Safety | Earthquake Early Warning | Broadcasting Distribution Function

Technology Reports

# Emergency Information Broadcasting Distribution System

*Systems for broad and general emergency distribution of earthquake early warnings are being investigated in many places as a useful means of reducing damage from earthquakes. As an implementation of a broadcasting distribution service, NTT DoCoMo has developed a system that uses the CBS to achieve simultaneous information distribution when an emergency occurs, thus providing an infrastructure for safe and secure living.*

***Masateru Nakao, Masashi Onogi, Karin Sugiyama, Takahiro Hayashi and Hideyuki Sakuramoto***

## 1. Introduction

In recent years, Japan has suffered in frequent major earthquakes that had magnitudes of 6 or higher on the Japanese scale, including the Chuetsu Earthquake in Niigata Prefecture in 2004 and the Noto Peninsula Earthquake in 2007. The enormous damage that resulted from those earthquakes raised the interest in earthquake countermeasures to a very high degree. Those circumstances led the Japan Meteorological Agency (JMA) to hold "the Study Session on Implementation of the Earthquake Early Warning" [1] in 2005. On August 1, 2006, limited provision to local governments and research organizations began, and general distribution of the earthquake early warning began on October 1, 2007.

The earthquake early warning is not restricted to TV and radio, but also includes fixed-line phones and mobile phones. It is therefore expected to provide broad public notification. Mobile phones in particular are suitable for receiving the earthquake early warning 24 hours a day.

This article explains the emergency information broadcasting distribution system (hereinafter referred to as emergency information "Area Mail") that has been made available beginning with the FOMA 905i series.

## 2. Overview of the Emergency Information "Area Mail" Broadcasting Distribution System

The emergency information "Area Mail" is a message based on the earthquake early warning distributed by the JMA via emergency information "Area Mail" distribution system developed by NTT DoCoMo. The distribution concept is shown in **Figure 1.** The location of the epicenter and the magnitude of an earthquake are immediately detected at observation points near the earthquake epicenter, and estimated from the difference in arrival times of the Primary (P) wave (about 7 km/s) which is produced by the initial tremor of the earthquake, and the Secondary (S) wave (about 4 km/s) which is produced by the principal motion. A prediction of the magnitude and arrival time of the earthquake can then be sent out as a warning. Emergency information "Area Mail" converts the earthquake early warning distributed by the JMA in an emergency information "Area Mail" message and broadcasts the message to mobile terminal users who are in the affected region.

## 3. System Implementation

### 3.1 Main specifications

The emergency information "Area

Mail" distribution system is designed to satisfy the following requirements.

1) When and Where to Distribute

The JMA divides the nation into 186 warning areas (metropolitan Tokyo, eastern Kanagawa Prefecture, etc.). Those areas serve as the basis for the distribution of this service. A message is distributed to areas for which tremors of magnitude 4 or greater are expected when the estimated maximum magnitude is somewhat less than 5 or higher.

2) To Whom to Distribute

Users that have the emergency information "Area Mail" supported mobile terminals and are in the distribution area.

3) Time before Distribution

The message must be distributed as soon as possible because earthquake ground movement may start earlier, particularly in locations near the epicenter.

4) Contention with Other Services

The nature of emergency information requires that it must be distributed to all users with higher priority as possible than other services.

5) Content of the Emergency Information "Area Mail" Message

At the "Study Session on Implementation of the Earthquake Early Warning" held by the JMA, it was decided to use, as much as possible, the same text content that is displayed as a superimposed message in TV broadcasting for distribution to mobile terminals. The text is

"Earthquake early warning ○○○: Strong earthquake in region △△△ □□□" in Japanese.

