

EEBus UC Technical Specification

Overload Protection by EV Charging Current Curtailment

Version 1.0.1b

Cologne, 2019-07-01

EEBus Initiative e.V.

Butzweilerhof Allee 4
50829 Cologne
GERMANY

Rue d'Arlon 25
1050 Brussels
BELGIUM

Phone: +49 221 / 47 44 12 - 20
Fax: +49 221 / 47 44 12 - 1822

info@eebus.org
www.eebus.org

District court: Cologne
VR 17275

Terms of use for publications of EEBus Initiative e.V.**General information**

The specifications, particulars, documents, publications and other information provided by the EEBus Initiative e.V. are solely for general informational purposes. Particularly specifications that have not been submitted to national or international standardisation organisations by EEBus Initiative e.V. (such as DKE/DIN-VDE or IEC/CENELEC/ETSI) are versions that have not yet undergone complete testing and can therefore only be considered as preliminary information. Even versions that have already been published via standardisation organisations can contain errors and will undergo further improvements and updates in future.

Liability

EEBus Initiative e.V. does not assume liability or provide a guarantee for the accuracy, completeness or up-to-date status of any specifications, data, documents, publications or other information provided and particularly for the functionality of any developments based on the above.

Copyright, rights of use and exploitation

The specifications provided are protected by copyright. Parts of the specifications have been submitted to national or international standardisation organisations by EEBus Initiative e.V., such as DKE/DIN-VDE or IEC/CENELEC/ETSI, etc. Furthermore, all rights to use and/or exploit the specifications belong to the EEBus Initiative e.V., Butzweilerhof-Allee 4, 50829 Cologne, Germany and can be used in accordance with the following regulations:

The use of the specifications for informational purposes is allowed. It is therefore permitted to use information evident from the contents of the specifications. In particular, the user is permitted to offer products, developments and/or services based on the specifications.

Any respective use relating to standardisation measures by the user or third parties is prohibited. In fact, the specifications may only be used by EEBus Initiative e.V. for standardisation purposes. The same applies to their use within the framework of alliances and/or cooperations that pursue the aim of determining uniform standards.

Any use not in accordance with the purpose intended by EEBus Initiative e.V. is also prohibited.

Furthermore, it is prohibited to edit, change or falsify the content of the specifications. The dissemination of the specifications in a changed, revised or falsified form is also prohibited. The same applies to the publication of extracts if they distort the literal meaning of the specifications as a whole.

It is prohibited to pass on the specifications to third parties without reference to these rights of use and exploitation.

It is also prohibited to pass on the specifications to third parties without informing them of the authorship or source.

Without the prior consent of EEBus Initiative e.V., all forms of use and exploitation not explicitly stated above are prohibited.

Table of contents

3	Table of contents.....	3
5	List of figures	4
6	List of tables	4
7	1 Scope of the document	6
8	1.1 References.....	6
9	1.1.1 EEBUS documents	6
10	1.1.2 Normative references.....	6
11	1.2 Terms and definitions.....	6
12	1.3 Requirements	7
13	1.3.1 Requirements wording.....	7
14	1.3.2 Mapping of High-Level requirements.....	7
15	2 High-Level description.....	8
16	2.1 Introduction.....	8
17	2.2 Actors	9
18	2.2.1 EV.....	9
19	2.2.2 Energy Guard	9
20	2.3 Scenarios	10
21	2.3.1 Scenario 1 - Energy Guard curtails charging current of EV	10
22	2.3.2 Scenario 2 - EV checks Energy Guard availability	12
23	2.3.3 Scenario 3 - Energy Guard sends error state.....	12
24	2.4 Dependencies to other Use Cases.....	12
25	2.4.1 "EV Commissioning and Configuration"	12
26	2.4.2 "EVSE Commissioning and Configuration"	13
27	2.4.3 "EV Charging Electricity Measurement"	13
28	2.5 Assumptions and Prerequisites.....	14
29	3 Technical SPINE solution	15
30	3.1 General rules and information	15
31	3.1.1 Underlying technology documents	15
32	3.1.2 Use Case Discovery rules.....	15
33	3.1.3 Rules for "Content of Specialization..." tables and "Content of Function..." tables	16
34	3.1.4 Rules for "Feature Types and Functions..." tables	22
35	3.1.5 "Actor ... overview" diagram rules	23
36	3.1.6 Specializations	24
37	3.1.7 Order of messages within the sequence diagrams	25
38	3.1.8 Further information and rules.....	25
39	3.2 Actors	25
40	3.2.1 EV.....	25
41	3.2.2 Energy Guard	32
42	3.3 Pre-Scenario communication	37
43	3.3.1 General information	37
44	3.3.2 Detailed discovery	38
45	3.3.3 Binding.....	40
46	3.3.4 Subscription.....	40
47	3.3.5 Dynamic behaviour.....	41
48	3.4 Scenarios	41

49	3.4.1	Scenario 1 - Energy Guard curtails charging current of EV	41
50	3.4.2	Scenario 2 - EV checks Energy Guard availability	45
51	3.4.3	Scenario 3 - Energy Guard sends error state.....	47
52			

53 List of figures

54	Figure 1: High-Level Use Case functionality overview	8
55	Figure 2: Scenario overview	10
56	Figure 3: Scenario 1 overview	10
57	Figure 4: Example for asymmetric vs. symmetric charging curtailment	11
58	Figure 5: Actor overview example.....	24
59	Figure 6: Actor "EV" overview	26
60	Figure 7: Actor "Energy Guard" overview	32
61	Figure 8: Pre-Scenario communication - Detailed discovery sequence diagram.....	39
62	Figure 9: Pre-Scenario communication - Binding sequence diagram	40
63	Figure 10: Pre-Scenario communication - Subscription sequence diagram	41
64	Figure 11: Scenario 1 - Initial Scenario communication sequence diagram	42
65	Figure 12: Scenario 1 - Runtime Scenario communication sequence diagram.....	44
66	Figure 13: Scenario 2 - Initial Scenario communication sequence diagram	46
67	Figure 14: Scenario 2 - Runtime Scenario communication sequence diagram.....	47
68	Figure 15: Scenario 3 - Initial Scenario communication sequence diagram	48
69	Figure 16: Scenario 3 - Runtime Scenario communication sequence diagram.....	49
70		

71 List of tables

72	Table 1: Scenario implementation requirement for Actors	10
73	Table 2: Presence indication description	16
74	Table 3: Example table for cardinality indications	18
75	Table 4: Presence indication of Feature Types and Functions support	22
76	Table 5: Feature Types and Functions used within this Use Case by the Actor EV	27
77	Table 6: Content of Function "loadControlLimitDescriptionListData" at Actor EV	28
78	Table 7: Content of Function "loadControlLimitListData" at Actor EV	29
79	Table 8: Content of Function "electricalConnectionParameterDescriptionListData" at Actor EV.....	29
80	Table 9: Content of Function "electricalConnectionPermittedValueSetListData" at Actor EV	30
81	Table 10: Content of Specialization "Heartbeat_Timeout4Seconds" at Actor EV	31
82	Table 11: Content of Specialization "DeviceDiagnosis_FailureState" at Actor EV	32
83	Table 12: Feature Types and Functions used within this Use Case by the Actor Energy Guard	33
84	Table 13: Content of Function "deviceDiagnosisHeartbeatData" at Actor Energy Guard	34
85	Table 14: Content of Function "deviceDiagnosisStateData" at Actor Energy Guard	35
86	Table 15: Content of Specialization "LoadControlLimit_OverloadProtection" at Actor Energy Guard	37
87	Table 16: Initial Scenario communication content references for Scenario 1	43
88	Table 17: Runtime Scenario communication content references for Scenario 1	45
89	Table 18: Initial Scenario communication content references for Scenario 2	46
90	Table 19: Runtime Scenario communication content references for Scenario 2	47

91	Table 20: Initial Scenario communication content references for Scenario 3	48
92	Table 21: Runtime Scenario communication content references for Scenario 3	49
93		
94		

1 Scope of the document

This document describes the Use Case "Overload Protection by EV Charging Current Curtailment" (short-name: OPEV). Chapter 2 specifies the High-Level Use Case. Chapter 3 describes the technical solution for SPINE for this Use Case in detail. Within this document a top-down approach is used to derive the requirements for the technical solution from the High-Level description.

1.1 References

1.1.1 EEBUS documents

[UseCaseBaseSpecification] EEBus_UC_TS_UseCaseBaseSpecification.pdf

[ProtocolSpecification] EEBus_SPINE_TS_ProtocolSpecification.pdf

[ResourceSpecification] EEBus_SPINE_TS_ResourceSpecification.pdf

[SHIP] SHIP_Specification_v1.0.0.pdf

1.1.2 Normative references

[RFC2119] IETF RFC 2119: 1997, Key words for use in RFCs to indicate requirement levels
Please see section 1.3.1 for details.

1.2 Terms and definitions

Actor

An Actor models a role within a Use Case definition (e.g. an energy manager or an electric vehicle).

CEM

Abbreviation for Customer Energy Manager. The CEM is an energy manager located at the home or premises of the user or in a cloud application. The energy manager enables energy-optimized operation of the connected devices by harmonising energy demand and availability.

EV

Electric Vehicle

EVSE

Electric Vehicle Supply Equipment

OPEV

Overload Protection by EV Charging Current Curtailment (short name of this Use Case)

Scenario

Part of the Use Case. Splitting a Use Case in Scenarios helps to understand the Use Case more quickly. Some Scenarios are mandatory for a Use Case, whereas others may be recommended or optional.

129 **Specialization**

130 Reusable data collection for a specific functionality.

131 **SPINE**

132 **Smart Premises Interoperable Neutral-message Exchange: Technical Specification of EEBus Initiative**
133 **e.V.**

134

135 **1.3 Requirements**

136 **1.3.1 Requirements wording**

137 The following keywords are used:

- 138 - SHALL
- 139 - SHALL NOT
- 140 - SHOULD
- 141 - SHOULD NOT
- 142 - MAY

143 Note: They apply only if written in capital letters.

144 For the meaning of the keywords, please refer to [RFC2119].

145

146 **1.3.2 Mapping of High-Level requirements**

147 Within the High-Level Use Case description, the following abbreviation is used:

148 [OPEV-xyz]

149 e.g.: [OPEV-007]

150 The abbreviation is used to mark High-Level requirements or rules of this Use Case with a unique
151 number xyz. Those requirements are referenced throughout the technical solution to show how each
152 High-Level requirement is realised in the technical part.

153

2 High-Level description

2.1 Introduction

This Use Case aims to prevent an ongoing EV (Electric Vehicle) charging process from tripping the fuse of the supply side infrastructure (e.g. mains fuse) by curtailing an ongoing charging process of an EV by an Energy Guard.

To avoid an overload, the Energy Guard continuously monitors the electric current at the according measurement points and immediately commanding the EV to curtail the charging current if an overload at the corresponding circuit breaker is detected.



Figure 1: High-Level Use Case functionality overview

This is necessary for those installations, where the maximum power of the charging infrastructure (i.e. EV + EVSE (electric vehicle supply equipment)) may exceed the maximum allowed circuit current.

In order to detect overload situations in the circuit, the Energy Guard must have information about the actual current (e.g. by receiving information from a submeter). Alternatively, the Energy Guard may measure the circuit itself. Furthermore, the Energy Guard must know the maximum allowed current for the circuit.

Note: The administrator needs to make sure that the domestic installation can handle currents which are higher than the nominal current of the fuse, otherwise there is a fire hazard.

Note: The Energy Guard SHOULD consider not only the active current but the apparent current which consists of both active and reactive current, as the apparent current causes for the fuse to trip.

Derivation of the time limits for the involved units:

The trip time is the timespan that it takes from a current flow occurring at a specific level above the trip current until the circuit breaker trips. The trip time characteristics of a circuit breaker are model-specific and show the range of time that elapses between the occurrences of an overload until the circuit breaker trips.

In order to have a foundation for this Use Case to work with, it is assumed for the currents to be no larger than twice the trip current. There are circuit breakers which are rather sensitive and can trip within 6 seconds at a current that is twice the nominal current of the circuit breaker. Due to this, the time span between the occurrence of the overload event and the reaction of the EV to reduce the charge current accordingly shall take no longer than 6 seconds. However, the tripping time of the circuit breaker might also be longer or shorter than 6 seconds. Therefore, the reaction time of this Use Case SHOULD be adapted to the tripping time of the corresponding circuit breaker. Overload protection may also be used in the scope of peak load shaving and grid constraints.

In order to create individual requirements for each of the involved units (submeter, Energy Guard, EVSE and EV), we propose for the latency at the submeter and the Energy Guard to be 2 seconds, the latency between Energy Guard and EV should not exceed 1 second and at the EV should be 2 seconds which results in a buffer for potential delays of 1 second. If these requirements cannot be fulfilled, this Use Case may not operate correctly.

Further Information:

An unintentional reduction in the charging current due to short- or medium-term current spikes caused by household loads, e.g. starting currents of vacuum cleaner, SHOULD be avoided by the Energy Guard.

In this Use Case the correct phase connection of the EVSE installation is very important, otherwise the curtailment setpoints will not be applied correctly. The Energy Guard SHOULD check if the curtailment setpoints are applied correctly by monitoring the current at the according measurement points.

As the trip current may change according to the temperature, the Energy Guard should consider the temperature characteristic of the fuse. Overtemperature of the fuse can be estimated from the current values at the fuse.

