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Scientific Brief

Public Alerting Over Long Term Evolution (LTE) Wireless Networks: Technology Overview

Background

The purpose of this Scientific Brief is to provide a high-level overview of two approaches for wireless dissemination of alert messages over 4G LTE networks. This was requested after a DRDC-Centre for Security Science briefing on Wireless Alerting in August 2015. A detailed technical advisory note on this topic was prepared by DRDC in April 2015 at the request of the CRTC [1].

A public alerting system provides emergency management organizations the tools to warn and inform the public in times of impending emergencies such as hurricanes, tornados, floods, forest fires, explosions, child abductions, etc. An effective public alerting system helps limit or prevent social, economic, physical, and human losses that can occur during such emergencies.

Typically, alerting systems broadcast warning messages using radio, television, social media, and reverse-911 calls to landline phones. However, given the rapidly increasing number of mobile devices operating over different wireless access technologies, the need to leverage mobile wireless networks for public alerting in times of crisis becomes evident. Figure 1 illustrates the envisioned flow of alert messages within a Canadian public alerting system. The wireless public alerting function is highlighted in the figure.

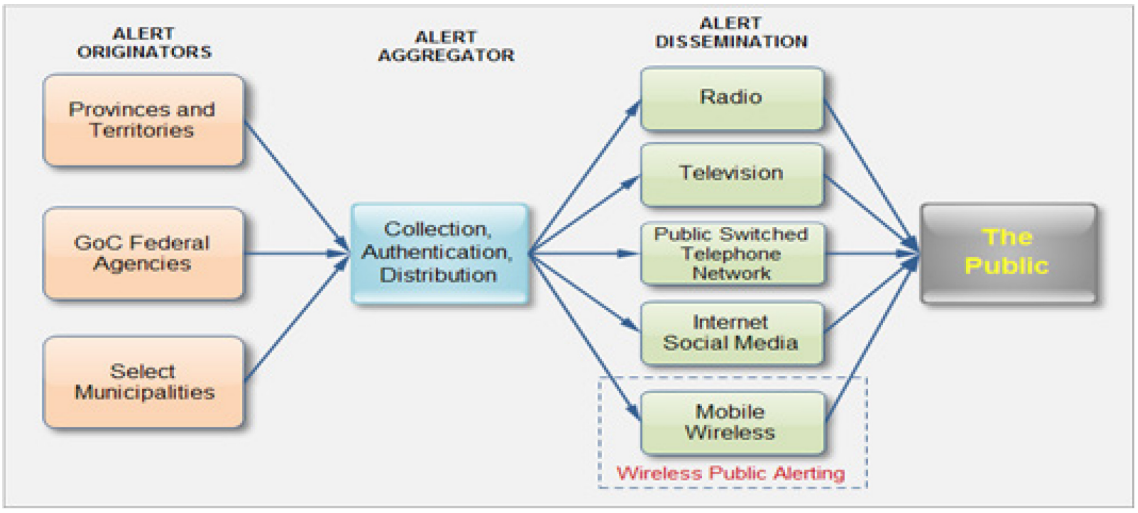

Figure 1: *Illustration of the flow of alert messages envisioned for a Canadian Public Alerting System (source: Ref.1).*

Wireless Public Alerting Approaches

Two approaches for the wireless dissemination of alert messages are considered in this Scientific Brief. One approach is a public alerting service called Short Message Service-Cell Broadcast, commonly referred to as cell broadcast service (CBS). The second approach is called Short Message Service-Point to Point, commonly referred to as the well-known short message service (SMS). LTE technology processes CBS and SMS differently than previous generations of wireless technologies. The key attributes of each approach are presented here and summarized in Table 1.

Cell Broadcast Service

The 3rd Generation Partnership Project (3GPP) is the authority for the specifications of 2G, 3G, and 4G/LTE wireless standards. The attributes concerning CBS examined in this section are in the context of 4G/LTE wireless dissemination. CBS is the mechanism specified by the 3GPP to broadcast alert messages to all mobile devices within a designated geographical area. Similar to radio and television, CBS is a one-to-many communication method where a single message is sent to all mobile devices simultaneously in a single communication instance. Hence, the time delay from the originator issuing an alert to its dissemination over a wireless network using CBS is in the order of a few seconds. LTE uses a special over-the-air channel to carry the CBS messages. The user device must have this channel enabled in order to receive CBS alert messages. Earlier this year, the CRTC Interconnection Steering Committee, in collaboration with DRDC-CSS developed the specifications for mobile handsets to support CBS alerting. One of the specifications concerns a unique vibration and audio cadence for alert messages, which would be programmed by the wireless service provider. The alert notification for CBS cannot be changed by the user, unlike SMS-based alerts. The specifications have been accepted by the Alliance for Telecommunications Industry Solutions (ATIS) and it is, therefore, expected that CBS-capable handsets that comply with Canada-specific wireless alerting requirements will become available.

