oneM2M 3GPP-MTC Interworking

Technology Reports

Interworking Functions for oneM2M Service Middleware Functions and 3GPP-MTC Transport Networks

In recent years, machine communication (M2M, MTC, IoT) has been used in a growing range of applications. But despite the wide diversity of areas where M2M is being applied, these applications have so far used vertically integrated architectures where each carrier constructs its own individual systems, resulting in issues such as increased development costs and development timescales. The oneM2M international standardization organization is working to mitigate such issues by adapting international standard specifications for the provision of common service functions via a standardized platform. In this article, we present an overview of the oneM2M organization and describe the first edition of the technical specifications and the interworking functions that use a 3GPP-MTC transport network.

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1. Introduction

In recent years, a growing number of applications have been making use of machine communication (Machine to Machine (M2M)*1, Machine Type Communication (MTC)*2, Internet of Things (IoT)*3). Despite the wide diversity of these M2M applications, it has so far been that case that M2M services are individually constructed by each service provider, and only provide services within a closed range of industries. It has been said that this vertically integrated service structure not only leads to increased development costs, longer development timescales, and duplication of development work, but also presents a barrier to the new entry of service providers who are trying to introduce M2M services.

The oneM2M international standardization organization [1] is working to resolve these issues by drawing up international standard specifications for the provision of a platform that supports the Common Service Functions (CSF) required by all M2M services. This will reduce the time and expense involved in the introduction of new services and the exchange of M2M data, thereby facilitating horizontal market expansion, the creation of innovative services that use big data, and the development of new businesses that extend beyond the confines of individual business sectors (**Figure 1**).

NTT DOCOMO is actively participating in oneM2M standardization, and

*1 **M2M:** A general term for communication between machines without human control or intervention.

*2 **MTC:** Machine-type communication. A collective term for 3GPP machine communication with no intervening communication operations performed by humans.

has proposed interworking[*4] functions that are needed when using 3rd Generation Partnership Project (3GPP)-MTC [2] transport networks. These functions were realized in the first edition of the oneM2M technical specification.

In this article, we describe the background to the formation of oneM2M and the configuration of this organization, and we present an overview of the first edition of the technical specification approved in August 2014 and their benefits. We also present an overview of interworking function between the oneM2M platform (oneM2M-PF) and the 3GPP-MTC network, and we describe the triggering scheme for functional cooperation between oneM2M-PF and 3GPP-MTC, which is a detailed practical function of this specification.

2. Overview of oneM2M and First Edition of Specifications

2.1 Background to the Establishment of oneM2M

In July 2011, to deal with the anticipated growth of activity on the international standardization of M2M services, the European Telecommunications Standards Institute (ETSI)[*5] initiated a study aimed at founding a global integrated organization for the unification of standardization initiatives for M2M services. Seven organizations participated in this study: the Association of Radio Industries and Businesses (ARIB)[*6] (Japan), the Alliance for Telecommunications Industry Solutions (ATIS)[*7] (US), the China Communications Standards Association (CCSA)[*8], ETSI (Europe), the Telecommunications Industry Association (TIA)[*9] (US), the Telecommunications Technology Association (TTA)[*10] (South Korea), and the Telecommunication Technology Committee (TTC)[*11] (Japan).

In December 2011, a basic agreement was reached regarding the establishment of an international joint organization for M2M standardization, which became officially known as oneM2M in January 2012. In July 2012, it began forming international standard specifications for an M2M service platform.

2.2 Organizational Structure of oneM2M

As shown in **Figure 2**, the oneM2M organization broadly comprises a Steering Committee (SC), a Technical Plenary

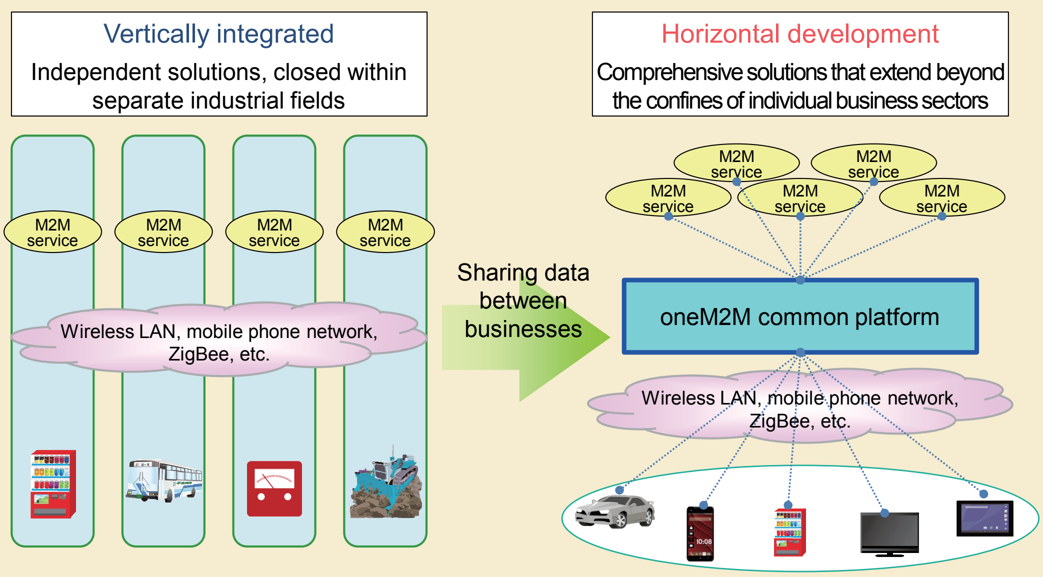

Figure 1 Direction of the M2M markets targeted by oneM2M

*3 **IoT:** General term for a style of control and communication where various "things" are connected via the Internet or cloud services.

*4 **Interworking:** Interaction between communications systems.

*5 **ETSI:** A standardization organization concerned with telecommunications technology in Europe.