The charging current constraints of an EV SHALL be considered by the Energy Guard if provided by the EV.

2.2 Actors

2.2.1 EV

The Actor EV is the electric vehicle that wants to charge with low environmental or monetary costs. Within this Use Case only one Energy Guard SHALL be connected to an EV, while multiple EVs MAY be connected to an Energy Guard.

2.2.2 Energy Guard

The Energy Guard protects against overload situations. Multiple EVs MAY be connected to an Energy Guard. However only one Energy Guard SHALL be connected to an EV within this Use Case.

2.3 Scenarios

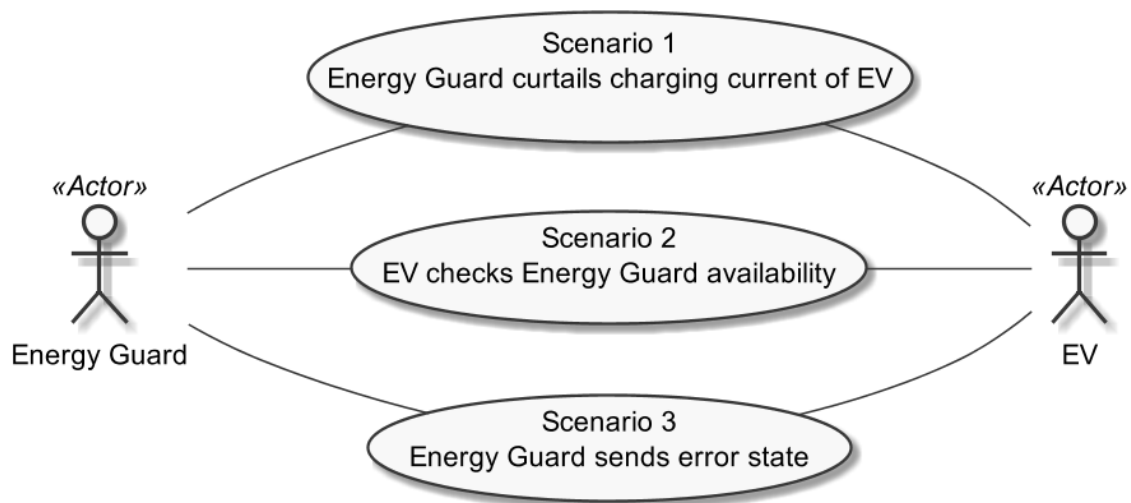


Figure 2: Scenario overview

Scenario number	Scenario name	EV	Energy Guard
1	Energy Guard curtails charging current of EV	M	M
2	EV checks Energy Guard availability	M	M
3	Energy Guard sends error state	M	M

Table 1: Scenario implementation requirement for Actors

2.3.1 Scenario 1 - Energy Guard curtails charging current of EV

2.3.1.1 Description

The Energy Guard curtails the charging current of the EV to ensure that no overload occurs [OPEV-001].

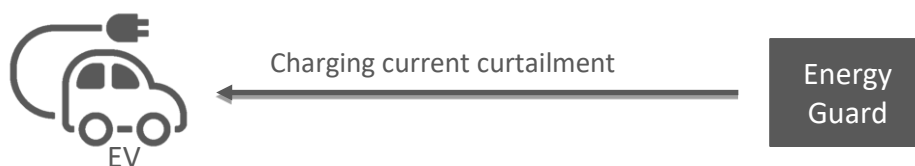


Figure 3: Scenario 1 overview

Before the Energy Guard curtails the EV current, the Energy Guard needs to know from the EV which phases are used for charging and the electrical charging constraints (e.g. minimum and maximum charging current) for the corresponding phases. The electrical charging constraints of the EV can also be limited by the electrical charging constraints of the EVSE where the EV is connected.

If asymmetric charging is supported, the Energy Guard can curtail the current of each phase independent from each other [OPEV-002]. In this case the asymmetric charging allows to charge with a high current on one phase and with low current on another phase that already has a high load. While without asymmetric charging the current for all phases always needs to be adjusted to the phase with the lowest current and therefore may lead to a distinguishably lower overall charging power.

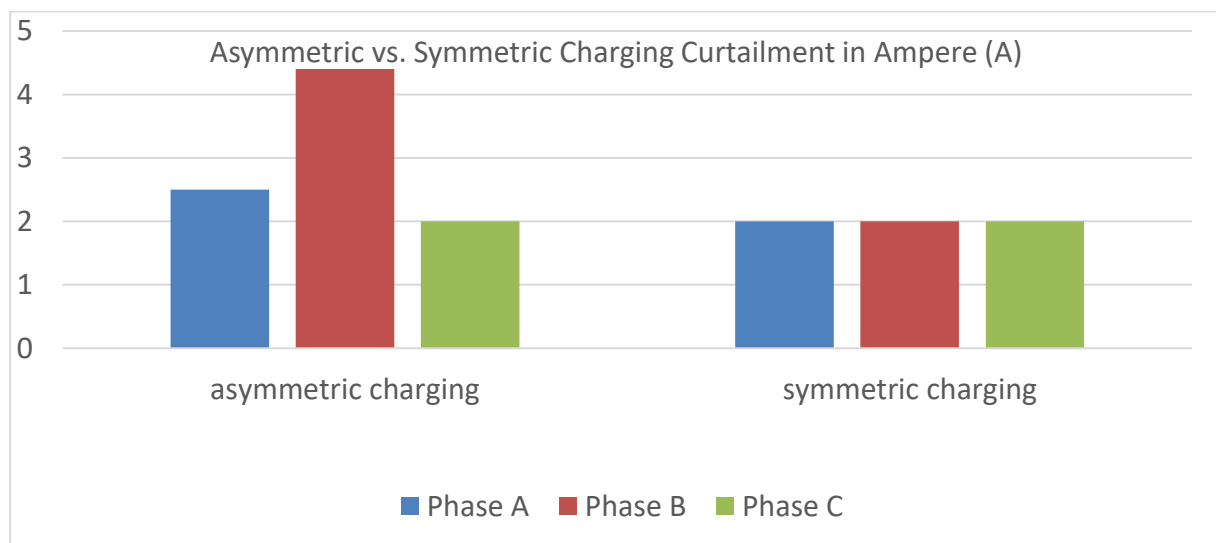


Figure 4: Example for asymmetric vs. symmetric charging curtailment

Within the example above, a charging power of 690 W is possible with asymmetric charging, while with symmetric charging only 460 W can be charged.

2.3.1.2 Conditions

Triggering Event:

The Energy Guard shall start curtailing the charging current directly after the EV was connected to the EVSE [OPEV-003]. If currently no curtailment is needed the Energy Guard shall also inform the EV [OPEV-004].

Pre-condition:

EV charging could lead to an overload that breaks a fuse or similar.

Post-condition:

EV charges within the limits given by the Energy Guard.

2.3.2 Scenario 2 - EV checks Energy Guard availability

2.3.2.1 Description

As a quick reaction might be necessary in case of overload situations, the EV shall check the availability of the Energy Guard. If the Energy Guard is not available for more than 4 seconds, the EV should switch to a safe current setting that guarantees that no overload occurs during absence of the Energy Guard [OPEV-005].

2.3.2.2 Conditions

Triggering Event:

The Scenario is typically triggered by connecting the EV to the EVSE [OPEV-006].

Pre-condition:

The Energy Guard may be absent without knowledge of the EV.

Post-condition:

The EV may detect whether the Energy Guard is absent or not.

2.3.3 Scenario 3 - Energy Guard sends error state

2.3.3.1 Description

Besides the availability of the Energy Guard, the EV also checks the error state of the Energy Guard. If the Energy Guard has announced an error, the EV should not trust the Energy Guard regarding its charging current curtailment and should switch to a safe current setting to guarantee that no overload occurs during absence of the Energy Guard [OPEV-007].

2.3.3.2 Conditions

Triggering Event:

The Scenario is typically triggered by connecting the EV to the EVSE [OPEV-008].

Pre-condition:

The Energy Guard may be in error state without knowledge of the EV.

Post-condition:

The EV may detect that the Energy Guard has announced an error. Then the EV should no longer rely on the charging current curtailment.

2.4 Dependencies to other Use Cases

2.4.1 "EV Commissioning and Configuration"

The Actor EV of this Use Case acts as Actor EV within the Use Case "EV Commissioning and Configuration".

288 The Actor Energy Guard of this Use Case acts as Actor CEM within the Use Case "EV Commissioning
289 and Configuration".

290

291 **2.4.1.1 "Scenario 1 - EV connected"**

292 If this Use Case talks about connecting the EV to the EVSE this Scenario is meant. Therefore, this
293 Scenario SHALL be supported by the Actors EV and Energy Guard.

294

295 **2.4.1.2 "Scenario 6 - EV sends charging power limits"**

296 The Actor Energy Guard can use the Actor EV's charging power limits during calculations for Scenario
297 1 of this Use Case. Therefore, this Scenario SHOULD be supported by the EV and this Scenario SHALL
298 be supported by the Energy Guard. The charging power limits shall not contradict the constraints
299 given in this Use Case.

300

301 **2.4.1.3 "Scenario 8 - EV disconnected"**

302 If the EV is disconnected the EV will no longer be charged. Then the EV can be removed from the
303 equation of the Energy Guard. Therefore, this Scenario SHALL be supported by the EV and this
304 Scenario SHALL be supported by the Energy Guard.

305

306 **2.4.2 "EVSE Commissioning and Configuration"**

307 **2.4.2.1 "Scenario 2 - EVSE sends error state"**

308 Indicate errors of the EVSE to the user. If the EVSE has announced an error, the EV may no longer be
309 able to follow the charging curtailment correctly and updates from the EV may no longer contain
310 valid data.

311

312 **2.4.3 "EV Charging Electricity Measurement"**

313 The Actor EV of this Use Case acts as Actor EV and the Actor Energy Guard acts as Actor CEM within
314 the Use Case "EV Charging Electricity Measurement".

315 If phase specific curtailment is supported also phase specific measurement is needed. Therefore, in
316 case of phase specific curtailment Scenario 1 or Scenario 2 with phase specific measurements
317 SHOULD be supported, otherwise the measurements SHALL be provided by other means (e.g. a
318 submeter).

319 If phase specific curtailment is not supported, Scenario 1 or Scenario 2 or Scenario 3 SHOULD be
320 supported, otherwise the measurements SHALL be provided by other means (e.g. a submeter).

321 If Scenario 2 is used, an Energy Guard has to know the voltage to calculate the current. As the voltage
322 may vary, the Energy Guard has to calculate with a certain tolerance.

323 The measurement values of Scenario 1 or Scenario 2 SHOULD be sampled at least each second.

In the case that an EV is not able in general or temporarily to support the High-Level Use Case "EV Charging Electricity Measurement" the Energy Guard SHALL still provide curtailment setpoints for the EV. In this case the Energy Guard may not be able to calculate a delta between the curtailment setpoints and the measurement of the charging current. Therefore, an Energy Guard may need to set the curtailment setpoints to zero in the fall-back case if an overload situation occurs. However, the implementation of an appropriate fall-back mechanism lies in the individual responsibility of the Energy Guard. In some cases, the Energy Guard may have other means that allow to estimate the charging current, e.g. EV external measurement of charging current.

2.5 Assumptions and Prerequisites

None.

3 Technical SPINE solution

3.1 General rules and information

3.1.1 Underlying technology documents

This technical solution relies on the SPINE Resources Specification version 1.1.1 [ResourceSpecification].

For interoperable connectivity this technical solution relies on:

- SPINE Protocol Specification version 1.1.1 [ProtocolSpecification] as application protocol.
- SHIP Specification version 1.0 [SHIP] as transport protocol.

Further applicable documents:

- EEBUS Use Case Base Specification version 1.0.0 [UseCaseBaseSpecification].

3.1.2 Use Case Discovery rules

The Use Case Discovery SHALL be supported by each Actor and the following rules SHALL apply:

- The string content for the Element "nodeManagementUseCaseData. useCaseInformation. useCaseSupport. useCaseName" within the Use Case Discovery (please refer to [ProtocolSpecification]) SHALL be "overloadProtectionByEvChargingCurrentCurtailment". The string content SHALL only be defined by this Use Case (regardless of the Use Case version).
- The string content of the Element "nodeManagementUseCaseData. useCaseInformation. actor" within the Use Case Discovery (please refer to [ProtocolSpecification]) SHALL be set to the according value stated within the corresponding Actor's section.
- An Actor A that is implemented to support this Use Case specification SHALL set the Element "nodeManagementUseCaseData. useCaseInformation. useCaseSupport. useCaseVersion" within the Use Case discovery (please refer to [ProtocolSpecification]) to "1.0.1" (for details on the structure of the Use Case version number please refer to [UseCaseBaseSpecification]).
- If an Actor A supports multiple versions of this Use Case with the same major version number, only the highest one SHOULD be set within the Use Case discovery.
- If an Actor A finds a proper counterpart Actor B for this Use Case that supports multiple versions of this Use Case with the same major version number as supported by Actor A, the Actor A SHOULD evaluate from these versions of Actor B only the highest version number.
- If an Actor A supports multiple versions of this Use Case with different major version numbers, for each major version number only the highest version number SHOULD be set within the Use Case discovery.
- If an Actor A finds a proper counterpart Actor B for this Use Case that supports only versions with a major version number not implemented by Actor A, it still might be possible to run the Use Case or parts of the Use Case. Therefore, the Actor A should try to evaluate the Actor B as a valid partner for this Use Case.

