

Mobile Communication Technology and Cell Broadcast Service for Emergency Alerts in Taiwan

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ABSTRACT

Taiwan is located in the collision zones between the Eurasian Plate and the Philippine Sea Plate. This has resulted in frequent earthquakes in Taiwan. In addition, the torrential and heavy rains in summer and autumn caused by typhoons or monsoons also resulted in large-scale disasters that endanger citizens' lives and property. As the country is confronted by unfavorable environment and climate conditions, how disaster alerts and information are accurately and timely released has become an important topic for facilitating the evacuation of citizens and dispatch of disaster relief personnel. Although the frequent nature disasters are happened in Taiwan, the community is still under the situation of lack of efficient and fast Public Warning System (PWS). In view of the advantage of mobile-based technologies reported by the European Telecommunication Standards Institute (ETSI) in 2005, the development of effective and efficient warning system is committed and promised by government. This service combined the mobile communications technology to enable our government to, with the Cell Broadcast Service (CBS), instantly send alerts to all 4G and 3G (WCDMA) mobile users within the coverage of designated base stations and without being affected by the network congestion through broadcasting channels. The service has been finalized in May 2016. After sending the first alert of Earthquake Early Warning on May 12th, 2016, the benefit and advantage for timely notify citizens to evacuate and reduce casualties from the CBS system has been evaluated and proved, and then this CBS system has been authorized by government for published.

Keywords

Public warning system, cell broadcast service, natural disaster, alerts

INTRODUCTION

Due to climate change in recent decades, global warming has affected the climate system and resulted in temperature anomalies. Additionally, as Taiwan is located in the convergent boundary between the Eurasian Plate and Philippine Sea Plate in the Circum-Pacific Seismic Zone, the country suffers from natural disaster frequently [Yu et al., 2003]. Threatened by natural disaster, the key investigation including manpower and resources from Taiwanese Government is devoted to disaster prevention, relief and response. As we often race against the clock while conducting disaster prevention and relief missions, the country must develop a tool that can massively releases alerts to specific targets or in specific regions on time and without mistakes for the benefit of developing a long-term plan.

By the meaning of being an effective public warning message, the message shall be quickly and seamlessly broadcasted to assist all citizen escape from the attack of natural disasters such as tsunami, flood and typhoon, and to minimize possible damages. It also provides government agencies and infrastructure operators more time

to build a safety network and to conduct disaster prevention and relief missions.

The Tōhoku earthquake occurred on March 11, 2011, was an example of good applications, where instant warning messages were released by the Japanese Government's Public Warning System, showing an efficacy of helping people respond to disasters and reducing casualty rate. The U.S. Federal Emergency Management Agency (FEMA) started to broadcast Wireless Emergency Alerts (WEAs) to mobile devices for notifying people who is under imminent hazards situations in 2011. Communication technique for public warning messages delivered over mobile devices also been investigated and addressed by Bean et al., 2015, especially focus on the difference between academe and public application and understanding (Bean et al., 2015).

The emergency messaging service based on the mobile-based technologies had been reported by the European Telecommunication Standards Institute (ETSI) in 2005. According to the report from GSMA [GSMA, 2013], Cell Broadcast Service (CBS) is the one of two main the most suitable technologies for delivering a mobile-driven PWS. There are three characteristics of CBS, Message Display, Message Delivery, Message Security, that make CBS is more appropriate as a PWS comparing with Short Message Service (SMS). CBS is with the capability for sending massive messages to specific targets in specific locations within specific timeframe quickly, timely, accurately and safely.

For so long, the warning messages always announced by government via the TV, radio station and internet website with the individual disadvantage. Following the popularization of mobile devices and the wide converge of mobile communication network, the government and telecom industry have cooperated to develop public warning system that enables users to receive cell broadcast messages with mobile devices. The reliable cell broadcasting technique has been proofed with advantages during emergencies happened as it operates on a separate frequency network from the frequencies used for phone calls (Mahan et al., 2009; Wong et al., 2017). This technology also has been implemented (similar) in Lithuania, Israel, Japan, and Chili (Gutteling et al. 2014; Gutteling et al. 2017).