*6 **ARIB:** An organization subordinate to the MIC that sets standards for systems that use the radio spectrum in the fields of communications and broadcasting in Japan.

*7 **ATIS:** Alliance for Telecommunications Industry Solutions (US).

*8 **CCSA:** China Communications Standards Association.

*9 **TIA:** Telecommunications Industry Association (US).

*10 **TTA:** Telecommunications Technology Association (South Korea).

*11 **TTC:** Telecommunication Technology Committee (Japan).

(TP), and various Working Groups (WGs).

The SC is responsible for overall administration of the oneM2M organization, draws up the organization's operating rules and objectives, and defines the scope of its studies. Based on the policies of the SC, the TP manages the progress of standardization work, and is responsible for approving the specifications examined by each of the subordinate WGs.

The scope of the activities of each WG are outlined below (**Figure 3**).

WG1: Responsible for the requirements on which the study of standardized specifications is based. Specifically, it collects M2M service use cases from various industries, extracts the common functions that are needed by each industry, classifies them into various classes of requirements (security, billing, device management, etc.), and prescribes functional requirements based on these results.

WG2: Responsible for the oneM2M architecture. Prescribes the layer model needed to implement the concept (application layer, service layer, network layer) and reference points*12 between each function in the architecture.

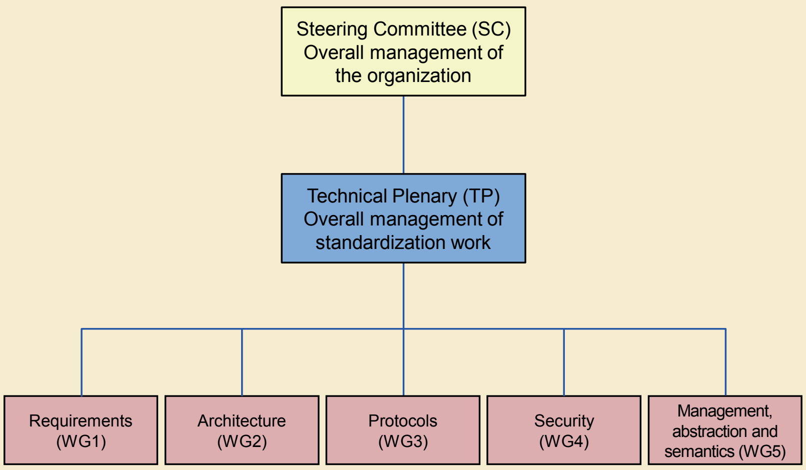

Figure 2　oneM2M organizational structure

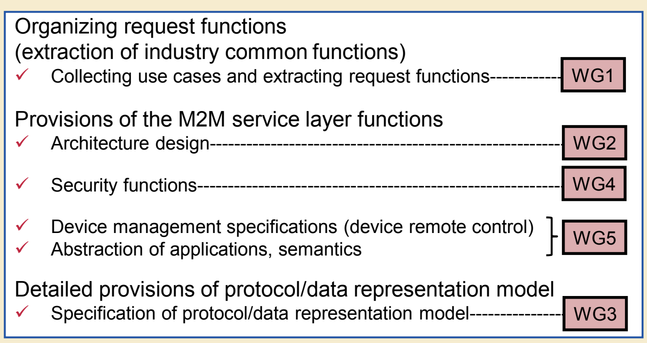

Figure 3　Principal study details in each WG

*12 **Reference point:** The interface part between elements.

WG3: Responsible for the protocols used in oneM2M. Prescribes the data representation methods used in communication protocols (data types, message parameters, resource types, etc.), and status codes associated with normal/quasi-normal procedures.

WG4: Responsible for security functions. Prescribes various security functions for M2M services (access management, service authentication, management of security credentials, ID management, etc.) and sequences for the establishment of secure communication paths between M2M nodes, etc.

WG5: Studies the abstraction of device management and applications, and prescribes device management functions that can manage and control multiple device management protocols of other standardization organizations (Open Mobile Alliance (OMA)*13/Broad-Band Forum (BBF)*14, etc.) by using an integrated interface.

2.3 First Edition of oneM2M Specifications

1) oneM2M Release-1

In August 2014, two years after its establishment, oneM2M published the first edition (Release-1) of its specification set (**Table 1**). Following the review comments that were received from outside following this publication, a revised specification was published in February 2015. There was also a release event held in December 2014 to demonstrate the first release of the oneM2M standard.

2) oneM2M Common Platform

This presents an overview of the common platform defined in the first edition of the oneM2M specification (**Figure 4**). The main scope of studies conducted by oneM2M is a common platform at the service middleware*15 layer situated between the application layer and the underlying transport layer. By adopting a standard specification for service middleware control functions in M2M services, it is possible for service providers to control a wide variety of M2M devices and applications with a single service middleware layer.

Based on the requirements extracted from use cases, the service middleware control functions are defined by a total of thirteen functional modules for purposes such as device management, application management, data management, positional information control, security control, and service billing functions (**Table 2**). The logical node that makes up the common platform is called the Common Service Entity (CSE), and the thirteen functional modules that make up the CSE are called CSFs (fig. 4).

Of these CSFs, the area mainly corresponding to the proposal submitted by NTT DOCOMO is the network service cooperation CSF associated with mobile communication networks, which is one of the functions handling the control of network congestion*16 and device triggering*17 (fig. 4, Table 2).

Table 1 List of specifications in the first edition of the oneM2M specification

Specification number	Title	Responsible WG
TS 0001	M2M Architecture	WG2
TS 0002	M2M Requirements	WG1
TS 0003	oneM2M Security Solutions	WG4
TS 0004	oneM2M Protocol Technical Specification	WG3
TS 0005	oneM2M Management Enablement (OMA)	WG5
TS 0006	oneM2M Management Enablement (BBF)	WG5
TS 0008	CoAP Protocol Binding Technical Specification	WG3
TS 0009	HTTP Protocol Binding Technical Specification	WG3
TS 0011	Definitions and Acronyms	ALL WGs

*13 **OMA:** An industry forum for standardizing and enabling technology for services and applications in mobile communications and for ensuring interoperability.