3.1.3 Rules for "Content of Specialization..." tables and "Content of Function..." tables

3.1.3.1 General presence indication definitions

Abbreviations for the presence indication of Elements listed in the tables are defined as follows:

Abbreviation	Meaning	Link to requirement keywords
M	Mandatory	SHALL
R	Recommended	SHOULD
O	Optional	MAY

Table 2: Presence indication description

An Actor MAY support Elements that are not listed in the tables. However, another Actor MAY ignore these Elements.

The presence indications "M", "R" and "O" are always meant relative to the respective parent Element. I.e. if a parent Element is optional ("O") and a child is mandatory ("M") the child Element can only be present if the parent Element is present as well.

Note: The indications and the aforementioned rules apply for "complete messages" (so-called "full function exchange", please refer to [ProtocolSpecification]). In contrast, the so-called "restricted function exchange" is designed to permit exchange of specific excerpts of data, i.e. fewer Elements than potentially available from the data owner (partially even not all "mandatory" Elements).

3.1.3.2 Presence indications for "Content of Specialization..." tables

This section only defines rules for the client side.

Elements that are marked with "M" SHALL be supported by the client in case of readable as well as writeable data. This Element may be optional on the server side.

The following applies for readable data that is exchanged in a "read/reply" or "notify" operation:

- "R" means that the data SHOULD be supported by the client. In other words: If the server responds with the according Element, the client SHOULD be able to interpret the according Elements.
- "O" means that the data MAY be supported by the client. In other words: If the server responds with the according Element, the client MAY be able to interpret the according Elements.

The following applies for writeable data that is exchanged in a "write" operation:

- "R" means that the data SHOULD be written by the client.
- "O" means that the data MAY be written by the client.
- "F" means that the data SHALL NOT be written by the client.

The following applies for Elements that are not listed in the Actor section:

- In case of a received "reply" message: The client MAY ignore the Element.
- In case of a "write" operation to be created: The client MAY set the Element but SHALL consider that the server may ignore the Element.

406 - In case of a received "notify" message: The client MAY ignore the Element.

407 M, R or O may be combined with the suffix "(event)" to express that a supported Element or value
408 only has to be supported during a certain event and hence does not need to be present at all times. If
409 the event is not active the Element may be omitted or another value may be set. In most cases a
410 High-Level requirement reference for the event is given in the rules column.

411

412 **3.1.3.3 Presence indications for "Content of Function..." tables**

413 This section only defines rules for the server side.

414 Elements that are marked with "M" SHALL be supported by the server in case of readable as well as
415 writeable data. In case of writeable data (marked with "M \W") the server does not need to set the
416 Element, because the Element is set only by the client.

417 The following applies for readable data that is exchanged in a "read/reply" or "notify" operation:

- 418 - "R" means that the data SHOULD be provided by the server.
- 419 - "O" means that the data MAY be provided by the server.
- 420 - "F" means that the data SHALL NOT be provided by the server.

421 The following applies for writeable data that is exchanged in a "write" operation:

- 422 - "R" means that the data SHOULD be supported. In other words: If the client writes the
423 Element, the server SHOULD accept those messages and the contained Elements.
- 424 - "O" means that the data MAY be supported. In other words: If the client writes the Element,
425 the server MAY accept those messages and the contained Elements.

426 The following applies for Elements that are not listed in the Actor section:

- 427 - In case of a received "read" request: The according Element MAY be set in the reply.
- 428 - In case of a received "write" operation: The server MAY ignore the Element.
- 429 - In case of a "notify" operation to be created: The server MAY set the Element.

430 Note: The server will only accept write operations if the result fulfils the server Function
431 requirements (permitted values, e.g.). Write operations on Elements that are not writeable MAY
432 result in an error message.

433 M, R or O may be combined with the suffix "(event)" to express that a supported Element or value
434 only has to be supported during a certain event and hence does not need to be present at all times. If
435 the event is not active the Element may be omitted or another value may be set. In most cases a
436 High-Level requirement reference for the event is given in the rules column.

437

438 **3.1.3.4 Cardinality indications - Permitted number of occurrences**

439 A cardinality indication expresses constraints on the number of occurrences of a given Element or
440 data set. In this section we use "X" as representation for such an Element or data set. Furthermore,
441 "a" and "b" represent constraints. The following rules apply for the occurrence of "X" and its content
442 related to a specific Scenario (see note underneath the list):

1. X
No cardinality indication.
2. X (a..b)
This means "X" SHALL occur at least "a" times and at maximum "b" times.
3. X (a..)
This means "X" SHALL occur at least "a" times and MAY occur more than "a" times.
4. X (..b)
This means "X" SHALL occur at maximum "b" times and MAY occur less than "b" times (even zero occurrences are permissive).

Note: These rules apply only under consideration of presence indications and with regards to the given Scenario or Function definition for this Use Case.

The following table is an example to explain this for two different placements.

Scenario [{...}]: M/R/O [W][C]	Element	Value	[High Level Mapping] Element and value rules
1: O
2: M \W	xFeatureType. xListData. xData. [UC-002] (1..3)		
2: M \W	xId	<g7> [<g8>] [<g9>]	PRIMARY IDENTIFIER of x
2: M \W	timePeriod		...
2: M \W	timePeriod. startTime	<xs:duration>	
2: M \W	xSlot. (1..)		
2: M \W	xSlot. xSlotId		...
2: M \W	xSlot. duration	<xs:duration>	...
2: M \W	qId	<h3>(-><g7>) [<h4>(-><g8>)] [<h5>(-><g9>)]	FOREIGN IDENTIFIER.
...

Table 3: Example table for cardinality indications

The field

xFeatureType. xListData. xData. [UC-002] (1..3)

introduces a data pattern (required Elements and values) for "xData" instances used for Scenario 2. The field itself specifies that such an "xData" instance SHALL occur at least 1 time and at maximum 3 times within "xListData" of Feature Type "xFeatureType". However, this holds only for Scenario 2 and only if such "xData" are required. In this case, they are required, as the left field

2: M \W

denotes that this data set is mandatory for Scenario 2. The "Value" definition

<g7> [<g8>] [<g9>]

of the Element "xId" specifies that this is the reason for the cardinality: There must be at least one "xData" instance and the corresponding "Value" placeholder is "<g7>" (see section 3.1.3.6 for the definition of "Value" placeholders). The second and third instance of "xData" are optional, as the corresponding placeholders "<g8>" and "<g9>" are put in brackets. Of course, the placeholders SHALL then have distinct values.

The "Value" definition of the Element "qId" contains the expression

```
<h3>(-><g7>) [<h4>(-><g8>)] [<h5>(-><g9>)]
```

This means that the placeholder "<h3>" is to be used with "<g7>". Likewise, "<h4>" is associated with "<g8>" and "<h5>" is associated with "<g9>".

Some Scenarios may require the association to two or more placeholders. As an example, we consider an expression

```
<t2>(-><v1>,<k3>)
```

In this case the placeholder "<t2>" is to be used with the pair of "<v1>" and "<k3>".

The field

```
xSlot. (1..)
```

expresses that the Element "xSlot" SHALL occur at least one time within its "xData", but MAY occur more than one time.

The remaining fields do not have an explicit cardinality indication.

3.1.3.5 Writability and changeability indication

In the same column where the presence indications are denoted, a mark is used to distinguish between writeable, changeable or readable Elements:

- Elements that are marked with "\W" are written by a client and SHALL be writeable at the server according to their presence indications. The client is not obliged to read the according data. Received notifications do not need to be evaluated.
- Elements that are marked with "\C" are changed by a client and SHALL be changeable at the server according to their presence indications. The client is not obliged to read the according data. Received notifications do not need to be evaluated.
- Elements that are marked with "\RW" are read and written by a client and SHALL be writeable and provided by the server according to their presence indications. Received notifications SHALL be evaluated according to their presence indications.
- Elements that are marked with "\RC" are read and changed by a client and SHALL be changeable and provided by the server according to their presence indications. Received notifications SHALL be evaluated according to their presence indications.
- Elements that are not marked are only read by a client and SHALL be provided by the server according to their presence indications. Received notifications SHALL be evaluated according to their presence indications.

"Writeable" means that the Element and its value may be written by a client. This includes the possibility to modify (if the Element is already present), create (if the Element is not present yet), and delete the Element. The server SHALL adjust its Function according to the received "write" operation (unless the server cannot accept the "write" operation according to section 3.1.3.3).

"Changeable" means that the Element's value may be changed by a client. If the Element is not present at the resource before, it probably **cannot** be created by the client via the "write" operation. In this case the server MAY decline such a message.

Note: "\W" includes "\C" already.

Note: Depending on the resource a client might need to request a proper binding before the server accepts a "write" operation.

3.1.3.6 Rules for "Value" placeholders

If the "Value" column contains values for identifiers they are always written as placeholder variable (i.e. placeholder for the real value of the Element) in angle brackets, e.g. <x1>. This means all Elements used within a Scenario that have <x1> (e.g.) in the "Value" column SHALL have set the same content of the Element.

A placeholder variable <xY> (e.g. <x1>) for Scenario A is, in general, independent from a placeholder variable <xY> for Scenario B. However, the server SHOULD combine datasets if possible. If there is the requirement that the same value SHALL be used for different stated Scenarios, the according Scenario numbers in column "Scenario" are put in curly brackets (" {... }") for the Element containing the variable. Several curly bracket groups may exist.

Example: An Element with variable <x1> contains in the column "Scenario" the following expression:
{2, 3}, {4, 5}

This means that Scenario 2 and 3 SHALL use the same value for the variable (e.g. 5) as well as Scenario 4 and 5 SHALL use the same value for the variable (e.g. 12). The variable values MAY differ between the two groups ({2, 3} and {4, 5}).

3.1.3.7 Rules for content of "Value" column

For a given Scenario the "Value" column may restrict the permitted content of a Function's Element to one or more particular values. This means that Elements with values deviating from the restriction (i.e. from the permitted values) do not belong to the respective Scenario and need to be considered as if the Element is not set. If more than one particular value is permitted for an Element the values are in a single line each.

If a presence indication is set for the value (in an additional column before the value) the following rules SHALL be applied:

- "M" means that the value SHALL be supported. This means the value needs to be set at a certain point in time (depending on the value rules) or for a certain Element within a list entry.
- "R" means that the value SHOULD be supported.

- "O" means that the value MAY be supported.

If all possible values of a given mandatory Element are optional or recommended and this Element is used for the purpose of the respective Scenario, one of the values SHALL be set. If all possible values of a given optional or recommended Element are optional or recommended, this Element MAY contain also other values, but then this Element SHALL NOT be considered as part of the respective Scenario.

M, R or O may be combined with the suffix "(event)" to express that a supported value only has to be supported during a certain event and hence does not need to be present at all times. If the event is not active another value may be set. In most cases a High-Level requirement reference for the event is given in the rules column.

If no presence indication is set for the value, the following rules SHALL be applied:

- In case of Elements where the server may set or change an Element on its own (see section 3.1.3.5):
 - within the tables in the "Server data - Resources" sections:
 - the server SHALL support at least one of the listed values.
 - within the tables in the "Client data - Specializations" sections:
 - the client SHALL support all listed values.
- In case of Elements that are writable or changeable (see section 3.1.3.5):
 - within the tables in the "Server data - Resources" sections:
 - the server SHALL support all listed values.
 - within the tables in the "Client data - Specializations" sections:
 - the client SHALL support at least one of the listed values.

Depending on the Element, different values may be used during runtime. If this is the case, those rules are described within the value rules.

If a value is placed in parenthesis, the corresponding value is a recommendation. The actual value MAY deviate from this, e.g. "(1024)".

3.1.3.8 General information on how to interpret the "Content of Function..." and "Content of Specialization..." tables

Within the "Client data - Specializations" sections each Specialization is described in an own sub-section with the name "Specialization "<name of the Specialization>" (e.g. "Specialization "Measurement_GridFeedInEnergy"). It contains only one table that includes all Elements needed for this Specialization. The different Functions are mentioned in a continuous row, highlighted with grey background colour. This row contains the following parts:

<Feature Type>. <Function>.[<list entry instance name>.]

The <list entry instance name> is only included if the <Function> is a list-based Function. An example could be:

DeviceConfiguration. deviceConfigurationKeyValueDescriptionListData.
deviceConfigurationKeyValueDescriptionData.

In the following rows, only the names of the Elements are stated, without the prefix described above.

Within the "Server data - Resources" sections each Feature Type is described in an own sub-section with the name "Feature Type "<name of the Feature Type>" (e.g. "Feature Type "Measurement"). It contains sub-sections for each Function named "Function "<name of the Function>" (e.g. "Function "measurementListData"). These sections contain one table with all Elements needed for this resource. The list entries are mentioned in a continuous row, highlighted with grey background colour. This row contains the following parts:

<Feature Type>. <Function>.[<list entry instance name>.]

The <list entry instance name> is only included if the <Function> is a list-based Function. An example could be:

Measurement. measurementDescriptionListData. measurementDescriptionData.

In the following rows, only the names of the Elements are stated, without the prefix described above.

For both kinds of tables, the following applies:

- Parent Elements are marked with a dot at the end of the name:
 <parent Element>.
 E.g.:
 value.
- If there are sub-Elements, they are described in own rows with the name of the parent Element as prefix, separated by a dot and a blank space:
 <parent Element>. <sub-Element>
 E.g.:
 value. number

3.1.4 Rules for "Feature Types and Functions..." tables

3.1.4.1 Presence indications for "Feature Types and Functions..." tables

The following presence indications are used:

Abbreviation	Meaning	Link to requirement keywords
M	Mandatory	SHALL
R	Recommended	SHOULD
O	Optional	MAY

Table 4: Presence indication of Feature Types and Functions support

If at least one Function of a Feature has the presence indication "M", it is mandatory to support the Feature.

