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TECHNICAL SPECIFICATION

SmartM2M;
Model for oneM2M Performance Evaluation

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ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00   Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
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Foreword

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

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**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 present document proposes a Meta-Model (MM), i.e. a general-purpose modelling of oneM2M applications, written using an UML-like general purpose language that is intended to provide a general pattern for representing IoT applications, using all the entities defined in the oneM2M standard, and offering a pragmatic tool for rapidly prototyping the most important characteristic to measure.

The MM will be instantiated to real examples to express some (but not all) application requirements (e.g. response time, level of scalability, hardware requirement) and resource representation (e.g. smart campus, traffic light system). The MM is composed of three subsets, each one representing a part of operational IoT systems and expressing an abstraction with four layers: the Application Scenario layer, the oneM2M resource layer, the oneM2M service platform layer and the infrastructure layer. Such onion-like view proves useful in the work to conceive, model, inject and decompose into the oneM2M standard almost any IoT application in full detail and make it ready to be explored from the performance evaluation standpoint. Those layers are expressed in three model views called, respectively:

1) oneM2M Application Scenario Descriptor (OASD);

2) oneM2M CSE Performance Descriptor (OCPD); and

3) oneM2M Solution Deployment Descriptor (OSDD).

For information purposes, a detailed instantiation of the common MM is proposed based on one of the use cases described in the present document, namely the one described in clause 9.

Introduction

The objective of the present document in conjunction with three other ones ETSI TR 103 841 [i.2], ETSI TR 103 842 [i.3] as well as ETSI TR 103 843 [i.4] is to provide a MM that is suitable to be instantiated to deploy an oneM2M application, based on application description, a oneM2M specific stack over a specific hardware and a network platform. A MM is very useful to capture the key performance evaluation aspects that need to be measured e.g. response time, data transfer volume. Use cases described in the present document will be able to be smoothly be instantiated within the MM. Based on this formalization, a simulation and performance evaluation can be created and executed, starting from a generic implementation of the MM in a generic or ad hoc simulator, a choice that is clarified in deliverables ETSI TR 103 841 [i.2] and ETSI TR 103 842 [i.3]). This will enable users of the present document to ultimately tune their oneM2M applications based on measurements of the most performance-critical aspects, usually called Key Performance Indicators (KPI).

1 Scope

1.1 Context for the present document

The oneM2M ETSI standard (oneM2M TS-0001 [1]) is now mature: multiple deployments exist all over the world at both experimental and operational levels. The experimental deployments are conducted for multiple reasons:

- To evaluate the capabilities of the standard in terms of expressiveness, usability on specific equipment, connection with specific existing systems or performance evaluation.
- To provide a methodological study, based on performance evaluation (time, space) on a given set of "paradigmatic use cases".
- To measure KPIs defined in the present document. Different implementations exist that are compliant with the oneM2M standard, available either freely or commercially.

Use cases are evaluated in terms of chosen KPI: e.g. running time, memory space, numerosity of oneM2M entities (e.g. AE, MN-CSE and CSE), data transfer volume and real-time needs. Using a select set of available oneM2M CSE implementations, a simulation library or an *ad hoc* simulator is to be provided, offering the ability to evaluate and simulate the performance of the use cases and give crucial information/feedback to the general user of the oneM2M to choose and tune their IoT applications based on oneM2M framework. The results of this tool development and evaluations of the use cases will be the basis to generate other deliverables. The present document was developed in the context of ETSI TTF T019, set up to perform work on "Performance Evaluation and Analysis for oneM2M Planning and Deployment". Five elements were addressed sequentially:

1) A collection of **use cases and derived requirements** were formally identified and defined. This work includes identification of relevant deployment scenarios. The use case style and template from oneM2M have been adopted with a minor modification to address some performances issues. This phase of the work resulted in ETSI TR 103 839 [i.5].

2) The definition of **performance evaluation model**, with specification of procedures to assess the performance of oneM2M-based IoT platforms. This includes the identification and definition of a set/list of KPIs necessary to assess the deployment. For those KPIs, provision of a formal description of the test campaign and the test results to be obtained. This phase of the work resulted in the present document.

3) The creation of a **proof of concept** of a performance evaluation tool. This work also relies on a formal description of the identified deployment scenarios (single vertical domain & multiple vertical domains). This phase of the work resulted in ETSI TR 103 841 [i.2].

4) A practical **demonstration and analysis** exercise putting the proposed tool to use, with a specific oneM2M implementation but aimed at being a blueprint for the adoption and re-use of the results of ETSI TR 103 839 [i.5], present document and ETSI TR 103 841 [i.2] with other oneM2M implementations and deployment scenarios. This phase of the work resulted in ETSI TR 103 842 [i.3].

5) The development of a set of **guidelines and best practices** documenting best practices and lessons learnt as well as providing instructions for IoT solution topology, capacity provisioning, and expected performances that will gives crucial directives and information to designer and implementors. This phase of the work resulted in deliverable provisioning and expected performances. This phase resulted in ETSI TR 103 843 [i.4].

The present document covers the second of the five items listed above and provides the basis for the related ETSI publications listed below:

- ETSI TR 103 839[i.5]: Scenarios for evaluation of oneM2M deployments.
- ETSI TS 103 840 (the present document): Model for oneM2M Performances Evaluation.
- ETSI TR 103 841 [i.2]: oneM2M Performance Evaluation Tool (Proof of Concept).
- ETSI TR 103 842 [i.3]: Demonstration of Performance Evaluation and Analysis for oneM2M Planning and Deployment.
- ETSI TR 103 843 [i.4]: oneM2M deployment guidelines and best practices.

1.2 Scope of the present document

The present document identifies additional requirements to be potentially submitted to oneM2M in the areas of performance evaluation by means of a MM able to characterize application representation and deployment in the oneM2M standard. 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 a layered vision of one IoT application, designed using oneM2M and deployed over a distributed and connected platform of execution.
- Clause 5 highlights Key Configuration Parameters that could be manipulated by IoT architect and Key Performance Indicators that they could expect.
- Clause 6 focuses on the oneM2M Application Scenario Descriptor (OASD) able to describe the application in term of behavior, requirements and description as oneM2M resource.
- Clause 7 presents the subset model oneM2M CSE Performance Descriptor (OCPD) that expresses how a specific oneM2M service layer is decomposed and how is used hardware resource to create the oneM2M function.
- Clause 8 describes the oneM2M Solution Deployment Descriptor (OSDD). This subset model expresses processing, storage and network part of the execution platform on which common service entities are running.
- Clause 9 presents how a use case could be instantiated with the previous model templates.
- Clause 10 provides the conclusions of the present document.

2 References

2.1 Normative 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.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

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 necessary for the application of the present document.

[1] oneM2M TS-0001 (V4.19.0): "Functional Architecture".

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] oneM2M-0011 (V1.4.0): "Common Terminology".

[i.2] ETSI TR 103 841: "SmartM2M; oneM2M Performances Evaluation Tool (Proof of Concept)".

[i.3] ETSI TR 103 842: "SmartM2M; Demonstration of Performance Evaluation and Analysis for oneM2M Planning and Deployment".

[i.4] ETSI TR 103 843: "SmartM2M; oneM2M deployment guidelines and best practices".

[i.5] ETSI TR 103 839: "SmartM2M; Scenarios for evaluation of oneM2M deployments".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

guidelines and good practices: methodological document that gives hints to deploy a oneM2M infrastructure

oneM2M Implementations Standard (OIS): list of the implementations of the oneM2M standard

oneM2M Numerosity Objects (ONO): scalability of a oneM2M application

performance evaluation: evaluation of temporal, data transfer volumetry, and scalability aspects of a system

Platform Evaluation Tool (PET): simulation environment that is used to calculate/demonstrate the performance of the oneM2M standard

Real Time Requirements (RTR): timing constraints to be fulfilled by a system

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in oneM2M TS-0011 [i.1] and the following apply:

ACP	Access Control Policy
ADN	Application Dedicated Node
AE	Application Entity
API	Application Program Interface
BER	Bit Error Rate
CIN	Content INstance
CNT	Container
COAP	Constrained Application Protocol
CPU	Central Process Unit
CRUD	Create, Read, Update, Delete
CSE	Common Service Entity
ETSI	European Telecommunications Standards Institute
FGT	Formal Graph Topology
GGP	Guidelines and Good Practices
HW	Hardware
IN-CSE	Infrastructure Node - Common Services Entity
IoT	Internet of Things
IPE	Interworking Proxy Entity

KCP	Key Configuration Parameters
KPI	Key Performance Indicators
M2M	Machine-to-Machine
M2MSP	M2M Service Provider
Mca	Reference Point for M2M Communication with AE
Mcc	Reference Point for M2M Communication with CSE
MM	Meta Model
MN	Middle Node
MN-CSE	Middle Node - Common Services Entity
MQTT	Message Queueing Telemetry Transport
NIC	Network Interface Controller
OASD	oneM2M Application Scenario Descriptor
OCPD	oneM2M CSE Performance Descriptor
OIS	oneM2M Implementations Standard
ONO	oneM2M Numerosity Objects
OS	Open Source
OSDD	oneM2M Solution Deployment Descriptor
PE	Performance Evaluation
PER	Packet Error Rate
PET	Platform Evaluation Tool
RAM	Random Access Memory
RDF	Resource Description Framework
RDM	Requirements and Domain Models
RT	Real-Time
RTR	Real Time Requirements
SPARQL	Simple Protocol and RDF Query Language

NOTE: See oneM2M TR-0002 [i.7].