DESIGN OF THE CBS-BASED PUBLIC WARNING SYSTEM IN TAIWAN

Taiwanese government intend to develop the system, which can send massive emergency broadcast messages every minute and is not affected by network congestion, enables 4G and 3G (WCDMA) mobile users in specific areas to instantly receive alerts released by central regulating authorities for disaster prevention and protection.

For example, instant torrential rain alert, instant earthquake alert, earthquake report, road closure alert, alert of reservoir flood discharge, debris-flow alert, epidemic alert, air defense alert and so on. It is critical and helpful for people to respond to disasters timely.

Based on the advantages of CBS and the applied models from Europe, U.S. and Japan, Taiwanese PWS is designed based on CBS to coordinates with disaster alert and message transmission platforms of the central regulating authorities for disaster prevention and protection. The emergency messages sent to local users' mobile communication devices enable them to respond to emergencies timely and result in a reduction of casualty.

Considering the dense distribution of mobile infrastructure and frequent typhoons and earthquakes in Taiwan, National Communications Commission (hereinafter shortened as NCC) promulgated "Regulations for Administration of Mobile Broadband Businesses" and "Technical Specifications for Mobile Broadband Subscriber Station, PLMN10" in 2013 for the needs of the country's long-term goals of disaster prevention and relief plans. According to these regulations, telecom industry are requested to build cell broadcast centers (CBC), provide public warning messages and list 4G LTE mobile phones on the compulsory examination list.

At the present stage, messages announced by our system are divided into "presidential (presidential) alert" and "alert notification" as follows:

- National Alert (or "Presidential Alert"): is released when there is a potential and immediate danger. For example, earthquake alert, air defense alert and some other emergency messages. This kind of message is received by citizens' mobile phones compulsorily and has unique alert alarm.
- Alert Notification: messages of this kind are relatively less emergent despite their connection to citizens' lives. No alert alarm goes with these messages and people can decide to receive them or not by adjusting their mobile phone setting.

The public warning system is formed by "government's public warning messages", "message collection and gathering", "messaging channel" and "applications" (as shown in Figure 1).