612 3.1.4.2 Rules for "Possible operations" column

613 Within the "Feature Types and Functions..." tables the column "Possible operations" state whether
614 the Function is read- or writeable (as defined in the detailed discovery mechanism, see
615 [ProtocolSpecification]).

616 If the "partial" concept (also called "restricted function exchange") SHALL be supported, the
617 following notation is used (separated for read and write access):

618 read (M). partial (M)

619 write (M). partial (M)

620 If the "partial" concept SHOULD be supported, the following notation is used:

621 read (M). partial (R)

622 write (M). partial (R)

623 If the "partial" concept MAY be supported, the following notation is used:

624 read (M). partial (O)

625 write (M). partial (O)

626 The server can decide whether a notification is submitted complete or partial (as described in
627 [ProtocolSpecification]) if not defined differently within this Use Case Specification.

628

629 3.1.5 "Actor ... overview" diagram rules

630 Within the "Actor [...] overview" diagrams in the "Actors" sub-sections the complete functionality of
631 this Use Case is provided, including optional Scenarios. Which Scenarios are optional can be found in
632 Table 1. The Actor MAY have more functionality implemented than needed for this Use Case.

633 For the following Actor overview example, a brief description of the graphical symbols will be
634 described.

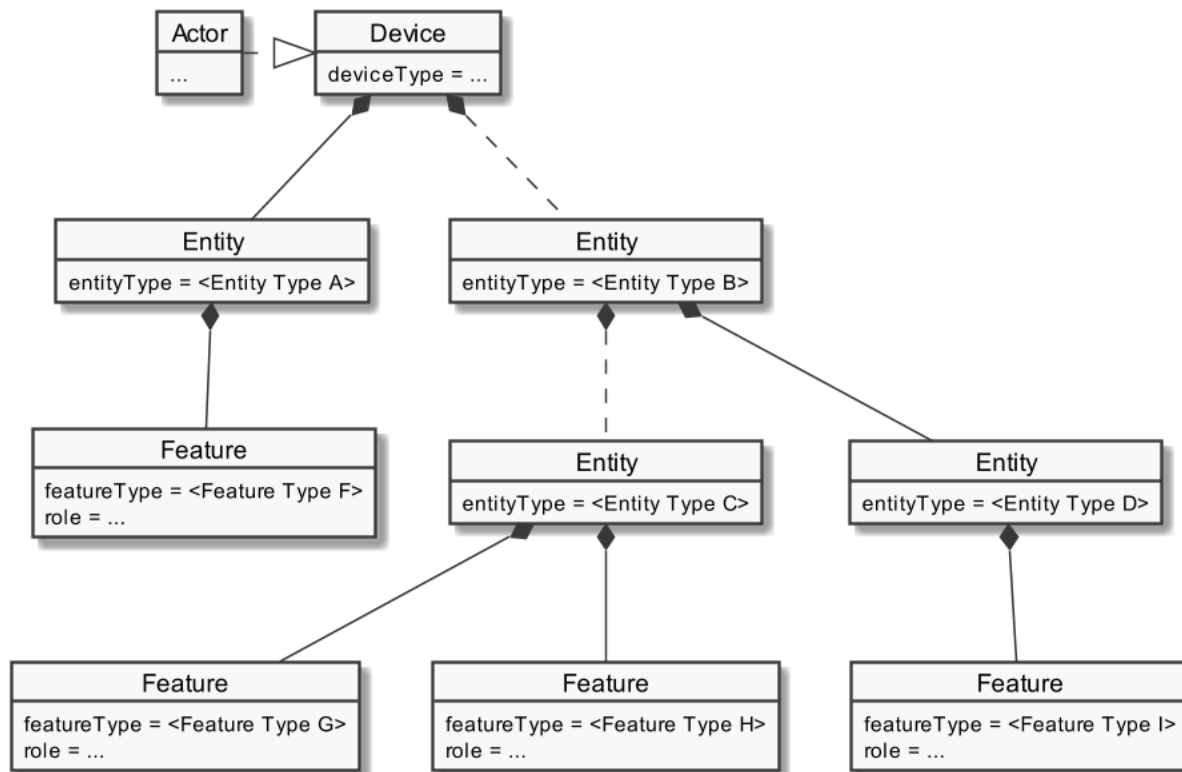


Figure 5: Actor overview example

The solid lines in the figure represent an immediate parent-childhood relation: The Entity with "<Entity Type A>" is a direct child of "Device". The Entity with "<Entity Type D>" is a direct child of the Entity with "<Entity Type B>". All Features are immediate child of the respective Entity.

The dashed lines in the figure express that there MAY be additional Entities between the shown Entities: A vendor's implementation MAY have one or more Entities between "Device" and the Entity with "<Entity Type B>". Likewise, a vendor's implementation MAY have one or more Entities between the Entity with "<Entity Type B>" and the Entity with "<Entity Type D>".

3.1.6 Specializations

Within the "Actors" sub-sections Specializations are referenced. A Specialization describes a dataset necessary to fulfil the specific requirements of a High-Level Use Case and its Scenarios. Often data from multiple different Features and Functions are needed to fulfil the requirements. Therefore, a Specialization defines a dataset that may encompass multiple related Functions from one or more different Features.

As different Use Cases sometimes share similar requirements, Specializations are also important from a re-usability perspective. This approach is used to improve consistency across Use Cases and avoid multiple variances of basically the same dataset. This is especially important in the case when an implementation supports multiple Use Cases. E.g. if a power measurement is necessary in two different Use Cases, both Use Cases could define slightly different datasets. In this case the server as well as the client functionality would have to implement both variances if both Use Cases are supported. This means, depending on the number of Use Cases, two or more datasets need to be

generated, transmitted and stored instead of one. Therefore, already existing Specializations specified within [UseCaseBaseSpecification] are used in this Use Case to avoid such problems.

If a Feature server can provide the data of a Specialization, the data does not necessarily always need to be available at the Feature server. There might be situations where the user deactivates a Use Case. There may also be other reasons why Use Case data cannot be provided currently. Therefore, a client always needs to be subscribed (as described in section 3.3.4) on the corresponding dataset to stay updated.

The SPINE resource description given in the "SPINE resources of the Actor" sections are derived from the Specializations given in the Actor's overview diagram. Please refer to [UseCaseBaseSpecification] for a detailed description of all Specializations.

3.1.7 Order of messages within the sequence diagrams

There are several sequence diagrams in this document describing message flows. The order of the messages SHOULD be kept by the communications partners, but there might be cases where a different order makes sense. The communications partners SHALL be able to handle the Scenario functionalities even if the messages are transmitted in a different order by the other Actor(s). The sequence diagrams can be seen as examples.

3.1.8 Further information and rules

None.

3.2 Actors

3.2.1 EV

3.2.1.1 Resource hierarchy

Within the Use Case discovery this Actor SHALL be denoted as "EV" in the Element "nodeManagementUseCaseData. useCaseInformation. actor".

The following diagram provides an overview of the Actor "EV" resource hierarchy.

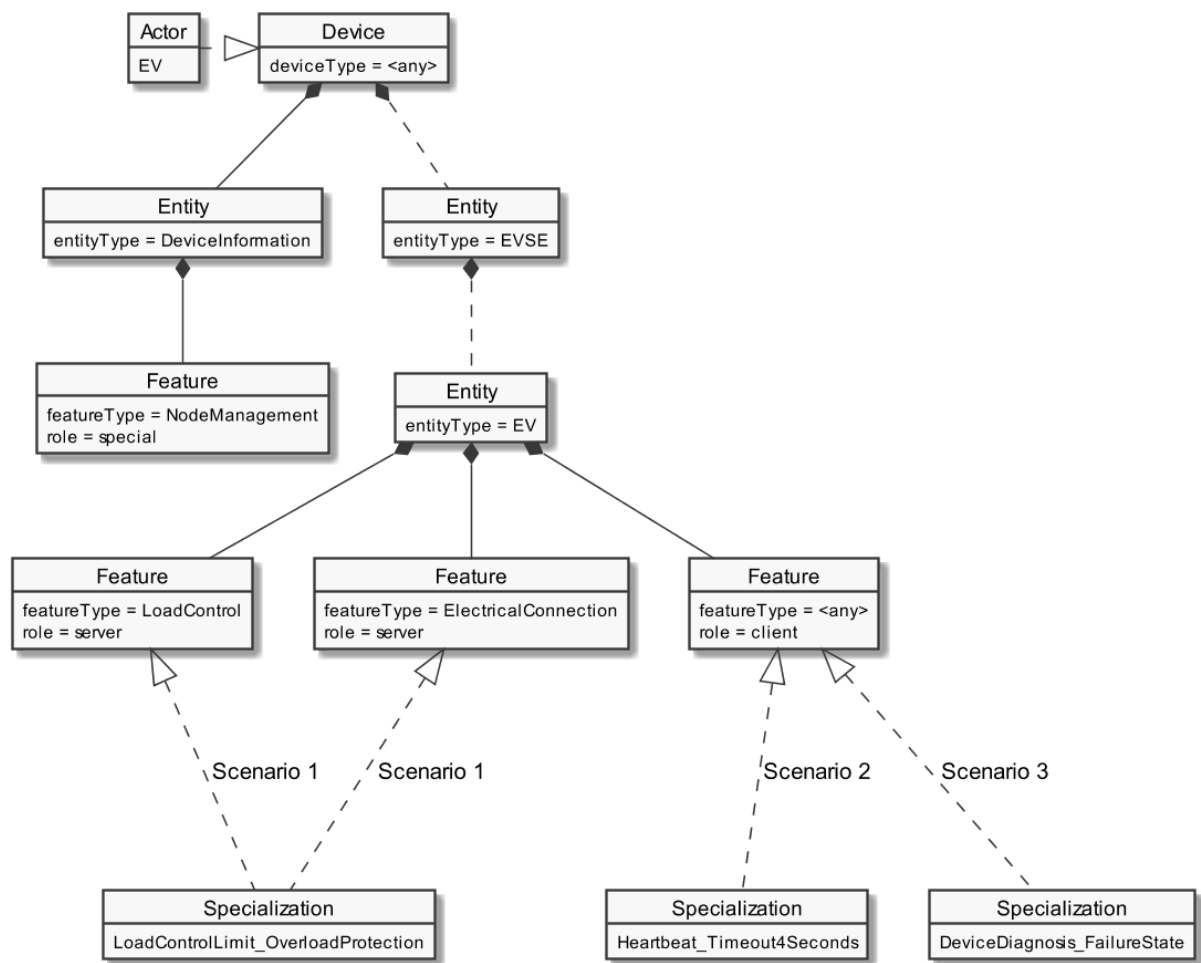


Figure 6: Actor "EV" overview

The "Actor ... overview" diagram rules" section describes how to interpret the diagram above. See the "Specializations" section for more information regarding the Specializations given in the diagram above.

Note: The entityType "DeviceInformation" with the featureType "NodeManagement" is required by the SPINE protocol and therefore SHALL be supported. Both types are added in the figure for completeness but are not directly linked to the Use Case.

The Use Case specific data follows behind the entityType "EV" which is a sub-Entity of the "EVSE" Entity. The Specializations represent the Scenario specific data that has to be supported for each Scenario and are realized with the according featureTypes.

If a Specialization is connected to a Feature with the role "client", the Actor has a client role for this data. This means the Actor accesses the data set described by the Specialization at a corresponding server Feature. Further details are described in the sub-section "Client data - Specializations".

If a Specialization is connected to a Feature with the role "server", the Actor has the server role for this data. This means the Actor must provide the corresponding data set of the Specialization on its Features. Further details are described in the sub-section "Server data - Resources".

3.2.1.2 Server data - Resources**3.2.1.2.1 Overview**

Behind the entityType "EV" the Actor EV SHALL offer the Feature Types and Functions given in the table below.

Feature Type	Scenario: M/R/O	Function	Possible operations
LoadControl	1: M	loadControlLimitDescriptionListData	read (M). partial (R)
	1: M	loadControlLimitListData	read (M). partial (R) write (M). partial (M)
ElectricalConnection	1: M	electricalConnectionParameterDescriptionListData	read (M). partial (R)
	1: M	electricalConnectionPermittedValueSetListData	read (M). partial (R)

Table 5: Feature Types and Functions used within this Use Case by the Actor EV

For each of these Feature Types the following rule applies: There SHALL be at maximum one Feature with the Feature Type in the Entity.

Note: As a consequence of the previous rule, an implementation may need to have Feature data from different Scenarios/Specializations or even Use Cases in a given Feature.

The Scenario number shows in which Scenarios the EV acts as server and which Feature Types and Functions are relevant in each Scenario.

A detailed definition of the Elements and values that shall be supported in each Function is given in the following sub-sections.

Note: If in the table above "partial" read is not mentioned or is only optional, it still might be mandatory to support partial notifications. The details of "partial" support are described within the Scenario sections.

Note: The presence indications stated above are meant relative to the ones of the according Scenario stated in Table 1. I.e. if a Scenario is optional ("O") and a Feature Type is mandatory ("M") the Feature Type must only be supported if the Scenario is supported, too.

Note: Further Features MAY be implemented on the same Entities, as well as further Functions MAY be implemented in the used Entities.

