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SmartM2M;
Digital Twins communication support in oneM2M

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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 builds on previous STF 628 work ETSI TR 103 844 [i.9], ETSI TS 103 845 [i.10], ETSI TS 103 846 [i.11] to guide the implementation of Digital Twins (DTs) within the oneM2M framework. It outlines the key oneM2M features that meet specific requirements and demonstrates how oneM2M can support DTs across various scenarios.

Key highlights include:

- Emphasis on modularity and adaptability to ensure interoperability across different platforms and technologies.
- Practical examples illustrating oneM2M's capabilities in meeting Digital Twin requirements.
- Critical analysis identifying potential gaps in oneM2M, offering insights for future enhancements.

The present document aims to provide a comprehensive guide for effectively integrating Digital Twins into the oneM2M ecosystem, promoting seamless IoT communication and functionality.

Introduction

The present document explores the insights and architectural foundations from ETSI TR 103 844 [i.9], ETSI TS 103 845 [i.10] and ETSI TS 103 846 [i.11] and compares them to the features and capabilities offered by oneM2M. It provides a guide for mapping Digital Twins (DTs) communication requirements to the oneM2M framework.

The present document emphasizes modularity and adaptability for communication, ensuring interoperability across installations and platforms. It uses oneM2M's features to keep elements and information technology-agnostic, minimizing the impact of evolving communication frameworks on DT information. The present document shows the mapping of DT requirements to oneM2M features in clauses 4,5 and 6.

Additionally in clause 8, it provides practical examples of Digital Twins within the oneM2M context. These examples show how oneM2M meets specific requirements, bridging the gap between concepts and real-world applications. This helps stakeholders understand the proposed solutions.

The present document also identifies potential gaps in the oneM2M framework, in clause 7, that may hinder the defined requirements. ETSI TS 103 845 [i.10] analyses these areas, suggesting enhancements to better accommodate Digital Twins communication. This aims to offer valuable insights for future developments, promoting effective integration of Digital Twins into the IoT communication landscape.

1 Scope

The purpose of the present document is to capture the requirements defined in ETSI TS 103 845 [i.10] and demonstrate the ways in which these requirements can be implemented using the oneM2M standard:

- List the architectural, communication, description and discovery requirements for DTs.
- Description of the oneM2M features that can be used to implement each requirement.
- Identification of any existing gaps within the oneM2M architecture with respect to implementation of requirements.

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 nonspecific. 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 118 112 (V2.0.0): "oneM2M; Base Ontology (oneM2M TS-0012 version 2.0.0 Release 2)".

[i.2] ETSI TS 118 125 (V2.0.0): "Definition of product profiles (oneM2M TS-0025 version 2.0.0 Release 2A)".

[i.3] ETSI TS 118 123 (V2.0.0): "oneM2M; Home Appliances Information Model and Mapping (oneM2M TS-0023 version 2.0.0 Release 2)".

[i.4] ETSI TS 118 103 (V1.0.0): "oneM2M Security solutions (oneM2M TS-0003)".

[i.5] oneM2M TS-0034: "Semantic Support".

[i.6] ETSI TR 118 524 (V2.0.0): "oneM2M; 3GPP Interworking (oneM2M TR-0024)".

[i.7] ETSI TS 118 133 (V4.0.1): "Interworking Framework (oneM2M TS-0033 v4.0.1 Release 4)".

[i.8] ETSI TS 118 101 (V1.0.0): "Functional Architecture (oneM2M TS-0001)".

[i.9] ETSI TR 103 844 (V1.1.1): "SmartM2M; Digital Twins and Standardization Opportunities in ETSI".

[i.10] ETSI TS 103 845 (V1.1.1): "SmartM2M; Digital Twins Communication Requirements".

[i.11] ETSI TS 103 846 (V1.1.1): "SmartM2M; Digital Twins: Functionalities and communication Reference Architecture".

[i.12] oneM2M TR-0073: "Developer Guide: Deploying Semantics".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

Application Entity (AE): application process that performs specific functions or services in an M2M (Machine-to-Machine) or IoT (Internet of Things) system

NOTE: An AE contains the application logic and processes required to perform specific tasks or provide services within the M2M/IoT environment. An AE can represent a physical or an application.

