timeout is exceeded and operation was incomplete.

7 Security and reliability

Security and reliability are achieved by ensuring that the communication happens with a trusted party and that all messages are delivered correctly.

7.1 Securing services

The security in Linkware IEC services is implemented by 1) securing the transport of messages and 2) authenticating and authorizing the client system and/or user properly.

7.1.1 Transport level security

Linkware IEC services use transport level security to enable secure communication between systems and the message level security (WS-Security) is not used. By default HTTPS protocol is used as a transport protocol for incoming and outgoing IEC Web Service requests. In addition Linkware IEC services may be configured for two-way SSL authentication to verify that communicating systems are trusted parties.

Linkware IEC services may NOT be configured to be used without HTTPS and encryption.

The same communication policy is assumed for incoming and outgoing service requests which means that the system receiving ad hoc and event messages must follow the same policy.

When using two-way SSL authentication client certificates must be securely exchanged and configured to be trusted. There are no specific requirements for the certificates except that they shouldn't use any weak encryption algorithms (for example MD2). The certificates may be self-signed or signed by a public certificate authority. In either case the client certificates need to be explicitly marked as trusted by Linkware and Linkware's certificate must be explicitly trusted by the client systems. Exchanging certificates should be done by secure transport methods.

7.1.2 Authentication and authorization

Linkware IEC services enforces authorization of client systems and/or users. Authorization is based on access tokens (API key) that are required to be used to access the services (see chapter 4.1.1 for required message headers). The access tokens are API keys that are generated in User Manager and manually delivered for each system (a system specific API key). User Manager verifies API key and checks which operations are permitted with API key.

In asynchronous response messages Linkware uses the same API key that was passed on an initial request, except in IEC Event messages.

7.2 Reliable messaging and guaranteed delivery

Guaranteed delivery in Linkware IEC interfaces is ensured by implementing service operations idempotent where possible and providing necessary retry and error handling functionalities. In terms of guaranteed delivery Linkware IEC services implement idempotency in a way that client systems may retry any service request as many time as it is necessary to get successful response.

In addition guaranteed delivery implementation poses requirements to both Linkware and client systems and they must implement certain set of functionality for guaranteed delivery to work as expected. Linkware can also be configured not to support guaranteed delivery disabling retry mechanisms in case the client system is unable to handle retries.

Following table lists requirements for client systems to fully implement guaranteed delivery with Linkware IEC services.

Requirement	Description

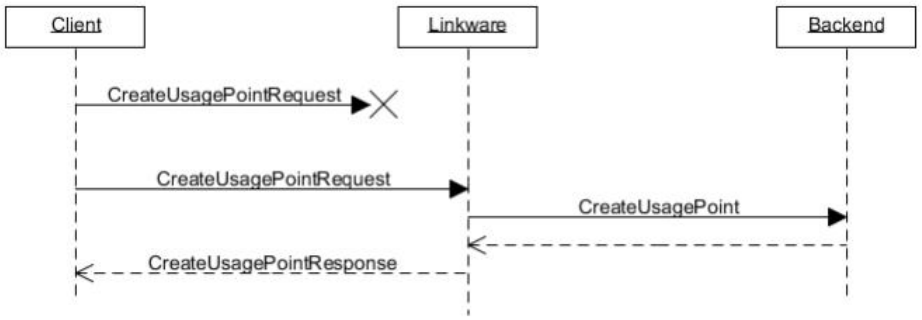
Retry synchronous requests in case of errors	It must be possible for a client system to retry any service request if there was an error during the service request. Errors related to guaranteed delivery may happen in the transport layer (for example unsuccessful connection to the service endpoint) or in the receiving server (unable to handle incoming request). In these instances retries must be sent with the same MessageID as the original request was sent for Linkware to identify possible duplicate messages. The MessageID is specified to be unique in context of a client system and for guaranteed delivery to work this must be implemented reliably by client systems. Retries should be done so that they don't flood the system in case there is a major outage on some component in the system. See Linkware retry policy below. If Linkware (or external system in outbound requests) is able to respond, but responds with error code (for example 5.0), then this is considered an error in the processing of the operation and it is not considered as an error from the perspective of the guaranteed delivery. In these cases guaranteed delivery only ensures that the response message with an error is delivered to the other system.
Retry asynchronous requests in case of errors	In asynchronous requests there must be similar retry mechanisms as in synchronous requests.
Handle duplicated replies for asynchronous responses	If delivering a reply to asynchronous service operation fails, Linkware tries to resend the reply. The client system must check for duplicate replies and act accordingly. If the reply with the same MessageID was handled earlier, it is safe to just acknowledge the reply again.
Handle duplicate events	If delivering an event fails, Linkware tries to resend the event. The client system must check for duplicate event messages and act accordingly. If the event with the same MessageID was handled earlier, it is safe to just acknowledge the event again.