725 3.2.1.2.2 Feature Type "LoadControl"

726 3.2.1.2.2.1 Function "loadControlLimitDescriptionListData"

Scenario [...]: M/R/O [W][C]	Element	Value	[High Level Mapping] Element and value rules
1: M	LoadControl. loadControlLimitDescriptionListData. loadControlLimitDescriptionData.		
1: M	limitId	<x1> [<x2>] [<x3>]	SHALL be used as the primary identifier.
1: M	limitType	"maxValueLimit"	
1: M	limitCategory	"obligation"	
1: M	measurementId	<z1>(-><x1>) [<z2>(-><x2>)] [<z3>(-><x3>)]	SHALL be set as FOREIGN IDENTIFIER, if a measurand or other feature is linked with the measurementId.
1: M	unit	"A"	
1: M	scopeType	"overloadProtection"	

727 Table 6: Content of Function "loadControlLimitDescriptionListData" at Actor EV

728

729 3.2.1.2.2.2 Function "loadControlLimitListData"

Scenario [...]: M/R/O [W][C]	Element	Value	[High Level Mapping] Element and value rules
1: M	LoadControl. loadControlLimitListData. loadControlLimitData.		
1: M	limitId	<x1> [<x2>] [<x3>]	SHALL be used as the primary identifier.
1: R	isLimitChangeable	true	If set to "false", the timePeriod, value and isLimitActive element SHALL NOT be writeable by a client. If omitted or set to "true", the timePeriod, value and isLimitActive element SHALL be writeable by a client.
1: M \W	isLimitActive		[OPEV-004] If set to "false", the limit and its timePeriod and value element SHALL be ignored. If set to "true" or omitted, the timePeriod and value element SHALL be applied, at least if timePeriod or value are set.
1: M \W	value		[OPEV-001]

			<p>If <i>isLimitActive</i> is set to "true", the <i>value</i> SHALL be set. Otherwise the element MAY be omitted. If <i>isLimitActive</i> is set to "false", but <i>value</i> is set, the content of <i>value</i> SHALL be ignored.</p> <p>The sub-elements "number" and "scale" represent a value according to the following formula: $\text{number} * 10^{\text{scale}}$</p>
1: M \W	value. number		SHALL be used.
1: M \W	value. scale		MAY be used. If absent, a default value of "0" applies.

Table 7: Content of Function "loadControlLimitListData" at Actor EV

3.2.1.2.3 Feature Type "ElectricalConnection"

3.2.1.2.3.1 Function "electricalConnectionParameterDescriptionListData"

Scenario [{...}]: M/R/O [\W][\C]	Element	Value	[High Level Mapping] Element and value rules
1: M	ElectricalConnection. electricalConnectionParameterDescriptionListData. electricalConnectionParameterDescriptionData.		
1: M	electricalConnectionId	<j1>	SHALL be set as PRIMARY IDENTIFIER.
1: M	parameterId	<i1> [<i2>] [<i3>]	SHALL be set as SUB IDENTIFIER.
1: M	measurementId	<z1>(-><j1>,<i1>) [<z2>(-><j1>,<i2>)] [<z3>(-><j1>,<i3>)]	SHALL be set as FOREIGN IDENTIFIER. If set, the related electrical connection data SHALL be linked to a measurand or data of another Feature that uses the same measurementId.
1: M	acMeasuredPhases	"a"	[OPEV-002]
		"b"	[OPEV-002]
		"c"	[OPEV-002]

Table 8: Content of Function "electricalConnectionParameterDescriptionListData" at Actor EV

3.2.1.2.3.2 Function "electricalConnectionPermittedValueSetListData"

Scenario [{...}]: M/R/O [\W][\C]	Element	Value	[High Level Mapping] Element and value rules
1: O	ElectricalConnection. electricalConnectionPermittedValueSetListData. electricalConnectionPermittedValueSetData.		
1: M	electricalConnectionId	<j1>	SHALL be set as PRIMARY IDENTIFIER.
1: M	parameterId	<i1> [<i2>] [<i3>]	SHALL be set as SUB IDENTIFIER.
1: M	permittedValueSet		At least one set of permitted values SHALL be stated.
1: O	permittedValueSet. value		The sub-elements "number" and "scale" represent a value according to the following formula: $\text{number} * 10^{\text{scale}}$
1: M	permittedValueSet. value. number		SHALL be used.
1: O	permittedValueSet. value. scale		MAY be used. If absent, a default value of "0" applies.
1: O	permittedValueSet. range		
1: M	permittedValueSet. range. min		The sub-elements "number" and "scale" represent a value according to the following formula: $\text{number} * 10^{\text{scale}}$
1: M	permittedValueSet. range. min. number		SHALL be used.
1: O	permittedValueSet. range. min. scale		MAY be used. If absent, a default value of "0" applies.
1: M	permittedValueSet. range. max		The sub-elements "number" and "scale" represent a value according to the following formula: $\text{number} * 10^{\text{scale}}$
1: M	permittedValueSet. range. max. number		SHALL be used.
1: O	permittedValueSet. range. max. scale		MAY be used. If absent, a default value of "0" applies.

Table 9: Content of Function "electricalConnectionPermittedValueSetListData" at Actor EV

3.2.1.3 Client data - Specializations

3.2.1.3.1 Topic "Heartbeat"

3.2.1.3.1.1 Specialization "Heartbeat_Timeout4Seconds"

Scenario {...}: M/R/O [W][C]	Element	Value	[High Level Mapping] Element and value rules
2: M	DeviceDiagnosis. deviceDiagnosisHeartbeatData.		
2: M	timestamp		SHALL be set to the time of creation.
2: M	heartbeatCounter		The value of the heartbeatCounter element SHALL be increased after every <i>heartbeatTimeout</i> (NOT with every sending of this function). The <i>deviceDiagnosisHeartbeatData</i> function can not only be sent initially by the device itself, but can be requested by another device, too. In this case, the element <i>heartbeatCounter</i> SHALL NOT be incremented and the <i>heartbeatTimeout</i> has (as always) its fixed value (i.e. not the remaining time to the next (automatic) notification by the device).
2: M	heartbeatTimeout	≤4s	[OPEV-005] deviceDiagnosisHeartbeatData SHALL be sent at least each heartbeatTimeout period.

Table 10: Content of Specialization "Heartbeat_Timeout4Seconds" at Actor EV

3.2.1.3.2 Topic "DeviceDiagnosis"

3.2.1.3.2.1 Specialization "DeviceDiagnosis_FailureState"

Scenario {...}: M/R/O [W][C]	Element	Value	[High Level Mapping] Element and value rules
2: M	DeviceDiagnosis. deviceDiagnosisStateData.		
2: M	operatingState	"normalOperation"	
		"failure"	[OPEV-007]
2: O	lastErrorCode		The string-length SHOULD NOT be longer than 128 characters. If it is longer, the sender SHALL consider the possibility that

			the receiver will shorten the string to 128 characters. Even if the device's "operationState" has a value of <i>normalOperation</i> again, the error code SHOULD remain in the Element <i>lastErrorCode</i> .
--	--	--	--

Table 11: Content of Specialization "DeviceDiagnosis_FailureState" at Actor EV

3.2.2 Energy Guard

3.2.2.1 Resource hierarchy

Within the Use Case discovery this Actor SHALL be denoted as "CEM" or "EnergyGuard" in the Element "nodeManagementUseCaseData. useCaseInformation. actor".

"EnergyGuard" SHOULD be chosen by an Actor that only acts as Energy Guard and "CEM" SHOULD be used by an Actor that acts as energy manager.

The following diagram provides an overview of the Actor "Energy Guard" resource hierarchy.

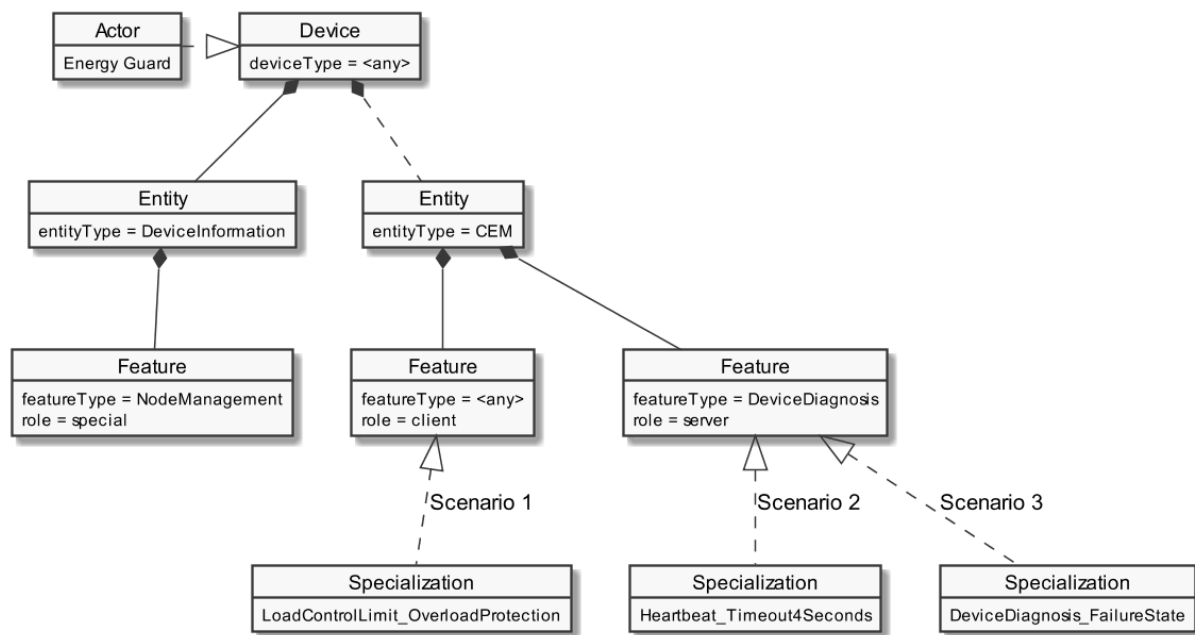


Figure 7: Actor "Energy Guard" overview

The "Actor ... overview" diagram rules" section describes how to interpret the diagram above. See the "Specializations" section for more information regarding the Specializations given in the diagram above.

Note: The entityType "DeviceInformation" with the featureType "NodeManagement" is required by the SPINE protocol and therefore SHALL be supported. Both types are added in the figure for completeness but are not directly linked to the Use Case.

The Use Case specific data follows behind the entityType "CEM". The Specializations represent the Scenario specific data that has to be supported for each Scenario. and are realized with the according featureTypes.

If a Specialization is connected to a Feature with the role "client", the Actor has a client role for this data. This means the Actor accesses the data set described by the Specialization at a corresponding server Feature. Further details are described in the sub-section "Client data - Specializations".

If a Specialization is connected to a Feature with the role "server", the Actor has the server role for this data. This means the Actor must provide the corresponding data set of the Specialization on its Features. Further details are described in the sub-section "Server data - Resources".

3.2.2.2 Server data - Resources

3.2.2.2.1 Overview

Behind the entityType "CEM" the Actor Energy Guard SHALL offer the Feature Types and Functions given in the table below.

Feature Type	Scenario: M/R/O	Function	Possible operations
DeviceDiagnosis	2: M	deviceDiagnosisHeartbeatData	read (M)
	3: M	deviceDiagnosisStateData	read (M)

Table 12: Feature Types and Functions used within this Use Case by the Actor Energy Guard

For each of these Feature Types the following rule applies: There SHALL be at maximum one Feature with the Feature Type in the Entity.

Note: As a consequence of the previous rule, an implementation may need to have Feature data from different Scenarios/Specializations or even Use Cases in a given Feature.

The Scenario number shows in which Scenarios the Energy Guard acts as server and which Feature Types and Functions are relevant in each Scenario.

A detailed definition of the Elements and values that shall be supported in each Function is given in the following sub-sections.

Note: If in the table above "partial" read is not mentioned or is only optional, it still might be mandatory to support partial notifications. The details of "partial" support are described within the Scenario sections.

Note: The presence indications stated above are meant relative to the ones of the according Scenario stated in Table 1. I.e. if a Scenario is optional ("O") and a Feature Type is mandatory ("M") the Feature Type must only be supported if the Scenario is supported, too.

Note: Further Features MAY be implemented on the same Entities, as well as further Functions MAY be implemented in the used Entities.

3.2.2.2.2 Feature Type "DeviceDiagnosis"

3.2.2.2.2.1 Function "deviceDiagnosisHeartbeatData"

Scenario [{...}]: M/R/O [\W][\C]	Element	Value	[High Level Mapping] Element and value rules
2: M	DeviceDiagnosis. deviceDiagnosisHeartbeatData.		
2: M	timestamp		SHALL be set to the time of creation.
2: M	heartbeatCounter		The value of the heartbeatCounter element SHALL be increased after every <i>heartbeatTimeout</i> (NOT with every sending of this function). The <i>deviceDiagnosisHeartbeatData</i> function can not only be sent initially by the device itself, but can be requested by another device, too. In this case, the element <i>heartbeatCounter</i> SHALL NOT be incremented and the <i>heartbeatTimeout</i> has (as always) its fixed value (i.e. not the remaining time to the next (automatic) notification by the device).
2: M	heartbeatTimeout	≤4s	[OPEV-005] deviceDiagnosisHeartbeatData SHALL be sent at least each heartbeatTimeout period.