Common Services Entity (CSE): fundamental component within the oneM2M architecture

NOTE: It represents a set of "common service functions" essential for M2M (Machine-to-Machine) and IoT (Internet of Things) environments. The CSE acts as a middleware layer, facilitating communication and management tasks between various Application Entities (AEs) and the underlying network services.

data sharing resource: oneM2M resources whose main purpose is to share data between a physical device or data source and applications

EXAMPLE: oneM2M data sharing resources are <contentInstance>, <timeSeriesInstance>, <flexContainer>. Other resources may have data that is shared, but they are generally considered meta-data or service parameters, e.g. subscription attributes.

Digital Communication Adapter (DCA): modular component within the Digital Communication Channel (DCC) that handles the specifics of communicating with external digital entities

NOTE: Each DCA is responsible for managing a specific protocol or interaction pattern, translating the DT's internal data into a format that can be understood by the target digital system and vice versa.

Digital Communication Channel (DCC): core component that enables the digital twin to communicate and interact with external digital entities, such as applications, services, and other digital twins

NOTE: It acts as the bridge between the DT's core and the external digital world, ensuring seamless and effective exchange of data, commands and interactions.

Digital Twin (DT): comprehensive software representation of an individual Physical Object

NOTE: It includes the properties, conditions, and behavior(s) of the real-life object through models and data. A Digital Twin is a set of realistic models that can digitalize and simulate an object's behavior in the deployed environment. The Digital Twin represents and reflects its physical twin and remains its virtual counterpart across the object's entire lifecycle [i.1].

Digital Twin Description (DTD): detailed representation of a physical entity or system in a digital format

NOTE: This description encompasses the physical characteristics, operational states, behavioral models, and interactions of the physical entity, allowing for real-time monitoring, analysis, and simulation. DTD is essential for creating an accurate and functional digital twin, which is a virtual counterpart of a physical object or system.

Interworking Proxy Entity (IPE): component within the oneM2M architecture designed to facilitate the integration and interoperability of non-oneM2M systems and protocols with the oneM2M framework

NOTE: The IPE acts as a bridge, enabling communication and data exchange between oneM2M-compliant devices and external systems that use different protocols or standards. The IPE is a special purpose AE.

Physical Communication Adapter (PCA): modular component within the Physical Communication Channel (PCC) designed to interface with various physical assets, such as sensors, devices and machinery

NOTE: The PCA enables communication between the DT and these physical assets by translating the physical characteristics, protocols, and data formats into a standardized format that the DT can understand and process.

Physical Communication Channel (PCC): fundamental component designed to facilitate seamless interaction between digital twins and their physical counterparts

NOTE: It serves as a conduit for communication, ensuring that DTs can effectively interact with various physical entities, such as sensors, devices and machinery.

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
API	Application Program Interface
ASN	Application Service Node

NOTE: Contains one Common Services Entity and contains at least one Application Entity.

CDT	Composed Digital Twin
CMDH	Communication Management and Delivery Handling
CoAP	Constrained Application Protocol
CSE	Common Service Entity

NOTE: Represents an instantiation of a set of Common Service Functions of the M2M environments. Such service functions are exposed to other entities through reference points.

DCA	Digital Communication Adapter
DCC	Digital Communication Channel
DT	Digital Twin
DTD	Digital Twin Description
HTTP	Hyper Text Transfer Protocol
IoT	Internet of Things
IPE	Interworking Proxy application Entity
JSON	Java Script Notation Object
MN	Middle Node

NOTE: Contains one Common Services Entity and contains zero or more Application Entities.

MQTT	Message Queue Telemetry Transport
NoDN	Non-oneM2M Device Node
OPC-UA	Open Platform Communications Unified Architecture
PCA	Physical Communication Adapter
PCC	Physical Communication Channel
PT	Physical Twin
PTD	Physical Twin Description
QoS	Quality of Service
RDM	Requirements and Domain Models
SDT	Smart Device Template
WoT	Web of Things
XML	eXtensible Mark-up Language

