SAE | Emergency Warning System | Area Mail

Technology Reports

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Advanced Warning Message Distribution Platform for the Next-generation Mobile Communication Network

3GPP Release 8 accepted the standard technical specification for warning message distribution platform such as Area Mail, which adopts pioneering technology for faster distribution, in order to fulfil the requirements concerning the distribution of emergency information e.g. earthquakes, tsunamis and so on in LTE/EPC. The standard specifies the delivery of emergency information in two levels. The Primary Notification contains the minimum, most urgently required information such as "An earthquake occurred"; the Secondary Notification includes supplementary information not contained in the Primary Notification, such as seismic intensity, epicentre, and so on. This separation allows implementation of excellent information distribution platforms that can achieve the theoretically fastest speed of the warning distribution.

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1. Introduction

Earthquake is a common occurrence in Japan, and Japan is a worldwide leader in social infrastructure for emergency earthquake warning distribution. One example of that infrastructure is the Area Mail*1 [1] service that began distributing earthquake warnings to mobile terminals in 2007.

The requirement to deliver emergency information as fast as possible to as many people as possible is not limited to Japan, but exists everywhere around the world. There is a strong need for development of an emergency information broadcast platform for rapid distribution of accurate information on the dangers and artificial threats associated with international disputes and so on as well as natural disasters. There is also a strong demand for a way to instantly provide disaster information via the mobile terminal, which can distribute information in a broad range and is thus one way to provide people means to have safe and worry-free daily lives.

That situation led 3rd Generation Partnership Project (3GPP) to begin study of a warning message distribution platform called the Public Warning System (PWS). As a result, 3GPP has standardized the Earthquake and Tsunami Warning System (ETWS) based on NTT DOCOMO's Area Mail, which

*1 **Area Mail**: A service for instantly broadcasting emergency earthquake warnings from the Japan Meteorological Agency, etc.

satisfies the requirements concerning the distribution of emergency information on earthquakes, tsunamis and other such disasters with pioneering technology for increasing the warning message distribution speed. This is to meet the requirements throughout the world as well as in Japan, which is exposed to many threats from natural disasters. There are respective ETWS standards for 2G (GSM), 3G and the new wireless technology, Long Term Evolution (LTE)[*2].

This article describes an overview of the ETWS standard and explains in detail the implementation of the ETWS for LTE and the differences in implementation.

2. ETWS Overview

The purpose of the ETWS is to broadcast emergency information such as earthquake warnings provided by a local or national governments to many mobile terminals as quickly as possible by making use of the characteristic of the widespread mobile communication networks.

The ETWS, in the same way as Area Mail, detects the initial slight tremor of an earthquake, the Primary Wave (P wave)[*3], and sends a warning message that an earthquake is about to happen to the mobile terminals in the affected area. ETWS can deliver the first notification to mobile terminals in the shortest theoretical time possible in a mobile communication system (about four seconds after receiving the emergency information from the local or national government), which is specified as a requirement by 3GPP.

3. Features of ETWS

The biggest difference between Area Mail and the ETWS is the disaster notification method (**Figure 1**) [2]. Earthquake warnings in Area Mail have a fixed-length message configuration that notifies of an earthquake. ETWS, on the other hand, achieves distribution of the highest priority information in the shortest time by separating out the minimum information that is needed with the most urgency, such as "Earthquake about to happen," for the fastest possible distribution as a Primary Notification; other supplementary information (seismic intensity, epicentre, etc.) is then distributed in a Secondary Notification. This distinction thus implements a flexible information distribution platform that prioritizes information distribution according to urgency.

The Primary Notification contains only simple patterned disaster information, such as "Earthquake." When a mobile terminal receives a Primary Notification, it produces a pre-set alert sound and displays pre-determined text on the screen according to the message content to notify users of the danger. The types of disaster that a Primary Notification can inform about are specified as "Earthquake," "Tsunami," "Tsunami + Earthquake," "Test" and "Other," regardless of the type of radio access.