*14 **BBF:** An international organization that aims to promote the spread of broadband forums.

*15 **Service middle:** Middleware platform functions that are used in common by many different services.

*16 **Congestion:** Impediments to communications services due to communications requests being concentrated in a short period of time and exceeding the processing capabilities of the service control server.

*17 **Device triggering:** Transmitting information to a device in order to trigger an application that runs inside it.

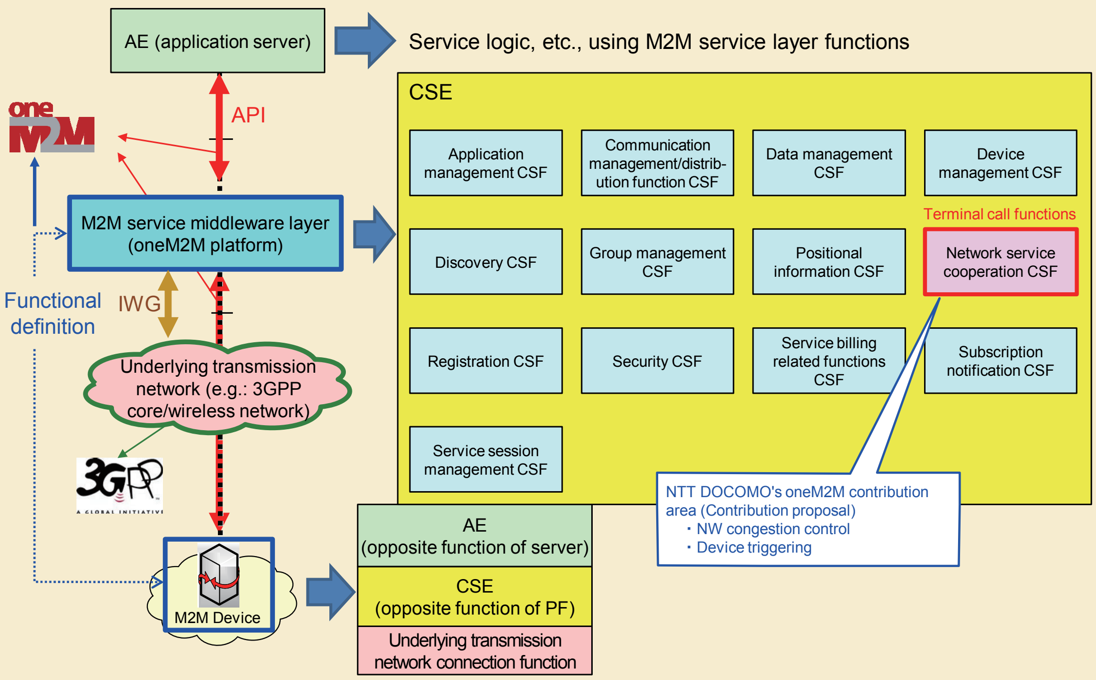

Figure 4 Constituent elements of oneM2M-PF and the underlying transmission network

Table 2 Constituent CSFs of the oneM2M CSE

Function (CSF)	Overview
Application management CSF	CSE self-configuration and diagnostic functions, AE software management functions
Communication management/distribution function CSF	Functions for management of communication between entities (CSE/AE/NSE)
Data management CSF	Functions for storage and mediation of application data, subscriber information, positional information, device information, etc.
Device management CSF	Device remote management functions (using, e.g., OMA-DM/LWM2M, TR-069, etc.)
Discovery CSF	Functions for retrieval of information resources based on requests from AEs and other CSEs
Group management CSF	Group management functions
Positional information CSF	Functions for the provision of terminal position information
Network service cooperation CSF	Access functions for the network service functions of each NSE (network)
Registration CSF	Functions for registering AEs/other CSEs/device terminals etc. to a CSE
Security CSF	Security functions (data encryption, security management, authentication, authorization, etc.)
Service billing related functions CSF	Billing management
Subscription notification CSF	Service session management
Service session management CSF	Functions for the management of subscriptions to resources and notifications when resources change

3) Conceptual Implementation of oneM2M Functions

The conceptual implementation of oneM2M functions is shown in **Figure 5**. The logical node CSE that provides oneM2M service middleware control functions is implemented as a software function in M2M devices and at each server node. An Application Entity (AE) is an application, and the figure shows how these two entities*18 are located within the nodes. An Infrastructure Node (IN) is a server positioned on the transmission network side, which is called the infrastructure domain in oneM2M. On the other hand, in the field domains, a Middle Node (MN), such as M2M devices and M2M gateway that aggregates those M2M devices are included. The M2M devices are called the Application Service Nodes (ASNs), Application Dedicated Nodes (ADNs) and Non-oneM2M devices according to differences in the positioning of AEs and CSEs. The difference between and ADN and an ASN is that an ASN has a CSE that allows it to take charge of Non-oneM2M devices. A Non-oneM2M device has no AE or CSE and is thus unable to provide oneM2M functions, but the connection of such devices is envisaged.

2.4 Advantages of oneM2M Technical Specifications

The main benefits of using the oneM2M standard specifications are summarized below.

First, it reduces the business costs of providing services. M2M service providers do not need to prepare a separate platform for each service, and can use a common platform to initiate business by providing only applications and devices. This reduces the start-up costs and allows smaller businesses to compete, and is thus expected to result in market expansion.

Second, the oneM2M CSE is designed to be used with any underlying network (mobile, fixed, local-area, etc.), and thus offers the benefits of versatility across different transport networks and communication methods.

