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## ETSI SmartM2M Technical Report 103714: Study for oneM2M Discovery and Query use cases and requirements

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TECHNICAL REPORT

**SmartM2M;  
Study for oneM2M  
Discovery and Query use cases and requirements**

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Reference

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# Contents

Intellectual Property Rights .....	5
Foreword.....	5
Modal verbs terminology.....	5
Executive summary .....	5
Introduction .....	5
1 Scope .....	7
1.1 Context for the present document.....	7
1.2 Scope of the present document.....	7
2 References .....	8
2.1 Normative references .....	8
2.2 Informative references.....	8
3 Definition of terms, symbols and abbreviations.....	10
3.1 Terms.....	10
3.2 Symbols.....	11
3.3 Abbreviations .....	11
4 Method for collecting Use Cases.....	12
5 Use Case - Semantic discovery in presence of a "network" of M2M Service Providers (M2MSP) .....	12
5.1 Description .....	12
5.2 Source.....	13
5.3 Actors .....	13
5.4 Pre-conditions.....	13
5.5 Triggers .....	14
5.6 Normal Flow .....	15
5.7 Alternative Flow.....	16
5.8 Post-conditions .....	16
5.9 High level illustration.....	17
5.10 Potential Requirements for the oneM2M system .....	17
6 Use Case - Semantic recommendation in CSEs for discovery .....	17
6.1 Description .....	17
6.2 Source.....	18
6.3 Actors .....	18
6.4 Pre-conditions.....	18
6.5 Triggers .....	19
6.6 Normal Flow .....	19
6.7 Alternative Flow.....	19
6.8 Post-conditions .....	19
6.9 High level illustration.....	20
6.10 Potential Requirements for the oneM2M system .....	20
7 Use Case - Facility management of a supermarket chain.....	20
7.1 Description .....	20
7.2 Source.....	21
7.3 Actors .....	21
7.4 Pre-conditions.....	21
7.5 Triggers .....	22
7.6 Normal Flow .....	22
7.7 Alternative Flow.....	22
7.8 Post-conditions .....	22
7.9 High level illustration.....	23
7.10 Potential Requirements for the oneM2M system .....	23
8 Use Case - Healthcare network and clinical knowledge administration .....	24
8.1 Description .....	24

8.2	Source.....	24
8.3	Actors .....	25
8.4	Pre-conditions.....	25
8.5	Triggers .....	25
8.6	Normal Flow .....	25
8.7	Alternative Flow.....	26
8.8	Post-conditions .....	26
8.9	High level illustration.....	26
8.10	Potential Requirements for the oneM2M system .....	27
9	Lessons learned and conclusions.....	27
<b>Annex A:</b>	<b>Change History .....</b>	<b>28</b>
History .....		29

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# Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Smart Machine-to-Machine communications (SmartM2M).

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# Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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# Executive summary

The oneM2M system has implemented basic native discovery capabilities. In order to enhance the semantic capabilities of the oneM2M architecture by providing solid contributions to the oneM2M standards, four Technical Reports have been developed. Each of them is the outcome of a special study phase: requirements, study, simulation and standardization phase. The present document covers the first phase and provides the basis for the other documents.

The use cases specified in the present document lead to potential requirements, which extend the existing requirements of the use case documented in oneM2M TR-0001 [i.19], clause 12.9 with a focus on the discovery and query capabilities, introducing a direct relation with the semantic aspects and enabling more sophisticated semantic queries as e.g. a capability in the CSE, that takes routing decisions for forwarding a received Advanced Semantic Discovery Query.

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# Introduction

oneM2M has currently native discovery capabilities that work properly only if the search is related to specific known sources of information (e.g. searching for the values of a known set of containers) or if the discovery is well scoped and designed (e.g. the lights in a house). When oneM2M is used to discover wide sets of data or unknown sets of data, the functionality is typically integrated by ad hoc applications that are expanding the oneM2M functionality. This means that this core function may be implemented with different flavours and this is not optimal for interworking and interoperability.

The objective of the present document [i.1] in conjunction with three other ones [i.2], [i.3] and [i.4] is the study and development of semantic Discovery and Query capabilities for oneM2M and its contribution to the oneM2M standard.

The goal is to enable an easy and efficient discovery of information and a proper interworking with external source/consumers of information (e.g. a distributed data base in a smart city or in a firm), or to directly search information in the oneM2M system for big data purposes.

# 1 Scope

## 1.1 Context for the present document

In order to enhance the semantic capabilities of the oneM2M architecture by providing solid contributions to the oneM2M standards, four Technical Reports have been developed. Each of them is the outcome of a special study phase.

The study and development of semantic Discovery and Query capabilities for oneM2M and its contribution to the oneM2M standard is composed of four phases:

- 1) A **requirements** phase where requirements and use cases are formally identified and defined. As a minimum, this work includes discovery of specific information and of aggregated information, and interaction with external sources of data and queries. The oneM2M architecture [i.6], the oneM2M semantic approach [i.7], the current oneM2M capabilities and SAREF [i.8], [i.9], [i.10], [i.11], [i.12], [i.13], [i.14] are at the basis of these use cases and requirements. This work is documented in ETSI TR 103 714 [i.1] (the present document).
- 2) A **study** phase where possible approaches (existing and new ones) to a discovery and data aggregation solution are analysed with respect to the use cases and requirements. In particular, the need to plug in the solution on the oneM2M standard drives the solution analysis, to determine the best approach to be followed. The present document also looks to the query and discovery mechanisms already available, starting from the ones defined by ETSI (e.g. the one included in NGSI-LD [i.15]) to extract (and potentially adapt) the applicable components and to assure a smooth interworking with non-oneM2M solutions. This is documented in ETSI TR 103 715 [i.2].
- 3) A **simulation** phase is conducted in parallel and "circular" feedback with respect to the study phase, with the goal to provide a proof of concept, run suitable scenarios provided by previous phases and a performance evaluation to support the selection/development of the Discovery and Query solution. The simulator/emulator and the simulation results are documented in ETSI TR 103 716 [i.3]. An extract of the simulation results is included ETSI TR 103 715 [i.2] and ETSI TR 103 717 [i.4]. A selection of the use cases includes a set of oneM2M relevant configurations scenarios to be considered for the simulation activity described below.
- 4) A **standardization** phase where the Discovery and Query solution is specified and documented in ETSI TR 103 717 [i.4].

The present document covers the first of the four phases and provides the basis for the other documents listed below (the present document is highlighted in *italic* script in the list):

- *ETSI TR 103 714: SmartM2M; Study for oneM2M Discovery and Query use cases and requirements [i.1] (present document);*
- ETSI TR 103 715: SmartM2M; Study for oneM2M Discovery and Query solutions analysis & selection [i.2];
- ETSI TR 103 716: SmartM2M; oneM2M Discovery and Query solution(s) simulation and performance evaluation [i.3];
- ETSI TR 103 717: SmartM2M; Study for oneM2M Discovery and Query specification development [i.4].

## 1.2 Scope of the present document

The present document identifies additional requirements to be potentially submitted to oneM2M in the areas of discovery mechanism and query languages (syntax and semantic), by means of relevant use cases. It includes discovery of specific information and of aggregated information, and interaction with external sources of data and queries. The oneM2M architecture [i.5], [i.6], the oneM2M semantic approach [i.7], the current oneM2M capabilities and SAREF [i.8], [i.9], [i.10], [i.11], [i.12], [i.13], and [i.14] are at the basis of these use cases and requirements.

The present document is structured as follows:

- Clauses 1 to 3 set the scene and provide references as well as definition of terms, symbols and abbreviations, which are used in the present document.
- Clause 4 describes the method used for collecting Use Cases.



- Clause 5 presents a kind of generic Use Case, which could be considered as either the "use-case zero", or a "parametric use-case" for Advanced Semantic Discovery (ASD) because it is suitable to be instantiated in many concrete cases. It shows the importance of fixing, formalizing and extending Formal Graph Topologies (FGT), Formal Semantic Discovery Routing Mechanism (SDRM), Formal Semantic Discovery Query Language (SDQL) and Formal Semantic Resolution Query Mechanism (SRQM).
- Clause 6 presents a Use Case, which looks at the semantic discovery requirements illustrating a Hospital that has a large number of IoT devices from different domains, which have different goals in the infrastructure. In this scenario, it is necessary to perform a discovery task of suitable devices relying on fine-grained discovery criteria. In addition, the discovery should cope devices belonging to different administrative domains.
- Clause 7 presents a Use Case, which looks at the semantic discovery requirements through a facility manager working for a supermarket chain and being responsible of dozens of buildings, who has to deal with energy efficiency strategies to all buildings and to compare buildings to detect leaks, adjust the heat and the lighting according to forecast or predictive models, assessing the warehouses stocks to refill in time, centralized fault detection to take countermeasures. Supermarkets data of their parking lot sensors and energy consumption are made available to other Service providers.
- Clause 8 presents a Use Case, which looks at the semantic discovery requirements through a networking environment between people with disease (patients), the elderly, who want to live an independent life while remaining in their homes, special invalid people with a high risk of falling in their homes, doctors/care taking people, people practicing fitness exercises to improve their health, and institutions/organizations, who manage a clinical knowledge & information data basis or analyses of patient data.
- Clause 9 provides some lessons learned and conclusions.