The Secondary Notification contains the same kind of message as does the existing Area Mail service, which is, for example, textual information distributed from the network to the mobile terminal to inform of the epicentre, seismic intensity and other such information. That message also contains, in

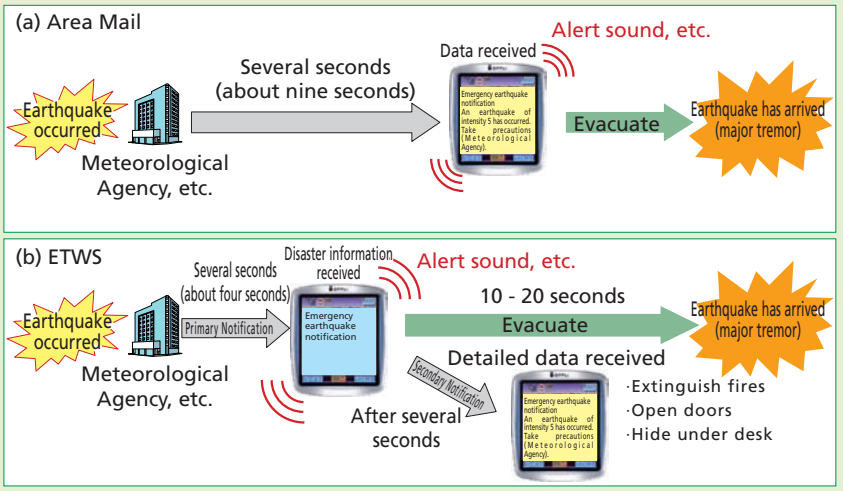

Figure 1 Differences in information distribution method in Area Mail and ETWS

*2 **LTE**: Extended standard for the 3G mobile communication system studied by 3GPP. It is equivalent to "3.9G" or Super3G as proposed by NTT DOCOMO.

*3 **P wave**: The first tremor of an earthquake to arrive at a location.

addition to text, a Message Identifier and Serial Number that identifies the type of disaster.

A major feature of the ETWS is compatibility with international roaming. Through standardization, mobile terminals that can receive ETWS can receive local emergency information when in other countries if the local network provides the ETWS service.

These services are provided in a manner that is common to all types of radio access (3G, LTE, etc.).

4. Technical Realisation of ETWS

4.1 Network Architecture

The ETWS platform is designed based on the Cell Broadcast Service (CBS)[*4] that is used by the existing Area Mail service. The ETWS network architecture is shown in **Figure 2** [3]. Fig. 2 also shows the architecture for 3G network to highlight the features differences between LTE and 3G.

In the ETWS architecture for 3G, a Cell Broadcast Centre (CBC), which is the information distribution server, is directly connected to the 3G Radio Network Controller (RNC)[*5]. The CBC is also connected to the Cell Broadcast Entity (CBE), which distributes information from the Japan Meteorological Agency and other such sources.

In an LTE radio access network, however, the eNodeB (eNB)[*6] is directly connected to the core network, and eNB does not have a centralized radio control function as the one provided by the RNC of 3G [4]. Accordingly, if the same network configuration as used for 3G were to be adopted, the number of eNB connected to the CBC would increase and add to the load on the CBC. To overcome that issue, ETWS for LTE adopts a hierarchical architecture in which the CBC is connected to a Mobility Management Entity (MME)[*7]. The MME, which acts as a concentrator node, is connected to a number of eNBs. This architecture gives advantages to the network, such as reducing the load in the CBC and reducing the processing time, and, thus preventing delay in distribution.