Following table lists functionalities implemented in Linkware IEC services.

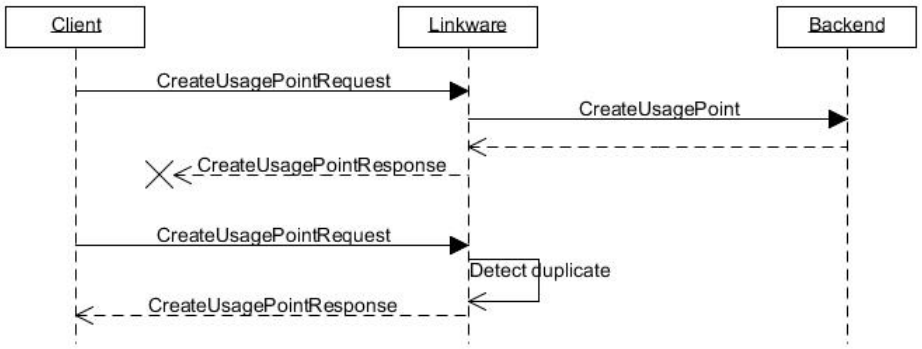
Functionality	Description
Handle duplicate requests	Linkware catches duplicate requests (identified by Source and MessageId header elements) and responds to those as it responded to the original request. In some cases it is possible that the original request is still processing which Linkware waits before responding to the request. Duplicate handling affects both synchronous and asynchronous requests.
Retry adhoc replies and events	Linkware tries to resend adhoc replies and events in case of failures. Linkware IEC services tries to resend request with following increasing intervals to avoid flooding the client system in case of major outage: - 5 seconds delay (3 times) - 1 minute delay (3 times) - 5 minute delay (3 times) - 30 minutes delay (3 times) - 1 hour delay (until 6 hours from original request has passed) If the request can not be made successfully within specified time then Linkware gives up and the message is not delivered. This is the default retry policy and it may be reconfigured at installation time.

7.2.1 Synchronous request

In case the client system doesn't receive proper response for a service request there may be two instances in the transport layer what has happened: 1) the request never reached the Linkware server or 2) delivering the response failed. In both instances the client system should try resending the message to Linkware service.



