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Recent advancements in the Internet-of-Things related standards: A oneM2M perspective☆

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Abstract

Internet of Things (IoT) devices are likely to be developed by using different technologies and standards. Such IoT devices are being deployed in large numbers in various domains; thus, collaboration between standards bodies to provide interoperability is a key to the success of IoT. This paper describes a recent effort in oneM2M to broaden the IoT ecosystem. Semanticsenabled IoT platforms allow IoT devices to understand the meaning of IoT data in a standard way. oneM2M interoperability specifications guarantee that IoT devices from different vendors can communicate with each other. Additionally, an interworking framework bridges different IoT technologies.

Keywords: OneM2M; Internet of Things; Interoperability; Interworking

1. Introduction

Internet of Things (IoT) is a technology used to provide smarter services to users by connecting various devices connected to the Internet and allowing these devices to exchange information with each other. IoT has been identified as an emerging technology in many IT trend reports [1], and the number of IoT devices is expected to grow rapidly [2,3]. Some IT trend reports predict that the global IoT market will be worth $14.4 trillion by 2022 [3,4].

As the number of IoT devices are increasing steeply, the interconnection between the different types of IoT devices becomes a key issue for the success of IoT. IoT standards bodies have made various attempts to solve the interconnection issue. For example, the development of a standardized IoT service layer platform interconnecting various industry driven IoT technologies is a most promising activity led by global IoT standards bodies such as oneM2M [5]. Several standards bodies are aiming at the development of IoT markets by transforming the fragmented vertical platforms of the past into a horizontal platform. ITU-T and IEEE P2413 are trying to standardize a high-level architecture framework for IoT whereas industry alliances such as Allseen Alliance,[1] Open Connectivity Foundation (OCF),[2] and IPSO Alliance[3] are focusing on supporting the connectivity of local IoT devices.

Among them oneM2M is a standard partnership project founded in 2012 by standards developing organizations (SDOs) of each country including TTA (Korea), ETSI (Europe), TIA, ATIS (USA), TTC, ARIB (Japan), CCSA (China) and India (TDSI) [6]. The main objective of oneM2M is to define a common service platform that can support various IoT application services such as Smart Home, Smart Car, and Smart Healthcare [7,8].

In order to provide interoperability and interworking, oneM2M has been developing various specifications. An interworking proxy entity is introduced to interconnect various local connectivity protocols [9]. Semantics technologies that have been developed for the Semantic Web are introduced as a way to describe the meaning of oneM2M resources. In addition,

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[1] https://allseenalliance.org/.
[2] http://openconnectivity.org/.
[3] http://www.ipso-alliance.org/.

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oneM2M is currently working on developing standard documentations for interoperability and conformance testing. In this paper, we provide an introduction to such standards activities for interoperability in oneM2M together with future directions.

In summary, the main contributions of this paper are as follows:

– Introduction to a global IoT service layer standards project called oneM2M, and its latest activities related to standards.
– New interworking features with other local area connectivity standards to extend the IoT ecosystem.
– Testing activities ensuring interoperability between IoT products and conformity to oneM2M specifications.

In the following sections, we first provide an introduction to oneM2M and its Release 1 development in Section 2. We then explain interworking standards activities in oneM2M Release 2 in Section 3 followed by introducing oneM2M testing in Section 4. Finally, Section 5 presents the conclusion and future direction of oneM2M.

2. oneM2M overview and release 1

Many Internet of Things (IoT) platforms have been developed and deployed over the past decade. However, most platforms were implemented based on proprietary solutions or developed to solve specific domain problems. Therefore, there is a strong need to develop a standardized IoT platform to interconnect various proprietary platforms and provide common IoT services to users. In order to solve such interoperability issues, seven standard development organizations (SDOs) have initiated a global standards project, i.e., oneM2M, creating scalable and interoperable IoT standards for communication of devices and services. The main aim of oneM2M is to pursue a single horizontal service platform for exchanging and sharing data among IoT applications that can be used in various industries providing smarter IoT services to users.

The first candidate release of oneM2M specifications was published in August 2014 with a deployable IoT solution mainly for satisfying short-term needs. The first release provides a set of common standards functions that is sufficient to construct a unified and horizontal IoT service platform. It also defines the access-independent IoT service layer architecture and supports various service functions such as registration and discovery. A logical oneM2M node in a oneM2M service layer platform consists of three parts, i.e., Common service Entity (CSE), Application Entity (AE), and Network Service Entity (NSE). oneM2M defines three reference points that connect oneM2M entities: Mca between Applications and CSE, Mcc between two CSEs, and Mcn between CSE and underlying networks (see Fig. 1). CSE consists of a set of Common Service Functions (CSFs), and some of them are described as follows:

- Communication Management and Delivery Handling (CMDH): decides at what time to use which communication connection for communication (e.g. CSE-to-CSE communications) and, when needed and allowed, to buffer communication requests so that they can be forwarded later.