4.2 Message Distribution Area

In the 3G ETWS and Area Mail systems, the distribution area can be specified only in cell[*8] units, which creates the issue of huge distribution area database in CBC. In LTE ETWS, however, the distribution area is specified in three different granularities (**Figure 3**). This allows the operator to perform area planning according to the charac-

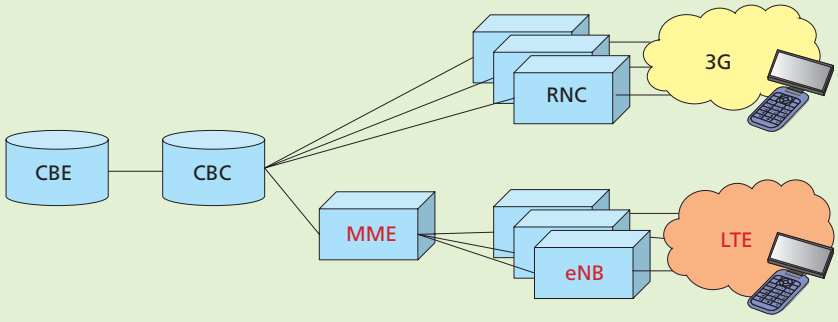

Figure 2 ETWS network architecture

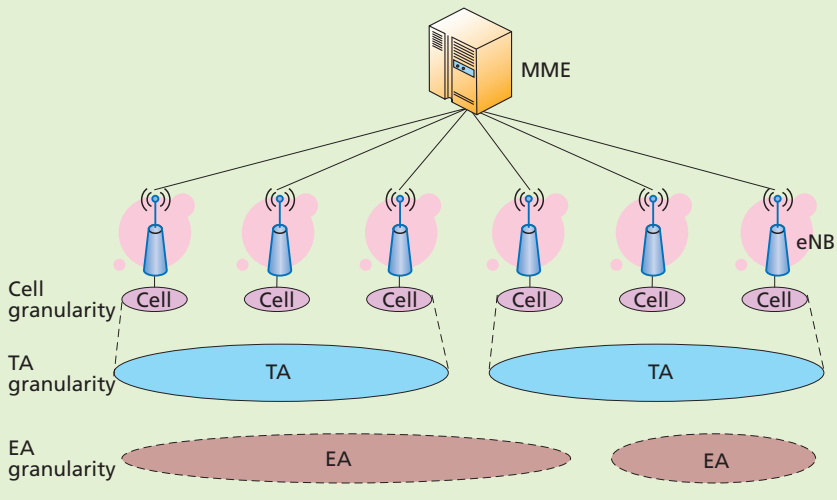

Figure 3 Distribution area

*4 **CBS**: A broadcasting service for simple textual information that is being standardized by 3GPP.
*5 **RNC**: Equipment that performs radio circuit control and mobility control in the 3G network specified by 3GPP.
*6 **eNB**: A base station for the LTE radio access system.
*7 **MME**: A logical node that provides mobility management (see *9) and other such functions to the UE. This node acts as a concentrator of the eNBs.
*8 **Cell**: The smallest area unit for sending and receiving radio signals between mobile communication network and mobile terminals.

teristic of the warning/emergency occasions, e.g. notice of an earthquake with a certain magnitude needs to be distributed in a certain width of area, thus allowing efficient and more flexible broadcast of the warning message.

1) Cell Level Distribution Area

The CBC designates the cell-level distribution areas by sending a list of cell IDs. The emergency information is broadcasted only to the designated cells. Although this area designation has the advantage of being able to pinpoint broadcast distribution to particular areas, it necessitates a large processing load in the network node (CBC, MME and eNB) especially when the list is long.

2) TA Level Distribution Area

In this case, the distribution area is designated as a list of Tracking Area Identities (TAIs). TAI is an identifier of a Tracking Area (TA), which is an LTE mobility management[*9] area[*10]. The warning message broadcast goes out to all of the cells in the TAIs. This area designation has the advantage of less processing load when the warning message has to be broadcast to relatively wide areas.

3) EA Level Distribution Area

The Emergency Area (EA) can be freely defined by the operator. An EA ID can be assigned to each cell, and the warning message can be broadcasted to the relevant EA only. The EA can be larger than a cell and is independent of the TA. EA is a unit of mobility management. EA thus allows flexible design for optimization of the distribution area for the affected area according to the type of disaster.