---

## 2 References

### 2.1 Normative references

Normative references are not applicable in the present document.

### 2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] ETSI TR 103 714: "SmartM2M; Study for oneM2M Discovery and Query use cases and requirements".
- [i.2] ETSI TR 103 715: "SmartM2M; Study for oneM2M Discovery and Query solutions analysis & selection".
- [i.3] ETSI TR 103 716: "SmartM2M; oneM2M Discovery and Query solution(s) simulation and performance evaluation".
- [i.4] ETSI TR 103 717: "SmartM2M; Study for oneM2M Discovery and Query specification development".

[i.5] oneM2M TS-0001 (V4.6.0): "Functional Architecture".

NOTE: Available at

<http://member.onem2m.org/Application/documentapp/downloadLatestRevision/default.aspx?docID=31496>.

[i.6] ETSI TS 118 101: "oneM2M; Functional Architecture (oneM2M TS-0001 version 3.9.0 Release 3)".

[i.7] oneM2M TS-0034 (V4.2.0): "Semantics Support".

NOTE: Available at

<http://member.onem2m.org/Application/documentapp/downloadLatestRevision/default.aspx?docID=31425>.

[i.8] ETSI TS 103 264: "SmartM2M; Smart Applications; Reference Ontology and oneM2M Mapping".

[i.9] ETSI TS 103 410-1: "SmartM2M; Extension to SAREF; Part 1: Energy Domain".

[i.10] ETSI TS 103 410-2: "SmartM2M; Extension to SAREF; Part 2: Environment Domain".

[i.11] ETSI TS 103 410-3: "SmartM2M; Extension to SAREF; Part 3: Building Domain".

[i.12] ETSI TS 103 410-4: "SmartM2M Extension to SAREF Part 4: Smart Cities Domain".

[i.13] ETSI TS 103 410-5: "SmartM2M; Extension to SAREF Part 5: Industry and Manufacturing Domains".

[i.14] ETSI TS 103 410-6: "SmartM2M; Extension to SAREF; Part 6: Smart Agriculture and Food Chain Domain".

[i.15] ETSI GS CIM 009: "Context Information Management (CIM); NGSI-LD API".

[i.16] ETSI SR 003 680: "SmartM2M; Guidelines for Security, Privacy and Interoperability in IoT System Definition; A Concrete Approach".

[i.17] ETSI TR 102 732: "Machine-to-Machine Communications (M2M); Use Cases of M2M applications for eHealth".

[i.18] AIOTI Report: "IoT Relation and Impact on 5G, Release 3.0".

NOTE: Available at <https://aioti.eu/wp-content/uploads/2020/05/AIOTI-IoT-relation-and-impact-on-5G-R3-Published.pdf>.

[i.19] oneM2M TR-0001 (V4.3.0): "Use Cases Collection".

NOTE: Available at

<http://member.onem2m.org/Application/documentapp/downloadLatestRevision/default.aspx?docID=28153>

[i.20] oneM2M TS-0012 (V3.7.3): "oneM2M Base Ontology".

NOTE: Available at

<http://member.onem2m.org/Application/documentapp/downloadLatestRevision/default.aspx?docID=29554>

[i.21] oneM2M TR-0045 (V0.3.1): "Developer Guide Implementing Semantics".

NOTE: Available at [https://www.onem2m.org/component/rsfiles/download-file/files?path=Draft\\_TR%5CTR-0045-Developer\\_Guide\\_Implementing\\_Semantics-V0\\_3\\_1.docx](https://www.onem2m.org/component/rsfiles/download-file/files?path=Draft_TR%5CTR-0045-Developer_Guide_Implementing_Semantics-V0_3_1.docx).

[i.22] Lixin Gao: "On inferring autonomous system relationships in the internet. IEEE/ACM Trans. Netw. 9(6): 733-745 (2001).

NOTE: Available at <http://dl.acm.org/doi/10.1109/90.974527>.

[i.23] Luigi Liquori, Rossano Gaeta, and Matteo Sereno: "A Network Aware Resource Discovery Service", EPEW 2019 - 16<sup>th</sup> European Performance Engineering Workshop, Nov 2019, Milano, Italy, Volume 12039 of Lecture Notes in Computer Science, Springer Verlag, pages 84-99, 2019.

NOTE: Available at <https://hal.inria.fr/hal-01895452>.

[i.24] oneM2M REQ-2014-0005R01: "Semantics-query-for-device-discovery-on-Inter-M2M-SP".

NOTE: Available at [http://ftp.onem2m.org/Meetings/REQ/2014%20meetings/20140407\\_REQ10.0\\_Berlin/REQ-2014-0005R01-Semantics\\_query\\_for\\_device\\_discovery\\_on\\_Inter-M2M\\_SP.DOC](http://ftp.onem2m.org/Meetings/REQ/2014%20meetings/20140407_REQ10.0_Berlin/REQ-2014-0005R01-Semantics_query_for_device_discovery_on_Inter-M2M_SP.DOC).

[i.25] Raphael Chand and Michel Cosnard and Luigi Liquori: "Powerful Resource Discovery for Arigatoni Overlay Network", Future Generation Computing System, volume 23, number 1, pages 31-38, 2008.

NOTE: Available at <https://hal.inria.fr/hal-00909630>.

[i.26] oneM2M-Template-Use-Case.

NOTE: Available at <http://ftp.onem2m.org/Templates/oneM2M-Template-Use-Case.doc>.

[i.27] ETSI TS 103 410-10: "SmartM2M; Extension to SAREF; Part 10: Water Domain".

[i.28] oneM2M TS-0002-V4.6.0: "Requirements".

NOTE: Available at

<http://member.onem2m.org/Application/documentapp/downloadLatestRevision/default.aspx?docID=29274>.

[i.29] IETF RFC 4271: "Border Gateway Protocol 4 (BGP4)", January 2006.

NOTE: Available at <https://tools.ietf.org/html/rfc4271>.

## 3 Definition of terms, symbols and abbreviations

### 3.1 Terms

**Advanced Semantic Discovery (ASD):** an extension of the present oneM2M semantic discovery across a network of CSEs statically connected among them in a *tree-like* topology inside a single or multiple Service Provider (SP), including non oneM2M ones and in a *mesh-like* topology between the root of the different SPs

**Advanced Semantic Discovery Query (ASDQ):** word in the Advanced Semantic Discovery Query Language (ASDQL) according to the Theory of Formal Languages

**Advanced Semantic Discovery Query Language (ASDQL):** extension of the actual oneM2M Semantic Discovery Query Language (SDQL), which has to be suitable enough to describe queries that will be resolved in a *cooperative* way by a distributed network of CSEs

NOTE: Each CSE involved in the resolution participates in resolving subqueries and aggregating results by coordinating and cooperating among each other's.

**Semantic Discovery Agreement (SDA):** aims at adding a semantic registering information for the cooperation between CSEs

NOTE 1: With an analogy with the Border Gateway Protocol 4 [i.29], 2 kinds of cooperations are set:

- CSE1 to CSE2 meaning that CSE1 takes advantage of the infrastructure, MN-CSEs, and AEs registered in CSE2, and also shares security policies of CSE2. CSE1 is a *CUSTOMER* and CSE2 is a *PROVIDER*.
- CSE1 to CSE2 means that CSE1 and CSE2 mutually share infrastructure, MN-CSEs, and AEs and common security policies. CSE1 and CSE2 are *PEERS*.

NOTE 2: CUSTOMER and PROVIDER are roles that conform an *asymmetric relationship*, while PEER is a role conforming a *symmetric relationship*.

NOTE 3: Inside a single Service Provider, the SDA is not mandatory since it can be considered as PEER.