SUB	Subscription
SW	Software
TC	Technical Committee
TR	Technical Report
TS	Technical Specification
TTF	Testing Task Force
UCT	Use Case Template
UML	Unified Markup Language

4 Multi-models For IoT solutions based on oneM2M

4.1 Multi-layer abstraction

A view of a layered IoT system used in the present document is shown in figure 1. This model makes it possible to break down all the physical, hardware, software and human entities involved. Each layer has interactions with the other layers and finally merges to constitute the IoT system and its environment of use.

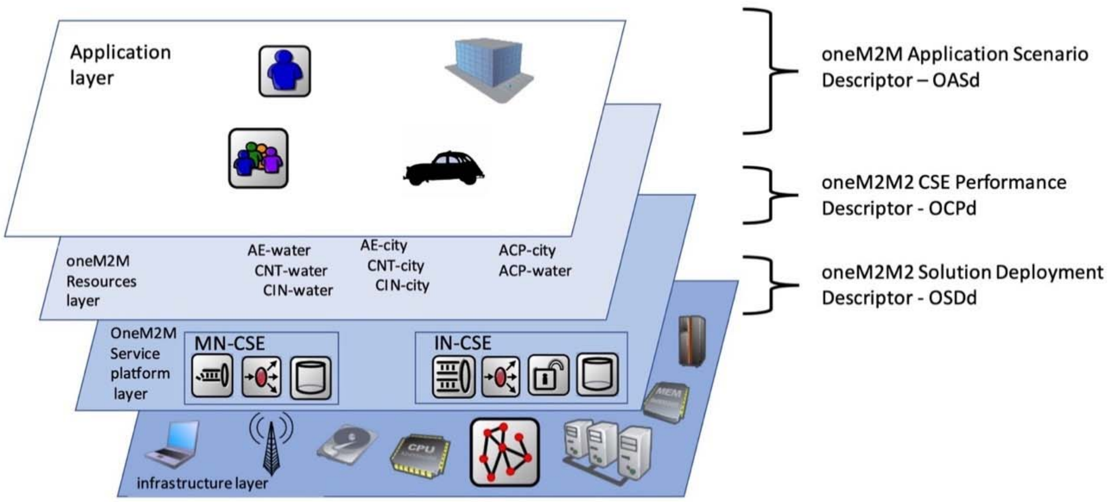


Figure 1: multi-layers vision of oneM2M IoT system

The first layer, called the **application layer** in the broad sense, corresponds to the physical world with which the IoT system interacts. This layer is on the one hand made up of the interaction that humans and the environment have with sensors and actuators and on the other hand of the constraints and needs that application domains can express for an action for example in the physical world.

The second layer, called the **resource layer**, reflects the projection of the IoT system and the specific use case on resources (in the oneM2M sense). This layer models the relationships between its resources as well as their ownership. This layer expresses the business logic on the application side.

The environment and resource layers will be described in clause 6 through a model called oneM2M Application Scenario Descriptor (OASD).

The third layer, called the **oneM2M service platform layer [1]**, represents the software or middleware system to be put in place to support the needs of layers 1 and 2. In the oneM2M world, it represents on the one hand the CSEs and the links between them and on the other hand, it models the behavior and performance of the CSE according to its configuration and the projection of layers 1 and 2 in this service platform layer. This layer will be instantiated in a model called oneM2M2 CSE Performance Descriptor (OCPD) in clause 7.

The fourth and last layer called **Infrastructure layer** represents the hardware infrastructure that hosts all of the previous layers. It makes it possible to define the equipment, the communication links and any hardware characteristics. The oneM2M2 Solution Deployment Descriptor (OSDD) model will allow to describe this layer.

This vision makes it possible to dissociate and break down the complexity of an IoT system and to call on targeted skills in each layer. Designing and deploying an IoT system means implementing and merging all of these layers. At the performance analysis level, this makes it possible to characterize the needs, parameters and behavior of each layer and to clearly explain the links between these layers through models.

4.2 Meta Model

The MM on figure 2 integrates and links OASD, OCPD, and OSDD descriptions. Each model is represented by a different color. The root item of an IoT system is represented by the Solution class. This one is connected to one or several "IoT application layer" made of one or multiple applications. Each application runs on hardware nodes and is composed of sensors and actuators. Those applications make requests to one CSE. The CSE is running on a hardware node and could use a persistent system to store data. All the hardware nodes are connected to one or several networks to exchange information between CSE, application and MQTT or data persistency system.

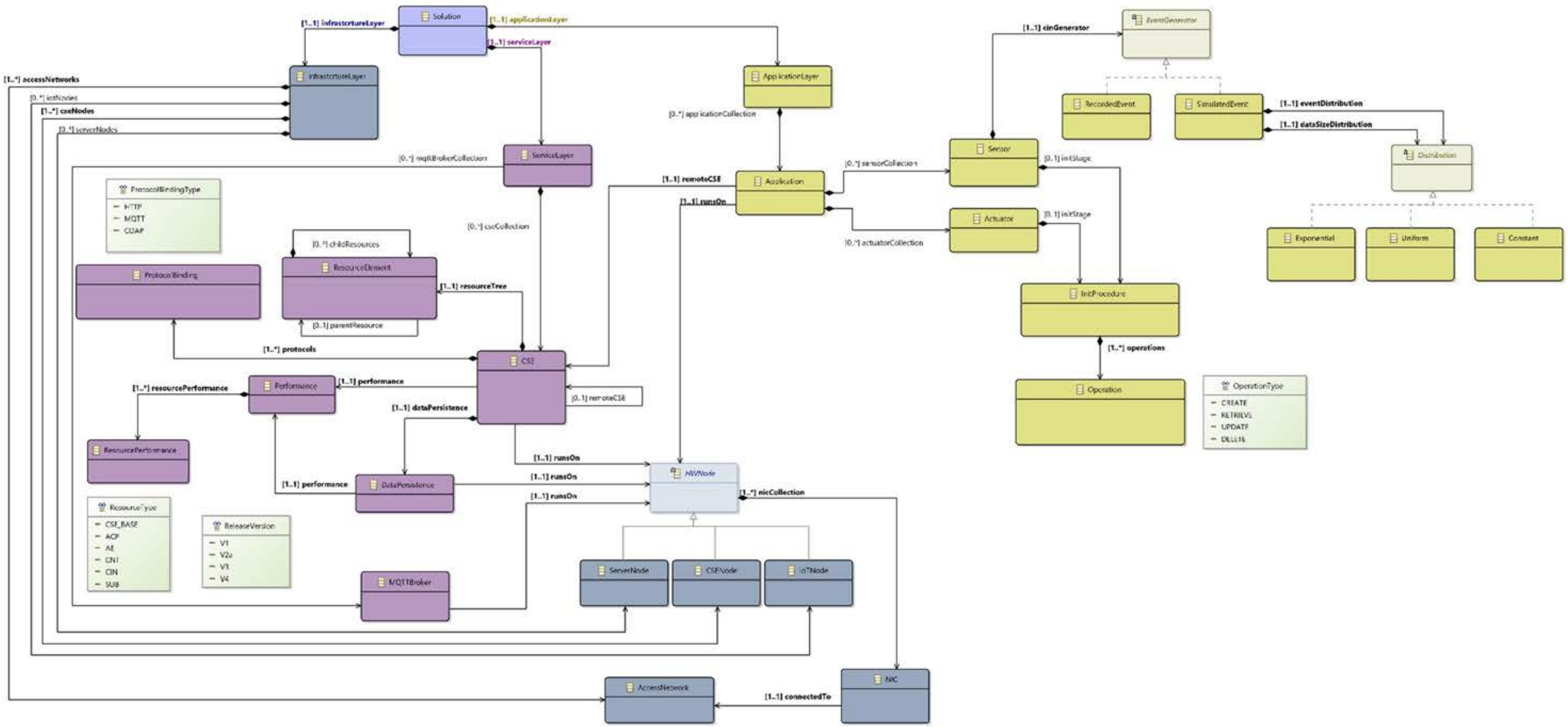


Figure 2: Meta-model for oneM2M IoT system

5 Key Performance Indicators and Key Configuration Parameters

5.1 Introduction

Key Performance Indicators (KPI) and Key Configuration Parameters (KCP) have been selected and validated by the oneM2M community to express important input of IoT systems and performance requirements.