Table 13: Content of Function "deviceDiagnosisHeartbeatData" at Actor Energy Guard

3.2.2.2.2.2 Function "deviceDiagnosisStateData"

Scenario [{...}]: M/R/O [\W][\C]	Element	Value	[High Level Mapping] Element and value rules
3: M	DeviceDiagnosis. deviceDiagnosisStateData.		
3: M	operatingState	"normalOperation"	
		"failure"	[OPEV-007]
3: O	lastErrorCode		The string-length SHOULD NOT be longer than 128 characters. If it is longer, the sender SHALL

			consider the possibility that the receiver will shorten the string to 128 characters. Even if the device's "operationState" has a value of <i>normalOperation</i> again, the error code SHOULD remain in the element lastErrorCode.
--	--	--	--

Table 14: Content of Function "deviceDiagnosisStateData" at Actor Energy Guard

3.2.2.3 Client data - Specializations

3.2.2.3.1 Topic "LoadControlLimit"

3.2.2.3.1.1 Specialization "LoadControlLimit_OverloadProtection"

Scenario [...]: M/R/O [W][C]	Element	Value	[High Level Mapping] Element and value rules
1: M	LoadControl. loadControlLimitDescriptionListData.	loadControlLimitDescriptionData.	
1: M	limitId	<x1> [<x2>] [<x3>]	SHALL be used as the primary identifier.
1: M	limitType	"maxValueLimit"	
1: M	limitCategory	"obligation"	
1: M	measurementId	<z1>(-><x1>) [<z2>(-><x2>)] [<z3>(-><x3>)]	SHALL be set as FOREIGN IDENTIFIER, if a measurand or other feature is linked with the measurementId.
1: M	unit	"A"	
1: M	scopeType	"overloadProtection"	
1: M	LoadControl. loadControlLimitListData.	loadControlLimitData.	
1: M	limitId	<x1> [<x2>] [<x3>]	SHALL be used as the primary identifier.
1: M	isLimitChangeable	true	If set to "false", the timePeriod, value and isLimitActive element SHALL NOT be writeable by a client. If omitted or set to "true", the timePeriod, value and isLimitActive element SHALL be writeable by a client.
1: M \W	isLimitActive		[OPEV-004] If set to "false", the limit and its timePeriod and value element SHALL be ignored. If set to "true" or omitted, the timePeriod and value element SHALL be applied,

			at least if timePeriod or value are set.
1: M \W	value		[OPEV-001] If <i>isLimitActive</i> is set to "true", the <i>value</i> SHALL be set. Otherwise the element MAY be omitted. If <i>isLimitActive</i> is set to "false", but <i>value</i> is set, the content of <i>value</i> SHALL be ignored. The sub-elements "number" and "scale" represent a value according to the following formula: $\text{number} * 10^{\text{scale}}$
1: M \W	value. number		SHALL be used.
1: M \W	value. scale		MAY be used. If absent, a default value of "0" applies.
1: M	ElectricalConnection. electricalConnectionParameterDescriptionListData. electricalConnectionParameterDescriptionData.		
1: M	electricalConnectionId	<j1>	SHALL be set as PRIMARY IDENTIFIER.
1: M	parameterId	<i1> [<i2>] [<i3>]	SHALL be set as SUB IDENTIFIER.
1: M	measurementId	<z1>(-><j1>,<i1>) [<z2>(-><j1>,<i2>)] [<z3>(-><j1>,<i3>)]	The FOREIGN IDENTIFIER MAY be set. If set, the related electrical connection data SHALL be linked to a measurand or data of another Feature that uses the same measurementId.
1: M	acMeasuredPhases	"a"	[OPEV-002]
		"b"	[OPEV-002]
		"c"	[OPEV-002]
1: M	ElectricalConnection. electricalConnectionPermittedValueSetListData. electricalConnectionPermittedValueSetData.		
1: M	electricalConnectionId	<j1>	SHALL be set as PRIMARY IDENTIFIER.
1: M	parameterId	<i1> [<i2>] [<i3>]	SHALL be set as SUB IDENTIFIER.
1: M	permittedValueSet		At least one set of permitted values SHALL be stated.
1: M	permittedValueSet. value		The sub-elements "number" and "scale" represent a value according to the following formula: $\text{number} * 10^{\text{scale}}$
1: M	permittedValueSet. value. number		SHALL be used.
1: M	permittedValueSet. value. scale		MAY be used. If absent, a default value of "0" applies.
1: M	permittedValueSet. range		
1: M	permittedValueSet. range. min		The sub-elements "number" and "scale" represent a value

			according to the following formula: $\text{number} * 10^{\text{scale}}$
1: M	permittedValueSet. range. min. number		SHALL be used.
1: M	permittedValueSet. range. min. scale		MAY be used. If absent, a default value of "0" applies.
1: M	permittedValueSet. range. max		The sub-elements "number" and "scale" represent a value according to the following formula: $\text{number} * 10^{\text{scale}}$
1: M	permittedValueSet. range. max. number		SHALL be used.
1: M	permittedValueSet. range. max. scale		MAY be used. If absent, a default value of "0" applies.

Table 15: Content of Specialization "LoadControlLimit_OverloadProtection" at Actor Energy Guard

3.3 Pre-Scenario communication

3.3.1 General information

The Pre-Scenario communication is needed if a client does not know the corresponding addresses on the server or if the required subscriptions or bindings are not active. In this case certain general communication mechanisms SHALL be used within SPINE:

- a) Detailed discovery: allows to discover resource addresses.
- b) Binding: allows to bind to resource address, which is frequently necessary to obtain write privileges.
- c) Subscription: allows to subscribe to resource addresses, which is necessary to receive unsolicited notifications if a resource changes during runtime.

It is possible to combine those steps for multiple Scenarios or also multiple Use Cases:

- E.g. if multiple Scenarios in multiple Use Cases use the same Feature, only one subscription needs to occur.
- E.g. a complete detailed discovery or a subscription to the NodeManagement Feature needs to occur only once for all Use Cases.

Depending on which Entity, Feature and Functions are used within a Scenario the payload of the corresponding messages may slightly differ, but the basic principles and messages used stay the same.

The subsequent messages SHALL be exchanged for those parts that have not already been performed since the current connection is established or if those parts are outdated for another reason (e.g. if the detailed discovery is needed, but the bindings and subscriptions are still active from a previous connection only the detailed discovery messages need to be exchanged). If all Pre-Scenario communication parts are up-to-date, this section MAY be skipped, and the implementation can proceed as described in the corresponding "Scenario communication" sections.

831 After the connection is re-established (e.g. due to a power loss or a firmware update) the Pre-
832 Scenario communication SHALL be performed as well. There may be circumstances where messages
833 from the Pre-Scenario communication may be exchanged again.

834 Often the necessary messages of different Scenarios can be combined, so that only one single
835 message is needed instead of multiple messages for the different Scenarios. This also is the case for
836 the Pre-Scenario communication. In most cases only one "read" operation on the detailed discovery
837 is necessary, as well as only one subscription request or binding request is needed for each Feature.
838 Often multiple Scenarios within a Use Case access the same Feature, so only one subscription or
839 binding is necessary.

840

841 **3.3.2 Detailed discovery**

842 For the functionality where a client already has current detailed discovery information (i.e.
843 independent of this Use Case or any Scenario of it) the remainder of this section SHOULD be skipped.

844 Otherwise, the following procedure SHALL be performed in the given order:

- 845 1. If a client is not subscribed to the primary NodeManagement instance, the client SHALL
846 acquire a subscription according to the figure provided within this sub-section.
- 847 2. A client SHALL read the detailed discovery information according to the figure provided
848 within this sub-section. It SHALL keep the received information as far as it concerns
849 mandatory and supported optional Entity Types, Feature Types and Functions of this Use
850 Case that are needed by the client. This means that a client may choose how to store the
851 necessary information. E.g. a client Actor can store the information how to address the
852 necessary Features of the implemented Scenarios but may discard the Entity information.
- 853 3. If and as long as a client has a subscription to the detailed discovery information of an Actor
854 and receives proper notifications, it SHALL consider (i.e. integrate into the kept detailed
855 discovery information) the received information as far as it concerns mandatory and
856 supported optional Entity Types, Feature Types and Functions of this Use Case.

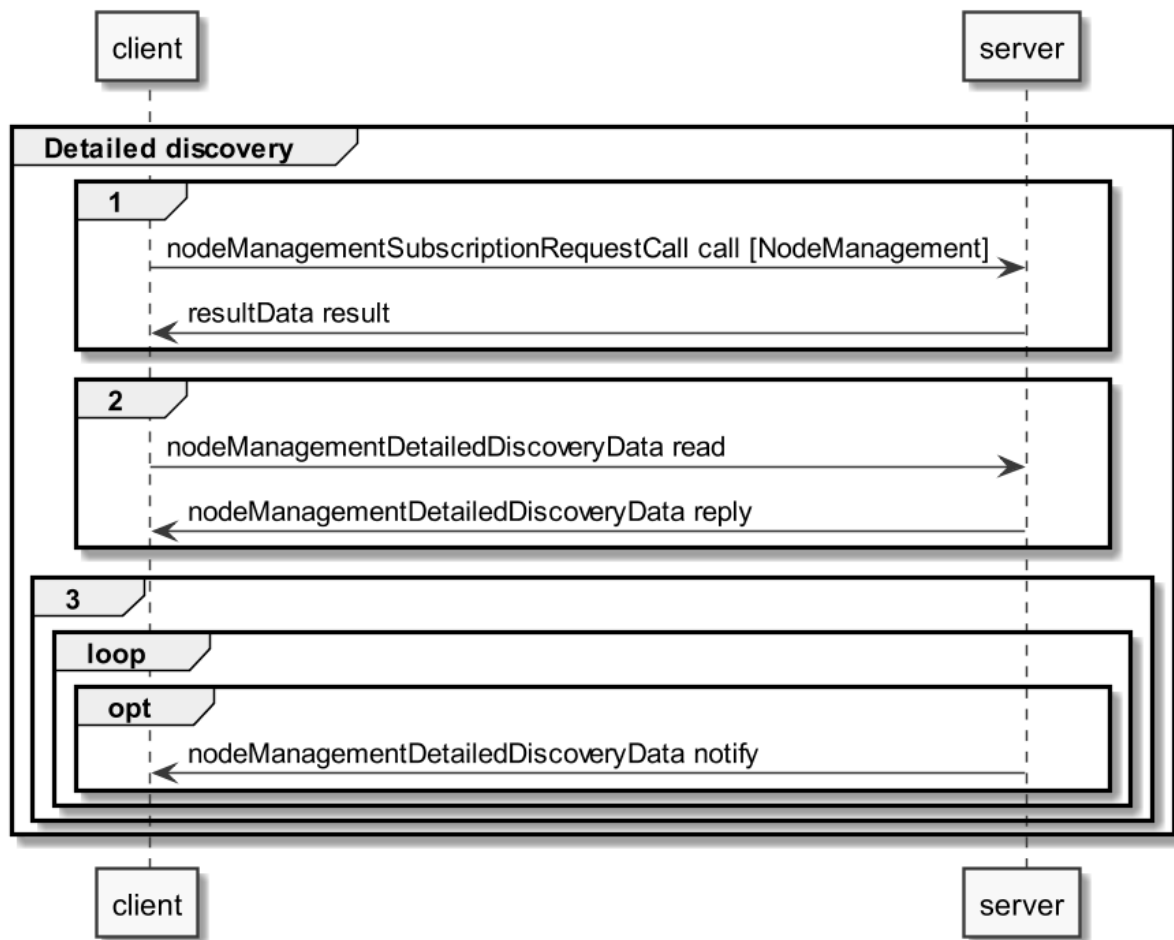


Figure 8: Pre-Scenario communication - Detailed discovery sequence diagram

If the "nodeManagementDetailedDiscoveryData read" fails, the client SHOULD retry to read the detailed discovery information until the "nodeManagementDetailedDiscoveryData reply" message was received successfully.

If all functionality is present at all times: The "nodeManagementDetailedDiscoveryData reply" message contains at least the mandatory Entities and Features given in the "Actor [...] overview" diagrams as well as the used Functions and their "possible operations" described in section 3.2 and its sub-sections.

If functionality is added or removed dynamically: The "nodeManagementDetailedDiscoveryData reply" message does not need to contain all mandatory Entities and Features given in the "Actor [...] overview" diagrams as well as all needed Functions and their "possible operations" described in section 3.2 and its sub-sections. However, as soon as the functionality is available it will be announced via a "nodeManagementDetailedDiscoveryData notify" message.

For the nodeManagementDetailedDiscoveryData read Function it is recommended to use a partial read with separated Selectors that may use one of the following Elements:

- entityType
- featureType

Note: Even with the usage of Selectors Features and Entities that are not relevant for this Use Case may be discovered. However, only Features and Entities that fulfil the hierarchical order as described within the Actors' sections shall be considered for this Use Case.