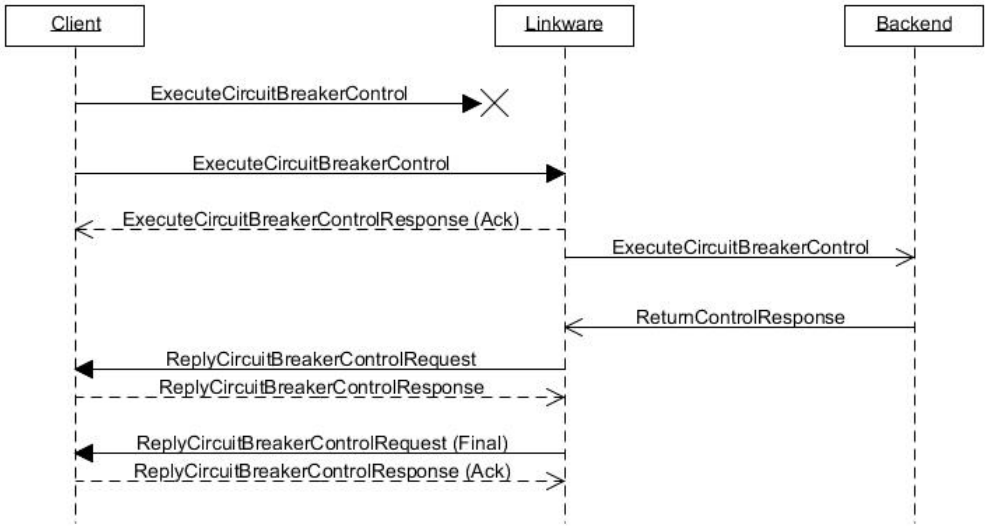
If delivering the request fails, it's safe to resend, because Linkware never started to process the request.



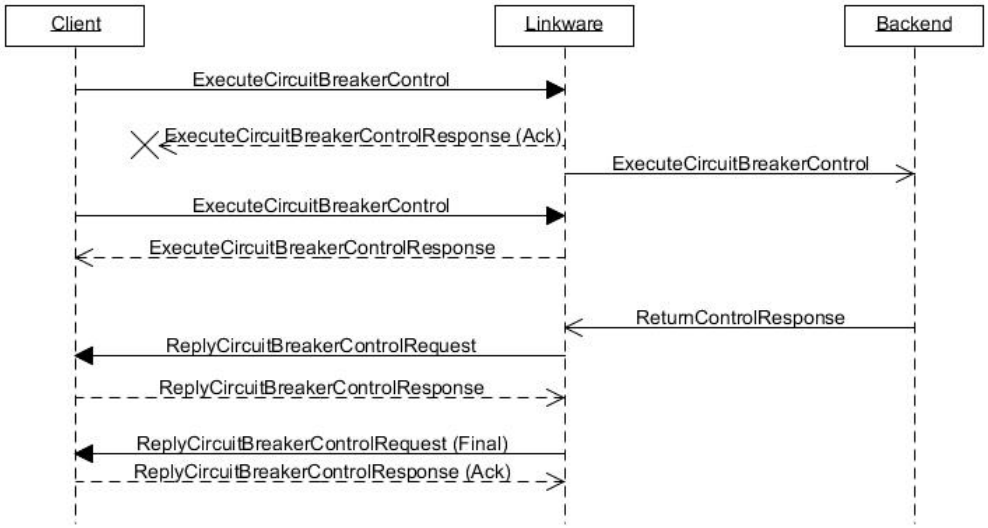
If delivering the response fails, the client system must retry sending the request. In this case Linkware detects duplicate message based on Header/MessageID value and it will send back the response from the original request.

7.2.2 Asynchronous requests

In asynchronous processing retry mechanism works in similar manner for both asynchronous requests from client system and asynchronous responses from Linkware to client system. For asynchronous responses to work the client system must implement duplicate detection method to acknowledge duplicate messages normally, but not handling the actual request twice (for example storing the same event twice). In case the client system is not able to implement these methods, Linkware can be told not to use guaranteed delivery by sending the element Header/UseGuaranteedDelivery as false (see chapter 4.1.1 for more information).