5.2 Key Performance Indicators

This list is naturally not exhaustive, but it will be suitable to be extended according to usage and extension of use cases:

- Running time.
- Memory space.
- Data transfer volume.
- Per CRUD Operation:
    - [Min, Avg, Max, Variance, Std-Dev] Processing Time.
    - [Min, Avg, Max, Variance, Std-Dev] Persistence Delay.
    - [Min, Avg, Max, Variance, Std-Dev] Persistence Usage.
- Per CSE:
    - [Min, Avg, Max, Variance, Std-Dev] CPU Usage.
    - [Min, Avg, Max, Variance, Std-Dev] Memory Usage.
    - [Min, Avg, Max, Variance, Std-Dev] Disk Usage.
    - [Min, Avg, Max, Variance, Std-Dev] Network Usage.
- Per oneM2M object:
    - [Min, Max] Number of CIN per CSE.
    - [Min, Avg, Max, Variance, Std-Dev] Event to Notification Time.
- Networking:
    - [Min, Avg, Max, Variance, Std-Dev] Network Usage per kind of Network employed.

5.3 Key Configuration Parameters

These parameters will be able to measure the impact of key parameters of the IoT application on KPI of the simulation. Those key parameters could be:

- Infrastructure Layer aspects:
    - Total Number of IoT devices.
    - Number of IoT devices per CSE.
    - Type of access networks (Rate, Delay, PER, BER).

- Service Layer Aspects:
  - Total Number of CSEs.
  - CSE Topology.
  - CSEs' Hardware Nodes (CPU, RAM, Disk).
  - CSE Software (name, version, oneM2M Release Version).
  - oneM2M resources organization (over CSEs).
- Application Layer Aspects:
  - IoT traffic generation profiles.
  - Way of interaction with CSE.

6 oneM2M Application Scenario Descriptor (OASD)

The objective of the OASD model in figure 3 is to represent the behavior of the IoT application. To do so, sensors and actuators are endowed with a behavior modelled by event generation (for the sensors). The policy for the generation of sensor data is based on different distribution profiles i.e. constant (equivalent to periodic) or sporadic with different laws. Sensors and actuators have at an initial stage a transient behavior that corresponds to the creation of oneM2M resources.

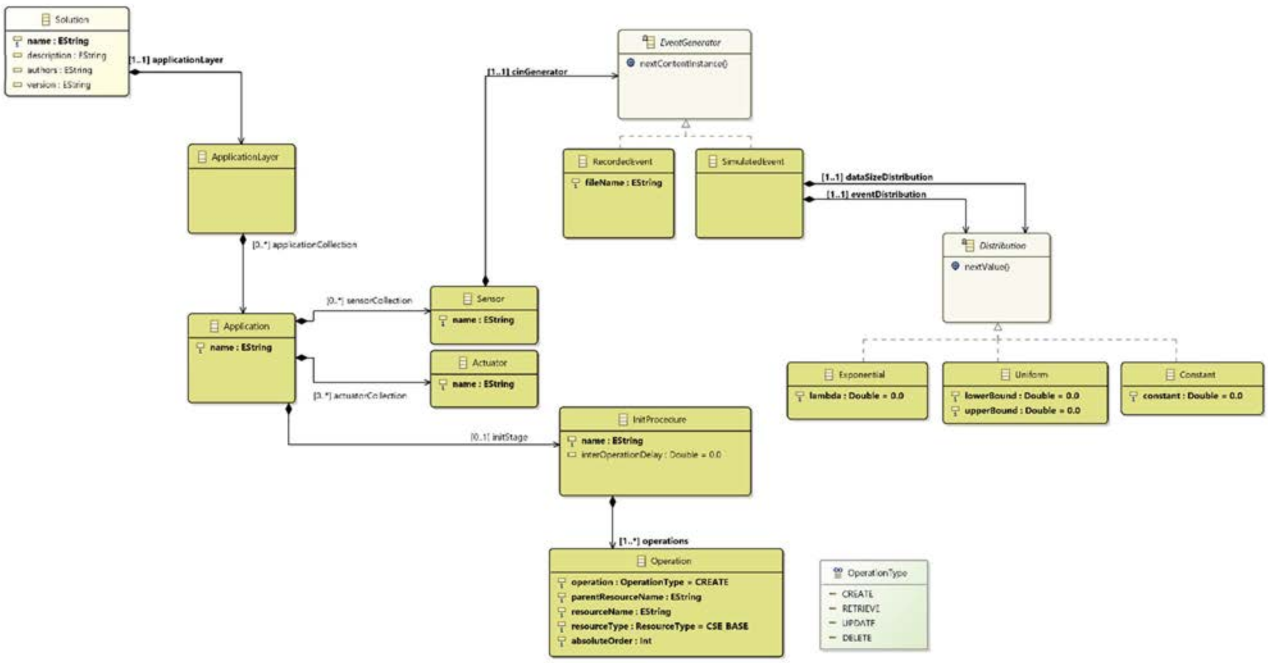


Figure 3: OASD model (Application Layer)

The detailed description of the model attributes, with related type and informal description is given below.

ApplicationLayer			
Attribute	**Cardinality**	**Type**	**Short text description**
applicationCollection	1..n	Application	A collection of all the IoT applications in the IoT solution. The IoT Solution have at least one IoT application.

Application			
Attribute	**Cardinality**	**Type**	**Short text description**
name	1..1	String	Name of the IoT application.
remoteCSE	1..1	CSE	Reference of the remote CSE this IoT application is connected to.
runsOn	1..1	HWNode	Reference of the hardware node this IoT application is running on (see Note).
sensorCollection	0..n	Sensor	Collection of sensors managed by the IoT application.
actuatorCollection	0..n	Actuator	Collection of actuators managed by the IoT application.
initStage	0..1	InitProcedure	Reference to an eventual initialization procedure.
NOTE: An IoT application can run on both a dedicated HWNode::IoTNode or on a HWNode::CSENode. It can also run on a HWNode::ServerNode to represent a server side applications.			

Sensor			
Attribute	**Cardinality**	**Type**	**Short text description**
name	1..1	String	Name of the sensor.
cinGenerator	1..1	EventGenerator	Reference to a CIN generator.

EventGenerator			
This is an abstract class used to describe how an event will be generated. It is derived into two classes : RecordedEvent and SimulatedEvent.			
Attribute	**Cardinality**	**Type**	**Short text description**
(void)	(void)	(void)	(void)

RecordedEvent: EventGenerator			
Attribute	**Cardinality**	**Type**	**Short text description**
fileName	1..1	String	File name where the sequence of events is stored. Each event is timestamped. The generated message size is also recorded.

SimulatedEvent: EventGenerator			
Attribute	**Cardinality**	**Type**	**Short text description**
eventDistribution	1..1	Distribution	The way to compute the next event date.
dataSizeDistribution	1..1	Distribution	The way to compute the next message size.

Distribution			
This is an abstract class used to describe statistical distribution. It is derived into: Exponential and Uniform. For harmonization purposes, the periodic process is also derived from Distribution and is called Constant.			
Attribute	**Cardinality**	**Type**	**Short text description**
(void)	(void)	(void)	(void)

Exponential: Distribution			
Attribute	**Cardinality**	**Type**	**Short text description**
lambda	1..1	Decimal	Parameter of the exponential distribution.
Uniform: Distribution			
Attribute	**Cardinality**	**Type**	**Short text description**
lowerBound	1..1	Decimal	Lower bound of the uniform distribution.
upperBound	1..1	Decimal	Upper bound of the uniform distribution.

