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TECHNICAL REPORT

**SmartM2M;**
**Scenarios for evaluation of oneM2M deployments**

Reference

DTR/SmartM2M-103839

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IoT, methodology, oneM2M, performance, scenarios, simulation

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# Foreword

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



# 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 present document proposes three use cases scenario of IoT systems specially selected and defined for representing situations where a modelling and an analysis of the application performances is mandatory. These uses cases are compliant with the oneM2M standard. They will serve to define a data and a behavioural model for an evaluation of the application but also the deployment on a oneM2M implementation. The first use case is currently deployed in a smart campus environment, the second is a generic one that highlights IoT application with event-triggered and time-triggered characteristics. The last one is a traffic light control system with synchronization features. For all of the scenarios specific temporal and behavioural constraints to be verified and Key Performance Indexes (KPIs) that have to be verified are identified.

# Introduction

The objective of the present document in conjunction with three other ones [i.2], [i.3] and [i.4] is to provide three use cases that articulate across different verticals and identify a list of common requirements across these verticals and to reason on it with a perspective of simulation and performance evaluation.

# 1 Scope

## 1.1 Context for the present document

The oneM2M standard is now mature and 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". The present document will evaluate use cases in terms of running time, memory space, numerosity of oneM2M entities (like e.g. AE, MN-CSE, CSE, etc.), data transfer volume and real-time needs. The present document will use a selection of available oneM2M CSE implementations. The present document will provide a tool to evaluate and simulate the performance of the use cases. The results of this tool development and evaluations of the use cases will be the basis to generate three Technical Reports [i.2], [i.3] and [i.4] and one Technical Specification [i.1]. The present document was developed in the context of ETSI Testing Task Force (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 present document adopted the use case style and template from oneM2M with a minor modification to address some performances issues. This phase of the work resulted in ETSI TR 103 839 (the present document).

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 deliverable ETSI TS 103 840 [i.1].

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 (the present document), ETSI TS 103 840 [i.1] 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, expected performances. This phase of the work resulted in ETSI TR 103 843 [i.4].

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

- ETSI TR 103 839: Scenarios for evaluation of oneM2M deployments (the present document);
- ETSI TS 103 840: Model for oneM2M Performance Evaluation [i.1];
- ETSI TR 103 841: oneM2M Performances Evaluation Tool (Proof of Concept) [i.2];
- ETSI TR 103 842: Demonstration of Performance Evaluation and Analysis for oneM2M Planning and Deployment [i.3];
- ETSI TR 103 843: oneM2M deployment guidelines and best practices [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 performance evaluation by means of relevant use cases. The oneM2M architecture ([i.5] and [i.6]) is targeted as the standard to be evaluated regarding 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 providing a proposal of a tiny extension of the use case "template" as provided in oneM2M-Template-Use-Case [i.7] and extensively used in oneM2M TR-0001 [i.8].
- Clause 5 presents Use Case, called "Smart Campus".
- Clause 6 presents a Use Case, called "Generalization of event trigger/periodic event IoT system" that focuses on classical event triggered and or time triggered behavioural aspects to be captured in IoT systems. The objective is to obtain, based on such an example, some generic constraints to be expressed and to determine the associated constraints and KPI to be evaluated.
- Clause 7 presents a Use Case, called "Traffic lights Control and monitoring", reflecting a deployment by C-DAC, India and several generic implementation variations.
- Clause 8 presents oneM2M feature coverage analysis of the use cases collected.

# 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 TS 103 840: "SmartM2M; Model for oneM2M Performance Evaluation".

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

[i.6] ETSI TS 118 111 (V2.4.1): "oneM2M; Common Terminology (oneM2M TS-0011 version 2.4.1 Release 2)".

[i.7] oneM2M-Template-Use-Case.

[i.8] oneM2M TR-0001 (V4.3.0): "Use Cases Collection".

[i.9] Shubham Mante, SVSLN Surya Suhas Vaddhiparthy, Muppala Ruthwik, Deepak Gangadharan, Aftab M. Hussain, Anuradha Vattem: "A Multi-Layer Data Platform Architecture for Smart Cities using oneM2M and IUDX", 8th IEEE World Forum on the Internet of Things (loT), June 2023, Yokohama, Japan.