**Semantic Discovery Routing (SDR):** CSEs support a distributed Semantic Discovery Routing that listens for Advanced Semantic Discovery Query (ASDQ) and:

- i) reduces the Advanced Semantic Discovery Query (ASDQ) by means of the Semantic Query Resolution (SQR);
- ii) solves and forwards in a distributed way the queries;
- iii) reconstructs the partial results, sending back to the originator of the Advanced Semantic Discovery Query (ASDQ).

NOTE: Generally, as described in [i.24] two kinds of routing are discriminated, namely:

- 1) "Exhaustive". As example, in the case that a semantic resource exists somewhere in the CSEs network, then the system will explore the entire distributed network until it will found it.
- 2) "Non-exhaustive". As example, even in the case a semantic resource that exists somewhere in the CSEs network, the system will explore part of the distributed network until it will be stopped.

**Semantic Query Resolution (SQR):** each CSE contains a Semantic Query Resolution capability that takes as input an Advanced Semantic Discovery Query (ASDQ) and:

- i) as output, produces a *normalized* Advanced Semantic Discovery Query (ASDQ);
- ii) produces a set of ordinary oneM2M Semantic Discovery Query (SDQ) from the normalized Advanced Semantic Discovery Query (ASDQ) one.

**Semantic Recommendation (SR):** capability in the CSE that takes routing decisions for forwarding a received Advanced Semantic Discovery Query (ASDQ)

NOTE: This capability uses the Semantic Routing Tables (SRT) and the Semantics Discovery Agreement (SDA).

**Semantic Routing Table (SRT):** contained in each CSE provides suitable routes to propagate the discovery queries according to the SDA

## 3.2 Symbols

Void.

## 3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ADN	Application Dedicated Node
AE	Application Entity
AIOTI	Alliance for Internet Of Things Innovation
API	Application Program Interface
ASD	Advanced Semantic Discovery
ASDQ	Advanced Semantic Discovery Query
ASDQL	Advanced Semantic Discovery Query Language
BGP4	Border Gateway Protocol 4
CNF	Conjunctive Normal Form
CSE	Common Services Entity
DNF	Disjunctive Normal Form
ETSI	European Telecommunications Standards Institute
FGT	Formal Graph Topology
IN-CSE	Infrastructure Node - Common Services Entity
IoT	Internet of Things

M2M	Machine-to-Machine
M2MSP	M2M Service Provider
Mca	Reference Point for M2M Communication with AE
Mcc	Reference Point for M2M Communication with CSE
MN-CSE	Middle Node - Common Services Entity
RDF	Resource Description Framework
RDM	Requirements and Domain Models
SAREF	Smart Applications REference ontology
SDA	Semantics Discovery Agreement
SDQ	Advanced Discovery Query
SDQL	Semantic Discovery Query Language
SDQM	Semantic Discovery resolution Query Mechanism
SDR	Semantic Discovery Routing
SDREQ	Semantic Discovery REQuest
SDRM	Semantic Discovery Routing Mechanism
SDRP	Semantic Discovery Routing Protocol
SP	Service Provider
SPARQL	Simple Protocol and RDF Query Language
SQR	Semantic Query Resolution
SQRS	Semantic Query Resolution System
SR	Semantic Recommendation
SRQM	Semantic Resolution Query Mechanism
SRS	Semantic Recommendation System
SRT	Semantic Routing Tables
SW	SoftWare
TC	Technical Committee
TR	Technical Report

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## 4 Method for collecting Use Cases

The oneM2M template for the contribution of use cases [i.26] served as the source for structuring the clauses of the present document, which describes the use cases and the potential requirements to oneM2M derived from them. Use cases of the IoT domains Smart Buildings and eHealth and a generic one, suitable to be instantiated in many concrete cases of Advanced Semantic Discovery have been evaluated and described. These use cases have been contributed to oneM2M Working Group RDM (Requirements and Domain Models). After their acceptance by RDM, they have been incorporated to the present document.

---

## 5 Use Case - Semantic discovery in presence of a "network" of M2M Service Providers (M2MSP)

### 5.1 Description

The oneM2M system has implemented basic native discovery capabilities. The use cases specified in clauses 5 to 8 lead to potential requirements, which extend the existing requirements of the use case documented in oneM2M TR-0001 [i.19], clause 12.9 with a focus on the discovery and query capabilities, introducing a direct relation with the semantic aspects and enabling more sophisticated semantic queries as e.g. a capability in the CSE, that takes routing decisions for forwarding a received Advanced Semantic Discovery Query.

This use case of clause 5 could be considered as either the "use-case zero", or a "parametric use-case" for Advanced Semantic Discovery (ASD) and it can be instantiated in many domain specific cases.

This use case illustrates the needs for an ASD within distributed network of CSEs belonging a single Service Provider and across different IoT Service Providers. This distributed scenario is partially faced in oneM2M TR-0001 [i.19] in clause 12.9 (Semantics query for device discovery across M2M Service Providers).

It shows the importance of formalizing:

- an Advanced Semantic Discovery Query Language (ASDQL) able to write Advanced Semantic Discovery Query (ASDQ);
- a Semantic Discovery Routing Protocol (SDRP) to route an Advanced Semantic Discovery Query (ASDQ) between different CSEs;
- a Semantic Discovery Agreement (SDA), to state some communication agreements between CSEs;
- a Semantic Query Resolution functionality (SQR) allowing to locally resolve an Advanced Semantic Discovery Query (ASDQ) into some elementary standard oneM2M Semantic Discovery Queries (SDQ).

The concepts included in the use case of clause 5 are intensively used in the following clauses 6 to 8.

## 5.2 Source

Void.

## 5.3 Actors

- 5 Application Entities (AE) X of type T1, Y of type T2, Z of type T3, V of type T4, and W of type T5.
- 2 Middle Node Common Service Entities (MN-CSE) P, and Q:
  - A MN-CSE has a local database containing information on their registered AE. The local database includes location information (where each device is presently located), the device type, etc. Assuming P and Q have some Semantic Discovery Agreement (SDA) with A. Semantic Discovery Agreement (SDA) can be relaxed inside a single Service Provider, see note 3 of SDA definition in clause 3.1.
- 4 Infrastructure Node Common Service Entities (IN-CSE) A, B, C, and D:
  - An IN-CSE has a local database containing information on their registered MN-CSE and AE. The local database includes location information (where each device is currently located), the device type, etc. Assuming A, B, C, and D have some "Semantic Discovery Agreement" (SDA) among each other.

## 5.4 Pre-conditions

Consider the following topology.

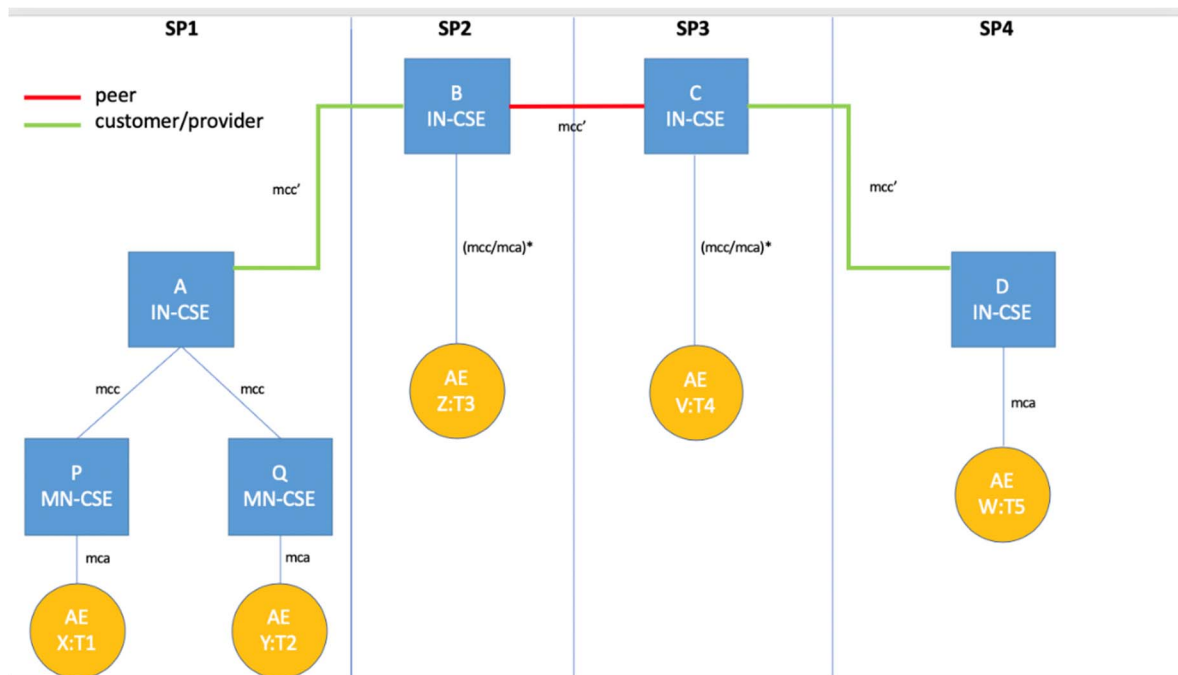


Figure 5.4-1: Pre-condition topology

## 5.5 Triggers

This clause presents, informally, three examples of the Advanced Semantic Discovery Query Language (ASDQL). Assuming AND, OR, NOT be *non-terminals* and ?T means a *meta-variable* of type T to be resolved.