4.3 Message Distribution

The method of distributing emergency information to LTE radio networks is shown in **Figure 4** [3]. When the CBC receives a request for emergency information distribution from CBE, it creates the text to be sent to the terminals and specifies the distribution area from the information in the request message (Fig. 4 (1) (2)).

Next, the CBC sends a Write-Replace Warning Request[*11] message to the MME of the specified area. This message contains information such as disaster type, warning message text, message distribution area, Primary Notification information, etc. (Fig. 4 (3))[5]. When the MME receives this message, it sends a response message to the CBC to notify that the message was correctly received. The CBC then notifies the CBE that the distribution request was received and the processing has begun (Fig. 4 (4) (5)). At the same time, the MME checks the distribution area information in the received message (Fig. 4 (6)) and, if a TAI list is included, it sends the Write-Replace Warning Request message only to the eNB that belong to the TAI in the list (Fig. 4 (7)). If the TAI list is not included, the message is sent to all of the eNB to which the MME is connected.

When the eNB receives the Write-Replace Warning Request message from the MME, it determines the message distribution area based on the

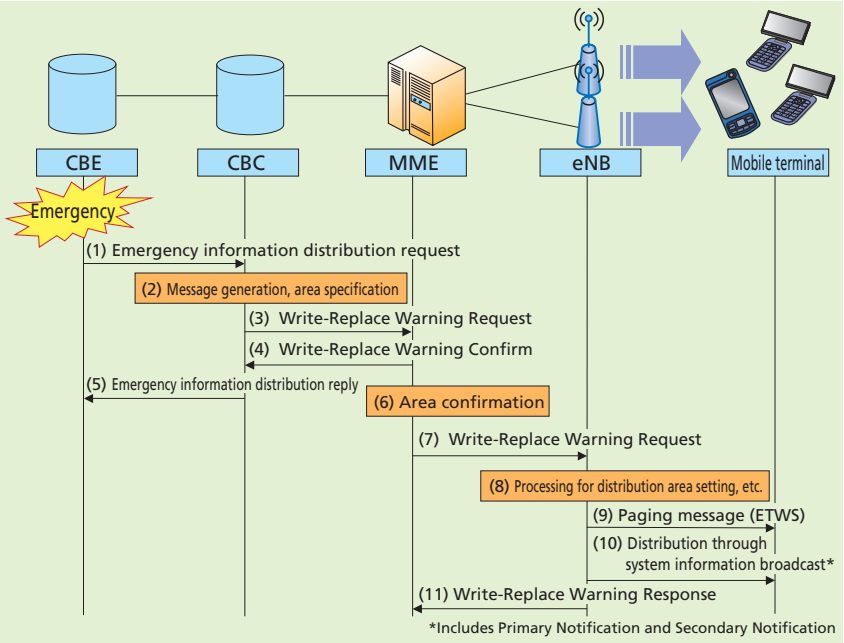

Figure 4 Emergency information distribution method

*9 **Mobility management**: Management of terminals which provides transmission, reception and continuous communication even if terminals move.

*10 **Mobility management area**: An area in which a mobile terminal can move without registering location.

*11 **Write-Replace Warning Request**: A signal for requesting emergency information distribution sent from the CBC to the MME and from the MME to the eNB.

information included in the Write-Replace Warning Request message (Fig. 4 (8)) and starts the broadcast (Fig. 4 (9) (10)). The following describes how the eNB processes each of the specified information elements [6].

1) Disaster Type Information (Message Identifier/Serial Number)

If an on-going broadcast of a warning message exists, this information is used by the eNB to decide whether it shall discard the newly received message or overwrite the ongoing warning message broadcast with the newly received one. Specifically, if the received request message has the same type as the message currently being broadcasted, the received request message is discarded. If the type is different from the message currently being broadcast, the received request message shall overwrite the ongoing broadcast message and the new warning message is immediately broadcasted.