Constant: Distribution			
Attribute	**Cardinality**	**Type**	**Short text description**
constant	1..1	Decimal	The constant value this distribution is always returning.

Actuator			
Attribute	**Cardinality**	**Type**	**Short text description**
name	1..1	String	Name of the actuator.

InitProcedure			
Attribute	**Cardinality**	**Type**	**Short text description**
name	1..1	String	Name of the initialization procedure.
operations	1..n	Operation	Sequence of elementary operation composing the initialization procedure.
interOperationDelay	0..1	Decimal	Delay between two consecutive operations in seconds.

Operation			
Attribute	**Cardinality**	**Type**	**Short text description**
operation	1..1	OperationType	Type of operation to be performed (CREATE, RETREIVE, UPDATE, or DELETE).
parentResourceName	1..1	String	Name of the parent resource.
resourceName	1..1	String	Name of the resource to be created, retrieved, updated, or deleted.
resourceType	1..1	ResourceType	oneM2M resource type for this operation.
absoluteOrder	1..1	Integer	Absolute order of this operation in all the IoT solution.

OperationType	
Short text description	An enumeration for the CRUD operations.
Values	- CREATE - RETRIEVE - UPDATE - DELETE

7 oneM2M2 CSE Performance Descriptor (OCPD)

The objective of the OCPD sub-model on figure 4 is to describe the service layer. To do this, it describes the interconnection between CSEs (IN-CSE, MN-CSE, ASN), the impact of the implementation choices of a CSE by a supplier, the deployment on equipment taking into account their processing capabilities, their memory and network connection.

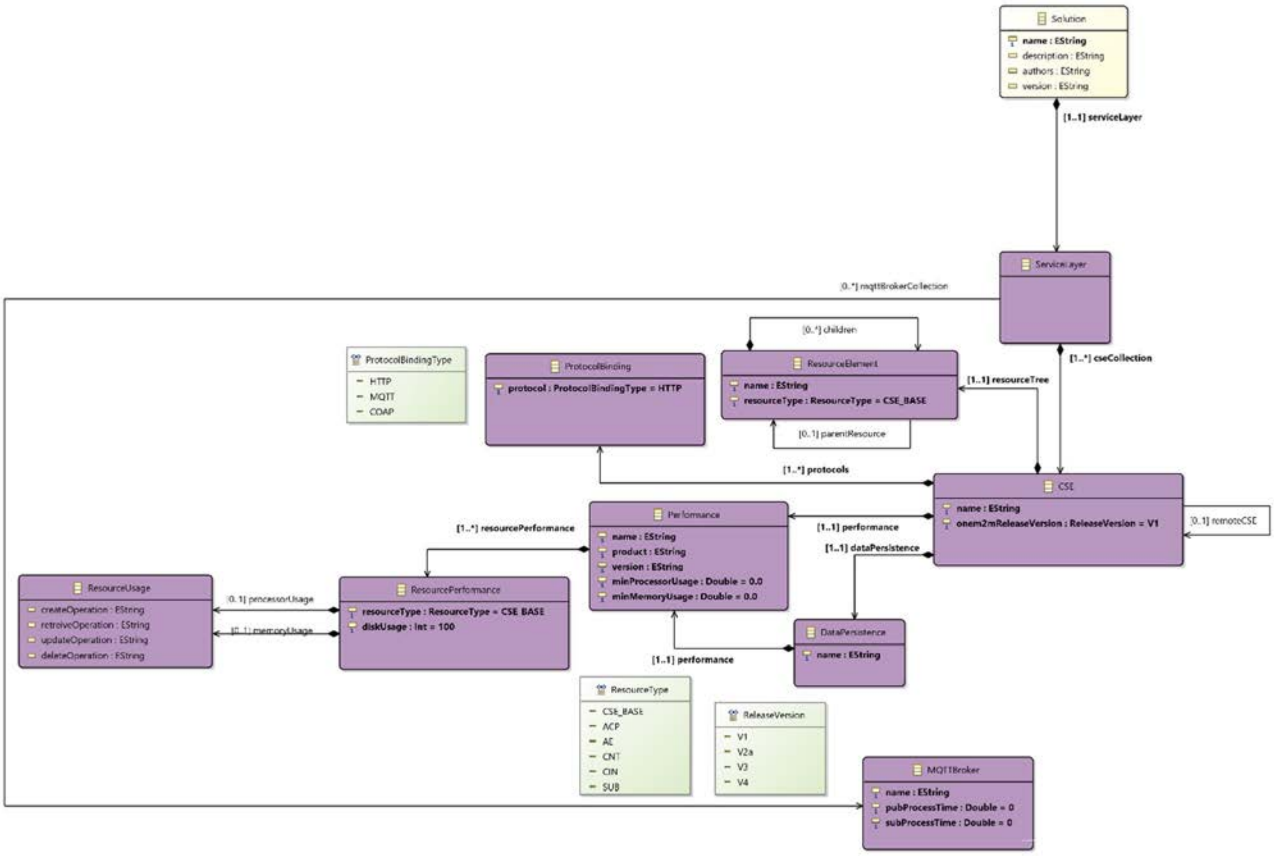


Figure 4: OCPD model (Service Layer)

The detailed description of the model attributes, with related type and informal description is given below.

ServiceLayer			
Attribute	**Cardinality**	**Type**	**Short text description**
cseCollection	1..n	CSE	The collection of CSEs in the IoT solution. At least one CSE is present.
mqttBrokerCollection	0..n	MQTTBroker	The collection of MQTT brokers in the IoT solution.

CSE			
Attribute	**Cardinality**	**Type**	**Short text description**
name	1..1	String	Name of the CSE in the IoT Solution.
remoteCSE	0..1	CSE	Reference to the remote CSE this CSE is connected to.
runsOn	1..1	HWNode	Reference to the hardware node this CSE is running on. A CSE runs only on a dedicated HWNode::CSENode.
dataPersistence	1..1	DataPersistence	Reference to the persistency mechanism.
performance	1..1	Performance	Performance descriptor of CRUD operations supported by the CSE.
protocols	1..n	ProtocolBinding	Collection of the protocol bindings supported by the CSE.
resourceTree	1..1	ResourceElement	Reference to the oneM2M CSEBase resource (i.e. the root element of the oneM2M resource tree).
onem2mReleaseVersion	1..1	ReleaseVersion	The oneM2M release version selected for the CSE.

Performance			
Attribute	**Cardinality**	**Type**	**Short text description**
name	1..1	String	Textual description.
product	1..1	String	Name of the CSE implementation.
version	1..1	String	Version of the CSE implementation.
minProcessorUsage	1..1	Decimal	Processor usage at start-up.
minMemoryUsage	1..1	Decimal	Memory usage at start-up.
resourcePerformances	1..n	ResourcePerformance	The performance of CRUD operation for each resource supported by the CSE.

DataPersistence			
Attribute	**Cardinality**	**Type**	**Short text description**
name	1..1	String	Name of the data persistence service.
runsOn	1..1	HWNode	Reference of the hardware node this data persistence service is running on. A data persistence service can run on the same HWNode::CSENode along its CSE. It can also run on a dedicated HWNode::ServerNode.
performance	1..1	Performance	Performance descriptor of CRUD operations for this data persistence service.

ResourceElement			
Attribute	**Cardinality**	**Type**	**Short text description**
name	1..1	String	Name of the oneM2M resource.
resourceType	1..1	ResourceType	The oneM2M resource type.
parentResource	0..1	ResourceType	Reference to the parent resource.
childResources	0..n	ResourceType	References to the child resources.

ResourcePerformance			
Attribute	**Cardinality**	**Type**	**Short text description**
resourceType	1..1	ResourceType	oneM2M resource type.
processorUsage	1..1	ResourceUsage	Reference to a resource usage description for the processing resource on the HW node.
memoryUsage	1..1	ResourceUsage	Reference to a resource usage description for the memory resource on the HW node.
diskUsage	1..1	Decimal	Memory in bytes occupied by this resource.

ResourceUsage			
Attribute	**Cardinality**	**Type**	**Short text description**
createOperation	1..1	String	A string expressing a formula to describe a resource usage (processor or memory) for the CREATE operation.
retreiveOperation	1..1	String	A string expressing a formula to describe a resource usage (processor or memory) for the RETREIVE operation.
updateOperation	1..1	String	A string expressing a formula to describe a resource usage (processor or memory) for the UPDATE operation.
deleteOperation	1..1	String	A string expressing a formula to describe a resource usage (processor or memory) for the DELETE operation.
NOTE: Each formula can depend on parameters such as time, resource type, CPU usage of the host, etc.			