EXAMPLE 1: X:T1 send to MN-CSE P:

ASDQ1 = ?T2|FC2 AND ?T3|FC3 AND ?T4|FC4 AND ?T5|FC5

The query can be intuitively read as follows: X is looking for:

some AE of type T2 registered in any CSE satisfying the filter criteria FC2, AND  
 some AE of type T3 registered in any CSE satisfying the filter criteria FC3, AND  
 some AE of type T4 registered in any CSE satisfying the filter criteria FC4, AND  
 some AE of type T5 registered in any CSE satisfying the filter criteria FC5

EXAMPLE 2: X:T1 send to MN-CSE P

ASDQ = ?T2|FC2 OR ?T3|FC3 OR ?T4|FC4 OR ?T5|FC5

The query can be intuitively read as follows: X is looking for:

some AE of type T2 registered in any CSE satisfying the filter criteria FC2, OR  
 some AE of type T3 registered in any CSE satisfying the filter criteria FC3, OR  
 some AE of type T4 registered in any CSE satisfying the filter criteria FC4, OR  
 some AE of type T5 registered in any CSE satisfying the filter criteria FC5

EXAMPLE 3: X:T1 send to MN-CSE P

ASDQ = (?T2|FC2 OR ?T3|FC3) AND (?T4|FC4 OR ?T5|FC5)

EXAMPLE 4: X:T1 send to MN-CSE P

ASDQ = (?T2|FC2 AND ?T3|FC3) OR (?T4|FC4 AND ?T5|FC5)

EXAMPLE 5: X:T1 send to MN-CSE P

ASDQ = (?T2|FC2 AND ?T3|FC3) OR (?T4|FC4 AND (NOT ?T5|FC5))

It is also possible to consider other non-terminals, such as (list not exhaustive):

ANY = search in all CSE databases;

CURRENT = search in the CSE local database;

CUSTOMER[N] = search in the databases of N CUSTOMER CSE;

PROVIDER[N] = search in the databases of N PROVIDER CSE;

PEER[N] = search start on the databases of N PEER CSE;

BETWEEN\_TIME[SEC] = search should return in SEC;

BETWEEN\_SPACE[METER] = search should give results in METER;

OF\_BRAND[NAME] = search should give results of brand NAME.

## 5.6 Normal Flow

A "trace" of the Semantic Discovery Routing (SDR) generated by Example 1 (see clause 5.5) is presented, the other examples can be easily traced following the same logic. This trace is inspired to a semantic discovery routing as described in [i.24] and [i.25] and proceeds as follows:

- X sends an Advanced Semantic Discovery Query (ASDQ1) to P.
- P verifies the integrity of ASDQ1 and forwards the ASDQ1 to A that starts the Semantic Discovery Routing Protocol (SDPR) into the network of CSE.
- ASDQ1 is resolved using the Semantic Query Resolution System (SQRS) locally in A into four subqueries, namely ASDQ2, ASDQ3, ASDQ4, and ASDQ5, where:

ASDQ2 = ?T2|FC2

ASDQ3 = ?T3|FC3

ASDQ4 = ?T4|FC4

ASDQ5 = ?T5|FC5

- 1) A starts lookups in its local database, trying to solve {ASDQ 2,3,4,5} but fail.
- 2) A down-forwards ASDQ1 to Q via an mcc pointer.
- 3) Q solve the subquery ASDQ2 ?T2|FC2 in its local database returning Y to A.
- 4) A send back Y to P and X.
- 5) A up-forwards ASDQ3 and ASDQ4 and ASDQ5 to B via an mcc' pointer.
- 6) B solves the ASDQ3 ?T3|FC3 in its local database returning Z to A (and back to P and X).
- 7) B side-forwards ASDQ4 & ASDQ5 to C.
- 8) C solves the ASDQ4 ?T4|FC2 in its local database returning V to B (and back to A, P and X).
- 9) C down-forwards ASDQ5 to D.
- 10) D solves the ASDQ5 ?T5|FC5 in its local database returning W to C (and back to B, A, P and X).



NOTE: When A up-forwards to B, it follows that A respect the CUSTOMER-PROVIDER SDA with B (e.g. A respects the SDA directives of B). When B side-forwards to C, it follows that B and C respect the PEER-PEER SDA directives. When C down-forwards to D, it follows that D respects the PROVIDER-CUSTOMER SDA with C (e.g. D respects the SDA directives of C).  
**The moral is:** B and C should be "acknowledged" for their "routing job".

## 5.7 Alternative Flow

In the following alternative topology the CUSTOMER-PROVIDER SDA are reversed.

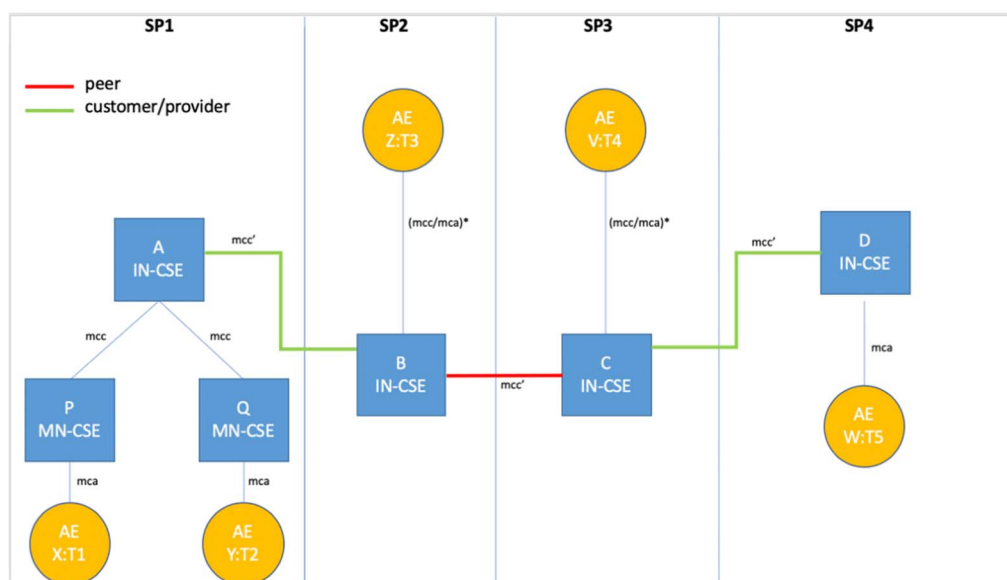


Figure 5.7-1: Pre-condition topology for alternative flow

A possible "trace" of the SDRM, again inspired to [i.22], [i.23], [i.19], [i.24] proceeds as in clause 5.5, excepting for the following caveat.

**Caveat.** When A down-forwards to B, it expects that B should respect the provider-customer SDA with A (e.g. B should acknowledge A. **This is not intuitive** since B does a favour to A and acknowledge A). When B side-forwards to C, it expects that B and C have a common SDA agreement and, as such, they do not acknowledge it each other. When C up-forwards to D, it expects that C and D have a common SDA agreement (e.g. C should acknowledge D. **This is not intuitive** since C do a favour to D and acknowledges D).

**The moral is:** B and C do a job for their providers and, moreover, they have to acknowledge for their "routing job".

Alternative traces happen in practice. Because of the distributed nature of the SDR, it is beneficial to try to incentivize routing respecting the SDA, and, as such, avoid routing not respecting the SDA. Those situations are not new in Internet and are referred as VALLEY ROUTING by Gao [i.22]. "Good routing" should guarantee that routing is always "valley preserving" (or "no valley"). Valley routing property is also preserved in the network aware Resource Discovery Protocol of Liquori et al. [i.23].

## 5.8 Post-conditions

X can start to interact with Y, Z, V, and W.