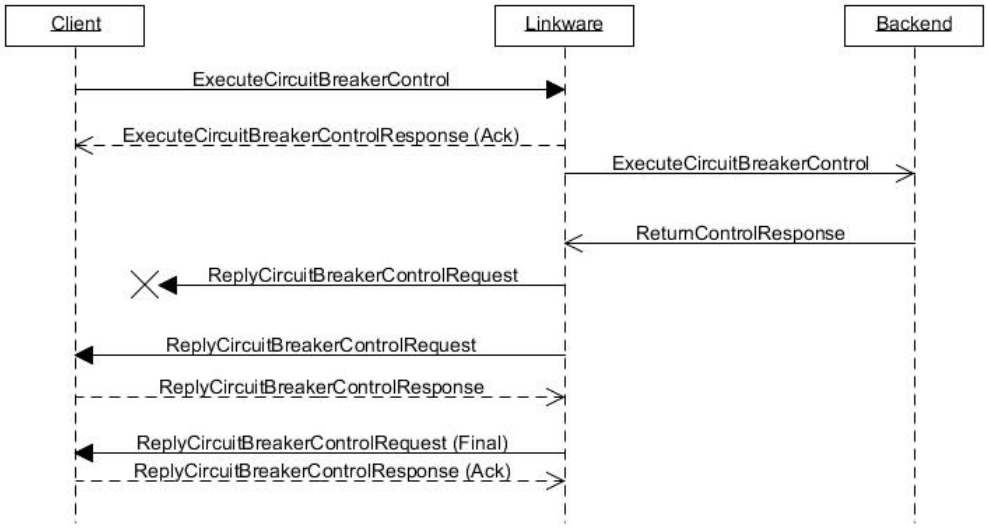
If delivering the request fails, it's safe to resend, because Linkware never started to process the request.



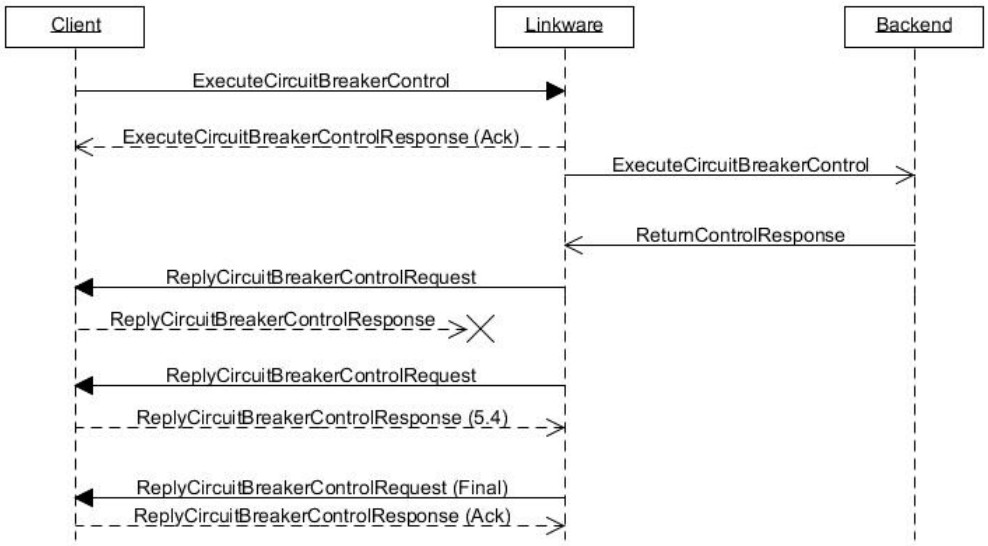
If delivering the response to the initial request fails, the client system must try resending the request. In this case Linkware replies with the original response acknowledging the request is running for the device as it was already sent to device.

7.2.3 Asynchronous replies

In asynchronous replies Linkware is executing synchronous reply request back to the client system to the end point specified by the client in the original asynchronous request. The retry and error handling mechanisms are similar to asynchronous request retries: Linkware retries sending the reply request until it gets correctly acknowledged by the client system. In this case client system should return result "0.0 OK" even though the response request is duplicate.



If delivering the request fails, it's safe to resend, because the client system never started to process the reply request. Successful request will get acknowledged with result code 0.0: OK.