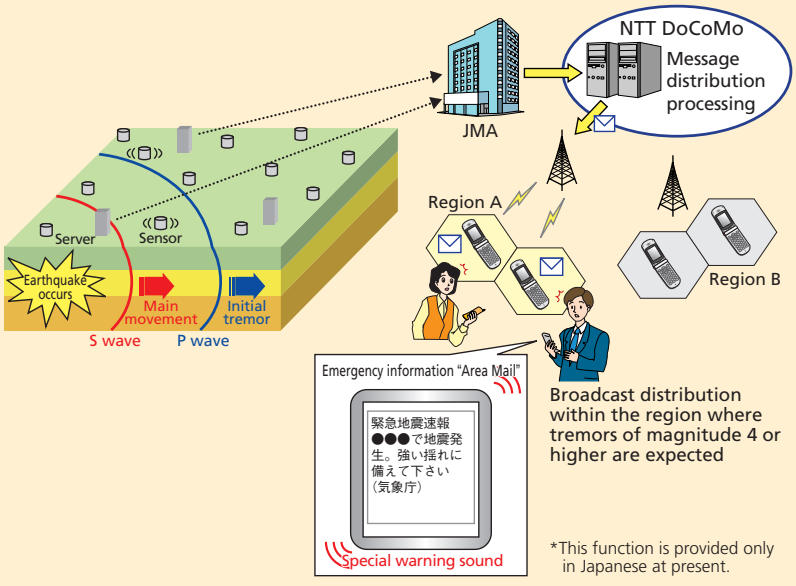



**Figure 1 Distribution of emergency information "Area Mail"**

### 3.2 Implementation

We studied the broadcasting distribution system taking the five requirements listed in Section 3.1 and the time frame up to implementation into consideration, and chose to adopt the Cell Broadcast Service (CBS)[*1] [2] system because of the large amount of experience accumulated in its introduction overseas and because it has the shortest implementation period. The network configuration and an overview of using the CBS system for the broadcasting distribution system is described in Chapter 4.

## 4. Network Configuration and Overview

The process flow from emergency information "Area Mail" distribution to reception of the message is shown in **Figure 2**. The JMA creates an earthquake early warning telegram (dedicated protocol) that contains the earthquake epicenter, magnitude information by region, and other such information and sends the telegram to operators that are connected to the system (Fig. 2 (1)). The earthquake early warning that is distributed by the agency is distributed to users via the Japan Meteorological Business Support Center. NTT DoCoMo receives the earthquake early warning telegram at the broadcasting distribution facility (Cell Broadcast Center: CBC[*2]), which is connected to the JMA, and parses the information. The CBC determines the target areas for distribu-

*1 **CBS:** Broadcast distribution system standardized by 3GPP.
*2 **CBC:** Terminates an interface with the JMA and sends messages to RNC (see *7).

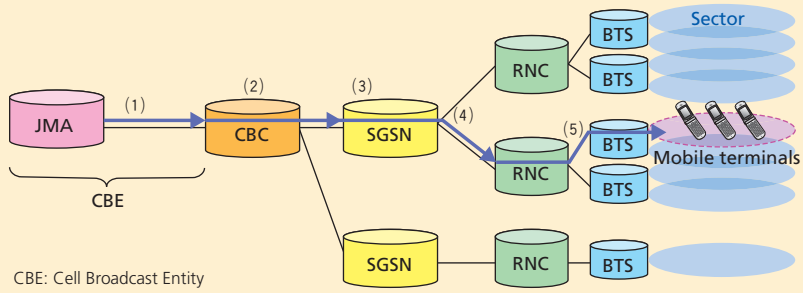



**Figure 2 Flow of messages received from the emergency information "Area Mail" distribution**

tion from the "regions expected to be strongly affected" contained in the telegram and creates a message for distributing to the mobile terminals in these areas (Fig. 2 (2)). The Serving General packet radio service Support Node (SGSN)[*3] is interfaced with the CBC and receives the Write-Replace[*4] (message) that is contained in the message from the CBC and gives instructions for distribution of the message to mobile terminals over the Service Area Broadcast Protocol (SABP)[*5] (Fig. 2 (3)). The SGSN uses the existing Iu interface[*6] with the Radio Network Controller (RNC)[*7] to send the Write-Replace received from the CBC to the RNCs that accommodate the distribution areas (Fig. 2 (4)). The RNC that receives the Write-Replace converts the CBS message to the Broadcast Multicast Control (BMC) protocol[*8], which is used by the interface to the mobile terminals, for distribution to the terminals (Fig. 2 (5)). The inter-node protocol stack is shown in **Figure 3**.