MQTTBroker			
Attribute	**Cardinality**	**Type**	**Short text description**
name	1..1	String	Name of the MQTT Broker.
runsOn	1..1	HWNode	Reference of the hardware node this MQTT broker is running on. An MQTT Broker can run on the same HWNode::CSENode along a CSE. It can also run on a dedicated HWNode::ServerNode.
pubProcessTime	1..1	Decimal	Processing time in seconds for publish operations on this MQTT Broker.
subProcessTime	1..1	Decimal	Processing time in seconds for subscribe operations on this MQTT Broker.

ProtocolBinding			
Attribute	**Cardinality**	**Type**	**Short text description**
protocol	1..1	ProtocolBindingType	The protocol supported by this protocol binding.

Enumerations:

ReleaseVersion	
Short text description	An enumeration for all supported oneM2M release versions.
Values	- V1 (oneM2M v1) - V2a (oneM2M v2a) - V3 (oneM2M v3) - V4 (oneM2M v4)

ProtocolBindingType	
Short text description	An enumeration for all supported protocol bindings.
Values	- HTTP - MQTT - COAP

ResourceType	
Short text description	An enumeration for all currently supported oneM2M resource types.
Values	- CSE_BASE - ACP - AE - CNT - CIN - SUB

8 oneM2M2 Solution Deployment Descriptor (OSDD)

The OSDD model on figure 5 describes the hardware platform that hosts the IoT application. This infrastructure is made of multiple nodes of different types, interconnected by a network. This model quantifies the capacities (memory storage, processing capabilities, location) of the physical nodes and the underlying communication networks, The deployment refers to the allocation of CSEs on these physical hardware nodes.

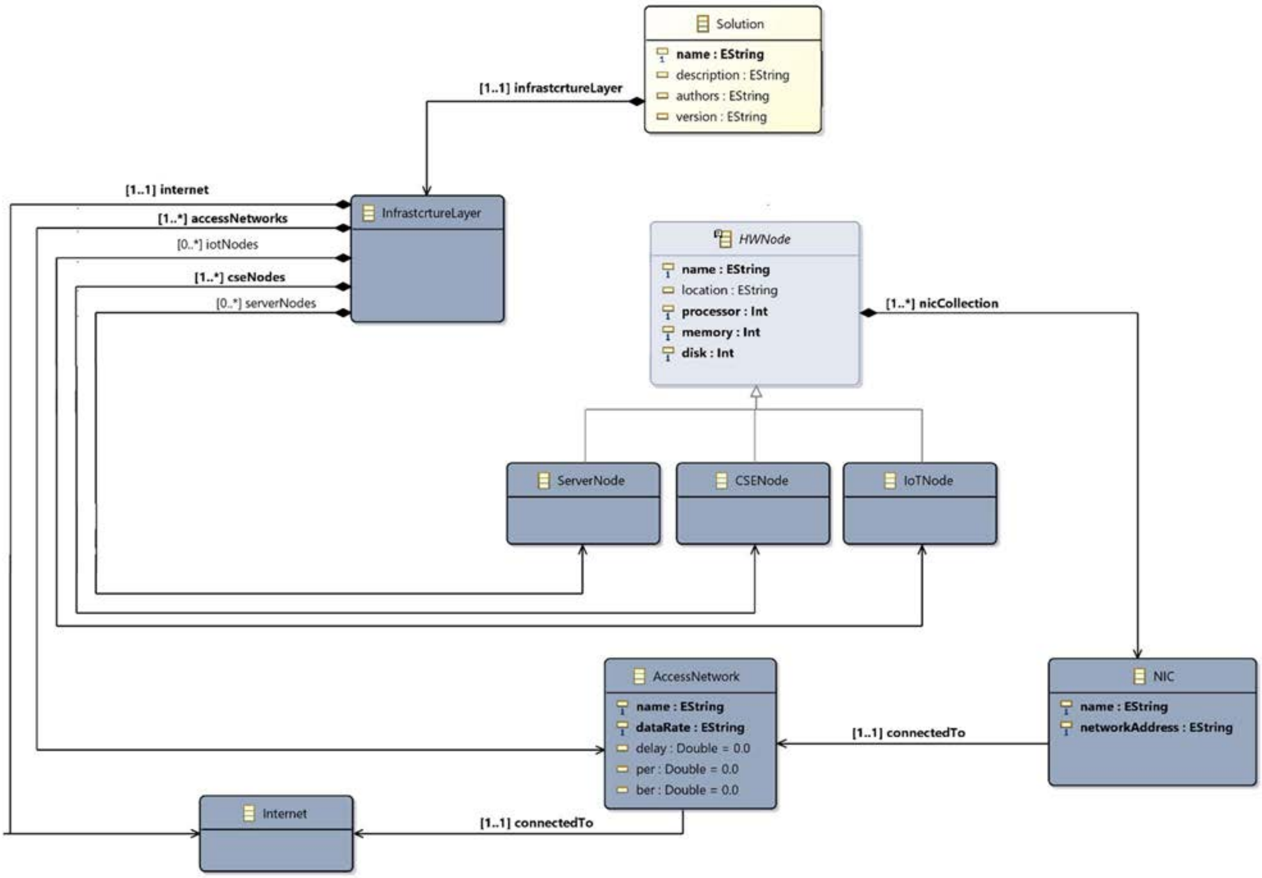


Figure 5: OSDD model (Infrastructure Layer)

The detailed description of the model attributes, with related type and informal description is given below.

InfrastructureLayer			
Attribute	**Cardinality**	**Type**	**Short text description**
iotNodes	0..n	IoTNode	List of IoT devices in the IoT solution.
cseNodes	1..n	CSENode	List of CSE nodes in the IoT
serverNodes	0..n	ServerNode	List of specific servers if needed for MQTT or persistency
accessNetworks	1..n	AccessNetwork	List of Network connected to this node

HWNode			
This is an abstract class that describes a runtime node. It is derived into IoTNode, CSENode, and ServerNode.			
Attribute	**Cardinality**	**Type**	**Short text description**
name	1..1	String	Name of the Hardware node.
nicCollection	1..n	NIC	Collection of the NICs available on this hardware node.
processor	1..1	Integer	Quantifier of the processing capability of this node in terms of number of instructions per second.
memory	1..1	Integer	Quantifier of the memory capability of this node in terms of number of bytes.
disk	1..1	Integer	Quantifier of the storage capability of this node in terms of number of bytes.
location	0..1	String	Geographical location of the node.

IoTNode : HWNode			
Attribute	**Cardinality**	**Type**	**Short text description**
(void)	(void)	(void)	(void)

CSENode : HWNode			
Attribute	**Cardinality**	**Type**	**Short text description**
(void)	(void)	(void)	(void)

ServerNode : HWNode			
Attribute	**Cardinality**	**Type**	**Short text description**
(void)	(void)	(void)	(void)

NIC			
Attribute	**Cardinality**	**Type**	**Short text description**
name	1..1	String	Name of the NIC.
networkAddress	1..1	String	Network address of the NIC.
connectedTO	1..1	AccessNetwork	Reference of the AccessNetwork this NIC is connected to.

AccessNetwork			
Attribute	**Cardinality**	**Type**	**Short text description**
name	1..1	String	Name of the access network.
dataRate	1..1	String	A string expressing a formula for representing the data rate based on parameters such as distance.
delay	1..1	Decimal	Network delay in seconds.
packetErrorRate	0..1	Decimal	The packet error rate in percentage.
bitErrorRate	0..1	Decimal	The bit error rate in percentage.
NOTE: Any network topology in the meta model is composed of a list of access networks connected to the Internet.			

Internet			
This a special class that represents the core network interconnecting all access networks present in the IoT solution. This class is instantiated only once. Its network characteristics are assumed perfect since any network characteristics (delay, data rate, etc.) to be considered are expressed at the level of the access networks.			
Attribute	**Cardinality**	**Type**	**Short text description**
(void)	(void)	(void)	(void)

9 Example of instantiation

The MM proposed in the present document is instantiated to represent the traffic lights use case of document [i.5]. It includes a simple execution infrastructure, the deployment of CSEs and the oneM2M resources necessary to represent this scenario.

The instance of the meta-model can be presented using different views. Figure 6 presents the list of the available views.

