M2M 3GPP Standardization

Technology Reports

Further Development of LTE/LTE-Advanced – LTE Release 10/11 Standardization Trends –

Core Network Infrastructure and Congestion Control Technology for M2M Communications

The number of M2M devices is expected to increase even more in the future, and network operators must accommodate this large number of devices with high reliability. In addition to the core network architecture for accommodating M2M communication, the 3GPP has also specified technologies to handle congestion due to this large number of M2M devices, which reduce signaling traffic using the features of M2M communications, and perform other related tasks. In this article, we describe these latest M2M technologies.

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1. Introduction

Machine to Machine (M2M) communication is called Machine Type Communication (MTC) at the 3GPP, and is defined as communication conducted without human intervention [1]. It has already been in wide use for some time in Japan, with terminals such as the ubiquitous module.

Since 3GPP Release 10 (Rel. 10) in 2010, there has been active study of technical specifications to develop M2M communications further, and NTT DOCOMO has been contributing proactively to creating these technical specifications.

In this article, we describe two of the most significant functions standardized between 3GPP Rel. 10 and Rel. 11: the M2M Core network[*1] communications infrastructure, which enables M2M service operators to introduce solutions more easily, and congestion[*2] handling technologies, which improve reliability on networks accommodating a large number of terminals.

2. Overview of M2M Core Network Communication Infrastructure

The architecture of the M2M core network communication infrastructure is specified in Rel. 11 (**Figure 1**)[2]. New logical entities[*3] added in Rel. 11 include the Service Capability Server (SCS)[*4] and the Machine Type Communication-InterWorking Function (MTC-IWF)[*5].

An SCS is equipment implemented by an M2M application and provides an endpoint for communication with a terminal.

An MTC-IWF implements various functions, but its main functions are:

(1) Authenticate connection requests from the SCS to the 3GPP network

(2) Authenticate Control Plane (C-

*1 **Core network**: A network comprising switching equipment, subscriber information management equipment, etc. A mobile terminal communicates with the core network via a radio access network.