2) Message Distribution Area (Warning Area List)

When a list of cells has been specified as the distribution area, the eNB scans the list for cells that it serves and starts warning message broadcast to those cells. If the message distribution area is a list of TAIs, the eNB scans the list for TAIs that it serves and starts the broadcast to the cells included in those TAIs. In the same way, if the distribution area is specified as an EA (or list of EAs), the eNB scans the EA ID list for EA IDs that it serves and starts the broadcast to the cells included in the EA ID.

If the received Write-Replace Warning Request message does not contain distribution area information, the eNB broadcasts the warning message to all of the cells it serves.

3) Primary Notification Information

If Primary Notification information indication exists, that information is mapped to a radio channel that is defined for the broadcast of Primary Notification.

4) Message Text

The eNB determines whether or not there is message text and thus whether or not a Secondary Notification needs to be broadcasted. If message text exists, that text is mapped to a radio channel that is defined for the broadcast of Secondary Notification. The Secondary Notification is broadcast according to the transmission intervals and number of transmissions specified by the CBC. Upon the completion of a broadcast, the eNB returns the result to the MME (Fig. 4 (11)).

5. Radio Function Specifications

5.1 Overview

In the previous Area Mail service, only mobile terminals in the standby state (RRC_IDLE) could receive emergency information, but in ETWS, emergency information can be received also by mobile terminals in the connected state (RRC_CONNECTED), and hence the information can be delivered to a broader range of users[7][8]. In LTE, when delivering emergency information to mobile terminals, the eNB sends a bit in the paging message[*12] to notify that emergency information is to be sent (ETWS indication), and sends the emergency information itself as system information broadcast[*13]. In 3G, on the other hand, the emergency information is sent through the paging message and CBS messages.

5.2 Message Distribution Method for LTE

When the eNB begins transmission of the emergency information, a paging message in which the ETWS indication is set is sent to the mobile terminal. ETWS-compatible terminals, whether in standby or connected, try to receive a paging message at least once per default paging cycle, whose value is specified by the system information broadcast and can be set to 320 ms, 640 ms, 1.28 s or 2.56 s according to the 3GPP specifications. If a paging message that contains an ETWS indication is received, the terminal begins receiving the system information broadcast that contains the emergency information [7]. The paging message that has the ETWS indication set is sent out repeatedly at every paging opportunity, thus increasing the reception probability at the mobile terminal.

The ETWS message itself is sent as

*12 **Paging message**: A radio signal for notifying a mobile terminal that is in the standby state of an incoming call or network information update.

*13 **System information broadcast**: Broadcasted information including location registration area identifier, neighboring cell information, access control information, etc, used by the mobile terminal to access network.

system information broadcast. Specifically, the Primary Notification is sent as the Warning Type[*14] in System Information Block Type 10 (SIB10) and the Secondary Notification is sent as a Warning Message in SIB11. By repeated sending of SIB10 and SIB11 (at an interval that can be set to 80 ms, 160 ms, 320 ms, 640 ms, 1.28 s, 2.56 s, or 5.12 s according to the 3GPP specifications), the probability of the information being received at the residing mobile terminal can be increased. In addition, the SIB10 and SIB11 scheduling information is included in SIB1 issued at 80-ms intervals, so mobile terminals that receive the ETWS indication try to receive SIB10 and SIB11 after first having received the SIB1. By checking the disaster type information (Message Identifier and Serial Number) contained in SIB10 and SIB11, the mobile terminal can prevent the receiving of multiple messages that contain the same emergency information [7].