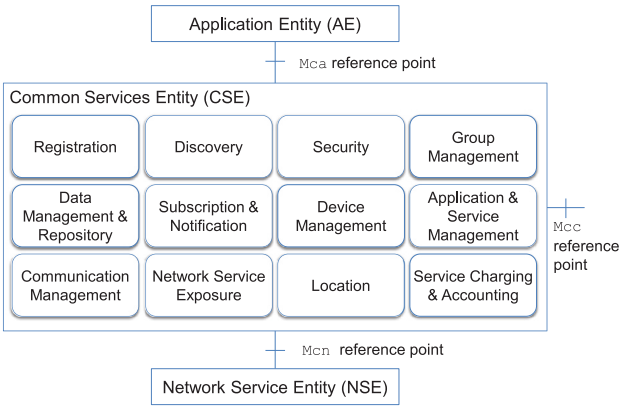

Fig. 1. oneM2M common service functions.

- Data Management and Repository (DMR): is responsible for providing data storage and mediation functions. It includes the capability of collecting data for the purpose of aggregating large amounts of data, converting this data into a specified format, and storing it for other purposes such as analytics and semantic processing.
- Device Management (DMG): provides management of device capabilities on MNs (e.g., M2M Gateways), ASNs and ADNs (e.g., M2M end devices), as well as devices that reside within an M2M Area Network.
- Discovery (DIS): searches information about applications and services as contained in attributes and resources based on text-matching mechanisms.
- Group Management (GMG): responsible for handling group-related requests. A request is sent to manage a group and its membership as well as for the bulk operations supported by the group.
- Network Service Exposure, Service Execution, and Triggering (NSSE): manages communications with the underlying networks such as 3GPP LTE or Zigbee for accessing network service functions over the Mcn reference point.
- Registration (REG): processes a request from an AE or another CSE to register with a Registrar CSE to allow the registered entities to use the services offered by the Registrar CSE.
- Security (SEC): comprises functionalities such as sensitive data handling, security administration, security association establishment, access control including identification/authentication/authorization, and identity management.
- Subscription and Notification (SUB): provides notifications pertaining to a subscription that tracks changes on a resource (e.g., deletion of a resource).

In the following, we discuss how oneM2M is developing its second release based on the Rel-1 basic functions described in this Section.

3. Release 2 and interworking

oneM2M is currently developing its second release featuring interworking with OMA Lightweight M2M [10,11], AllSeen, and OCF interworking together with a generic interworking specification. Whereas oneM2M Release 1 is providing a set

Table 1
Main function of oneM2M release 2.

Topics	Details
Platform/Network interworking function	• AllJoyn interworking • OIC interworking • Lightweight M2M interworking • Generic interworking • 3GPP Rel-13 interworking
Home domain support	• Home appliance information model
Industry domain support	• Time series data
Semantics	• oneM2M base ontology • Semantic discovery • Semantic description
Security	• End-to-end security • Dynamic authorization

of deployable basic functions, Release 2 is intended to provide various new functions for expanding the IoT ecosystem. In particular, interworking features will enable interworking with other local network technologies including legacy deployments of IoT systems. oneM2M Release 2 also provides data abstraction and semantic interoperability, which will enable the reuse of various IoT data and achieve high level interoperability regardless of the underlying technologies.

Apart from standardizing enhanced service functions, collaborations with other standards bodies are developing in three main directions.

– First, oneM2M is working with de jure and de facto standards organizations such as ITU-T, Open Mobile Alliance (OMA), and Broadband Forum (BBF). oneM2M collaborates with such bodies by either instantiating oneM2M architecture into other groups' high level architecture framework (with ITU-T SG20 and IEEE P2413) or introducing their existing protocols or architecture into oneM2M service layer architecture (with OMA Device Management protocol and BBF TR-069).
– Second, oneM2M is cooperating with various IoT service domains. For example, Home Gateway Initiative (HGI), which is a standards organization to develop key specifications and standards for residential gateways, agreed to transfer their home device profile specifications into oneM2M. In addition, oneM2M is collaborating with IEEE P2413 to identify requirements working for the application of the oneM2M architecture industry and for requirements sharing of the IEEE P2413 developing standard for the industry domain for the industrial IoT and to address gaps in various IoT architectures
– Lastly, oneM2M is attempting to bring together various industry-driven IoT connectivity standards for interconnecting local IoT devices such as AllSeen Alliance and Open Connectivity Foundation (OCF). As such, local IoT devices can only communicate with devices using the same technology, oneM2M is now providing interworking functions allowing them to communicate with each other via oneM2M service layer functions.