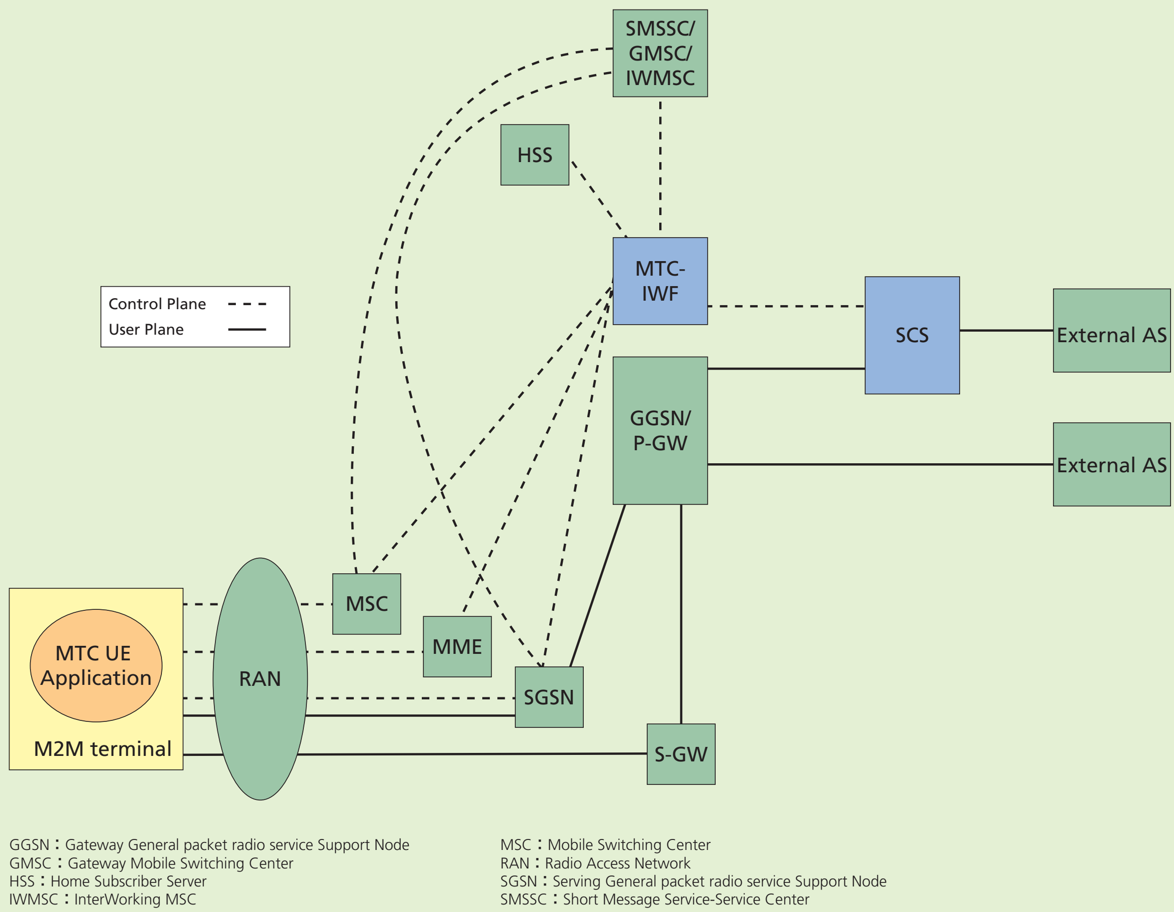

Figure 1 Rel. 11 M2M Network architecture accommodating M2M

Plane)[*6] request signals from the SCS

(3) Device trigger function

Rel. 11 specifies a device trigger process, which implements reception by this equipment from an external Application Server (AS), and an external identifier for M2M terminals, used by the external AS in this process.

The external identifier is a globally-unique terminal identifier that can be used between the M2M service provider and the 3GPP network. By specifying such an identifier, the M2M service provider no longer needs to manage an International Mobile Subscriber Identity (IMSI)[*7], a Mobile Station International Integrated Services Digital Network Number (MSISDN)[*8] or a terminal IP address. With the external identifier, the M2M service provider can send messages (including PUSH) to a terminal using SMS[*9] without needing to know the terminal telephone number or IP address.

3. Overview of M2M Congestion Control

Regardless of whether the network has the architecture described above, congestion can occur for network operators accommodating M2M terminals

*2 **Congestion**: A state where communication requests are concentrated inside a short time period and exceed the processing capabilities of the network, thereby obstructing communications.

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

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

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

*6 **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.

*7 **IMSI**: A number used in mobile communications that is unique to each user and stored on a User Identity Module (UIM) card.

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

for the following reasons [3]:

(1) Continuous transmissions from a defective terminal.
(2) Simultaneous transmissions from a large number of M2M terminals due to some external circumstance.
(3) Simultaneous transmissions from M2M terminals at specific times.

The number of devices performing M2M communication is expected to become very large, on the order of tens of millions. For example, if devices become disconnected by network equipment damage due to a natural disaster, those devices would all be expected to attempt reconnection at once.

The type of issue described above can be avoided if applications on M2M terminals operate in ways that do not crowd the network, but it is not always possible for network operators to force M2M operators to abide by the operating standards that they hope for.

Because of this, it is important for network operators to be able to control congestion, regardless of the applications connected to the network.

It is also a responsibility of network operators to continue to provide other communication services normally when controlling specific traffic that is causing congestion.

To satisfy these requirements, various congestion control functions available to the network have been standardized in moving from Rel. 10 to Rel. 11.

There are two main elemental technologies used to control congestion for M2M communications. The first is a technology that identifies M2M terminals and services, and the second is a technology that actually controls congestion on the network.

3.1 Method for Identifying M2M Terminals

In studying methods for identifying M2M terminals, the 3GPP classified communication as either “Low Priority” or “Normal Priority” [4][5]. These categories anticipate scenarios in which some M2M communication will have lower priority than general services such as voice and data communications.

M2M terminals designated to be low-priority are configured with the Low Access Priority Indicator (LAPI). The LAPI can be configured when the terminal is manufactured, or it can be set remotely by the M2M operator, using Over-The-Air (OTA) or other technology. Note that the LAPI is defined for all wireless access technologies defined by the 3GPP, including LTE, 3G (W-CDMA), and 2G (GSM).

Each time an M2M terminal registers its location or sends a message on the network, it notifies the network of its LAPI, and this LAPI information is preserved between the Serving GateWay (S-GW)[*10] and Packet data network GateWay (P-GW)[*11], which is the network equipment related to data communication (3G-PS domain[*12], LTE).

The LTE attach operation is shown in **Figure 2**, as a concrete example of this procedure.

To send a message, the terminal first sends a radio configuration request signal to the Radio Network Controller (RNC)[*13] and eNB[*14] using the Radio Resource Control (RRC)[*15] protocol. The LAPI is set in this signal, and the RNC preserves the received LAPI.

Then, the terminal sends an attach[*16] request signal including the LAPI, using the Non-Access Stratum (NAS)[*17] protocol, to the Mobility Management

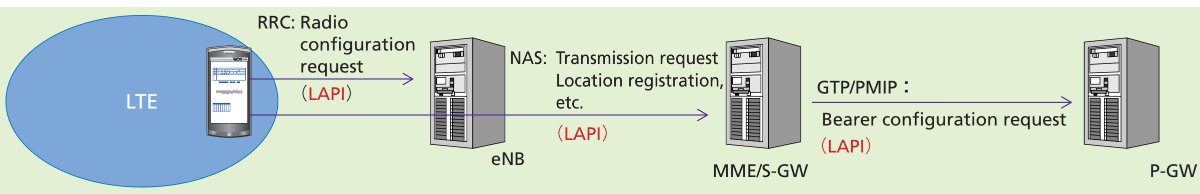

Figure 2 Terminal identifier notification scheme

*9 **SMS**: A service for sending and receiving short text-based messages, mainly between mobile terminals.