Third, it ensures interconnectivity with existing M2M protocols, which is a major benefit. In oneM2M, only the core protocols are prescribed, and the specification is designed assuming that interconnections will also be made with existing protocols such as HTTP that do not conform with the oneM2M spec-

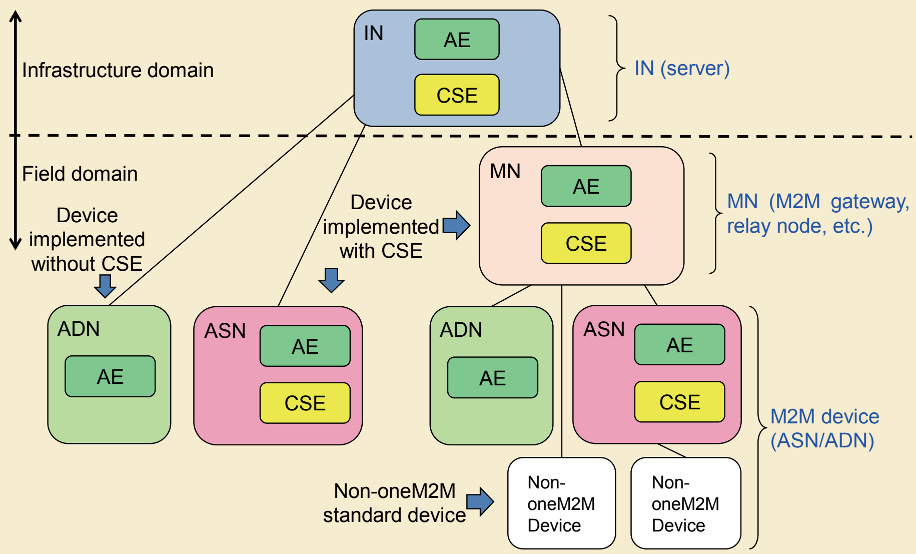

Figure 5　Conceptual implementation of oneM2M functions

*18 **Entity:** A structural element that provides functionality within a logical architecture.

ification.

Finally, in oneM2M, standards are being studied for the utilization of data such as semantics*19 that can be re-used by horizontal deployment between different business fields. For example, it is expected to promote the use of stored data and the creation of new businesses across the boundaries between business fields, for example by realizing smart cities through the cooperative use of diverse business fields such as ITS and electric power.

3. Interworking between oneM2M-PF and 3GPP-MTC Networks

The constituent functions of oneM2M-PF are first implemented by cooperation with transmission networks as shown in fig. 4. When viewed from the oneM2M-PF, any underlying transport network should work, but as a mobile communication network operator, it is essential that these new functions operate integrally in concert with our existing (3G and LTE) networks. NTT DOCOMO has been particularly active in this regard in the standardized specifications of oneM2M Release-1. In fig. 4, it is envisaged that any network can be applied as the underlying network, but in 3GPP, since MTC network functions have already been specified independently, the functions on the oneM2M side had to be designed so as to be highly compatible with these functions. Therefore, in order to realize the interworking of MTC networks in oneM2M and 3GPP, we tried to take a broad view of the technical content of both systems and promoted activities to enhance their compatibility. The following sections describe the features of M2M devices and the considerations and aims necessary for functional cooperation, and presents a summary of the 3GPP Release-11 MTC network platform and its triggering scheme.

3.1 Features of M2M devices, and Considerations and Aims of Functional Cooperation

1) M2M Device Features

There are a wide variety of examples of machine communication (M2M, MTC, IoT, etc.), but these are considered to involve terminal devices that are much smaller and whose functions are much more limited than ordinary mobile phones and the like. These modes of use are considered to encompass many applications where, for example, sensors are distributed around a room to form miniature terminals with limited sensing capabilities as a compact and inexpensive way of measuring environmental parameters such as temperature, humidity and dust levels. These devices may even be so small as to not require a power supply [3] [4].

Environment sensing M2M devices such as these tend to be small, functionally limited, and have a limited power supply capacity. Therefore, these devices only operate for short periods of time, and once they have finished making measurements, they typically transition to a dormant*20 state or transmit only small amounts of data. On the other hand, as a use case of which IoT is a typical example, it is envisaged that a huge quantity of devices will be used, so studies are being conducted on ways of efficiently accommodating these M2M devices in a wide area network [5] [6].

2) MTC-GW Proxies

The terminals that are measurement devices with characteristics as discussed in 1) above, and functions that act as intermediates between these terminals and a public network or other wide area network are MTC gateways (MTC-GW) called device proxies. As their name suggests, they perform functions on behalf of devices. **Figure 6** describes these functions and effects by way of an example. In the uplink communication of measured values from the measurement devices to the network side (e.g., temperature measurements taken once per hour), the measurement devices do not communicate during other time periods and thus transition into a dormant state, while the measured values are stored in the MTC-GW proxy shown in fig. 6. The measurement devices are also arranged so that communication with the GW can be performed using short-range radio communication so as to reduce their power consumption. On the other hand, when the server side that lies on the network wants to obtain the device measurement

*19 **Semantics:** Arrangements relating to the meaning conveyed by data.

*20 **Dormant:** One of the states of communication equipment in which it is standing by to receive communication.

values, it accesses the MTC-GW proxy that is always connected, from where it retrieves the stored data. This sort of basic operation is being studied as a way of accommodating large numbers of inexpensive sensing devices that have limited functions, but in cases where real-time performance is not needed [4]. These are a large part of the background in the study of oneM2M (fig. 5), resulting in a configuration including an MN that aggregates devices.

3.2 Overview of MTC Related Functions in 3GPP

1) Connectivity via an Underlying 3GPP Transmission Network

Figure 7 shows a simplified view of the sort of InterFace (IF) through which connectivity is provided by the IN on the server side and the MTC-UE (ASN or MN) when using a 3GPP network as the underlying transmission network. The M2M devices considered for oneM2M correspond to the UE as shown in the figure on a 3GPP architecture including middleware (MTC-GW and MTC proxy) nodes.