If delivering the response to the reply request fails, Linkware tries to resend the request. In this case the client system should reply with result 0.0 to indicate that the reply has correctly been handled by the client system. Client system must also implement measures to keep services idempotent. For example retrieving end device events from the Linkware should not result in having multiple events recorded to the client system in case the reply was sent multiple times.

8 Schemas, namespaces and version control

The Linkware IEC interfaces are strongly typed Web Services that provides operations with specific payloads for each operation. Due to incomplete nature of IEC 61968 specifications and CIM model, the schemas have been extended to suit best transferring the data that is included in the Linkware operations. The schema extensions are separated by different namespaces to indicate Aidon specific definitions in the schema.

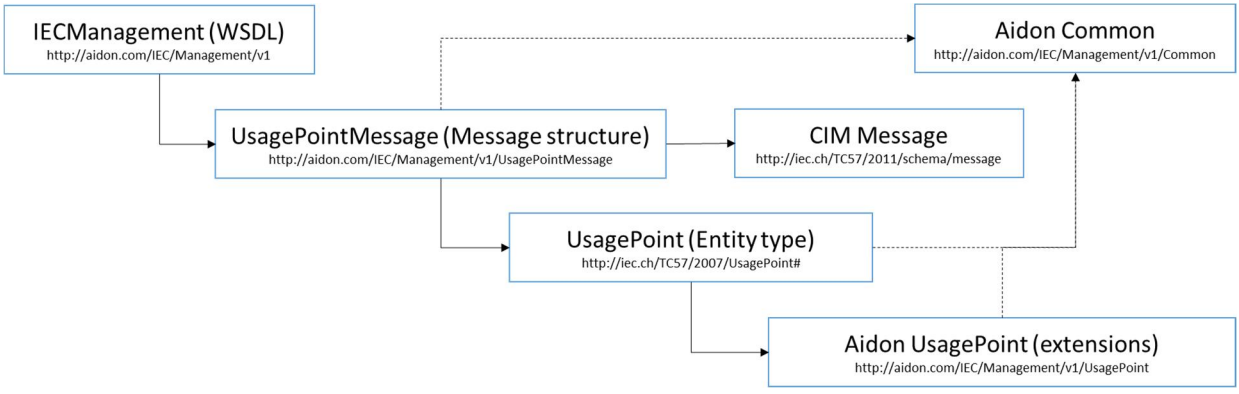
The Linkware IEC Web Services follows the rules described in the following list:

- All Web Service definitions (WSDL files) are in the Aidon namespace
- All common message envelope elements and types are in the IEC namespace
- All message types user in the Web Service operations are in the Aidon namespace
- Any payload types derived from the CIM model are in the IEC namespace
- All payload extensions and Aidon specific payloads are in the Aidon namespace

Following table defines namespaced used in the each level of the WSDL and its schema hierarchy. The hierarchy is based on the IEC schema hierarchy described in IEC 61968-9 specification annex C.

Schema level	Namespace	Description
WSDL	Aidon	WSDL descriptions are strongly-typed Aidon specific Web Service operation definitions which are described in Aidon namespace.
Message envelope	IEC	Header, Reply and Request types uses CIM model and are therefore in the IEC namespace. There may be operations where Request type has been extended with new elements.
Message Structure	Aidon	All message structures are in the Aidon namespace, because most of them are Aidon specific operations providing unique functionality.
Payload entities, IEC based	IEC	Payload entities that are based on IEC specification are by default in the IEC namespace. They however may have been extended with new elements which are defined in the Aidon namespace.
Payload entities, Aidon specific	Aidon	Payload entities that do not exist in IEC specification are defined in the Aidon namespace.
Common elements	Aidon	There is also a small set of common types which are in the Aidon namespace. These types may be for example an identified object with only mRID. This type may be used in different message payloads as a shortcut to define identifier for an entity. For example UsagePoint may be defined as a common identified object if only required value is mRID.