A "partial" notify SHALL be supported without using Selectors and Elements. Partial "delete" notify SHOULD also be supported with separated Selectors that may use one of the following Elements:

- entityAddress
- featureAddress

3.3.3 Binding

A server SHALL support binding for all Features that contain writeable or changeable data. Before a write on a Function of a Feature occurs, the client SHALL create a binding to the corresponding Feature. For this the nodeManagementBindingRequestCall Function is used as shown in the following sequence diagram:

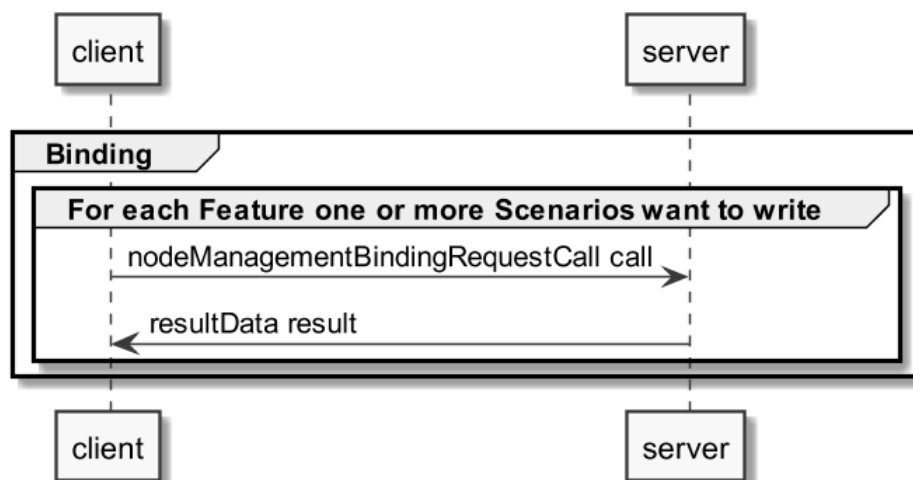


Figure 9: Pre-Scenario communication - Binding sequence diagram

If functionality is added or removed dynamically, binding may not be possible at all times on the required Functions. A client SHALL retry to create a binding again when receiving according updated detailed discovery information.

3.3.4 Subscription

A server SHALL support subscription for all Features that contain readable data that may change during runtime. The client SHALL create a subscription for all Features that the client wants to read. For this the nodeManagementSubscriptionRequestCall Function is used as shown in the following sequence diagram:

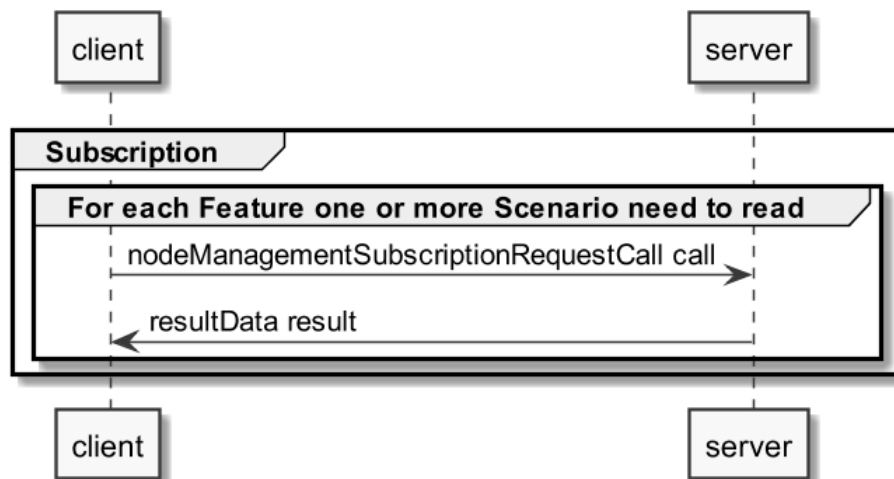


Figure 10: Pre-Scenario communication - Subscription sequence diagram

If the subscription request fails (e.g. because it is not supported by the server or the maximum number of possible subscriptions is reached), the client SHOULD read the data periodically (so-called "polling").

If functionality is added or removed dynamically, subscription may not be possible at all times on the required Functions. A client SHALL retry its subscription procedure again when receiving according updated detailed discovery information.

3.3.5 Dynamic behaviour

In case Entities or Features are removed, a nodeManagementDetailedDiscoveryData "notify" is transmitted that informs about the deleted Entities and Features. All existing binding or subscription entries on the deleted Features SHALL be deleted by each device.

In case Entities or Features are added the Pre-Scenario communication starts with transmitting a nodeManagementDetailedDiscoveryData "notify" that contains the added Entities and Features.

3.4 Scenarios

3.4.1 Scenario 1 - Energy Guard curtails charging current of EV

3.4.1.1 Pre-Scenario communication

1. **Detailed Discovery:** Actors that act as client within this Scenario, need to know the addresses of the server Features used in the Initial Scenario communication. If an address of a particular server Feature is not known, the detailed discovery has to be used, as described in section 3.3.2.
2. **Binding:** Actors that write parts of a Feature within this Scenario, need to create a binding, as described in section 3.3.3. Only one binding partner is allowed to write the data specified in this Scenario.
3. **Subscription:** Actors SHALL create a subscription for each server Feature that is relevant for the corresponding Actor within this Scenario, as described in section 3.3.4.

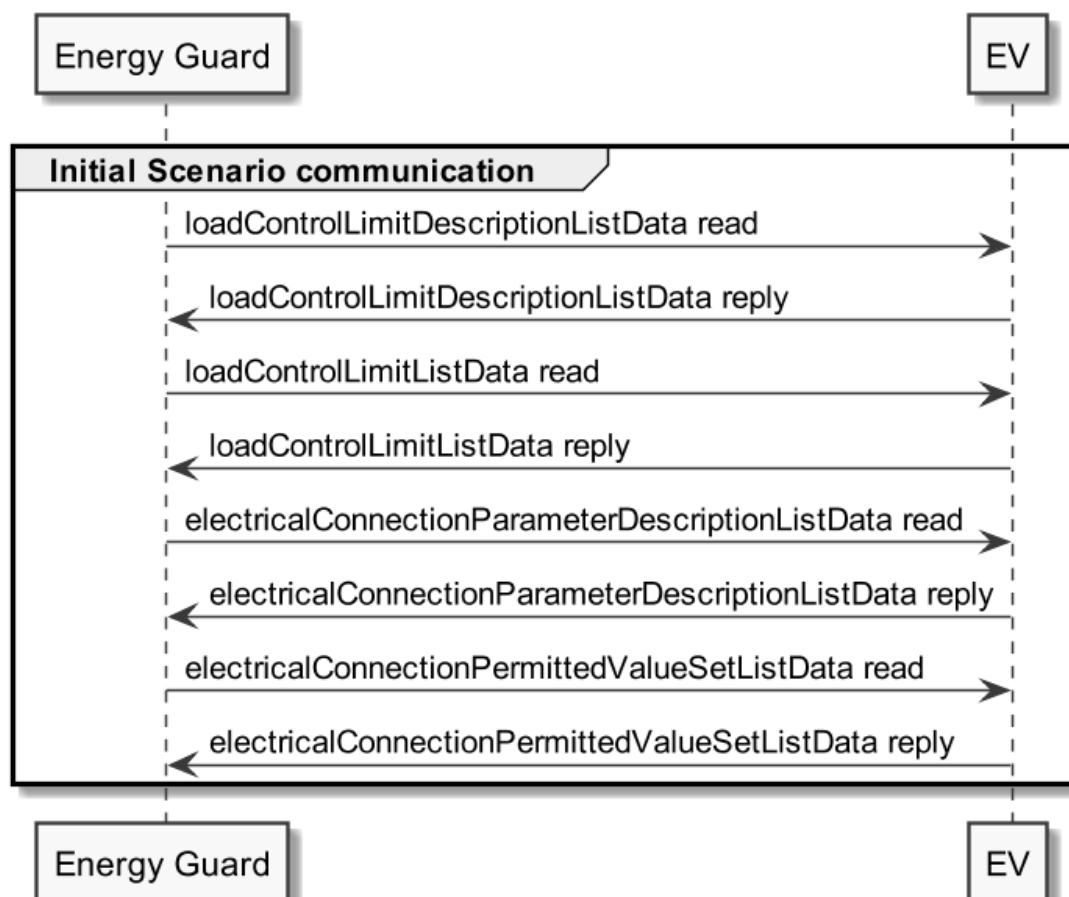
927 The Initial Scenario communication SHALL start at the latest when the required resources on an Actor
 928 are known and the necessary binding and subscription procedures have been finished. However, as
 929 soon as an address of a required resource is known, the Initial Scenario communication for this
 930 resource MAY start already, even if addresses of other required resources are not known yet.

931 If required resources are removed and added again, they are re-discovered, and the Initial Scenario
 932 communication is triggered again for those resources.

933

934 **3.4.1.2 Initial Scenario communication**

935 Each time a (re-)connection is established, even if the Pre-Scenario communication phase is skipped,
 936 the messages as shown in the following sequence diagram SHALL be exchanged, as the
 937 corresponding resources may have changed in the meantime:



938

939 *Figure 11: Scenario 1 - Initial Scenario communication sequence diagram*

940 For loadControlLimitDescriptionListData partial read with the following Selectors SHOULD be
 941 supported:

- 942 - scopeType = "overloadProtection"

943 For loadControlLimitListData partial read with the following Selectors SHOULD be supported:

- 944 - limitId (derived from the loadControlLimitDescriptionListData reply)

945 For electricalConnectionParameterDescriptionListData partial read with the following Selectors
 946 SHOULD be supported:

947 - measurementId (derived from the loadControlLimitDescriptionListData reply)

948 For electricalConnectionPermittedValueSetListData partial read with the following Selectors SHOULD
 949 be supported:

950 - electricalConnectionId (derived from the electricalConnectionParameterDescriptionListData
 951 reply)

952 - parameterId (derived from the electricalConnectionParameterDescriptionListData reply)

953 The following table shows where the necessary content of the messages from the sequence diagram
 954 is described:

Message name from sequence diagram	Content description in table	Scenario number in table
loadControlLimitDescriptionListData reply	Table 6	1
loadControlLimitListData reply	Table 7	1
electricalConnectionPermittedValueSetListData reply	Table 9	1
electricalConnectionParameterDescriptionListData reply	Table 8	1

955 *Table 16: Initial Scenario communication content references for Scenario 1*

956 Note: Within the Initial Scenario communication the content required by this Scenario MAY not be
 957 provided completely but later on during Runtime Scenario communication.

958

959 **3.4.1.3 Runtime Scenario communication**

960 Based on the Initial Scenario communication the Runtime Scenario communication provides updates
 961 during runtime.

962 If one of the referenced server Functions' data change, the server SHALL submit the change as shown
 963 in the following figure:

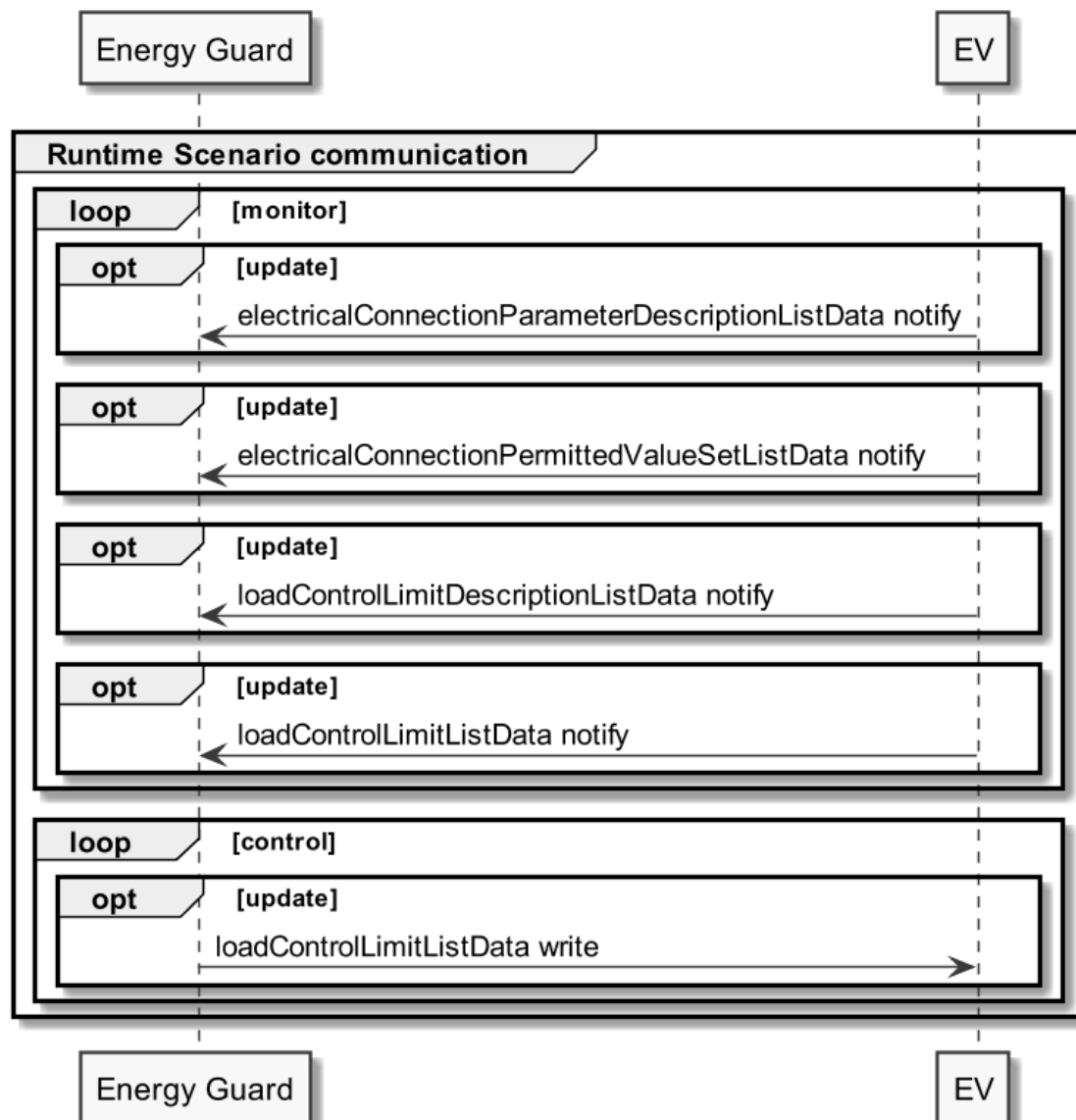


Figure 12: Scenario 1 - Runtime Scenario communication sequence diagram

Partial notifications without Selectors or Elements SHALL be supported for all Functions used in this Scenario.