We will first describe the MTC-UE shown on the left side of fig. 7. According to the oneM2M standard, an AE and CSE are situated in the UE. As in fig. 5 above, although the ASN and MN have this sort of oneM2M function, they appear as a single UE from the viewpoint of the 3GPP network. Thus the connections between ASN/MNCSE and the 3GPP network are connected via Uu-IF (3GPP air IF*21) [7].

On the other hand, the connectivity between the oneM2M network server functions defined by 3GPP as SCS: Service Capability Server*22 (CSE) and the 3GPP network is configured as shown at the right side of fig. 7, where the Infrastructure Node-CSE (IN-CSE) and 3GPP underlying transmission network, where the User Plane (U-Plane)*23 information is connected by the Mcc-IF*24, and the Control Plane (C-Plane)*25 is connected by the Tsp-IF*26.

The 3GPP underlay network in fig. 7 is a simplified representation of how IP connectivity is provided between the

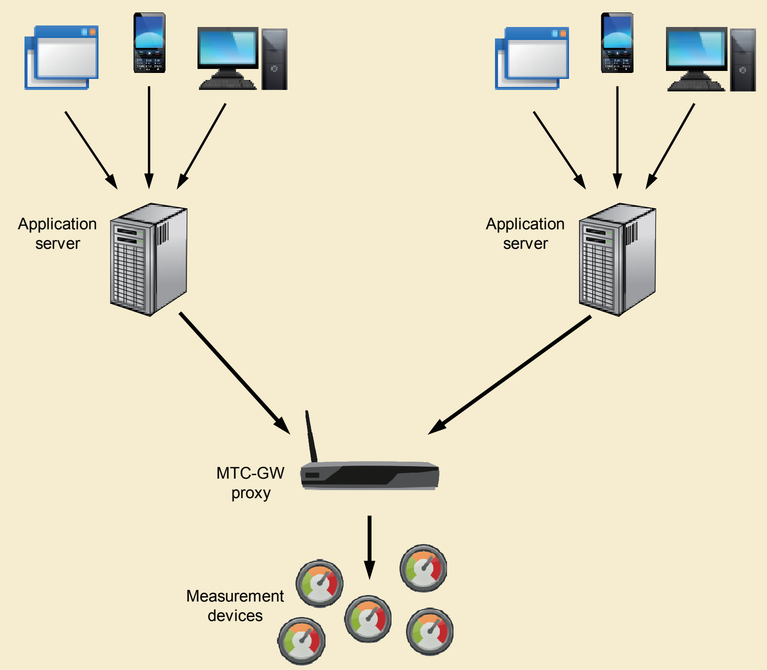

Figure 6 The effect of an MTC-GW proxy

*21 **Air IF:** General term for a radio communication link from a mobile terminal to a mobile base station.

*22 **SCS:** Equipment that provides a termination point for communication with terminals, implemented by an M2M application.

*23 **U-Plane:** A path for the transmission of user data to the C-Plane, which is a control signal transmission.

*24 **Mcc-IF:** One of the reference points in the oneM2M specification; the interface between CSE and the underlying network.

*25 **C-Plane:** This refers to the control plane, a series of control processes that is executed when a call is established and other such times.

*26 **Tsp-IF:** One of the reference points in the 3GPP MTC specification; the interface between MTC-IWF and SCS.

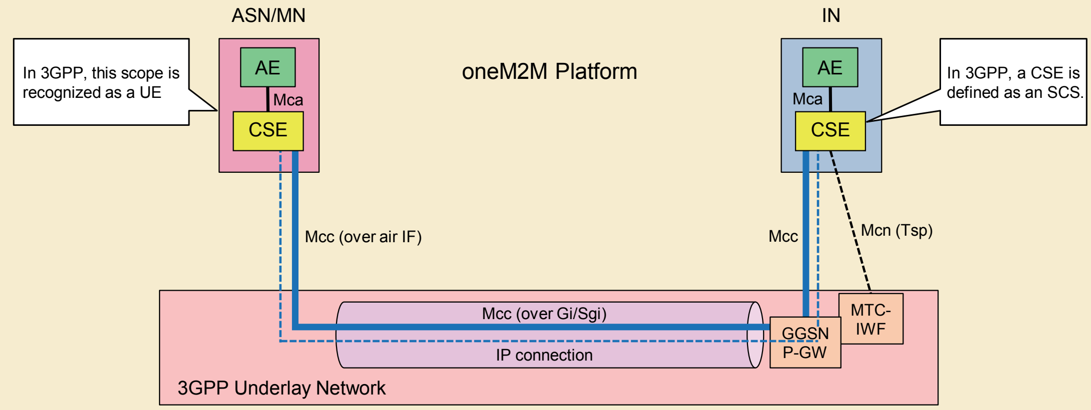

Figure 7 Providing connections via the underlying 3GPP transmission network

ASN/MN-CSE (MTCUE) and IN-CSE. In effect, this connectivity is provided by the MTC network platform in 3GPP Release-11. Its functions are shown below.

2) Underlying Transmission Network, Taking the 3GPP Release-11 MTC Network Platform as an Example

The original oneM2M discussions included a discussion of which 3GPP release's MTC network platform should be selected. NTT DOCOMO proposed using the 3GPP Release-11 MTC network platform based on its maturity and functional content, and as a result this proposal was incorporated into the oneM2M Release-1 specification. The overall architecture of the MTC network platform in 3GPP Release-11 is shown in **Figure 8** [8]. The locations labeled in red are the parts where functional entities are added as studied for oneM2M in this MTC network platform.

As the primary function, the SCS prescribed on the 3GPP side corresponds to the oneM2M IN-CSE described in chapter 2 (fig. 5). Also, the Mcc-IF that carries the U-Plane corresponds to Gi/SGi-IF*27, and the oneM2M Mcn-IF that carries the C-Plane signals corresponds to the Tsp-IF in 3GPP. On the terminal side, the oneM2M devices and middleware (ASN, ADN, etc.) also correspond to the 3GPP UE. When aligning the two standardized specifications, it initially took some time to achieve convergent discussions because the two standards had been developed by different groups in different locations. However, with the participation of experts on both sides, we finally managed to adapt and integrate these functions.