## 5. Core Network Function Specifications

### 5.1 Operational Overview of CBC and SGSN

The operation of the CBC in the core network during emergency information "Area Mail" distribution is shown in **Figure 4**.

When the CBC receives the earthquake early warning telegram, it creates the text of the emergency information "Area Mail" message (Fig. 4 (1)). The "epicenter place name code," which is contained in the earthquake early warning telegram, is used as a key to look up the "epicenter place name" in an internal CBC database for insertion into the message text.

Next, the CBC similarly determines the destinations for distribution of the emergency information "Area Mail" from the "region code," which is also contained in the earthquake early warning telegram, and indicates regions in which serious effects from the earthquake are expected. The destinations are extracted as "local government codes," which uniquely specify every local government unit in Japan. The CBC manages the sector information in table format, arranged by the "local government code." That table is used to determine from the "local government code" the SGSN and RNC, which are the sector number and Write-Replace destination, to serve as the distribution destination area information (Fig. 4 (2)).

The CBC creates the Write-Replace on the basis of the information obtained

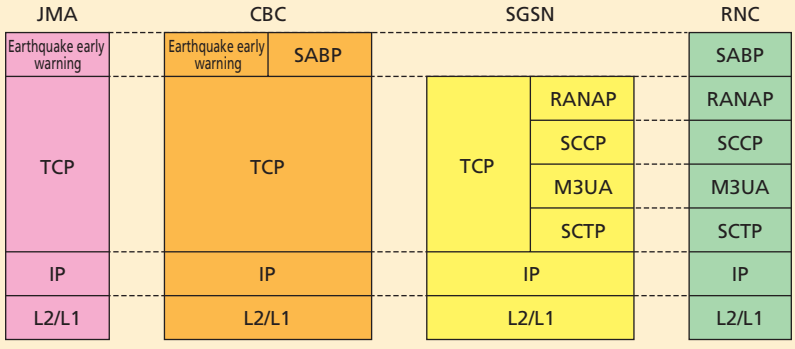



**Figure 3 Protocol stack**

*3 **SGSN**: 3GPP standard logical node name. Mainly provides packet services to mobile terminals.

*4 **Write-Replace**: 3GPP standard signal name. Indicates broadcast distribution. A signal sent from CBC to RNC that contains messages distributed to mobile terminals and the SAI (see*10) of the distribution destination.

*5 **SABP**: A protocol for exchange of CBS data and CBS control information between CBC and RNC.

*6 **Iu interface**: 3GPP standard interface between the RNC and the core network.

*7 **RNC**: 3GPP standard hardware for performing radio circuit and mobile control in the FOMA network.

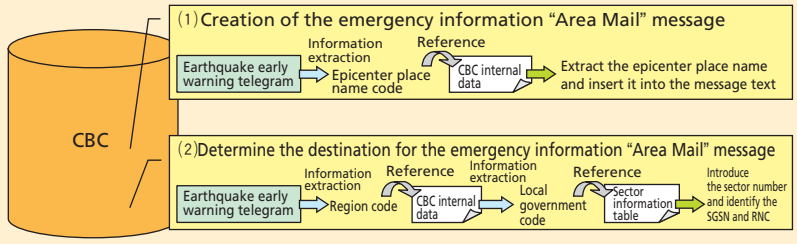



**Figure 4 Overview of CBC operation**

by the procedure and sends, to the SGSN, Write-Replace signals corresponding to the number of RNCs that accommodate the emergency information "Area Mail" distribution target sectors.