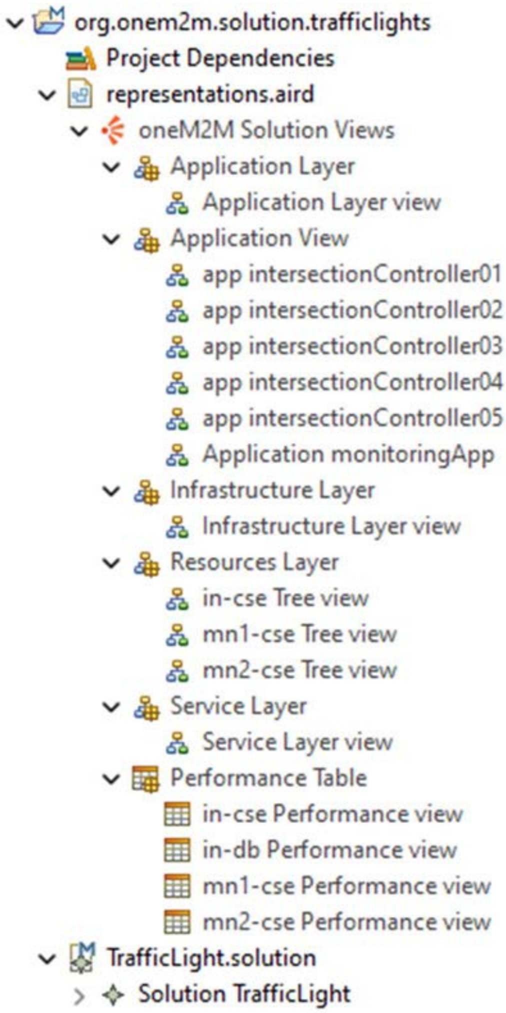


Figure 6: The different representations of the Traffic Light instance of the meta-model

The infrastructure view of this instance is as shown in figure 7.

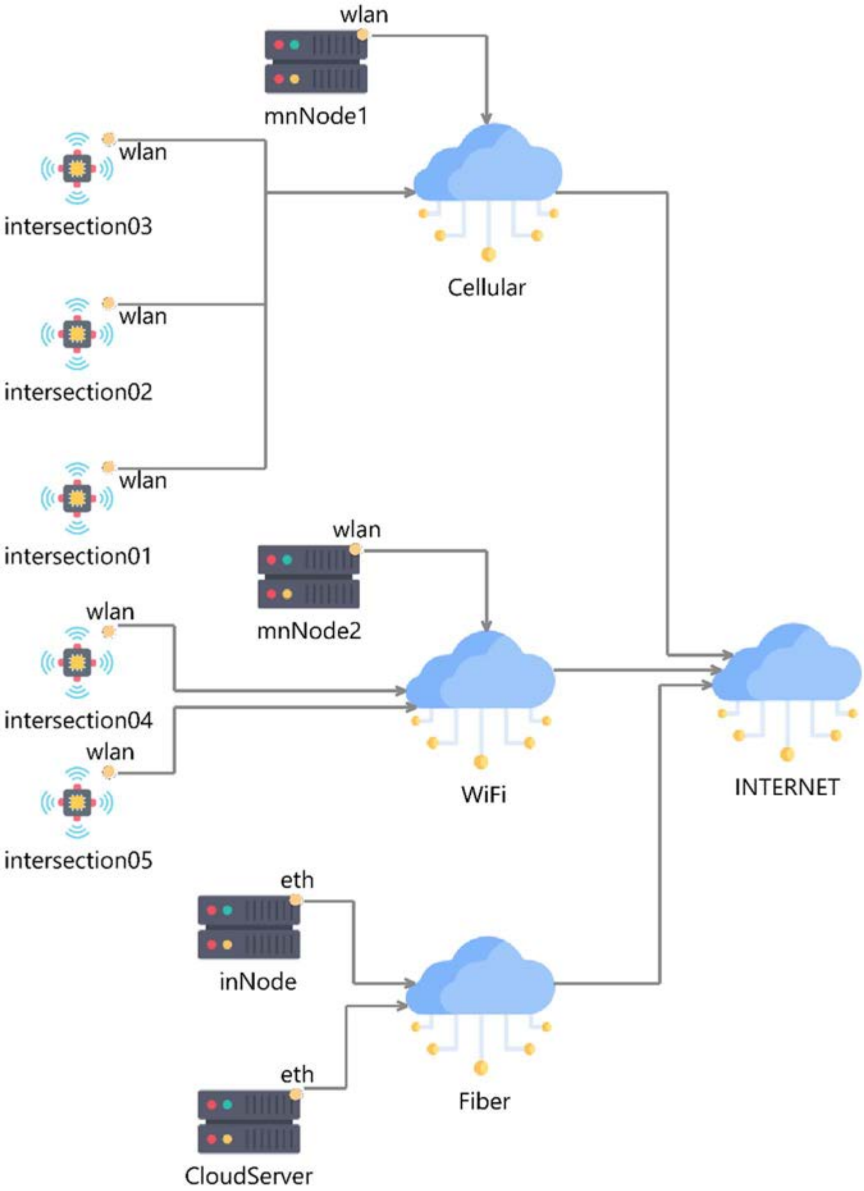


Figure 7: Infrastructure layer view of the Traffic Light use case

In this example, 5 intersections have been considered. IoT devices of intersections 01, 02, 03 are connected to a CSE node: **`mnNode1`** through a cellular network. IoT devices of intersections 04 and 05 are connected to another CSE node: **`mnNode2`** through a Wi-Fi network. Finally, a third CSE node: **`inNode`** is also part of this IoT solution and is connected to a fiber network. All the three access networks (Cellular, Wi-Fi®, Fiber) are connected to the Internet; thus, a connectivity exists between all the nodes.

Following the meta-model, the nodes have attributes describing their capacities in terms of memory, processing, and storage. The access networks have attributable describing their rate, delay, and error rates.

The oneM2M service layer view is as shown in figure 8.