*10 **S-GW**: The area packet gateway accommodating the 3GPP access system.

*11 **P-GW**: A gateway acting as a point of connection to a PDN, allocating IP addresses and transporting packets to the S-GW.

*12 **PS domain**: A network domain that provides services based on packet switching.

*13 **RNC**: A type of node specified by 3GPP that manages radio resources and controls mobile terminals and base stations.

*14 **eNB**: A base station for the LTE radio access system.

*15 **RRC**: A protocol for controlling radio resources on a wireless network.

*16 **Attach**: The process of registering a mobile terminal to a network when the terminalÅfs power is turned on, etc.

*17 **NAS**: A functional layer between the UE and core network.

Entity (MME)[*18] which is the LTE core network equipment.

The S-GW and P-GW, which are the network equipment that establish the communication bearer, are notified of the LAPI when the LTE switcher packet route (the bearer[*19]) is configured within the network using a protocol such as GPRS Tunneling Protocol (GTP)[*20] or Proxy Mobile IP (PMIP)[*21], and this equipment maintains the LAPI as one element of the EPS Bearer Context while it is establishing the bearer.

The network is able to provide the following functions using the LAPI received as described above.

One is LAPI terminal specific control of priority level. For example, priority can be given to processing control signals from radio and core network equipment, or to downlink data traffic from the S-GW and terminal call processing. In this way, for example, priority can be given to ordinary terminals when there is congestion.

Other possible functions include reducing network signalling by notifying LAPI terminals using a specialized location registration period, or applying specialized rates to LAPI terminals.

Rel. 11 has also added extensions to the LAPI functionality described above, so that a terminal can temporarily send messages at normal priority, even if it is a LAPI terminal.

This function takes into considerations cases when, for example, a low-priority M2M terminal needs to communicate with higher urgency (for emergency calls, alarms, etc.).

3.2 M2M Congestion Control

1) Backoff Functions

- SM-Backoff

Session Management Backoff (SM-Backoff) is a function whereby the M2M terminal restricts transmission of packets when there is congestion [4][5]. It enables the timing of retransmissions to be dissipated by randomizing retransmission control timers for each terminal. This function is regulated for 2G, 3G and LTE, and we describe an example for LTE below (**Figure 3**).

The terminal sends a packet transmission request to the MME. The MME sends a request to configure a communication bearer to the P-GW (Fig. 3 (1)(2)). If the P-GW has determined internally that conditions are congested, it rejects the connection, returning a Reject signal, with the congestion flag set, to the MME (Fig. 3(3)(4)). Having received the Reject signal from the P-GW, the MME detects the congestion flag and sends a Reject signal to the terminal, which includes a congestion notification and a retransmission control timer value (Fig. 3(5)). Having received the congestion notification and retransmission control timer value from the MME, the terminal configures the timer with the value received and waits till it expires before retransmitting to the request destination from step (1) (the Access Point Name (APN)[*22]). It is possible to transmit to a different APN during this time (Fig. 3(6)).

Note that at step (1), if the MME has detected congestion, or has already received notification of congestion from the P-GW, step (3) can also be initiated before step (2).

- MM-Backoff

Mobility Management Backoff (MM-Backoff) is a function whereby, when the network cannot accept an attach/location registration request due to congestion, it sets a randomized timer value in the Reject signal, and the terminal sup-

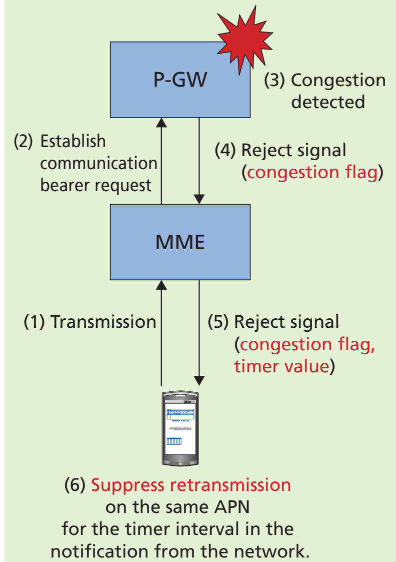

Figure 3 SM-Backoff

*18 **MME**: A logical node accommodating a base station (eNB) and providing mobility management and other functions.