[i.10] S. Mante, R. Muppala, D. Niteesh, and A. M. Hussain: "Energy monitoring using LoRaWAN-based smart meters and oneM2M platform", in Proc. IEEE Sensors, October 2021.

[i.11] S. U. N. Goparaju, S. S. S. Vaddhiparthy, C. Pradeep, A. Vattem, and D. Gangadharan: "Design of an IoT system for machine learning calibrated TDS measurement in smart campus", in Proc. 7th IEEE World Forum Internet Things (WF-IoT), June 2021, pp. 877-882.

[i.12] oneM2M TS-0023 (V3.9.0): "Home Appliances Information Model and Mapping".

[i.13] oneM2M TS-0031 (V3.0.1): "Feature Catalogue".

[i.14] IEEE 802.11: "IEEE Standard for Information Technology--Telecommunications and Information Exchange between Systems - Local and Metropolitan Area Networks--Specific Requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications".


# 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:** list of the implementations of the oneM2M standard

**oneM2M numerosity objects:** scalability of a oneM2M application

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

**platform evaluation tool:** simulation environment that is used to calculate/demonstrate the performance of the oneM2M standard

**real time requirements:** 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 ETSI TS 118 111 [i.6] and the following apply:

| | |
|---|---|
| AC | Air Conditioning |
| ACP | Access Control Policy |
| ADN | Application Dedicated Node |
| AE | Application Entity |
| AE-CM | Application Entity - Crowd Monitoring |
| API | Application Program Interface |
| AQ | Air Quality |
| ASN-CSE | Application Service Node - Common Services Entity |
| ATCS | Adaptive Traffic Control System |
| C-DAC | The Centre for Development of Advanced Computing |
| CM | Crowd Monitoring |

| | |
|---|---|
| CO | Carbon monoxide |
| COAP | Constrained Application Protocol |
| CoSMiC | Common SMart iot Connectivity |
| COVID | Coronavirus Disease |
| CSE | Common Services Entity |
| CSF | Common Services Function |
| DEL | Data Exchange Layer |
| DML | Data Monitoring Layer |
| DPA | Data Platform Architecture |
| DSL | Data Storage Layer |
| ETSI | European Telecommunications Standards Institute |
| EV | Emergency Vehicle |
| HTTP | HyperText Transfer Protocol |
| HTTPS | HyperText Transfer Protocol Secure |
| HVAC | Heating Ventilation Air Conditioning |
| IEEE | Institute for Electrical and Electronic Engineers |
| IIIT | International Institute of Information Technology |
| IIIT-H | IIIT-Hyderabad |
| IN | Infrastructure Node |
| IN-CSE | Infrastructure Node - Common Services Entity |
| IoT | Internet of Things |
| IPE | Interworking Proxy application Entity |
| IUDX | Indian Urban Data Exchange |
| KPI | Key Performance Indexes |
| LORA | LOng RAnge (LoRa) |
| LoRaWAN | LoRa-Wide Area Network |
| LTE | Long Term Evolution |
| M2M | Machine-to-Machine |
| MN | Middle Node |
| MN-CSE | Middle Node - Common Services Entity |
| MQTT | Message Queuing Telemetry Transport |
| NoSQL | Not only Standard Query Language |
| OM2M | Open-Source platform for M2M communication (Eclips) |
| RAM | Random Access Memory |
| RDF | Resource Description Framework |
| SDT | Smart Device Template |
| SQL | Standard Query Language |
| TC | Technical Committee |
| TDS | Total Dissolved Solids |
| TR | Technical Report |
| TRAM | Traffic Monitoring and Management |
| TRAMMA | Traffic Monitoring and Management Application |
| TS | Technical Specification |
| TTF | Testing Task Force |
| URI | Uniform Resource Identifier |
| WF-IoT | World Forum Internet Things |
| Wi-Fi® | Wireless Fidelity (IEEE 802.11family) |
| WiSUN | Wireless Smart Ubiquitous Network |



# 4 Method for Collecting Use Cases

The oneM2M template for the contribution of use cases [i.7] 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. A call for input was issued to oneM2M delegates to provide real deployed use cases that may be examined as proof of concept examples for analysis. The following clauses capture the inputs received.

# 5 Use Case - Smart Campus

## 5.1 Description

This use case is based on the deployment made at International Institute of Information Technology, Hyderabad (IIIT). It is focused on smart campus with several domains involved such as: smart buildings, energy, water, streetlight, pollution, etc.