The following diagram describes the message hierarchy of IEC Management interface and more specifically operations related to metering point (UsagePoint).



The Aidon namespaces for IEC interfaces are constructed with the default part "http://aidon.com/IEC/" continued with interface name (for example "Management") and suffixed by the interface major version. For example Linkware IEC Management interface may be:

```
http://aidon.com/IEC/Management/v1
```

The IEC 61968 standard follows the Organization for the Advancement of Structured Information Standards (OASIS) guidelines for namespaces versioning. More information in the IEC 61968-100 chapter 10. The version of the message payloads is defined in the targetNamespace of the xs:schema element.

The targetNamespace of the XML schemas is defined by the version of the CIM used to create the schema in question. It has the following format, where yyyy defines the year when the CIM was released:

```
targetNamespace="http://iec.ch/TC57/yyyy/<Payload Type Name>"
```

Namespace defines only the major version of the interface and any minor versions are described only in the documentation and XML comments of the WSDL file. Therefore interface schemas should always be handled as a single package containing all WSDL and schema files related to the given version of the interface.

A major version update occurs when a major update has been done to the XSD or WSDL and backward compatibility has been broken. A minor version update occurs when backward compatibility is intact. For example a new optional element would only result in a minor version update.

9 Appendix: Change history

Version	Author	Date	Changes
2.05D	HKl	28.1.2015	Added final response to asynchronous messaging, updated chapters 3.1.2 and 4.3.2
2.06D	HKl	29.1.2015	Fixes to error codes
2.07D	HKl	5.3.2015	Add more detailed description to namespaces and their separation to IEC and Aidon namespaces. Added example messages for asynchronous acknowledgements.
2.08D	VLa	17.4.2015	Updated error codes
2.09D	HKl	7.5.2015	Updated details for securing the services, added draft of the glossary
2.10D	HKl	15.5.2015	Added table for other reading types
2.11D	HKl	14.7.2015	Added dip and swell reading types
2.12D	HKl	16.7.2015	Added description of partial responses for asynchronous processing
2.13	HKl	27.8.2015	Published Linkware 1.6 release version
2.14	HKl	29.8.2015	Published Linkware 1.7 release version
2.15D	HKl	16.9.2015	Added error code 2.31
2.16D	HKl	16.9.2015	Added quality flag 64 (SelfVerification) to meter reading quality attributes
2.17D	HKl	21.10.2015	Added error code 2.32
2.18D	HKl	21.10.2015	Removed sentResponses from partial asynchronous response
2.19D	HKl	26.10.2015	Fixed description for result code 2.20
2.20D	HKl	28.10.2015	Fixed description for result code 2.20
2.21D	HKl	9.11.2015	Added result codes 2.33 and 2.34
2.22D	HKl	18.11.2015	Added voltage quality and communication network diagnostics related reading types
2.23	HKl	18.11.2015	Published Linkware 1.8 release version
2.24D	HKl	20.11.2015	Added result code 2.35
2.25	HKl	20.11.2015	Published updated Linkware 1.8 release version
2.26D	HKl	4.12.2015	Fixed cardinalities for Reply/Result/Error elements
2.27	HKl	8.12.2015	Published updated Linkware 1.8 release version
2.28D	HKl	9.12.2015	Fix description for Error element acknowledgement response
2.29D	HKl	10.12.2015	Added OrganisationID to message header and added security related details: AccessToken to message header and rewritten chapter 7.1
2.30D	HKl	16.12.2015	Added result code 2.36
2.31D	HKl	17.12.2015	Changed result code 5.2 description to include device as well, fixed description for result code 2.20 and removed result code 2.33
2.32	HKl	17.12.2015	Published updated Linkware 1.8 release version
2.33D	HKl	21.12.2015	Added Reply/ID element for asynchronous partial replies