## 5.9 High level illustration

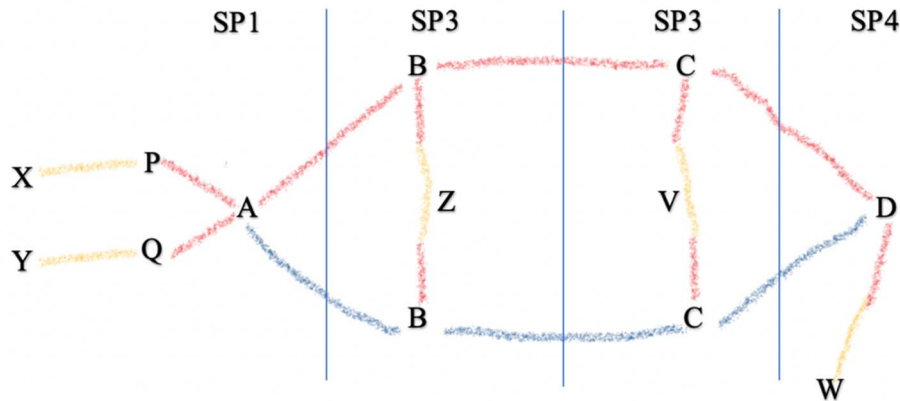


Figure 5.9-1: Illustration for multiple service providers semantic discovery use case

## 5.10 Potential Requirements for the oneM2M system

- 1) *The oneM2M system should provide mechanisms for Advanced Semantic Discovery (ASD) across a distributed network of IoT nodes within a single oneM2M Service Provider and across different IoT Service Providers.*
- 2) *A CSE receiving an Advanced Semantic Discovery Query (ASDQ) should extract the Semantic Discovery Query (SDQ), embedded in the packet payload, and shall resolve the query with respect to the locally available information and shall forward to other suitable CSEs the Advanced Semantic Discovery Query (ASDQ) to complete the discovery.*
- 3) *More specifically, the M2M system should provide:*
  - *an Advanced Semantic Discovery Query Language (ASDQL) that the ability to write Advanced Semantic Discovery Query (ASDQ);*
  - *a Semantic Discovery Agreement (SDA) to state some communication agreements between CSE;*
  - *a Semantic Query Resolution (SQR) that allows to locally translate an Advanced Semantic Discovery Query (ASDQ) into some elementary oneM2M Semantic Discovery Queries (SDQ);*
  - *a Semantic Discovery Routing (SDR) to route an Advanced Semantic Discovery Query (ASDQ) between different CSEs.*

---

# 6 Use Case - Semantic recommendation in CSEs for discovery

## 6.1 Description

This use case is built upon a cross-domain scenario in which a hospital has a large number of IoT devices which are in charge of performing different tasks. The IoT devices can be classified into the following categories: energy devices (load consumption, flexibility monitoring, energy switch, etc.), building devices (lights, door sensors, occupancy sensors, etc.), personal devices (smart bands, smartphones, etc.), and devices related to health (heart rate sensor, glucose monitor, etc.). These IoT devices are connected across the hospital network, but they do not necessarily belong to the same oneM2M Service Provider.

In this scenario, several actors need to discover and use IoT devices that are allocated outside their oneM2M Service Provider. For instance, if the energy devices detect an incoming negative peak of energy, entailing that a large number of devices should be switched off to avoid the whole hospital to run out of energy (losing critical systems for the patients). Then, the energy devices (or an application in charge) should be able to discover all the sensors in the building that are related to energy (like light bulbs or air condition) and switch them off. Also, the same actor (the energy devices or an application in charge) should detect the critical eHealth IoT devices for the patients and ensure that they are switched on. In the case that one of the eHealth IoT devices would run off, then the energy devices, or an application in charge, should perform a discovery task over the personal devices in order to find relevant people, i.e. doctors, nearby the critical eHealth IoT devices that are running out of energy in order to assist the patients.

This use case assumes that there is an interoperability platform (oneM2M) that allows monitoring and controlling the different IoT devices regardless their vendor. Also, the platform should ensure a secure and private environment so no unauthorized third party could access the network. This platform should ensure a sufficient rich discovery in order to meet the previous example.

- It is fully distributed in order for the Advanced Semantic Discovery (ASD) to reach from one oneM2M Service Provider to others that may contain relevant infrastructures.
- The Advanced Semantic Discovery Query (ASDQ) is expressed using an Advanced Semantic Discovery Query Language (ASDQL) so specific semantic terms from domains like energy or eHealth can be used.
- The Advanced Semantic Discovery (ASD) needs to happen in quasi real-time and therefore the communication mechanism across infrastructures that belongs to different Service Providers should not be blind; instead it should be guided by a Semantic Recommendation (SR).

This use case can be generalized to other domains in which IoT devices are spitted in different Service Providers and discovery needs be performed across them avoiding flooding the infrastructures, i.e. relying on a guided Semantic Recommendation System (SRS) to which infrastructures perform the Advanced Semantic Discovery (ASD), and to which discard, leveraging the network load.

## 6.2 Source

- oneM2M TS-0012: "oneM2M Base Ontology" [i.20].
- oneM2M TR-0045: "Developer Guide Implementing Semantics" [i.21].
- oneM2M TS-0001: "Functional Architecture" [i.5].

## 6.3 Actors

- M2M Applications, M2M Service providers.
- IN-CSE and MN-CSE.
- IoT devices from the different domains.
- Medical staff, building staff, or technicians.

## 6.4 Pre-conditions

A network infrastructure distributed across different Service Providers. Intuitively, network infrastructure of oneM2M Service Providers is a set of M2M devices and Application Entities (AE) that have been installed and registered to their corresponding MN-CSE (Middle Node - Common Services Entity). The MN-CSEs have in turn been registered to the corresponding IN-CSE (Infrastructure Node - Common Service Entity).

All the different CSEs have Semantic Discovery Agreements (SDA) with each other, resulting in a tree-like network topology. In such a topology, the CSEs should rely as a Semantic Recommendation (SR) in order to assist the advanced semantic discovery resolution task performed by the CSEs involved in. As smarter the Semantic Recommendation (SR) is, as efficient will be the discovery in terms of time, CSEs visited, and number of query forwarded, among others. The discovery should allow expressing some network directives to address efficient routing across CSEs.

Both the registering and the discovery should be expressed according to the oneM2M described in oneM2M TS-0012 [i.20]. Nevertheless, due to tailored-domain terms required in the use case, the registering and the discovery should be also expressed with specific domain ontologies like the different extensions of SAREF.

## 6.5 Triggers

The IoT energy devices, or a technician, send first an Advanced Semantic Discovery Query (ASDQ) to find all the non-critical IoT devices allocated in the building. Then, a second ASDQ is issued to find all the critical IoT devices from the eHealth domain, and if required, a third ASDQ is issued to find relevant medical staff that could be near critical devices. The different ASDQs will rely on specific semantics, the first will contain information about devices and if they consume energy, the second about eHealth devices that are critical and cannot be switched off, and the third about the people, their roles in hospital, and their location.

## 6.6 Normal Flow

Following the first discovery task is showcased:

- 1) An IoT energy device, or a technician, sends an ordinary oneM2M Semantic Discovery Query (SDQ) to its CSE, written in SPARQL. The SPARQL query will contain terms about sensors that consume energy, are not from the eHealth domain, and are located in the building.
- 2) The CSE verifies the integrity of the SDQ, and it tries to answer. If the CSE is not able to reply, it builds an ASDQ wrapping the SDQ.
- 3) Then the CSE forwards the ASDQ to other CSEs that may be located in the same oneM2M Service Provider, or in a different oneM2M Service Providers, or even sent to a non oneM2M IoT Service Provider.
- 4) Relying on the SR, the CSE selects and queries the relevant CSEs.
- 5) The CSE of the building will receive the ASDQ and will try to solve the embedded SDQ. The building contains suitable IoT devices so that the CSE will be able to produce and forward back a positive answer.
- 6) Finally the IoT energy device, or a technician, will receive the answer and the semantic discovery terminates successfully.

## 6.7 Alternative Flow

Void.

## 6.8 Post-conditions

The query is answered if a resource that fulfils the discovery criteria is present in the network and "reasonably" reachable. For example, the discovery task needs be completed in a given threshold time even when crossing different IoT Service Providers is required.