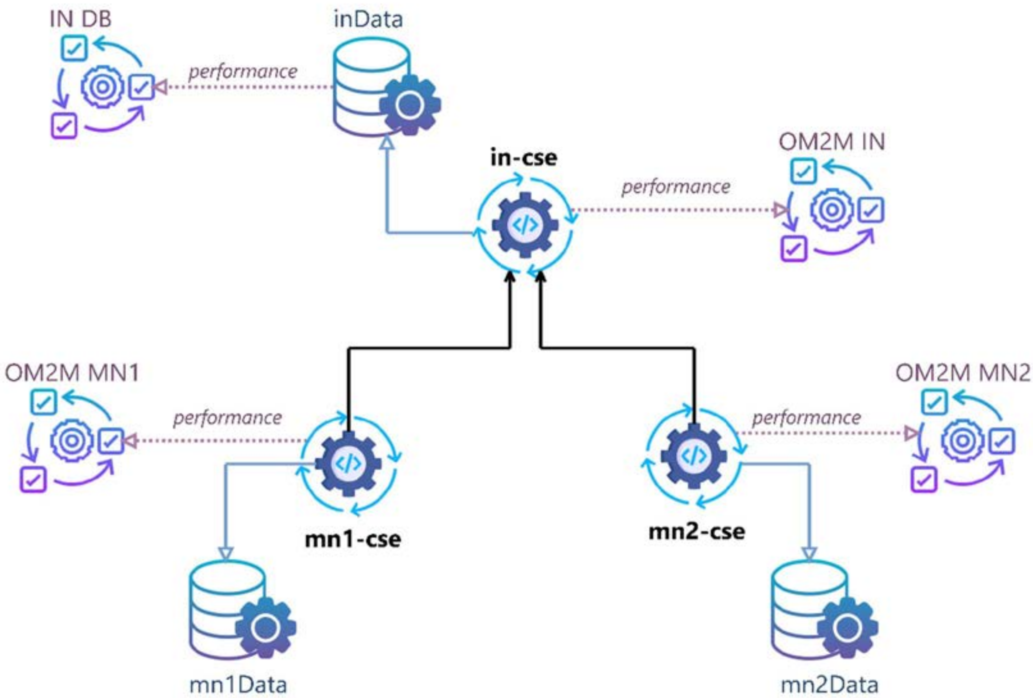


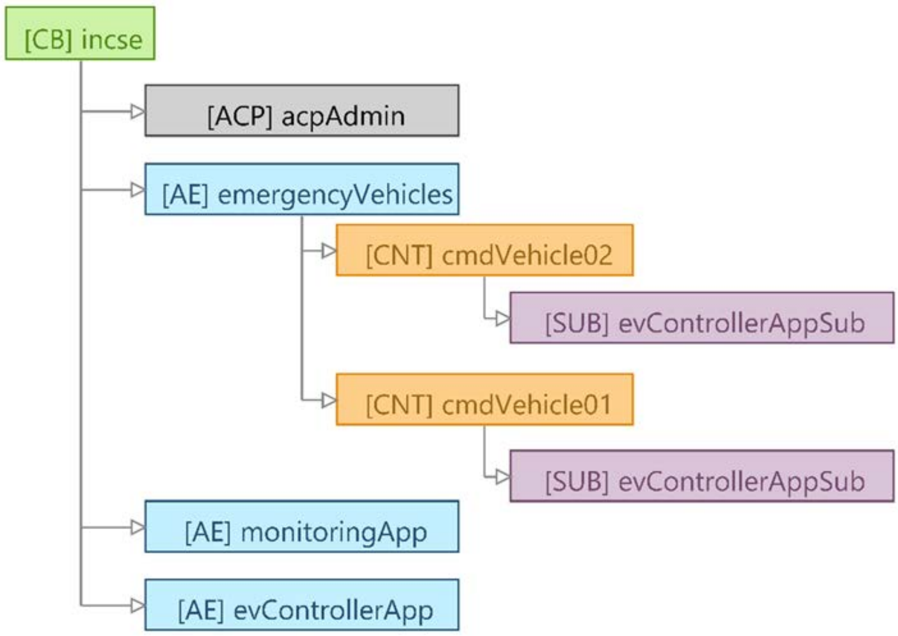
Figure 8: Service layer view of the Traffic Lights use case

In this example, a simple oneM2M topology is considered. The IoT solution is composed of two middle nodes CSEs : **`mn1-cse`** and **`mn2-cse`**. They are registered to an infrastructure node CSE: **`in-cse`**.

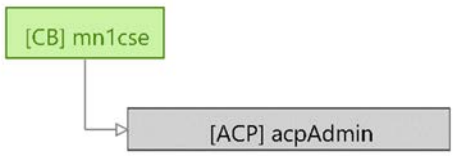
It is worth noting that these 3 CSEs are running on different hardware nodes not represented in this view. **`mn1-cse`** is running on **`mnNode1`**, **`mn2-cse`** is running on **`mnNode2`**, and **`in-cse`** is running on **`inNode`** (see figure 7).

The data persistence service of each CSE is also represented in this view. Both CSE and data persistence service can have a descriptor of their performances. The data persistence service of the **`in-cse`** is also described. However, the performances of the data persistence service on **`mn1-cse`** and **`mn2-cse`** are supposed negligeable (thus not shown in this instance).

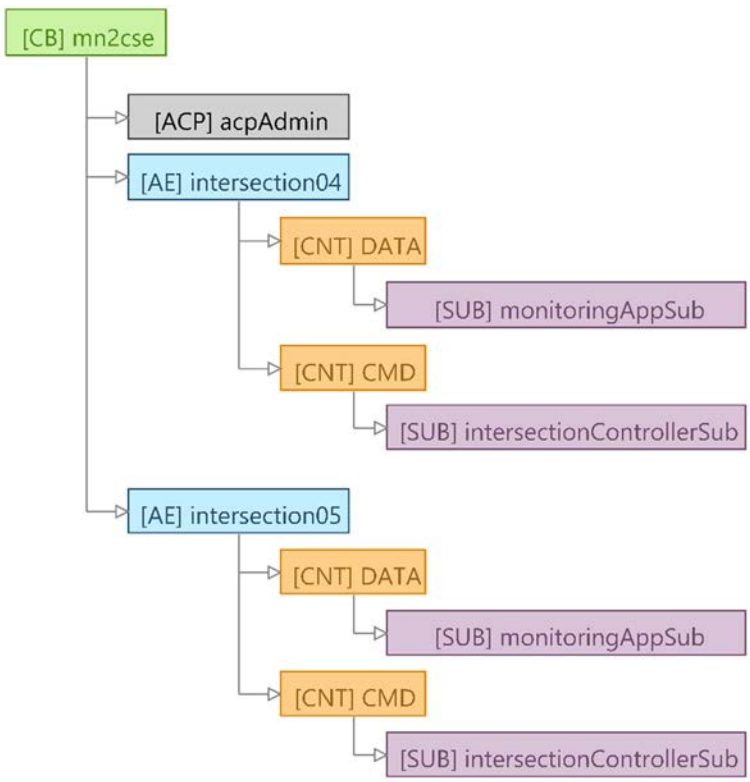
Following the meta-model, every CSE maintains a resource tree (figure 9). A different view can show this tree structure. The following figures shows these resource trees.



in-cse oneM2M Resource Tree



mn1-cse oneM2M Resource Tree



mn2-cse oneM2M Resource Tree

Figure 9: Resource Tree of MN and IN CSE

It is worth noting that the resource tree is predetermined on **`mn2-cse`** but not on **`mn1-cse`**.

Figure 10 shows the relationship between the IoT applications and the oneM2M service layer.

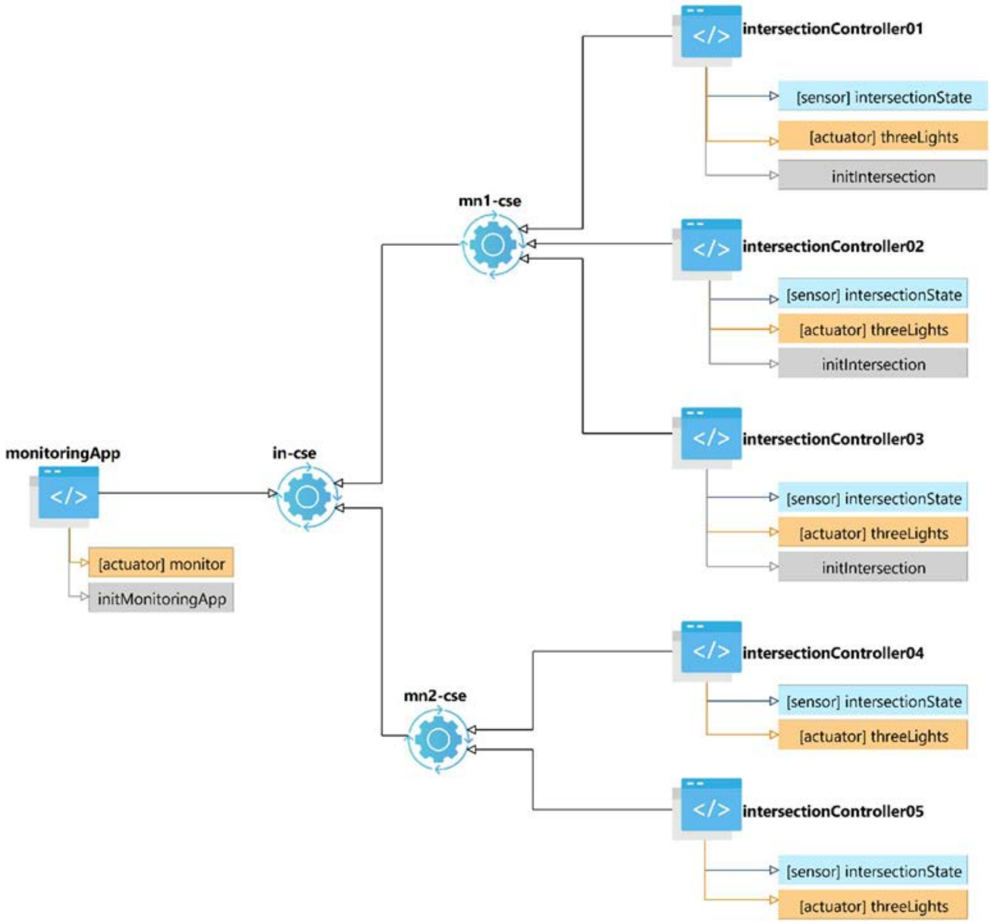
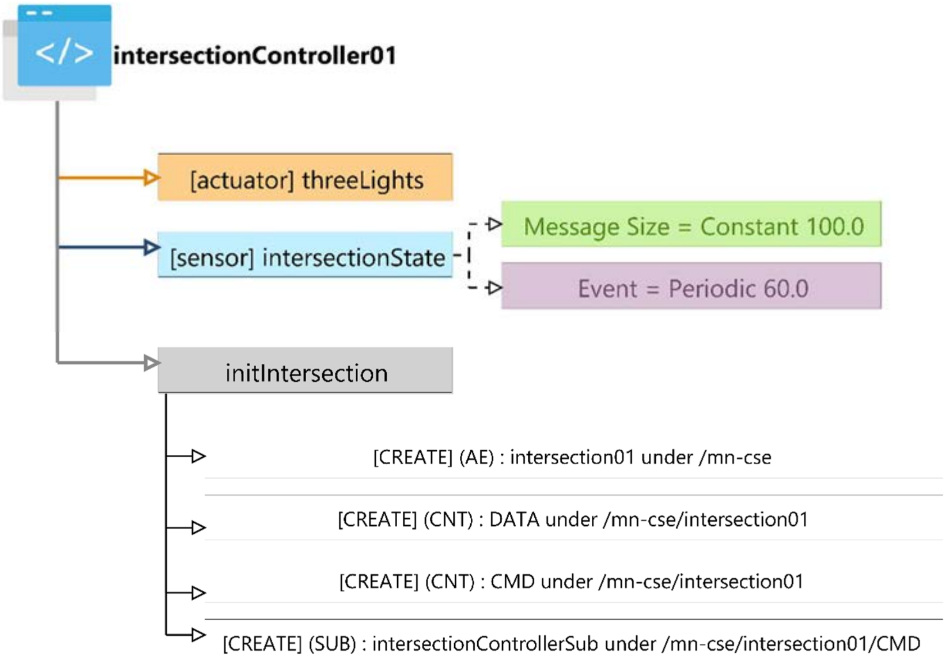