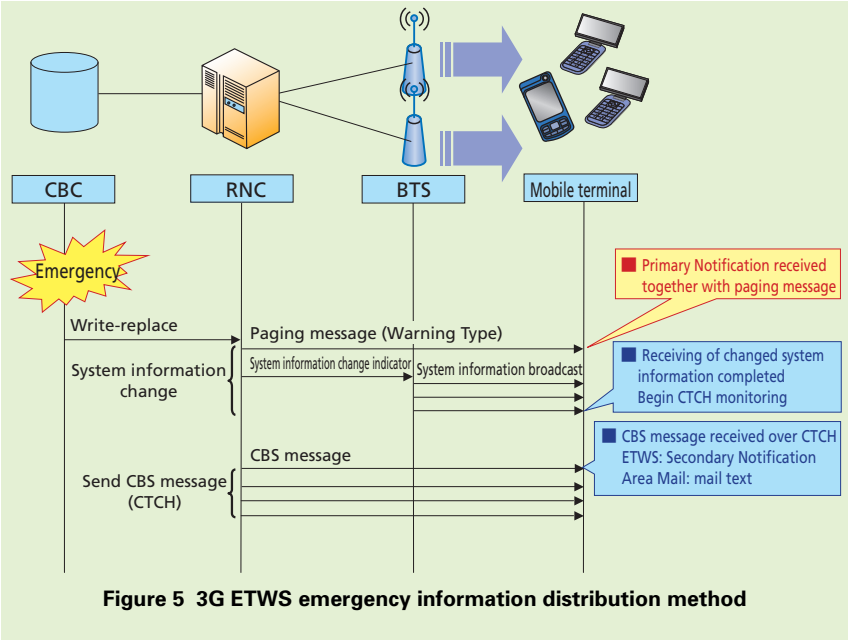

Figure 5 3G ETWS emergency information distribution method

5.3 3G Message Distribution Method

For faster information delivery and increased range of target uers in 3G also, the CBS message distribution control used in Area Mail was enhanced. An overview of the 3G radio system is shown in **Figure 5**.

In the Area Mail system, a Common Traffic Channel (CTCH)[*15] logical channel is set up in the radio link, and emergency information distribution is implemented by sending CBS messages over that channel. To inform the mobile terminals that the CTCH logical channel has been set up, the RNC orders the base station (BTS)[*16] to set the CTCH Indicator information element in the system information broadcast to TRUE, and transmits the paging message indicating a change in the system information broadcast to the mobile terminals [1]. When the mobile terminal receives the CTCH Indicator, it begins monitoring the CTCH logical channel and can receive CBS messages.

In ETWS, by including the Warning Type in the paging message indicating a change in the system information broadcast, processing for a pop-up display[*17] and alert sound processing (Primary Notification) at the mobile terminals according to the Warning Type can be executed in parallel to the processing at the mobile terminals to start receiving the CBS messages. This enhancement allows users whose terminals are in the connected state (RRC_CONNECTED) to also receive emergency information[8]. In the previous system, it was not possible for these users to receive emergency information. Also including disaster type information (Message Identifier and Serial Number) in this paging message makes it possible to prevent receiving multiple messages containing the same emergency information at the mobile terminal.

More detailed information (Secondary Notification) is provided in CBS messages in the same way as in the conventional Area Mail system, thus achieving an architecture that is common to ETWS users and Area Mail users.

*14 **Warning Type**: A parameter that specifies the disaster type in the Primary Notification.
*15 **CTCH**: A one-to-many one-way channel used for data alerts to all of the mobile terminals accommodated by a base station or a specified set of those terminals.
*16 **BTS**: 3G radio base station.
*17 **Pop-up display**: The display of a simple text message or image on the device screen.

6. Conclusion

There is international awareness of the need to prepare for a variety of threats to public safety, and work on standardizing an emergency information distribution platform has been done. The standardization has achieved wider distribution that is more efficient and faster that the earlier Area Mail system.

In future work, we look forward to development of the PWS by extending the base of requirements for ETWS in Japan with additional requirements for the United States and other countries. The International Telecommunication Union (ITU) and other standardization organizations are also engaged in the same kinds of activities, so we can expect emergency information distribution via mobile terminals to spread worldwide.

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