## 6.9 High level illustration

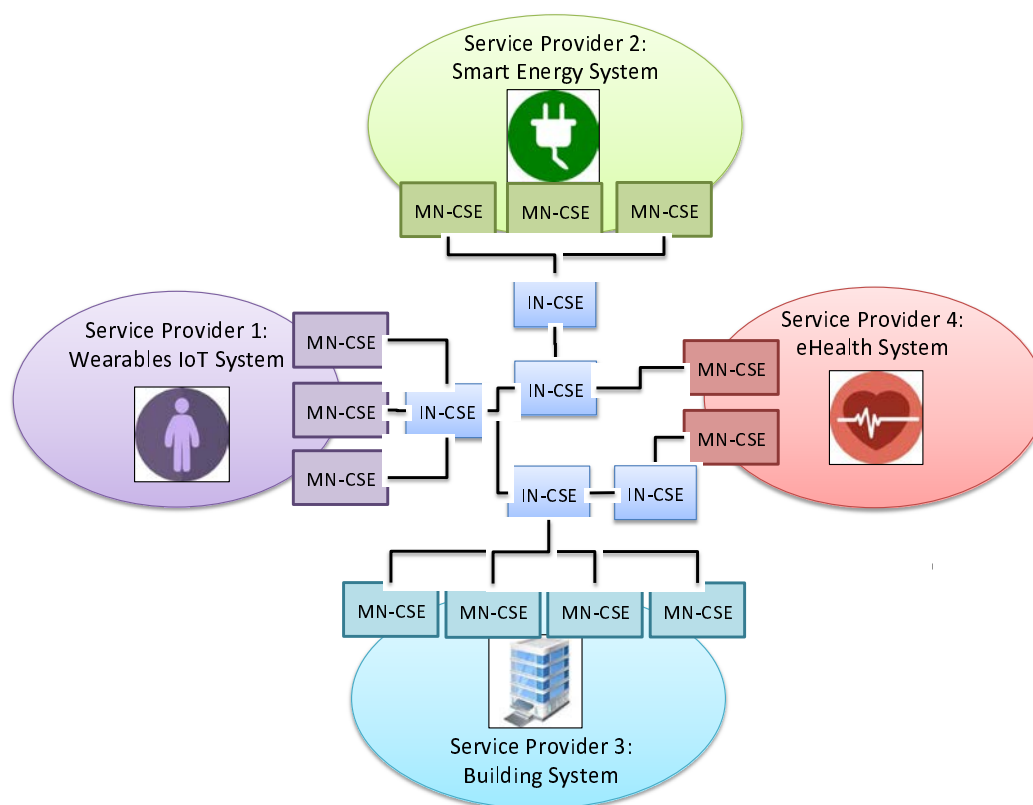


Figure 6.9-1: Semantic Recommendation in CSEs for Discovery

## 6.10 Potential Requirements for the oneM2M system

The following potential requirements are additional to the ones already identified in clause 5:

- 1) The oneM2M system should integrate already standardized ontology extensions to the current oneM2M ontology to cope with new specific domains (e.g. SAREF core and its extensions SAREF4BLDG [i.11], SAREF4ENVI [i.10], SAREF4ENERGY [i.9], SAREF4CITY [i.12], SAREF4AGRI [i.14], SAREF4WATER [i.27]).
- 2) Based on semantic information, the oneM2M system shall take routing decisions for forwarding a received ASDQ. The semantic information will allow the oneM2M system to maximize and to accelerate the semantic discovery process.

---

## 7 Use Case - Facility management of a supermarket chain

### 7.1 Description

Building and facility managers need a helicopter view of the facilities management processes, regardless of existing building installations in order to make better-informed decisions and to enforce cross building policies. Building managers are faced with heterogeneous and vendor-specific installations. Centralized management of buildings oftentimes forces the owners to go through costly replacements to adopt mono-vendor solutions. Installation of new equipment requires costly system integration because devices are often designed to communicate with specific applications only.

This use case assumes a facility manager working for a supermarket chain and responsible of dozens of buildings. It is supposed that there is an interoperability platform (oneM2M) that offers a standard interface to monitor and control all the buildings regardless of vendor. The facility manager could apply energy efficiency strategies to all buildings on large scale. He could for example, compare buildings to detect leaks, adjust the heat and the lighting according to forecast or predictive models, and compliant with applicable regulations.

The exposure of the huge amounts of data through modern APIs allows proliferation of new building services such as situational awareness, energy efficiency, intrusion detection, preventive maintenance and smart data.

Through further APIs, wider integration of the buildings with the outside world is achieved to give rise to fully integrated cities. The buildings start to interwork with energy grids (smart and micro grids), smart parking, electrical vehicle charging, waste management, etc., the ultimate goal for buildings to be considered really smart.

Assuring interoperability between all the data producing, data storing, and data processing components, semantic discovery and query mechanisms across and between sensors, devices, APIs and even IoT platforms are essential.

This use case is similar to the use case "Semantics query for device discovery across M2M Service Providers" in clause 12.9 of oneM2M TR-0001-Use\_Cases\_Collection-V4\_3\_0 [i.19]. However, it extends the requirements with a focus on the discovery and query capabilities, introducing a direct relation with the semantic aspects and enabling more sophisticated semantic queries.

## 7.2 Source

- ETSI SR 003 680: "SmartM2M; Guidelines for Security, Privacy and Interoperability in IoT System Definition; A Concrete Approach" [i.16].

## 7.3 Actors

- M2M devices as e.g. energy meters, temperature sensors, fire detectors, leak detectors, lightning controls, heat and air condition controls, surveillance cameras , cash boxes, inventory controls.
- Facility manager.
- M2M Service providers.
- M2M Applications e.g. data analytics, fault detection, energy efficiency, hypervision.

## 7.4 Pre-conditions

M2M devices in the super markets have been installed and registered to their corresponding MN-CSE (Middle Node - Common Services Entity). The MN-CSEs have been registered to the corresponding IN-CSE (Infrastructure Node - Common Services Entity).

The M2M Application Provider 1 has contractual relationships with the M2M Service Providers 2, 3 and 4.

The M2M Service Providers 1 and 2 have databases that contain information on the devices located in the supermarkets of the supermarket chain.

The facility manager wants to make use of the devices within his supermarkets and of the API "Facility management" in order to apply energy efficiency strategies to all buildings on large scale and to compare buildings to detect leaks, adjust the heat and the lighting according to forecast or predictive models, and compliant with applicable regulations.

Assessing the warehouses stocks enables to refill it in time and a centralized fault detection ensures to take countermeasures.

The M2M Service Provider 3 wants to access data from energy consuming/measuring devices and/or respective databases of the M2M Service Providers 1 and 2 in order to optimize his energy providing balance.

The M2M Service Provider 4 wants to access data from parking lot sensors, from charging stations for electrical vehicles, data about the product range and warehouse stocks of the M2M Service Providers 1 and 2 in order to provide relevant services to the city inhabitants.

## 7.5 Triggers

The facility manager, the API "Facility management", the M2M Service Provider 3 or 4 (further on called "REQUESTER") sends an Advanced Semantic Discovery Query to the M2M Service Provider 1 or 2 (further on called "REQUEST RECEIVER"). The request contains information about the device to be discovered, e.g. a device type, a localization and other filters criteria.

## 7.6 Normal Flow

Following, one example of a typical scenario is described:

- 1) Via a device (e.g. user terminal), which is connected to the API "Facility management", the facility manager initiates an Advanced Semantic Discovery Query within the domain of the M2M Service Provider 1 to the smart meters of a specific area of a special supermarket, which enquires information about its energy consumption.
- 2) The API "Facility management" verifies the integrity of the Advanced Semantic Discovery Query and sends a semantic discovery request to the MN-CSE of the supermarket.
- 3) The MN-CSE searches for the specific requested type of devices whether they are connected t or not.
- 4) If the requested type of devices are connected to the MN-CSE, then it returns the requested information of the devices to the M2M Application.
- 5) If the requested devices are not connected to the MN-CSE, then a negative acknowledge is sent back to the M2M Application.
- 6) The API "Facility management" processes, if necessary, the received information and forwards it to the requesting device of the facility manager.

## 7.7 Alternative Flow

Following, one example of an alternative scenario is described:

- 1) An M2M Application of the Service provider 4 (Smart Cities domain) initiates an Advanced Semantic Discovery Query within the domain of M2M Service Providers 1 and 2 to find and identify the sensors of their parking lots, which enquires information about free parking spaces.
- 2) The IN-CSE of the Service provider 1 verifies the integrity of the Advanced Semantic Discovery Query and distributes it to the MN-CSEs of the supermarkets.
- 3) The MN-CSEs search for the specific requested type of devices whether they are connected to not.
- 4) If the requested type of devices are connected to the MN-CSE, then it returns the requested information of the devices to the IN-CSE, which forwards it to the requesting Service Provider 4.
- 5) If the requested devices are not connected to the MN-CSE, then a negative acknowledge is sent back to the IN-CSE, which forwards it to the requesting Service Provider 4.
- 6) The requesting M2M Application of Service Provider 4 processes the data and provides them in an appropriate way to the users of the M2M Application (e.g. city inhabitants).