The SGSNs that receive the Write-Replace messages send them to the RNC that accommodate the distribution destination areas. The relevant port numbers are those of the SGSN that terminate the Transmission Control Protocol (TCP), because the SGSN allocates port numbers according to the number of RNCs, for the RNCs that correspond to the TCP port numbers that receive the SABP signal the TCP data (Write-Replace) received from the CBC is routed by specifying the CBC IP address in the data part of the Radio Access Network Application Part (RANAP) signal[*9].

Because the emergency information "Area Mail" must be rapidly distributed to users after the telegram is received from the JMA, the emergency information "Area Mail" is processed with priority if there is a contention with the distribution processing of messages other than the CBC earthquake early warning.

The priority processing allows priority distribution of emergency information "Area Mail" to mobile terminals that are in the sectors relevant to the "regions expected to be strongly affected" in accordance with the content of the earthquake early warning.

### 5.2 Process for an Issuing Telegram Cancellation Message

When the CBC receives an earthquake early warning telegram, it parses the received telegram. If it judges to cancel an already received earthquake early warning (previously issued telegram), a CBS cancellation message is prepared on the basis of the area information stored by the CBC. If the canceling telegram does not specify the distribution destination area information, the CBC recognizes the cancellation as applying to the "regions expected to be strongly affected" of the previously issued telegram and distributes the cancellation message to the area as the previously distributed CBS message. For that purpose, the CBC stores the information from the previously issued telegram for a certain period of time. The distribution sequence and routing are the same as for an ordinary earthquake early warning.

## 6. Radio Function Specifications

In this chapter, we explain the basic technology and distribution of the earthquake early warning in the area served by the wireless system.

### 6.1 Overview of Message Distribution by Radio System

When the RNC receives the Write-Replace signal from the CBC, it reads the Service Area Identifier (SAI)[*10], which is a list of combinations of the Base Transceiver Station (BTS) and sector numbers that are contained in that signal, to determine the target cells of the distribution. The BMC CBS Message signal is then sent only to the target cells, and the earthquake early warning message is transmitted to the radio area via a BTS. These procedures are executed for all of the specified cells (**Figure 5**).

### 6.2 Radio Channel Configuration

The CBS message distribution must, in principle, be delivered to all users within the cell. For simultaneous distribution to all users in the cell, rather than to users individually, the radio channel is set up on a common channel (Secondary Common Control Physical CHannel: SCCPCH). As shown in **Figure 6**,

*8 **BMC protocol**: Protocol for sending CBS messages from RNC to the mobile terminal.
*9 **RANAP signal**: Protocol for the exchange of control information between UMTS Terrestrial Radio Access Network (UTRAN) and the core network.
*10 **SAI**: An ID used to specify a sector.