Table 1 summarizes several oneM2M Release 2 features that are being developed.

4. oneM2M testing

Testing activities are generally performed to confirm the interoperability and compliance of target implementation using a specific standards technology. oneM2M interoperability testing is used to prove that two oneM2M devices are communicating with each other properly based on oneM2M standards, whereas oneM2M conformance testing is used to verify the compliance of a testing implementation with protocol features specified in oneM2M specifications [12].

Conformance Testing. The main purpose of conformance testing is to show that a device (or a product) has properly implemented oneM2M protocols. In this sense, oneM2M conformance testing verifies the detailed values of oneM2M protocol messages and their format based on oneM2M protocol specifications. oneM2M conformance testing also checks both normal and abnormal situations responsible for generating system errors. oneM2M conformance testing consists of several items. First, the methodology defines the categorization of the features and options to be tested, which is known as an "Implementation Conformance Statement" (ICS) [13]. This process helps the testers to know which options have to be tested. Then, testing requirements are collected from the protocol specifications to generate a set of tests and a structure for the overall test suite (TSS). A Test Purpose (TP) should then be generated for each test, after which a Test Description (TD) should be developed [14]. The TD is then used as an input to generate a detailed Test Case (TC) written in a formal test description language such as TTCN-3 [15]. Conformance testing specifications consist of three standard documents: the Implementation Conformance Statement (ICS), Test Suite Structure and Test Purposes (TSS & TP), and the Abstract Test Suite (ATS).

Interoperability Testing. The main purpose of oneM2M Interoperability Testing is to check that a product is properly working with other products as described in the oneM2M specifications. The interoperability testing methodology framework

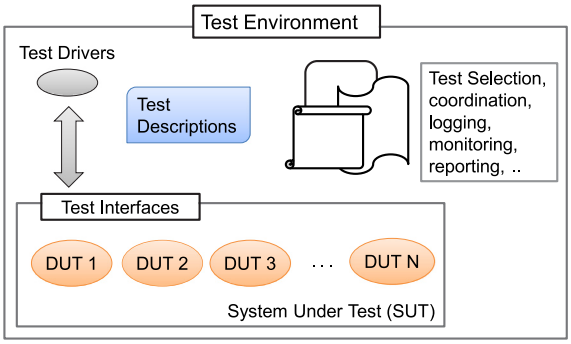

Fig. 2. oneM2M interoperability testing environment.

consists of three main components: the overall system for testing (System Under Test — SUT), testing device (Device Under Test — DUT), and Test Descriptions (TD). These components are connected via testing drivers and test interfaces.

Fig. 2 shows the overall system designed for interoperability testing [13]. DUTs are object devices for interoperability testing. The SUT consists of a number of DUTs provided by different suppliers. The interoperability testing process follows the TD, which provides the detailed set of instructions that are the functional response on the DUT, configurations of an SUT, a log, and so on. The interfaces are accessed by the test drivers to trigger and verify the test behavior written in the TD. At the time of writing this paper, oneM2M has developed TS-0013 (Interoperability Testing specification) [16] for its Release 1.

5. Future direction and conclusion

The development of the IoT platform according to the global standard is essential to provide interactions between IoT devices connected over the Internet. Therefore, standard developing organizations of each country have established an international standards consultative body (i.e. oneM2M) developing standards for IoT service layer platforms.

Since oneM2M Release 1 was published in early 2015, it has been continuously updated and used in various companies. oneM2M Release 1 has also been used as a standard for large-scaled IoT projects such as the Smart City in Busan. oneM2M Release 2 is planned for release in 2016 Q3 with new features such as home domain enablement, interworking functions for different technologies such as AllJoyn and LWM2M, and semantic interoperability. Additionally, both conformance and interoperability testing will increase confidence in establishing the most advanced IoT ecosystem.

As a next step, oneM2M Release 3 must improve the maturity of IT standards for large-scale commercialization and investigate integrating various innovative technologies to lead IoT standards. For example, IoT platforms can be smarter through integrating artificial intelligence technologies such as deep learning and machine learning.

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