3) SMS Incoming Routes

The triggering of the 3GPP Release-11 MTC network platform by incoming traffic is implemented using only SMS*28. We will describe an example where these incoming message routes and principal function entities are received by a specific terminal from Application Server (AS)*29 (1) in fig. 8.

The AS initiates a call to the SCS by applying unique identifying IDs called External IDs (EXT-IDs) to the call signals. The SCS (oneM2M IN-CSE) judges where the corresponding terminals are placed in the 3GPP network, and transfers the message to the 3GPP Machine Type Communication-Inter Working Function (MTC-IWF)*30 via the Tsp-IF. This MTC-IWF queries a Home Subscriber Server (HSS)*31 and extracts an Internal ID (INT-ID) needed for delivery inside the 3GPP network. Since incoming calls to MTC terminals in a Release-11 MTC network are SMS messages, an Mobile Station International Integrated Services Digital Network Number (MSISDN)*32 for delivering an SMS message to a specific terminal is essentially extracted as the INT-ID. This information is handed over via the T4-IF to an entity that is

*27 **Gi/SGi-IF:** One of the reference points in the 3GPP EPC specification; the interface between SGSN/PGW and an external server.

*28 **SMS:** A service for transmitting/receiving short text-based messages. SMS is also used for transmitting/receiving mobile terminal control signals.

*29 **AS:** A server that runs an application to provide a service.

*30 **MTC-IWF:** Equipment that implements functions including Device Triggers and authentication of connection request and control-plane signals on a 3GPP network.

*31 **HSS:** A subscriber information database in a 3GPP mobile network that manages authentication and location information.

*32 **MSISDN:** The phone number assigned to each subscriber as specified by the 3GPP.

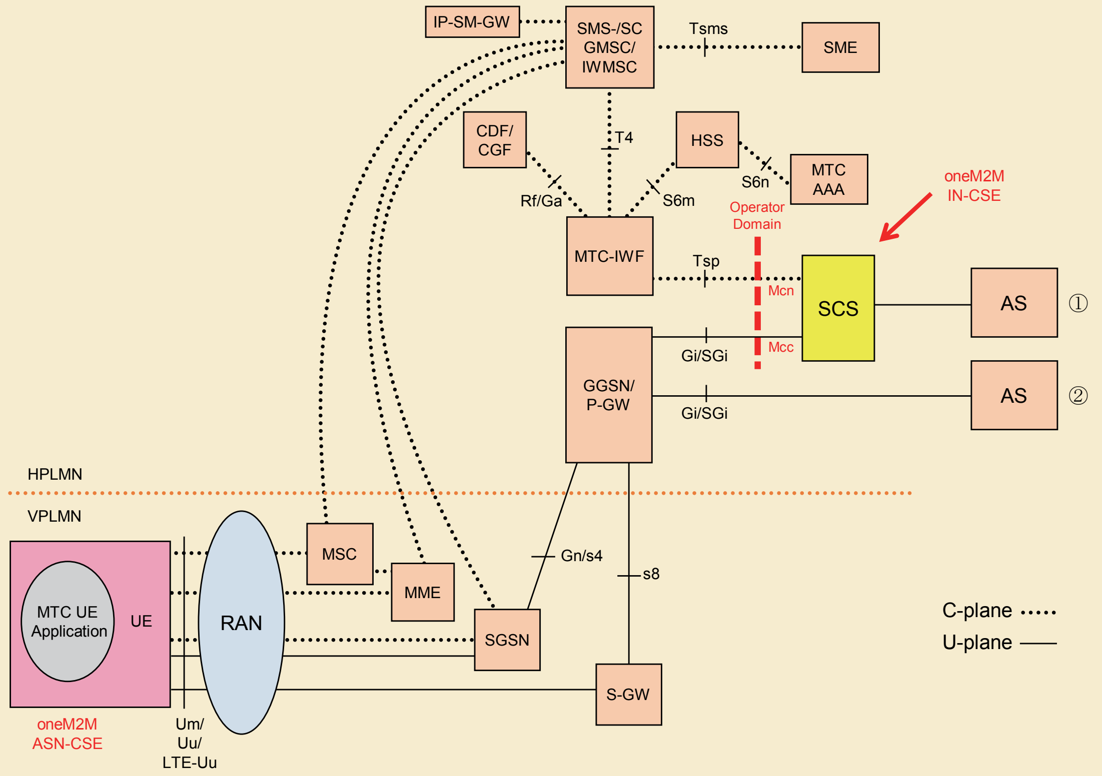

Figure 8 MTC platform (underlying transmission network) of 3GPP Release-11

required for SMS start-up (SMS-SC, etc.), and is delivered as an SMS message request to an Mobile Switching Center (MSC)*33 for 3G-CS, an Serving General packet radio service Support Node (SGSN)*34 for 3G-PS, or an Mobility Management Entity (MME)*35 for LTE. After performing paging*36 operations and the like, the message is delivered to the terminal's MTC-UE [8].

Although the route of an inbound SMS text is described above, it is necessary to register suitable information in the SCS (IN-CSE) before delivery is performed, and a reception operation must be started up only when the IN-CSE has obtained the status of a UE. With these mechanisms, it becomes possible for the first time to perform control without unnecessary actions such as forcing the reception of messages when the power is switched off.

3.3 Triggering Method based on Functional Cooperation between oneM2M and 3GPP Network

In a 3GPP network as described above, highly reliable message delivery operations can be implemented by ascertaining details about the UE state (i.e., switched off, dormant, busy, etc.). On the other hand, since a newly created oneM2M-PF does not have this sort of UE state information, it can lead to problems such as initiating reception to a terminal that is not switched on, for example. To address this sort of problem, NTT DOCOMO proposed a function that works by securing and holding the minimal state of a UE even in a oneM2M-PF, and finally allows the IN-CSE to report/hold these UEs when there is a change in the status of the UE. In addition, incoming content from IN-AE is

*33 **MSC:** A logical node having CS functions specified by 3GPP.
*34 **SGSN:** A logical node having packet communication functions specified by 3GPP.
*35 **MME:** A logical node for C-Plane control that accommodates an eNB and provides mobility control functions and other functions.
*36 **Paging:** Calling all mobile terminals at once when there is an incoming call.

also considered and connected to a method for selecting the reception behavior. The registration function and incoming call operations are described below.