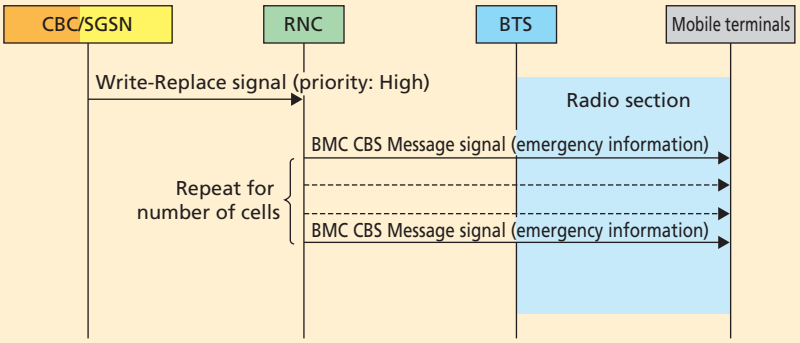



**Figure 5 Sequence from reception to transmission of CBS message in RNC**

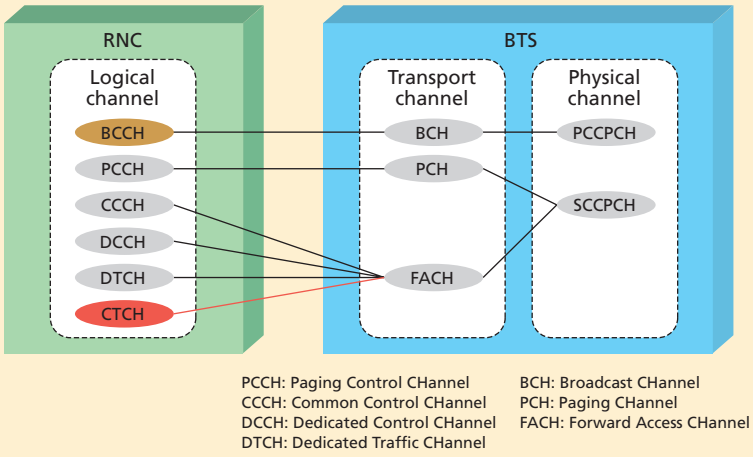



**Figure 6 W-CDMA system common channel**

multiple transport channels[*11] and logical channels[*12] that the system requires are available on SCCPCH, and the CBS message is transmitted on one of them, the Common Traffic CHannel (CTCH) logical channel.

In the common channel, as shown in Fig. 6, multiple logical channels share the same physical channel in a time-domain multiplexing configuration, so it is necessary to set an appropriate priority among the logical channels according to their use. As shown in **Figure 7**, the NTT DoCoMo CBS service satisfies requirement (3) of Section 3.1, so we chose to set the logical channel priority to the same as that for the BroadCast CHannel (BCCH)[*13], allowing transmission of the CTCH at a higher priority than the other logical channels. Thus, CBS messages can be sent quickly at an emergency.

## 6.3 CBS Service Notification

To notify mobile terminals of the availability of the CBS service, the 3rd Generation Partnership Project (3GPP) standard specifications provide a CTCH

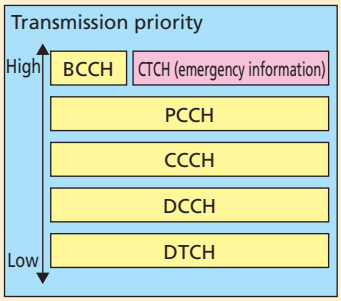



**Figure 7 Logical channel priority on SCCPCH**

Indicator[*14] in the BCCH information element that is transmitted via the Primary CCPCH System Information. Mobile terminals can be informed that CTCH is transmitted in the cell by setting the indicator value to TRUE [3].

## 6.4 CBS Message Distribution

The RNC transmits the BMC CBS Message signal to each cell as shown in Fig. 5. The information of the earthquake early warning is transmitted via the BMC CBS Message signal.

The CTCH transmission power is designed with consideration given to error rate in the radio transmission to achieve an adequate probability of signal arrival. Mobile terminals that are engaged in a call during CBS message distribution do not receive it on the common channel, so the system has the limitation that the message cannot be distributed to all mobile terminals. To increase the distribution probability, the same message can be sent repeatedly from the CBC.

*11 **Transport channel**: A channel defined between a physical channel and a logical channel. Establishing an intermediate layer between the physical channel and logical channel in W-CDMA which handles multiple logical channels, makes it possible to reduce the number of channels as seen from either the physical layer or the logical layer.

*12 **Logical channel**: The general name for channels that exist in the logical layer above the physical layer and the transport layer. It is a channel used by the mobile terminal and the RNC application layer.

## 7. Mobile Terminal Control

This chapter explains the mobile terminal control system in emergency information "Area Mail."

### 7.1 Mobile Terminal Control at Time of Reception

As described in Section 6.3, mobile terminals that recognize the presence of an emergency information "Area Mail" distribution by a changed data element in the BCCH, begin to receive emergency information "Area Mail" by CTCH.