*19 **Bearer**: In this article, the path taken by user data packets.

*20 **GTP**: A communication protocol for user data transmission which provides functions such as establishing communication path and data transfer in core network.

*21 **PMIP**: A communications protocol used for transmitting user data, which provides functions such as transmitting data and configuring a communications path on the LTE core network.

*22 **APN**: Similar to a telephone number, this identifies a connection destination and is used in packet communication.

presses retransmission for that timer interval (**Figure 4**).

The terminal sends an attach/location-registration request to the MME (Fig. 4(1)). The MME detects congestion and sends a Reject signal, configured with the congestion flag and a randomized timer value, to the terminal (Fig. 4(2)(3)). Upon receiving the congestion flag and retransmission timer value from the MME, the terminal waits until a timer with the configured value expires (Fig. 4(4)).

- RRC-Backoff

RRC-Backoff is a function whereby, when the radio network cannot accept a request for radio configuration due to congestion, a randomized timer value is configured in the Reject signal, and the terminal suspends retransmission for that interval (**Figure 5**).

The terminal sends a request for radio configuration to the eNB (Fig. 5(1)). Congestion is detected on the eNB, and a Reject signal is sent to the terminal with the congestion flag set and a randomized timer value (Fig. 5(2)(3)). Having received the congestion flag and retransmission timer value from the eNB, the terminal waits for a timer with the configured value to expire (Fig. 5(4)).

2) Signalling Reduction Functions

Besides specifications for operation during congestion, there are also specifications for lengthening the timer interval for periodic location registration, as a way of reducing signalling specialized for M2M communication characteristics [4][5].

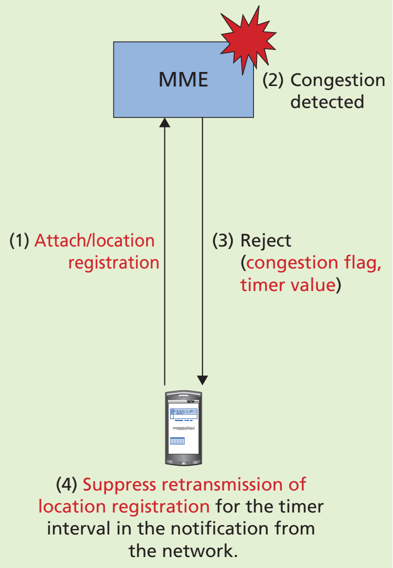

Figure 4 MM-Backoff

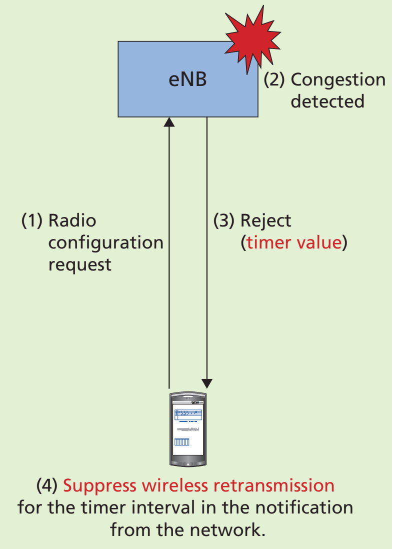

Figure 5 RRC-Backoff

One characteristic of M2M devices is that they have low mobility, as with smart meters and other fixed, embedded terminals.

Periodic location registration was originally used by frequently-moving devices to notify the network of their location at regular intervals, even while they were not moving. M2M devices move very infrequently, so the protocol has been extended to allow the periodic location registration timer values to be set on a per-subscriber basis, to reduce signalling [4][5].

4. Conclusion

In this article, we have described the architecture used to realize M2M communication and technologies used to deal with congestion.

The Rel. 11 architecture reduces the amount of information that must be managed by M2M service providers, so a service infrastructure can be provided that allows M2M solutions to be introduced more efficiently.

It also enables network providers to increase network reliability and operate their networks adequately considering the huge numbers of devices (in the tens of millions) that are anticipated, through the use of congestion technologies.

M2M communication continues to be advanced at the 3GPP, with active discussion on aspects such as reducing signalling and improving communication efficiency, and NTT DOCOMO will continue to contribute to this technical study.

References

[1] 3GPP TS 22.368 V11.6.0: "Service requirements for Machine-Type Communications (MTC); Stage 1," 2012.

[2] 3GPP TS 23.682 V11.3.0: "Architecture enhancements to facilitate communications with packet data networks and applications," 2012.

[3] 3GPP TR 23.888 V11.0.0: "System improvements for Machine-Type Communications (MTC)," 2012.

[4] 3GPP TS 23.401 V11.5.0: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access," 2013.

[5] 3GPP TS 23.060, V11.5.0: "General Packet Radio Service (GPRS); Service description; Stage 2," 2013.