1) Procedure for Forming an IN-CSE Connection from the Terminal Side

Figure 9 shows the procedure whereby an MTC-UE (ASN/MN-CSE) registers a UE destination address in the IN-CSE via the attach*37 procedure, and then forms a connection. In this figure, steps (1)-(3) are taken directly from the procedure prescribed by 3GPP [2], and through these steps, a connection is formed between the UE and IN-CSE at step (4).

Through this procedure, the IN-CSE maintains a set of destination addresses of this terminal and the ID specified by an arbitrary UE (M2M-Ext-ID). When a change has occurred in the UE's own state (e.g., it is powered down or becomes dormant), it has a mechanism that reports this to the IN-CSE. The IN-CSE is a part that saves this state information (including while connected), considers the incoming content from the IN-AE, and manages the procedure for selecting the reception behavior. If there is a change in the destination address (Point of Attachment (PoA)) of the UE after step (4), this is reported to the IN-CSE at step (5) [7].

2) Procedure for Forming a Connection from the IN-CSE to a Terminal

After completing the above registration procedure, it becomes possible to receive the first message on the terminal. This procedure is shown in **Figure 10**.

First, the IN-AE sends the IN-CSE an incoming call request including an M2M-Ext-ID that points to a particular terminal (fig. 10 (1)). On receiving this request, the IN-CSE identifies the destination on the underlying transmission network by consulting the Domain Name System (DNS)*38 based on this ID (fig. 10 (2)).

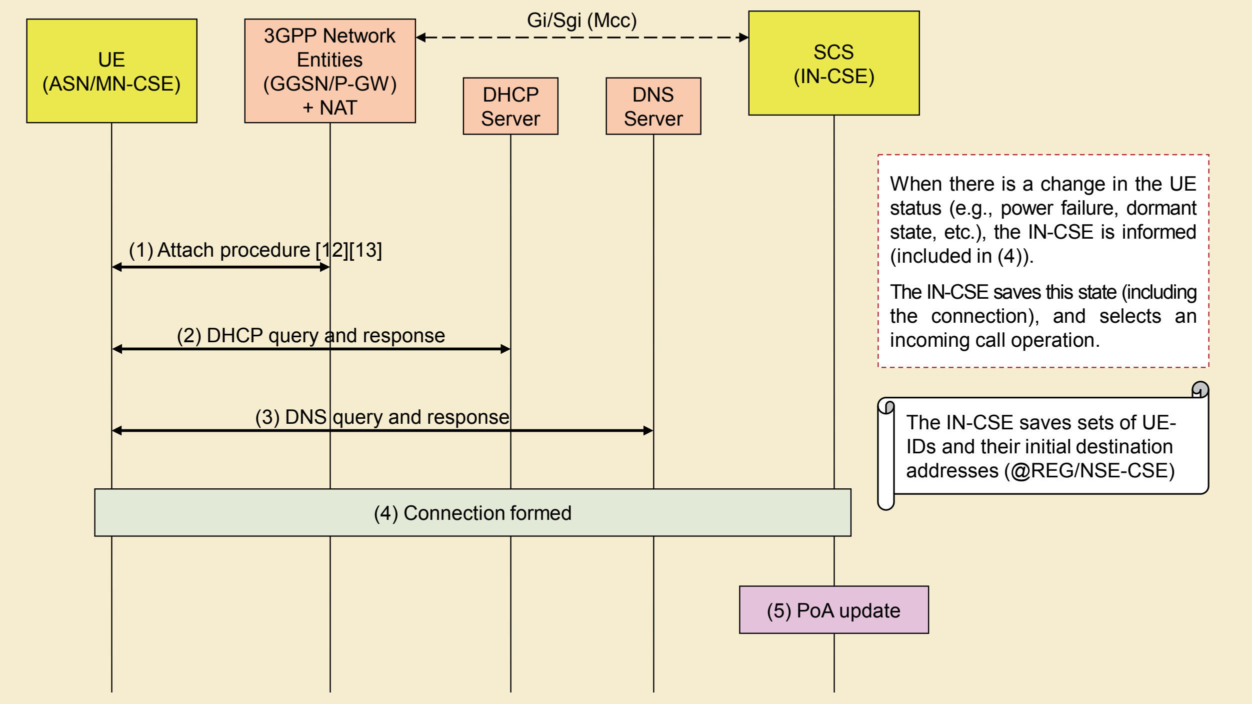

Figure 9　Connection procedure from a terminal to IN-CSE (UE Initiated)

*37 **Attach:** A procedure, and the status thereof, for registering a terminal on the network when, for example, its power is switched on.

*38 **DNS:** A system that associates host names with IP addresses on IP networks.