2.34D	HKl	4.1.2016	Removed certificate mapping from 7.1.1 and added 7.1.2.1
2.35D	HKl	4.2.2016	Updated guaranteed delivery descriptions, added support to disable guaranteed delivery mechanisms for asynchronous responses. Updated securing services chapter with details how to handle AccessToken.
2.36D	HKl	4.2.2016	Added result code 2.37 and 2.38
2.37D	HKl	5.2.2016	Updated security and guaranteed delivery specifications based on internal review comments
2.38D	HKl	18.2.2016	Added result codes 2.39, 2.40, 2.41, 2.42 and 2.43
2.39D	HKl	22.2.2016	Added result code 2.44
2.40D	HKl	4.3.2016	Added result codes 2.45 and 2.46
2.41D	HKl	8.3.2016	Changes to chapter 7.1.2 based on review comments
2.42D	PLe	9.3.2016	Chapter 4.1.1 fixed element order match with wsdl/schema
2.43D	HKl	12.3.2016	Added reading types for substation monitoring events, added result codes 7.0, 7.1 and 1.1, and added a chapter for time handling.
2.44D	HKl	31.3.2016	Clarified result code 5.0 in relation to guaranteed delivery in chapter 7.2
2.45D	HKl	31.3.2016	Added chapter 3.1.2.1 Scheduling asynchronous operations
2.46D	HKl	12.4.2016	Fixed typo and added default value for Header/UseGuaranteedDelivery element, added version information to chapters 1 and 2.
2.47D	HKl	13.4.2016	Defined a timeout error (result code 5.4) for asynchronous scheduled jobs
2.48D	HKl	25.4.2016	Added reading type for momentary earth fault voltage.
2.49D	HKl	25.4.2016	Added result code 6.1
2.50D	HKl	10.5.2016	Fixed description for result code 6.1
2.51	HKl	31.5.2016	Published Linkware 1.9 release version
2.52D	HKl	10.10.2016	Added result code 2.47
2.53D	HKl	17.10.2016	Added new substation monitoring reading types to chapter 4.5.1
2.54D	PSa	21.10.2016	Renamed the IEC interface's contents to use "usage point" as terminology, rather than "metering point". Both terms are valid in their respective domains. Therefore this document continues to use both terms. E.x. the "metering point" term is used in description texts and remarks sections since those sections use the internal system terminology.
2.55D	HKl	25.10.2016	Added note about error handling when multiple entities are included in the single operation to chapter 5.
2.56D	HKl	26.10.2016	Updated reading types related to substation monitoring
2.57D	HKl	31.10.2016	Added missing reading types for substation monitoring
2.58	TPa	15.11.2016	Published Linkware 1.10 release version
2.59D	TPa	21.3.2017	Removed Phase Lx 10 minute average current reading types.
2.60D	PVa	26.4.2017	Added new error messages 2.48, 2.49 and 2.50
2.61D	HKl	4.5.2017	Added result code 2.51

2.62D	HKl	5.5.2017	Fixed result description for code 2.51
2.63	Pva	11.5.2017	Published Linkware 1.11 release version
2.64D	PVa	4.8.2017	Added momentary harmonics reading types
2.65D	PVa	25.9.2017	Added new reading type: Duration of participating in NAN
2.66	PVa	7.11.2017	Published Linkware 1.12 release version
2.67D	PVa	9.4.2018	Added PARTIAL reply for acknowledgement response in asynchoronous requests
2.68	PVa	19.4.2018	Published Linkware 1.13.1 release version
2.69D	PVa	7.6.2018	Added new result code 7.5 Action not authorized for user
2.70D	PVa	23.8.2018	Removed error code 5.2 Active request already pending for the usage point or the device
2.71D	PVa	30.8.2018	Updated Security and reliability chapter. Updated header, accessToken is mandatory.
2.72	PVa	6.9.2018	Removed warning codes 2.26 and 2.32
2.73	PVa	6.9.2018	Published Linkware 1.14 release version