Localization: The campus of IIIT is in Telangana, India. IIIT is a residential institute spread over 66 acres.

The campus of IIIT University has deployed a Modular Data Platform Architecture (DPA) that is compliant with the Indian Urban Data Exchange - IUDX (https://iudx.org.in/) framework and oneM2M standards. The architecture consists of a oneM2M-based Data Monitoring Layer (DML) for seamless data accumulation from various sensor networks of a smart city such as air quality, water quality, and energy monitoring. This data is stored in the Data Storage Layer (DSL) using a multi-tenant architecture with multiple logical databases, enabling efficient and reliable data management. Finally, the Data Exchange Layer (DEL) enables secure data sharing in a format compliant with IUDX vocabulary.

## 5.2 Source

This oneM2M architecture is deployed at University Campus of International Institute of Information Technology, Hyderabad, India. Information has been collected based on [i.9].

## 5.3 Actors



M2M service provider: technical service and research department that provide the M2M service. This includes the server, sensors, networks and management of the oneM2M stack. The M2M service provider exposes API for the access of data.

External users: Based on authorization mechanism and specific layer, they can access the Data for campus management, research and industry activities.



## 5.4 Pre-conditions

The campus allows the deployment of sensors and connection to existing systems.

The M2M service provider proposes a oneM2M resources architecture, deploys the system and manages it.

## 5.5 Triggers

Some transitional phases will happen when the setting of the overall architecture and when new equipment should be connected (registration of new gateways on servers, registration of end devices on gateways).

On the permanent phase, the sensor data are sent to the IN-CSE through the oneM2M architecture. Through subscriptions and request response the external elements analyses and react to the data collected.

## 5.6 High Level Illustration

The proposed architecture consists of a DML, DSL and a DEL as illustrated in Figure 5.6-1. Multiple IoT nodes post data to the DML at predefined intervals depending on the parameters being monitored. The DML forwards this data using the subscription-notification CSF of oneM2M to the DSL, where it is parsed and ingested into a database. The data can be subsequently accessed by registered clients through the APIs defined in the DEL.

The architecture is deployed inside the campus with sensors, network, servers, etc. Several domains are covered: Smart spaces, Environment, Weather, Water, Energy, etc.

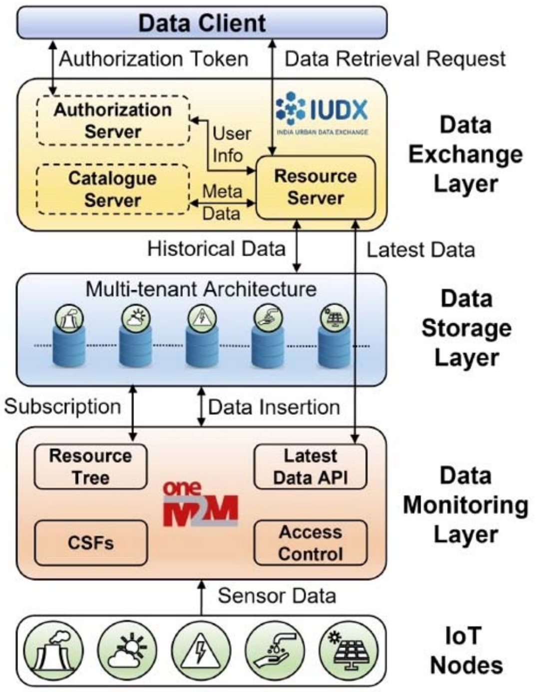


**Figure 5.6-1: Solution deployed at IIIT-H campus**



## 5.7 Normal Flow

Several types of equipment in different domains are connected to the oneM2M system:

a) Air Quality Monitoring: Several air quality parameters such as particulate matter (pm2.5 and pm10), temperature, relative humidity, and CO concentration are monitored through densely deployed sensor nodes to increase the spatial-temporal resolution of air quality data.



b) Crowd Monitoring: This sensor network monitors crowding of people to check the number of mask violations to avoid a COVID-outbreak inside the campus.

c) Energy Monitoring: Several energy parameters such as the individual phase currents and voltages, power factor, frequency, energy consumption, apparent and real power are monitored to understand the usage patterns and provide faster resolutions to power outages (see [i.10] S. Mante, R. Muppala, D. Niteesh, and A. M. Hussain, "Energy monitoring using LoRaWAN-based smart meters and oneM2M platform", in Proc. IEEE Sensors, Oct 2021, pp. 1-4.).