## 7.8 Post-conditions

The facility manager, the API "Facility management", the M2M Service Provider 3 or 4 can start to employ the devices based on the Advanced Semantic Discovery Query sent to the M2M Service Provider 1 or 2.

## 7.9 High level illustration

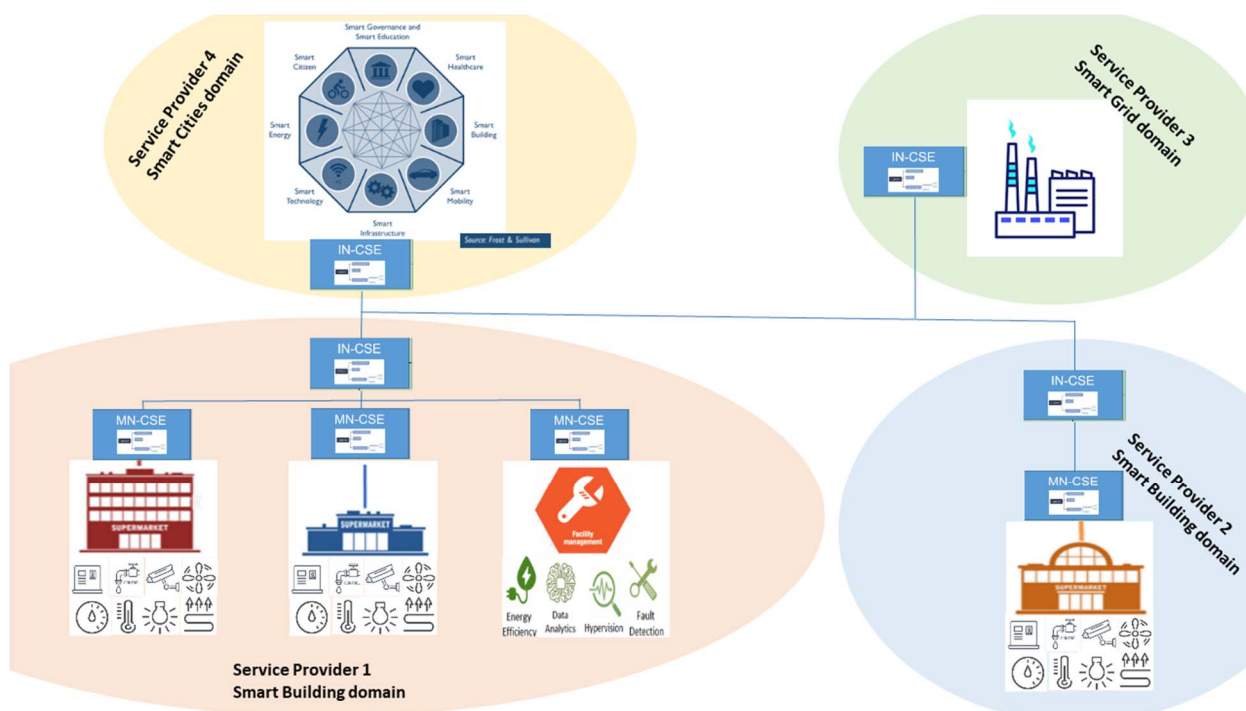


Figure 7.9-1: Facility management of a supermarket chain

## 7.10 Potential Requirements for the oneM2M system

The following potential requirements are additional to the ones already identified in clauses 5 and 6.

- 1) Advanced Semantic Discovery shall support queries written with specific domain ontologies, e.g. SAREF.
- 2) Advanced Semantic Discovery shall support semantic reasoning between the baseline oneM2M ontology and the identified domain specific ontologies, e.g. SAREF. As example, if a query is looking for a oneM2M device observing Celsius temperature, then the Advanced Semantic Discovery would potentially return a SAREF temperature sensor.
- 3) Advanced Semantic Discovery shall provide capabilities to identify multiple set of targets, and a multiplicity of searches (e.g. by setting parameters or filters).
- 4) The oneM2M Access Control Policy shall include discovery permissions to support Advanced Semantic Discovery. When an Advanced Semantic Discovery is performed by the oneM2M System, it shall operate according to the indications associated with the desired information.

It is also expected that:

- The solution would be based an evolution of the current oneM2M architecture and functionality and would reuse existing standard ontology mechanisms e.g. considering the SAREF standard developed in ETSI TC SmartM2M (which is also aligned with the W3C ontology approach). This intends to assure also a smooth interworking with relevant non-oneM2M solutions.
- The solution would be complete and will be a part of the oneM2M core functions, to avoid the need of ad hoc applications designed to expand the oneM2M functionality with the risk of being implemented with different flavours.



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## 8 Use Case - Healthcare network and clinical knowledge administration

### 8.1 Description

This use case looks at the semantic discovery requirements through a networking environment between people with disease (patients), the elderly, who want to live an independent life while remaining in their homes, special invalid people with a high risk of falling in their homes, doctors/care taking people, people practicing fitness exercises to improve their health, and institutions/organizations, who manage a clinical knowledge & information data basis or analyses of patient data.

On one side the number of the elderly is increasing permanently, on the other side, the doctors' anterooms are overcrowded. Therefore, telecare and telehealth systems get more and more important. M2M applications for eHealth support the remote management of patient illnesses by e.g. tracking blood sugar levels, controlling insulin dosage, measuring blood pressure and heartbeat, record infrequent abnormal heart rhythms, etc.

M2M applications for eHealth can enable the elderly to live an independent life and remain in their homes in cases when normally assistance would be needed. Remote monitoring of patient vital signs (e.g. pulse, temperature, weight, and blood pressure) minimizes the number of required doctor office visits. Further caretaking measures ensure that patients are taking their medications according to the required schedule and to track the activity level of seniors (e.g. time spent in bed each day, amount of daily movement in their homes) as a way of inferring their overall health and detecting changes that may require a doctor's or some other person's attention.

Various studies have concluded that falls in the home are the most common cause of injury among the elderly population, and one of the leading causes of morbidity and mortality among this population. A so called 'long lie' is a fall, in which the person remains on the ground for 5 min or more before being able to get up without assistance, or help arriving, which could detrimentally affect both the psychological as well as physical wellbeing of the individual. Automated fall detection systems are using worn fall detectors, which trigger an alarm, when both the orientation and acceleration forces of the person reach a pre-set threshold. In case of an emergency detection, an alarm will be sent immediately to the emergency service centre, possibly together with pictures or videos, which a camera being installed in the home has taken.

M2M applications for eHealth can be used to record health and fitness indicators such as heart and breathing rates, energy consumption, fat burning rate, etc. during exercise sessions, and to log the frequency and duration of workouts, the intensity of exercises, running distances, etc. When this information is uploaded to a back-end server, it can be used by the user's physician as part of their health profile, and by the user's personal trainer to provide feedback to the user on the progress of their exercise program. It allows adapting exercise programs or physiotherapy more precisely and more quickly to the needs of the patient/user.

This use case assumes that there is an interoperability platform (oneM2M) that offers a standard interface to monitor and control all the eHealth devices regardless of vendor. It is supposed that professional knowledge generation bodies (e.g. colleges/universities) get authorization to access the patient data. They can assist clinicians for the appropriate diagnosis and method of treatment by providing clinical (textual) guidelines and recommendations in order to reduce the risk of medical errors and to assist in decision-making processes.

Assuring interoperability between all the various data producing, data storing, and data processing components, semantic discovery and query mechanisms across and between sensors, devices, APIs and even IoT platforms are essential.

### 8.2 Source

- ETSI SR 003 680: "SmartM2M; Guidelines for Security, Privacy and Interoperability in IoT System Definition; A Concrete Approach" [i.16].
- ETSI TR 102 732: "Machine-to-Machine Communications (M2M); Use Cases of M2M applications for eHealth" [i.17].
- AIOTI Report: "IoT Relation and Impact on 5G, Release 3.0" [i.18].

## 8.3 Actors

- M2M eHealth devices as e.g. wearable sensors, falling detectors, blood pressure meter.
- Emergency supervisor.
- Doctors and caring people.
- Knowledge generation bodies.
- M2M Service providers.
- M2M Applications e.g. data analytics.