For loadControlLimitDescriptionListData and loadControlLimitListData partial delete notification SHOULD be supported with the Selector:

- limitId

For electricalConnectionParameterDescriptionListData partial delete notification with the following Selectors SHOULD be supported:

- electricalConnectionId
- parameterId
- measurementId

For electricalConnectionPermittedValueSetListData partial read with the following Selectors SHOULD be supported:

- 978 - electricalConnectionId
- 979 - parameterId

980 Partial write without Selectors or Elements SHALL be supported for the loadControlLimitListData
981 function.

982 Note: To interpret partial notification messages correctly the information obtained during the Initial
983 Scenario communication phase is necessary.

984 Note: A read operation ("polling") on all Functions is possible at any time, e.g. if a notification could
985 not be evaluated.

986 The following table shows where the necessary content of the messages of the sequence diagram is
987 described:

Message name from sequence diagram	Content description in table	Scenario number in table
electricalConnectionParameterDescriptionListData notify	Table 8	1
electricalConnectionPermittedValueSetListData notify	Table 9	1
loadControlLimitDescriptionListData notify	Table 6	1
loadControlLimitListData notify	Table 7	1
loadControlLimitListData write [OPEV-003]	Table 7	1

988 *Table 17: Runtime Scenario communication content references for Scenario 1*

989

990 **3.4.1.4 Additional information**

991 None.

992

993 **3.4.2 Scenario 2 - EV checks Energy Guard availability**

994 **3.4.2.1 Pre-Scenario communication**

- 995 1. **Detailed Discovery:** Actors that act as client within this Scenario, need to know the addresses
996 of the server Features used in the Initial Scenario communication. If an address of a
997 particular server Feature is not known, the detailed discovery has to be used, as described in
998 section 3.3.2.
- 999 2. **Binding:** Binding SHOULD NOT be used for this Scenario.
- 1000 3. **Subscription:** Actors SHALL create a subscription for each server Feature that is relevant for
1001 the corresponding Actor within this Scenario, as described in section 3.3.4.

1002 The Initial Scenario communication SHALL start at the latest when the required resources on an Actor
1003 are known and the necessary binding and subscription procedures have been finished. However, as
1004 soon as an address of a required resource is known, the Initial Scenario communication for this
1005 resource MAY start already, even if addresses of other required resources are not known yet.

1006 If required resources are removed and added again, they are re-discovered, and the Initial Scenario
1007 communication is triggered again for those resources.

3.4.2.2 Initial Scenario communication

Each time a (re-)connection is established, even if the Pre-Scenario communication phase is skipped, the messages as shown in the following sequence diagram SHALL be exchanged, as the corresponding resources may have changed in the meantime:

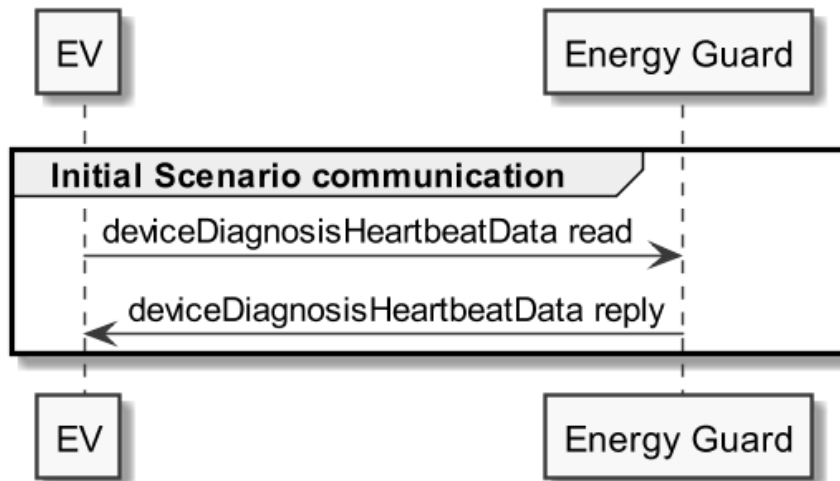


Figure 13: Scenario 2 - Initial Scenario communication sequence diagram

The following table shows where the necessary content of the messages from the sequence diagram is described:

Message name from sequence diagram	Content description in table	Scenario number in table
deviceDiagnosisHeartbeatData reply	Table 13	2

Table 18: Initial Scenario communication content references for Scenario 2

Note: Within the Initial Scenario communication the content required by this Scenario MAY not be provided completely but later on during Runtime Scenario communication.

3.4.2.3 Runtime Scenario communication

Based on the Initial Scenario communication the Runtime Scenario communication provides updates during runtime.

If one of the referenced server Functions' data change, the server SHALL submit the change as shown in the following figure:

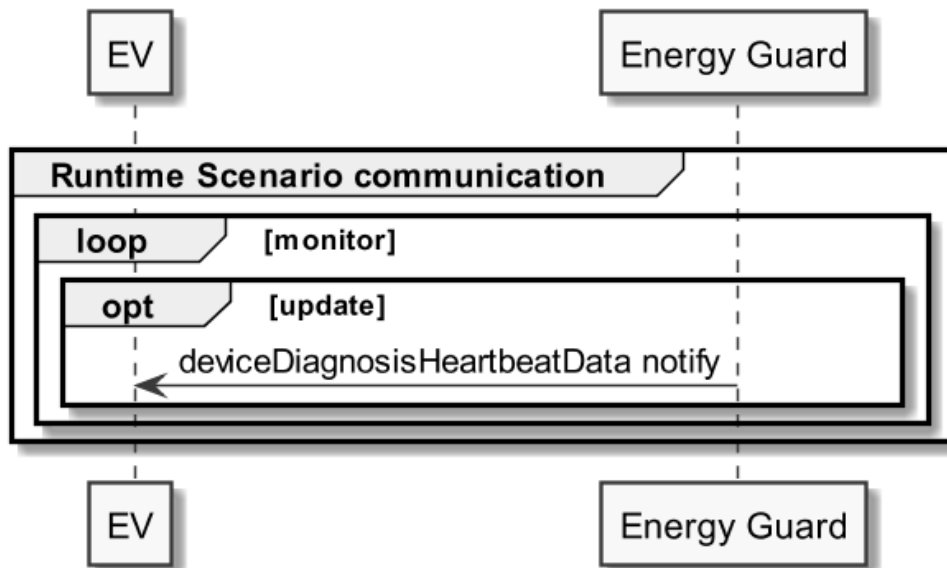


Figure 14: Scenario 2 - Runtime Scenario communication sequence diagram

Note: To interpret partial notification messages correctly the information obtained during the Initial Scenario communication phase is necessary.

Note: A read operation ("polling") on all Functions is possible at any time, e.g. if a notification could not be evaluated.

The following table shows where the necessary content of the messages of the sequence diagram is described:

Message name from sequence diagram	Content description in table	Scenario number in table
deviceDiagnosisHeartbeatData notify [OPEV-006]	Table 13	2

Table 19: Runtime Scenario communication content references for Scenario 2

3.4.2.4 Additional information

None.

3.4.3 Scenario 3 - Energy Guard sends error state

3.4.3.1 Pre-Scenario communication

- Detailed Discovery:** Actors that act as client within this Scenario, need to know the addresses of the server Features used in the Initial Scenario communication. If an address of a particular server Feature is not known, the detailed discovery has to be used, as described in section 3.3.2.
- Binding:** Binding SHOULD NOT be used for this Scenario.
- Subscription:** Actors SHALL create a subscription for each server Feature that is relevant for the corresponding Actor within this Scenario, as described in section 3.3.4.

The Initial Scenario communication SHALL start at the latest when the required resources on an Actor are known and the necessary binding and subscription procedures have been finished. However, as soon as an address of a required resource is known, the Initial Scenario communication for this resource MAY start already, even if addresses of other required resources are not known yet.

If required resources are removed and added again, they are re-discovered, and the Initial Scenario communication is triggered again for those resources.

3.4.3.2 Initial Scenario communication

Each time a (re-)connection is established, even if the Pre-Scenario communication phase is skipped, the messages as shown in the following sequence diagram SHALL be exchanged, as the corresponding resources may have changed in the meantime:

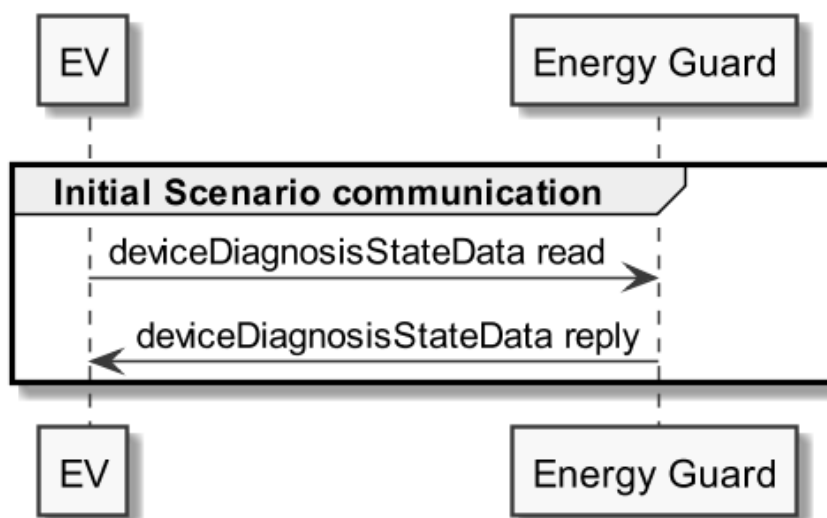


Figure 15: Scenario 3 - Initial Scenario communication sequence diagram

The following table shows where the necessary content of the messages from the sequence diagram is described:

Message name from sequence diagram	Content description in table	Scenario number in table
deviceDiagnosisStateData reply	Table 14	3

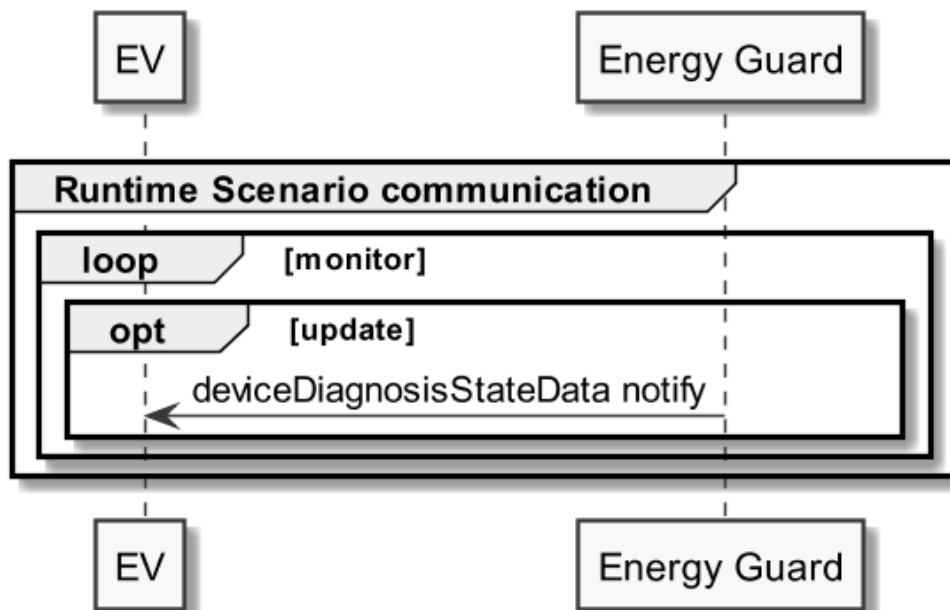
Table 20: Initial Scenario communication content references for Scenario 3

Note: Within the Initial Scenario communication the content required by this Scenario MAY not be provided completely but later on during Runtime Scenario communication.

3.4.3.3 Runtime Scenario communication

Based on the Initial Scenario communication the Runtime Scenario communication provides updates during runtime.

1071 If one of the referenced server Functions' data change, the server SHALL submit the change as shown
 1072 in the following figure:



1073

1074 *Figure 16: Scenario 3 - Runtime Scenario communication sequence diagram*

1075 Note: To interpret partial notification messages correctly the information obtained during the Initial
 1076 Scenario communication phase is necessary.

1077 Note: A read operation ("polling") on all Functions is possible at any time, e.g. if a notification could
 1078 not be evaluated.

1079

1080 The following table shows where the necessary content of the messages of the sequence diagram is
 1081 described:

Message name from sequence diagram	Content description in table	Scenario number in table
deviceDiagnosisStateData notify [OPEV-008]	Table 14	3

1082 *Table 21: Runtime Scenario communication content references for Scenario 3*

1083

1084 **3.4.3.4 Additional information**

1085 None.

1086