4 Architecture Requirements

4.1 Introduction

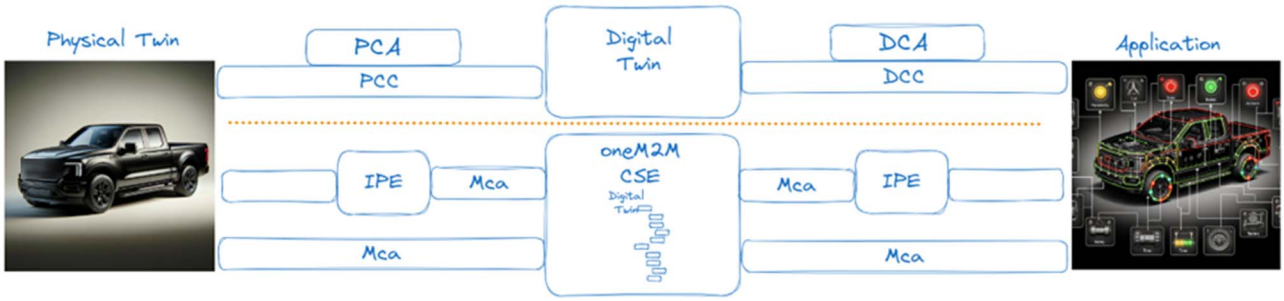

Figure 4.1-1: Architecture of a Digital Twin

A basic architecture of a digital twin system is shown in the top portion of Figure 4.1-1. It starts with the Physical Twin, an automobile, that can communicate with a Digital Twin through a PCA and PCC. There is also an application or service, a display shows status of vehicle systems, that communicates with the Digital Twin though a DCA and DCC. The same system, in the bottom of Figure 4.1-1, shows using a oneM2M system that has a device AE (on the left) that communicates through the Mca interface to the CSE, where the Digital Twin resides in the form of a resource tree. Applications or services also communicate to the CSE using the Mca interface. In a oneM2M deployment where the physical twin or the application does not use native oneM2M APIs, an IPE can be deployed to provide protocol and data model translation so that they can communicate with the oneM2M CSE.

The architectural description of a digital twin is readily implemented using a oneM2M solution. The present document uses the following mapping of architectural terms between the digital twin architecture and the oneM2M architecture.

Table 4.1-1: Mapping of Digital Twin Components to oneM2M Components

ETSI TS 103 845 [i.10] Digital Twin Architectural Components	oneM2M Architectural Components
Physical Twin	ADN-AE
PCA	IPE AE
PCC	Mca
Digital Twin Core	ASN-CSE, MN-CSE, IN-CSE
DCC	Mca
DCA	IPE AE
Digital Applications or services	IN-AE

4.2 Digital Twin Architecture Requirements

Table 4.2-1: Digital Twin Architecture Requirements

Requirement ID	Digital Twin Requirement	Mapping to oneM2M
REQ_4.2_001	A DT shall include an implementation of a PCC. A PCC allows communication between the Physical device and a Digital Twin.	The Mca reference point allows communication between the CSE and the device AEs. See Deployment Scenario #1.
REQ_4.2_002	The DT Core shall serve as the epicentre of the twin, housing its fundamental behaviors, properties, events, relationships, and actions.	A Common Services Entity (CSE) is crucial in the oneM2M architecture, providing essential middleware services that enable efficient, secure, and scalable communication and management of IoT devices and applications. It supports interoperability, modularity, and adaptability, making it a foundational component in M2M and IoT systems. See Deployment Scenario #1.