## 8.4 Pre-conditions

M2M devices in the patients/the elderly homes and fitness locations have been installed and registered to their corresponding M2M Service Provider. In this use case, the devices are represented by devices that are ADN registered to MN-CSEs.

The M2M Application Providers 1, 2 and 3 have relationships one with each other. The M2M Service Providers 1 and 2 host information on the devices located in the patients/the elderly homes and fitness locations.

The doctors and caring people want to make use of the devices in the patients/the elderly homes and fitness locations in order to check the health or behavioural data of the patients as a way of inferring their overall health and detecting changes that may require a doctor's or some other person's attention. The emergency supervisor is operating the Intelligent Emergency Response System and manages alarms.

The M2M Service Provider 3 wants to access data from of the M2M Service Providers 1 and 2 in order to manage its knowledge data basis and to update analysis results, recommendations and guidelines.

## 8.5 Triggers

The doctor or caring person, the API "Clinicians patient data analysis" or the M2M Service Provider 3 (further on called "REQUESTER") sends an Advanced Semantic Discovery Query to the M2M Service Provider 1 or 2 (further on called "REQUEST RECEIVER"). The request contains information about the device to be discovered, e.g. a device type, a localization and other filters criteria.

## 8.6 Normal Flow

Following, one example of a typical scenario is described:

- 1) Via a device (e.g. user terminal), which is connected to the API "Doctors or caring people", the doctor or caring person initiates an Advanced Semantic Discovery Query within the domain of the M2M Service Provider 1 to an eHealth device type of a specific group of patients, which enquires information about the pulse, temperature, weight or blood pressure.
- 2) The API "Doctors or caring people" verifies the integrity of the Advanced Semantic Discovery Query and sends a semantic discovery request to the MN-CSE of the specific group of patients.
- 3) The MN-CSE searches for the specific requested type of devices whether they are connected or not.
- 4) If the requested type of devices are connected to the MN-CSE, then it returns the requested information of the devices to the M2M Application.
- 5) If the requested devices are not connected to the MN-CSE, then a negative acknowledge is sent back to the M2M Application.
- 6) The API "Doctors or caring people" processes, if necessary, the received information and forwards it to the requesting device of the doctor or caring person.

## 8.7 Alternative Flow

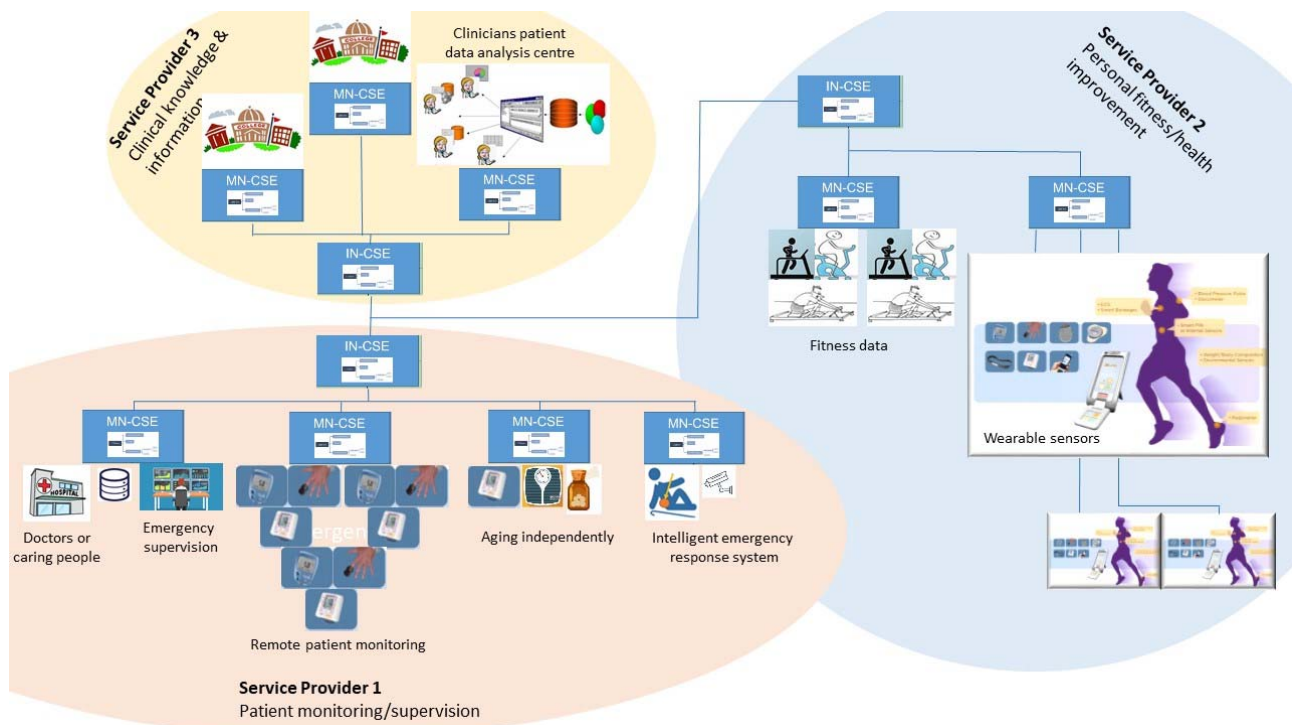
Following, one example of an alternative scenario is described:

- 1) An M2M Application of the Service provider 3 (Clinical knowledge & information) initiates an Advanced Semantic Discovery Query within the domain of M2M Service Provider 2 to find and identify the sensors of their treadmills, which enquires information about activities of users.
- 2) The IN-CSE of the Service provider 2 verifies the integrity of the Advanced Semantic Discovery Query and distributes it to the MN-CSEs of the fitness locations.
- 3) The MN-CSEs search for the specific requested type of devices whether they are connected or not.
- 4) If the requested type of devices are connected to the MN-CSE, then it returns the requested information of the devices to the IN-CSE, which forwards it to the requesting Service Provider 3.
- 5) If the requested devices are not connected to the MN-CSE, then a negative acknowledge is sent back to the IN-CSE, which forwards it to the requesting Service Provider 3.
- 6) The requesting M2M Application of Service Provider 3 processes the data and provides them in an appropriate way to the users of the M2M Application (e.g. "Clinicians patient data analysis centre").

## 8.8 Post-conditions

The REQUESTER (doctors or caring people, the API "Clinicians patient data analysis" or the M2M Service Provider 3) can start to employ the devices based on the Advanced Semantic Discovery Query sent to the M2M Service Provider 1 or 2.

## 8.9 High level illustration



**Figure 8.9-1: Healthcare network and clinical knowledge administration**

## 8.10 Potential Requirements for the oneM2M system

*The following potential requirements are additional to the ones already identified in clause 5, 6 and 7:*

- 1) *Advanced Semantic Discovery shall prioritize queries, e.g. to ensure a quick response to urgent situations.*
- 2) *Advanced Semantic Discovery shall minimize complexity to avoid impacting negatively the oneM2M system performance.*

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## 9 Lessons learned and conclusions

The use cases described in clauses 6, 7 and 8 can be considered as instantiations of the more generic one depicted in clause 5. They evaluate several concrete cases of Advanced Semantic Discovery in different IoT domains and illustrate the needs for an ASD within a distributed network of CSEs belonging to a single Service Provider and across different IoT Service Providers.

The proposed use cases of the present document have been incorporated into the oneM2M TR-0001 (use case collection [i.19]) and the requirements are contributed to the oneM2M TS-0002 [i.28]. Most of the potential requirements derived from the use cases are in common and solving them in the oneM2M system will enable more sophisticated semantic queries as e.g. a capability in the CSE, that takes routing decisions for forwarding a received Advanced Semantic Discovery Query. The functionalities identified in the use cases are providing a basis for the ETSI TR 103 715 [i.2].

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## Annex A: Change History

Date	Version	Information about changes
February 2020	0.0.1	TR Skeleton derived from the TR template, clauses 1-3 filled with initial text
March 2020	0.0.2	New version with fill in descriptions deleted, structure of clauses 5 and 6 adapted to oneM2M template for input contributions on use case, changes discussed during STF meeting #2
March 2020	0.1.0	Early Draft version for review at TC SmartM2M #53
April 2020	0.2.0	Stable Draft version for review by TC SmartM2M AdHoc meeting
May 2020	0.3.0	Final Draft version for approval by TC SmartM2M #54
July 2020	1.1.1	Verification by ETSI Technical Officer for Publication pre-processing with editHelp!

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## History

<b>Document history</b>		
V1.1.1	July 2020	Publication