d) Water Quality Monitoring: Water quality parameters such as Total Dissolved Solids (TDS), and temperature are being monitored to avoid health problems caused by poor quality water, as detailed in [i.11] S. U. N. Goparaju, S. S. S. Vaddhiparthy, C. Pradeep, A. Vattem, and D. Gangadharan, "Design of an IoT system for machine learning calibrated TDS measurement in smart campus", in Proc. 7$^{th}$ IEEE World Forum Internet Things (WF-IoT), June 2021, pp. 877-882.

e) Smart Room Monitoring: Occupancy state and energy consumption of a room are monitored to adjust the air conditioning, lighting, and ventilation dynamically.

f) Solar Monitoring: Parameters such as energy generated in a day, signed active power, instantaneous frequency, output power factor, voltage, and current are monitored to efficiently analyse the solar energy generated by solar panels.

g) Weather Monitoring: Multiple weather monitoring stations are deployed to monitor parameters such as solar radiation, temperature, relative humidity, wind direction, wind speed, gust speed and dew point. This data is used for weather forecasting.

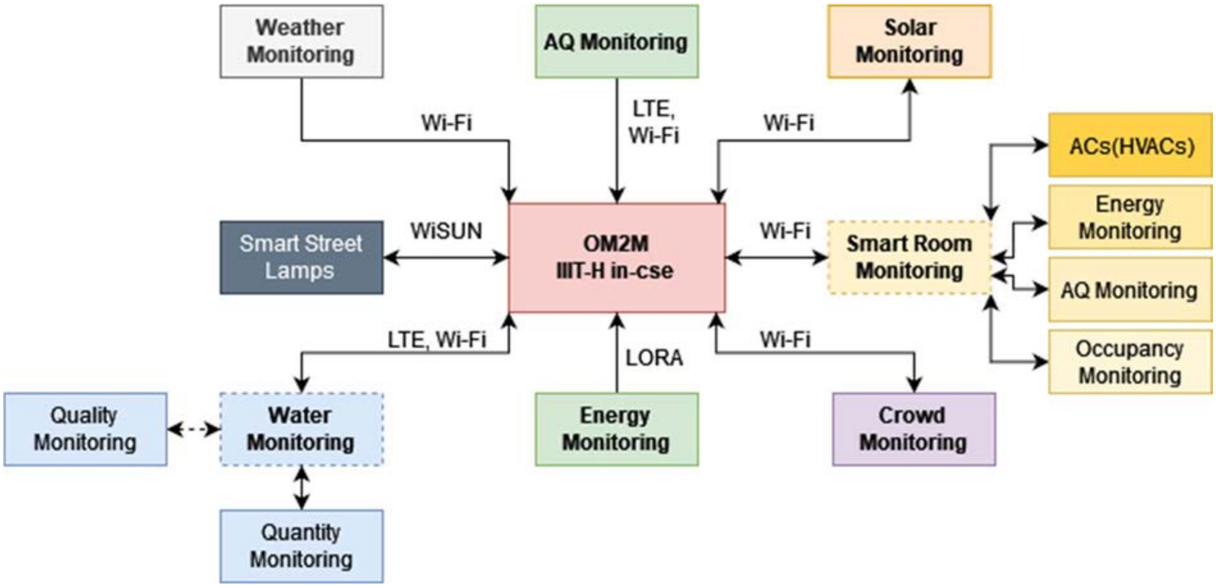


**Figure 5.7-1: OM2M deployment at IIIT-H campus**

The current deployment at IIIT-H uses one infrastructure node. As illustrated in Figure 5.7-1, different verticals use their respective communication protocols based on the interfaced sensors. The nodes use HTTP as the application protocol to publish periodic data (event triggered in the case of Occupancy) to their respective containers.

The former architecture adapted individual MN-CSE base for each respective vertical, which are interfaced to an IN-CSE. This former model was dropped since the deployments were implemented on the same base machine.



## 5.8 Alternate Flow

Not relevant.



## 5.9 Post-conditions

The data are stored in the specific database for long-term use.

## 5.10 oneM2M resources

Table 5.10-1 gives a detailed description of the effective exchange of message between the different parts of the architecture from sensors to gateways and servers.