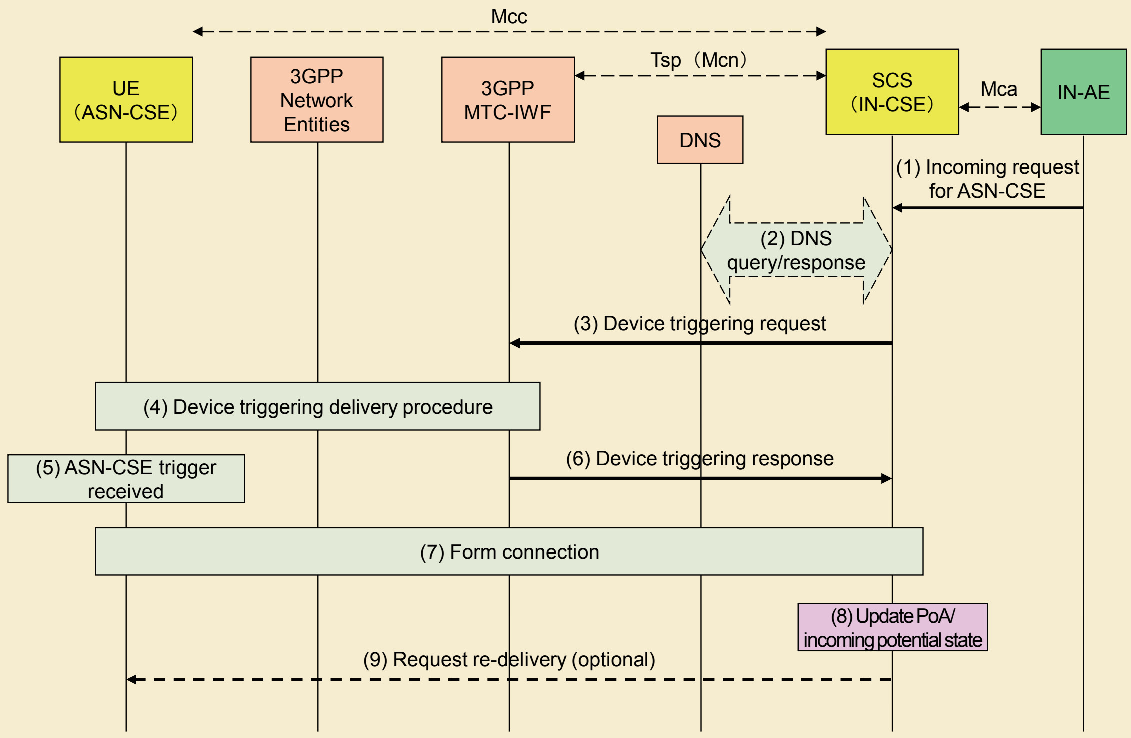

Figure 10 Procedure for forming connections from the IN-CSE to a terminal (NW Initiated)

Next, the IN-CSE transmits an incoming call request to the MTC-IWF of the underlying network to which it should be transferred (in this case, the 3GPP network) (fig. 10 (3)). The subsequent device triggering procedure (fig. 10 (4)) conforms to the 3GPP-MTC specification [8], and is used to deliver the trigger to the ASN-CSE terminal (fig. 10 (5)). On receiving this trigger, the UE initiates the procedure to establish a connection with the IN-CSE (fig. 10 (6), (7)).

When this happens, the IN-CSE is able to update the state necessary for reception and PoA, which is the transmission destination (fig. 10 (8)) [7].

4. Conclusion

In this article, we began by presenting an overview of the oneM2M organization, the first edition of its specification, its functions, and so on. We also reviewed the characteristics of M2M devices and an overview of the 3GPP-MTC network, and finally we described the interworking functions needed for the integral operation of oneM2M with 3GPP networks and MTC transmission networks. The method for triggering devices between oneM2M and 3GPP-MTC networks is one part of the contribution made by NTT DOCOMO in cooperation with other companies. By implementing this sort of function in oneM2M, it will be possible to integrate oneM2M-PF with the 3GPP underlying transmission network, and to make use of cooperative control.

In oneM2M, now that the Release-1 specification has been completed, discussions have started on the requirements for the next release. Also, the activities for Release-12/13 of 3GPP include studies of AESE (Architecture Enhancement for Service Exposure) [9] for enhanced cooperation with external servers such as oneM2M, MTC group control functions [10], and functions related to monitoring [11].

The triggering technique has forestalled the proposal of other methods to replace SMS, yet is expected to result in a more convenient triggering scheme for the provision of M2M services once further functional improvements have been made. M2M services have a broad range of applications, and it is thought that they will also make further advances in applications to, for example, the IoT. Service applications such as these are evolving, and are expected to continue developing in the future, so we hope to continue following these trends. Also, from the viewpoint of commercial use and the like, we intend to focus on these trends including partnerships with other companies.

References

[1] The oneM2M Web site. http://www.onem2m.org/

[2] 3GPP TR23.888 V11.0.0: "System improvements for Machine-Type Communications (MTC), Release-11," Dec. 2012.

[3] T. Kinoshita: "Build a smart society with wireless M2M!" Hitachi, New Generation M2M Consortium Symposium, Nov. 2013. http://ngm2m.jp/m2m/files/kouen_kinoshita.pdf

[4] D. Boswarthik, O. Elloumi and O. Hersent: "M2M Communications: A systems approach,"1st Edition, Wiley, 2012.

[5] T. Fujita, Y. Goto and S. Koike: "M2M architecture and technology challenges; Special Issue: ICT to support M2M services," IEICE Journal, Vol. 96, No. 5, May 2013.

[6] K. Hori, M. Hattori, T. Yoshihara, A. Ikenoue and N. Yamazaki: "M2M Area Networks; Special Issue: ICT to support M2M services," IEICE Journal, Vol. 96, No. 5, May 2013.

[7] oneM2M TS-0001 V1.0.0: "oneM2M Functional Architecture," Dec. 2014.

[8] 3GPP TS23.682 V11.5.0: "Architecture enhancements to facilitate communications with packet data networks and applications, Release-11," Sep. 2013.

[9] 3GPP TR23.708 V1.0.0: "Architecture Enhancements for Service Capability Exposure, Release-13," Dec. 2014.

[10] 3GPP TR23.769 V1.0.0: "Group based Enhancements, Release-13," Dec. 2014.

[11] 3GPP TR23.789 V1.0.0: "Monitoring Enhancements, Release-13," Dec. 2014.

[12] 3GPP TS23.401 V11.11.0: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access, Release-11," Dec. 2014.

[13] 3GPP TS23.060 V11.12.0: "General Packet Radio Service (GPRS); Service description; Stage 2, Release-11," Dec. 2014.