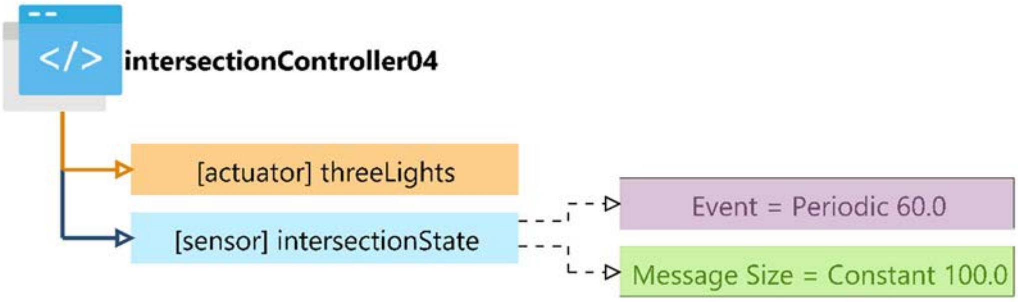
Figure 10: Application layer view of the Traffic Lights use case

From this view, for intersections 01, 02, and 03 controllers (i.e. IoT applications) initialization procedures have been defined along with one sensor: **`intersectionState`** and one actuator: **`threeLights`**. However, intersections 04 and 05 controllers are described with the same sensor and actuator but with no initialization procedures.

A detailed look into one IoT application shows the characteristics of the application behavior in terms of initialization procedure but also in terms of data generation (figure 11).



Application view of intersectionController01 application



Application view of intersectionController04 application

Figure 11: IntersectionController01 and 04 applications

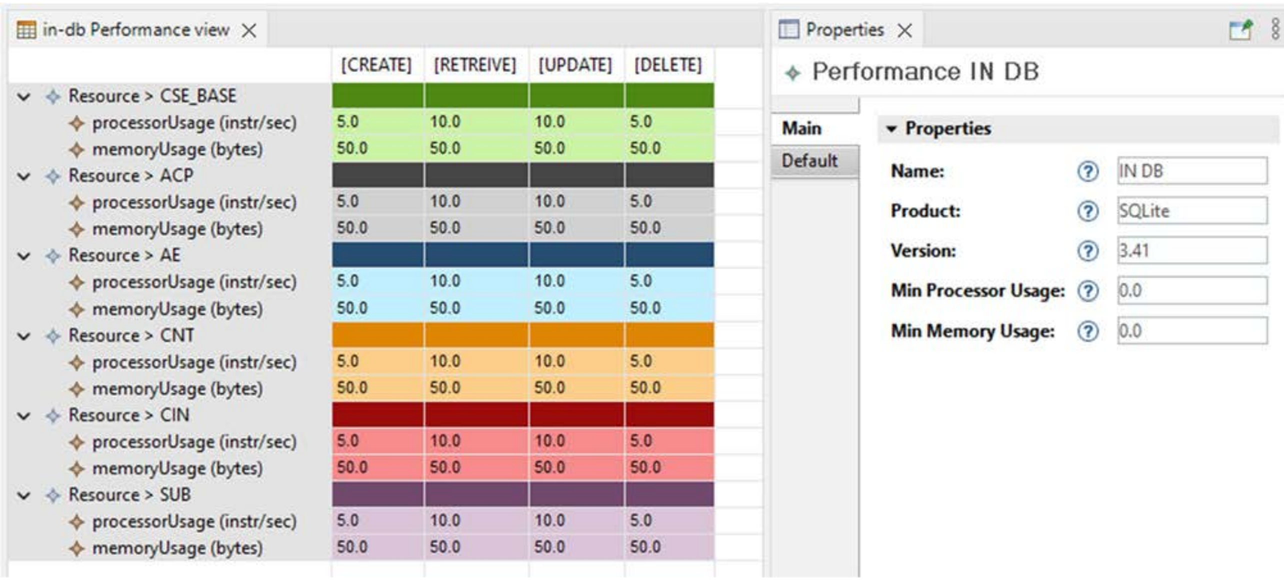
In intersectionController01, an initialization procedure has been defined. It is composed of list of the CRUD operation that will be executed at the startup of the simulation. In this example, an ApplicationEntity is first created under the remote CSE' base. Then two oneM2M containers: `DATA` and `CMD` are created. Finally, a subscription resource is created under the `CMD` container.

The data generated by the sensor representing the intersection state will be simulated through a periodic process with a period of 60 seconds and generated data messages with a constant size of 100 bytes.

Since the resource tree on the `mn1-cse` (the remote CSE for intersections 04 and 05) is already defined, `intersectionController04` does not have an initialization procedure. The sensor is described the same way as in the previous IoT application.

Finally, all the CSE involved in this IoT solution have performance characteristics that can be visualized in tables. Figure 12 shows an overview of performance of both the `in-cse` and its data persistence service.

in-cse Performance Table



in-db Performance Table

Figure 12: Performance tables overview of in-cse and in-db

As stated in the meta-model, a performance description includes the usage in terms of memory, processor, and disk for every oneM2M resource and for each of the CRUD operations. For example, from the **`in-db`** performance table, the resource of type **`CSE_BASE`** requires 5 instructions per second of processing for **`CREATE`** and **`DELETE`** operations. But it requires 10 instructions per second of processing for **`RETREIVE`** and **`UPDATE`** operations. In this example, the numbers in the table are chosen arbitrarily.

10 Conclusions

The present document gives a detailed view of a model able to describe at a high level, a oneM2M IoT system and to evaluate the performance of such a system.

The meta model developed in clause 4 gives an overview of the model. The different parts are detailed in clauses 6, 7 and 8. This meta model makes it possible to represent an overall oneM2M IoT system *i.e.* the hardware and network infrastructure, the CSEs deployed and the application that will generate exchanges through the oneM2M resources. In order to evaluate the performance of such a system clause 5 lists the set of KPIs and parameters needed to set up a performance analysis of the IoT system and to describe the expected simulation results. All of this information will be used in documents ETSI TR 103 842 [i.3] and ETSI TR 103 843 [i.4] for the development of a performance analysis tool and for the representation of the system to be analyzed.

Annex A (informative): Change History

Date	Version	Information about changes
Mars 2023	0.0.1	Bootstrapping Intro and Table of Contents of the document
Mars 2023	0.1.1	Filling Clauses 4, 6, and 7
April 2023	0.1.2	Filling Clauses 4, 6, 5 and 7
April 2023	0.1.3	Typos, Type and Proof checking in Tables, instantiation on traffic light
May 2023	0.1.4	Version review with comments to be addressed
May 2023	0.1.5	Revision with cleanup
June 2023	1.1.1	Technical Officer review for publication pre-processing

History

Document history		
V1.1.1	August 2023	Publication