The received message contains data elements called the Message ID and Serial Number. The Message ID indicates the source and topic (e.g., earthquake early warning from the JMA). The Serial Number contains a number that is unique to the Message ID and other such information. Messages can be distinguished by combining these two data elements as message-specific information. At the mobile terminal, these data element combinations are used to determine whether a received emergency information "Area Mail" message is a new message or is a retransmission of a message already received. Messages that have already been received are discarded.

On the other hand, messages judged to be new are stored in the incoming mail box in the same way as i-mode mail. In that case, a warning sound (buzzer) is played and the message content is presented in a pop-up display (**Photo 1**).

### 7.2 Implementation of CBC Controlled Warning Sound and Pop-up Display

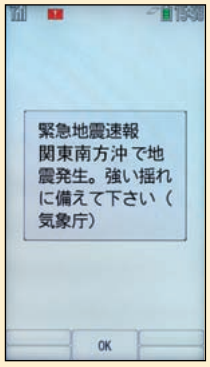
Assuming that, in the future, this broadcasting distribution system will be applied for the distribution of messages other than earthquake early warnings, we devised a way of indicating whether or not a message from the CBC is to be accompanied by a warning sound and pop-up display.

We placed two one-bit flags within the Serial Number described above to indicate whether or not the warning sound and pop-up display is to be used (**Figure 8**). Those two bits are respectively bits 5 and 4 of Oct 1. The mobile terminal decides whether or not to make the warning sound or present the pop-up display according to the values of those bits.

Also, to meet diverse user needs, a user setting is provided to disable the warning sound even if a message is received that has the warning sound flag set in the Serial Number.

## 8. Conclusion

We have explained the development of a broadcasting distribution service system for distributing an earthquake early warning received from the JMA to mobile terminals as emergency information. In future work, we will promote international standardization for even more advanced earthquake




*This function is provided only in Japanese at present.

**Photo1 Mobile terminal display**

| Serial Number | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct 1 | | | | | | | | Oct 2 | | | | | | | |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 0 | 1 | X | X | 0 | X | X | X | X | X | X | X | 0 | 0 | 0 | 0 |
| PLMN wide (fixed) | | Warning sound | Pop-up display | Reserved (fixed) | CBC number (0 – 3) | | | Increment counter (0 – 31) | | | | Fixed value (reserved) | | | |

PLMN: Public Land Mobile Network

**Figure 8 Serial Number**

*13 **Broadcast channel**: A common channel for reporting system operation information. Mobile terminals read this channel when their power is turned on and receive information that is needed to begin a call (operator code, common channel configuration, peripheral cell information, etc.).

*14 **CTCH Indicator**: An identifier that informs whether or not there is a CTCH.

early warning distribution systems and continue to investigate their practical application.

REFERENCES

[1] Japan Meteorological Agency: "Study Session on Implementation of the Earthquake Early Warning," http://www.seisvol.kishou.go.jp/eq/EEW/kaisetsu/Meeting_EEW.html
[2] 3GPP: TS23.041
[3] 3GPP: TS25.331

***Masateru Nakao***
**Core Network Development Department**

Joined in 1999. Engaged in the development of a broadcasting distribution platform and other IP services control systems.

***Masashi Onogi***
**Service & Solution Development Department**

Joined in 2003. Engaged in the development of new services, after working on the development of satellite mobile communication systems.

***Karin Sugiyama***
**Core Network Development Department**

Joined in 2000. Engaged in the development of core network equipment.

***Takahiro Hayashi***
**Assistant Manager,**
**Radio Access Network Development Department**

Joined in 1999. Engaged in development of W-CDMA systems, FOMA radio network design technology, and other such work. A member of IEICE.

***Hideyuki Sakuramoto***
**Communication Device Development Department**

Joined in 1998. Engaged in the development of protocol stack software for FOMA, after working on development of operation systems.