Requirement ID	Digital Twin Requirement	Mapping to oneM2M
REQ_4.2_003	Composition shall allow for the creation of hierarchical structures, enabling a parent DT to oversee and coordinate multiple child DTs.	In the oneM2M framework, resources can be composed to model a hierarchical structure where a parent Digital Twin (DT) organizes multiple child Digital Twins. This composition leverages the hierarchical nature of oneM2M resources and the ability to nest resources within containers and groups. Smart Devices Template models, defined in ETSI TS 118 123 [i.3], have examples of composition using <flexContainer> resources. Physical Twins should use <flexContainer> resources. See Deployment Scenario #2.
REQ_4.2_004	Composition shall integrate with the DCC of DTs, ensuring that digital interactions with external entities extend to the entire hierarchy.	To access a Digital Twin (DT) data model in a oneM2M framework, an application follows a structured process leveraging the oneM2M resource architecture and APIs. The process includes discovering the relevant resources, retrieving data, and potentially subscribing to updates. See Deployment Scenario #3.
REQ_4.2_005	Composition shall provide a unified description of the parent DT and its child DTs, including their relationships, properties, events, and actions.	In the oneM2M framework, the <semanticDescriptor> resource is used to provide semantic descriptions of other resources. This allows for a richer, more meaningful representation of data by adding context and relationships that can be understood by machines. For a Digital Twin (DT) data model, <semanticDescriptor> can be utilized to describe the structure, attributes, and relationships of the DT in a way that enhances interoperability and understanding across different systems and applications. Semantic descriptions of the DT shall be provided in <semanticDescription> resources. Semantic descriptions SHOULD use SAREF and oneM2M Base ontologies and MAY use other ontologies. See oneM2M TS-0034 [i.5] and ETSI TS 118 112 [i.1].
REQ_4.2_006	Composition shall facilitate collaboration between DTs from different domains or application scenarios.	The announceTo feature in oneM2M can be leveraged to share resources across different CSEs (Common Services Entities) or domains, facilitating the creation and management of a hierarchical parent-child Digital Twin (DT) structure. This feature allows resources to be "announced" to other CSEs, making them accessible in multiple locations. Composition shall be realized using announceTo functionality. Composition shall be realized using <flexContainer> resources. See Deployment Scenario #3.
REQ_4.2_007	Composition shall provide management interfaces that allow administrators and operators to control and configure the behavior of hierarchical DT structures.	For data models that allow control of the physical device, subscription and notifications shall be used. See Deployment Scenario #2.
REQ_4.2_008	DTs shall implement robust security measures to protect against unauthorized access, data breaches, and cyber-physical attacks.	oneM2M defines security and access control in ETSI TS 118 103 [i.4]. Digital Twins shall implement <accessControlPolicy> resources.

Requirement ID	Digital Twin Requirement	Mapping to oneM2M
REQ_4.2_009	Cross-Domain DTs shall implement robust security measures to protect data and interactions when bridging different domains.	oneM2M defines security and access control in ETSI TS 118 103 [i.4]. Digital Twins shall implement <accessControlPolicy> resources. Digital Twins shall implement authentication.
REQ_4.2_010	Access control mechanisms shall be in place to ensure that only authorized entities can interact with the DTs, preventing unauthorized access or malicious actions.	oneM2M defines security and access control in ETSI TS 118 103 [i.4]. See ETSI TR 118 524 [i.6]. Digital Twins shall implement <accessControlPolicy> resources. Digital Twins shall implement authentication.
REQ_4.2_011	Cross-Domain DTs shall be capable of transforming and normalizing data from various domains.	oneM2M can semantically describe data, but has no ability to transform or normalize data. RDM Gap. See clause 7.3.
REQ_4.2_012	Cross-Domain DTs shall be adaptable and customizable to meet the specific requirements of each domain they interact with.	The announceTo feature in oneM2M can be leveraged to share resources across different CSEs (Common Services Entities) or domains, facilitating the creation and management of a hierarchical parent-child Digital Twin (DT) structure. This feature allows resources to be "announced" to other CSEs, making them accessible in multiple locations. Cross-Domain Composition shall be realized using announceTo functionality. Cross-Domain Composition shall be realized using <flexContainer> resources. See Deployment Scenario #3.
REQ_4.2_013	DTs shall support replication strategies that enable them to create digital replicas and distribute them across edge nodes allowing replicas to effectively communicate without limitations associated to their architectural deployment on the edge or in the cloud.	The announceTo feature in oneM2M can be leveraged to share resources across different CSEs (Common Services Entities) or domains, facilitating the creation and management of a replica Digital Twin (DT) structure. This feature allows resources to be "announced" to other CSEs, making them accessible in multiple locations. Cross-Domain Composition shall be realized using announceTo functionality. Cross-Domain Composition shall be realized using <flexContainer> resources. See Deployment Scenario #3.
REQ_4.2_014	Edge and Cloud DTs shall allow for customization and configuration to meet the specific requirements of various edge environments and cloud infrastructures.	This is a platform requirement.
REQ_4.2_015	Both Edge and Cloud DTs shall address unique communication requirements.	This is a platform requirement.