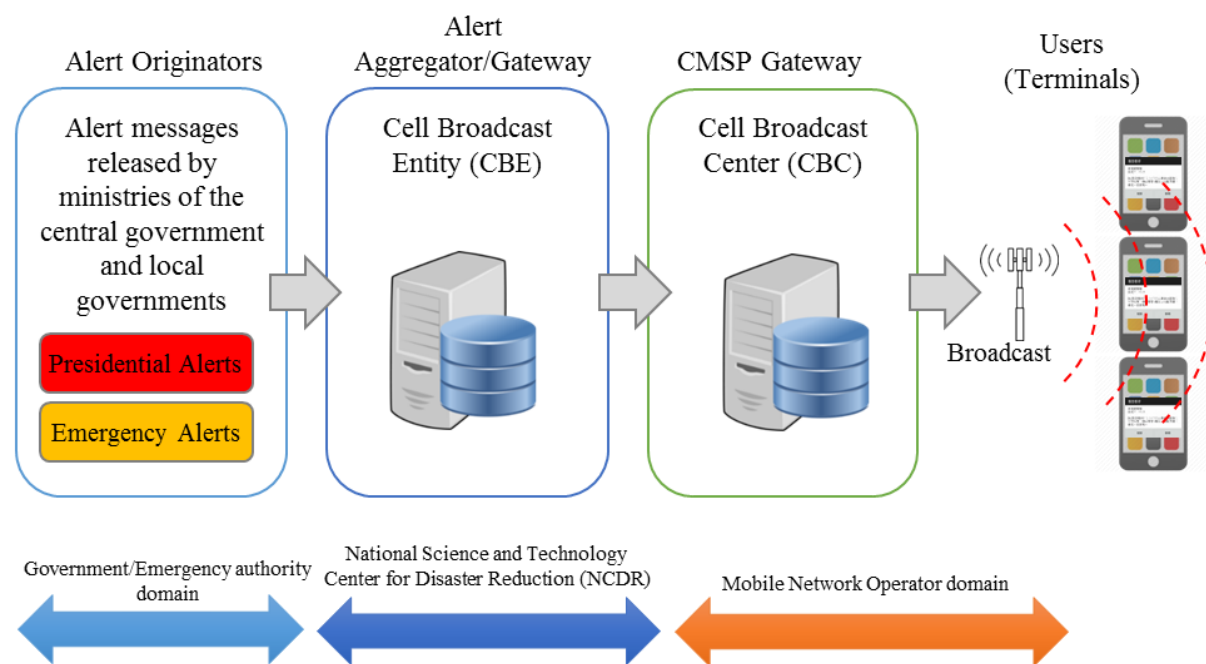


Figure 1. The PWS Framework

Upon the receipt of warning messages, central and local agencies of Taiwanese government (Alert Originators) will send the messages to Cell Broadcast Entity (CBE), where all messages have their format unified by the National Science and Technology Center for Disaster Reduction (NCDR) (Alert Aggregator/Gateway) before being sent to Cell Broadcast Centers (CBC) established by mobile network operator (CMSP Gateway). Then the messages will be sent to 4G or 3G (WCDMA) mobile phones of mobile communication operators' users (Users / Terminals).

THEORY AND IMPLEMENTATION OF CELL BROADCAST SERVICE

Taiwan public warning messages are mainly transmitted through CBS. The theory of cell broadcast is that every mobile communication base station contains one to several cells and is the smallest unit of cell broadcast. A broadcast region may have one or several cells, or have the entire public land mobile network (PLMN). Similar to television broadcast, cell broadcast sends messages to all receivers in specific regions.

CBS is the standard of global system for mobile communications (GSM) defined by European Telecommunications Standards Institute (ETSI). With applications mainly formed by base stations and mobile phones, it is originated from the GSM system (2G) and then extended to UMTS (3G) and LTD (4G) systems. At the current stage, the system 2G had been disabled by Taiwanese government few years ago. The percentage of mobile phone user between used system 3G and 4D are around 35.6%, and 64.4% respectively in 2016.

CBS is different from SMS-PP (Short Message Service – Point to Point), which sends messages only to one or few receivers through the core network of mobile communications and is easily blocked by network congestion. Figure 2 shows the framework of CBS.

Cell broadcast messages can only be sent from the base station to users' terminal devices as cell broadcast provides unidirectional transmission. The processes are: the cell broadcast entity (CBE) edits the message content and transmits the message code and content, including the transmission details, time, frequency, range and other parameters, to the cell broadcast center (CBC) through network. CBC then unifies geographical information of all regions and transforms them into cell information that covers the transmission range before sending them to the network management platform. The platform then transmits these messages to the responding base station, base transceiver station or eNodeB through equipment like IP router and MME. Next, the base station transmits the message code and content through cell broadcast, enabling terminals (users' devices) within the radio coverage to receive the message.

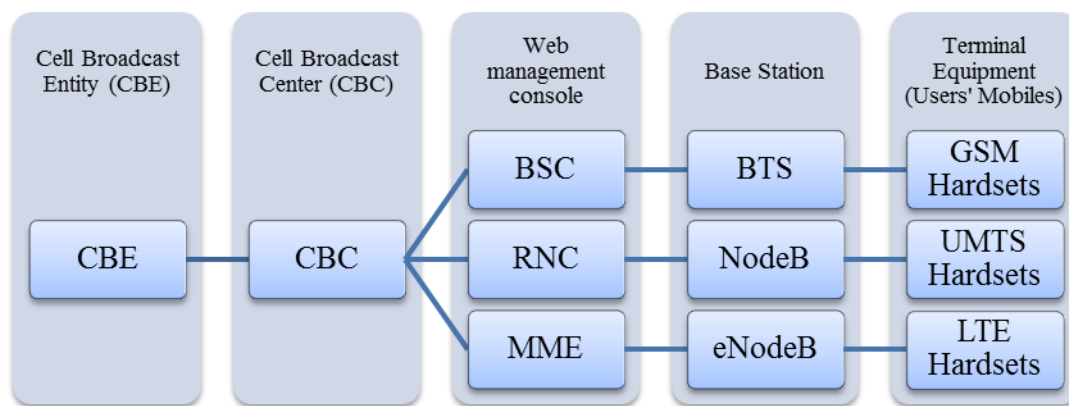


Figure 2. Framework of the CBS network

According to above principles, cell broadcast has adopted base station broadcast method to send out emergency messages through independent channels. This is the reason that specific messages can be simultaneously sent to ten thousands to millions of mobile communication devices in specific regions within few seconds and without being annoyed by network congestion. Below are the features of cell broadcast:

- Unidirectional broadcast, where messages can only be transmitted from the base station to users. No interaction with the user is required;
- Being able to quickly and massively transmit messages to millions of users every second;
- Possible to set the broadcast cycle including the time of starting / ending the broadcast and the broadcast frequency;
- A wide coverage with high regional adjustability. Different messages can be transmitted to different regions according to the level of disaster impact;
- Fast transmission through independent channels and without being affected by network congestion.
- High reliability. The messages are transmitted only by certified and authorized units, providing high reliability of the information source;
- A high penetration rate of the terminal device (mobiles), where the devices can be carried by people around.

As CBS identified different channels through message codes, message code is considered as the channel code. National Science and Technology Center for Disaster Reduction has listed message codes adopted by CBS and responding warning messages as below table (Table 1), which is made by the National Science and Technology Center for Disaster Reduction, has listed message codes for CBS provided by our country and the responding warning messages.

Table 1. CBS message codes and responding alert messages

Cell Broadcast Service Message Forwarding Unit	Notification	Message Code / Channel Coding
Central Weather Bureau	Torrential rain alert	Alert Message(911)
	Earthquake early warning	National Alert (4370)
	Tsunami alert	Alert Message(911)
Directorate General of Highways	Road closure alert	Alert Message(911)
Water Resources Agency	Reservoir discharge alert	Alert Message(911)
Soil and Water Conservation Bureau	Debris-flow alert	Alert Message(911)
Directorate-General of Personnel Administration	Suspension of offices and classes	Alert Message(911)
Centers for Disease Control	Epidemic disease(s)	Alert Message(911)
	International epidemic alert	Alert Message(911)
Civil Defense Headquarters	Air defense alert	National Alert (4370), Alert Message(911)

Among them, Channel 4370 (National Alert /Presidential Alert) is for disaster prevention and protection related

cell broadcast messages and cannot be switched off. Warning messages sent by Channel 911 (Alert Message) can be switched on or off depending on the user.

Besides, our country's CBS followed NCC's Technical Specifications for Mobile Broadband Base Station to add unique alarm to warning messages (the sound is different from that of ordinary SMS). This alert alarm is featured with specific frequency and intervals, and cannot be set or adjusted by users. Those who have adopted mixed audio frequency shall have the sounds created by fundamental frequencies (853Hz and 960Hz); those who have adopted monosyllabic audio frequency shall have the sounds created by 960Hz. Specific intervals: the alert alarm rings two times every time with an interval of 0.5 second. For each time, it rings 2 seconds once and 1 second twice with an interval of 0.5 second. The pattern repeats twice to create the alert alarm.

STATE OF APPLICATION DELIVERY

The system was authorized by government and published officially in May, 2016. On 22-June-2018, the heavy rain fall event was predicted and warned by Central Weather Bureau, Taiwan. The alerts were sent successfully and efficiently in time by the system. The amount of people who received the warning message in 0.41sec when disasters happened can reach millions people. The alert from the system shown on the cell phone and scene photos of this event are presented as figure 3.



Figure 3 Torrential rain alert and Scene photos (Oingshan Elementary and Junior High School) on 6/22, 2018

CONCLUSION

Not only the introduction of the mobile communications technology and CBS based public warning system are represented by this investigation, but also the great ability, excellent outcomes and milestone for integrating regulating authorities from up to down streams has been demonstrated by the Taiwanese government. Apart from a perfect integration of government agencies, all citizens are encouraged to possess CBS compatible mobile communication devices and be familiar with this service in order to be alerted to disasters or emergency issues.

The appropriate promotion of the system will be conducted for the capability extended to nationwide as the achievement of next phase. The guidance for dealing with the response to the situation under disasters happened will also be announced for all citizens. The system will then be able to protect our homeland and nation while perfecting our country's public warning services.

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