The Wireless Emergency Alert service in the United States of America (US) uses CBS and is operated by the Federal Emergency Management Agency (FEMA) as part of the Integrated Public Alert Warning System (IPAWS). In the US, devices that are capable of receiving CBS alerts are identified with the logo shown in Figure 2. Mobile devices whose service subscriptions are inactive would also receive the alerts. Since the CBS messages are sent over a special channel, CBS messages do not compete for the wireless cell site's capacity.

Figure 2: *Logo on packaging for CBS capable devices sold in the U.S.*

CBS messages are not sent to individual phone numbers. They are sent to cell sites, and more specifically to the sectors[1] that are contained within a geo-fenced alerting area that the alert originator defines. CBS message transmission is unidirectional and there is no acknowledgement of receipt from the mobile devices. However, the LTE infrastructure is able to

[1] Typically, a cell site is divided into three sectors, each one covering approximately 120°.

notify the Alert Aggregator if the message dissemination was successfully or unsuccessfully completed with the level of granularity of one sector. CBS messages do not pre-empt ongoing voice calls even if the message priority is designated as “high”. Until the wireless service provider (WSP) implements voice over LTE (VoLTE) services, a user engaged in an active voice call would not receive an alert message. The alert originator may set the alerting process to repeat an alert message with a configurable periodicity and duration. CBS messages can have a maximum length of 10,971 characters.

Short Message Service

SMS is a one-to-one communication service, meaning that a designated bi-directional communication session is established between two endpoints and, therefore, the mobile device can acknowledge the receipt of an SMS message. SMS-based messaging uses the location of the mobile devices to know where to send the messages in order to avoid needlessly paging a mobile device across the entire network of the wireless service provider (WSP). There are a number of industry-standardized and proprietary ways to estimate the location of mobile devices, with varying precision. Australia has opted to use Location Based SMS (LB-SMS) public alerting.

Although LTE does not support SMS natively, there are two methods to enable SMS messaging over LTE networks that have been standardized by the 3GPP. The Signaling Gateway Short Message Service (SG-SMS) method is intended as an interim support for SMS over LTE until wireless carriers upgrade their networks to support IP-based messaging, also known as IMS-SMS. SG-SMS messages are limited to 160 characters and are sent over a signalling channel. Messages that are longer than this are sent over multiple message instances (concatenated) but, upon reception, they can be truncated or received out of sequence at the mobile device which is not desirable. Internet Protocol Multimedia Subsystem Short Message Service (IMS-SMS) does not impose a limit on the message size. A cell site can become overloaded if there are a large number of SG-SMS messages that are sent in a short period of time to it, which could be the case for alert messages. To alleviate this, the WSP can tune the rate of dissemination, but because the tuning is done at the network-wide level, the WSP must balance the rate of dissemination versus the points where the cell sites become overloaded, which is different for each cell site. Hence, for the same rate of dissemination of SMS messages, some cell sites would become overloaded while others would not.

IMS-SMS can disseminate a larger number of messages in less time than SG-SMS, but can contribute to network congestion since it shares the network resources with other types of traffic such as voice, video, and data. The WSP can process IMS-SMS alert messages with higher priority if required, but this may have a negative impact on the other traffic especially during an emergency when, typically, the demand for wireless services is much higher.

Since the SMS messages are processed sequentially user-by-user, the time for messages to be delivered is variable. Some users will receive messages nearly instantaneously, while others will experience a more significant delay. The more alerts that are disseminated, the longer would be the delay. This especially affects SG-SMS messages since a signalling channel is used to send those messages rather than the much greater channel capacity that IMS-SMS can use.

Comparison of Technical Attributes

The following table summarizes the major differences between CBS and SMS-based public alerting with regards to their technical attributes.

Attribute	CBS	SMS
1. Delay to disseminate the message.	In the order of seconds; message is broadcast to all intended recipients simultaneously.	Since messages are processed sequentially user-by-user, the time for messages to be delivered is variable.
2. Impact of traffic loading of the 4G base station.	Message broadcast is unaffected by the traffic loading on the base station. Does not contribute to additional traffic loading on the base station.	Messages may be dropped and re-transmitted if the base station experiences traffic congestion. Adds to traffic loading of the base station.
3. Impact of user devices on the ability to receive alert messages.	a) User devices must be capable to receive alert messages. b) User devices that are CBS-capable are able to receive CBS messages even if the user's service subscription is inactive, expired, or suspended.	All user devices, including those that are roaming, are able to receive SMS messages.
4. Geo-targeting precision of alerting area.	The current size of the alert area can be from less than $1km^2$ to more than $300km^2$, and is dependent on the spacing of the cell sites. As smaller cell sites emerge, alert areas can be reduced.	Precision can be as high as 5m using GPS-assisted methods, or as low as 300m using triangulation methods.
5. Acknowledgement of receipt.	Done at the sector level.	Done at the user device level.
6. Ability to receive alerts during active voice calls.	a) If the wireless network uses circuit-switched voice fallback, the users would not receive the alert message. b) If the wireless network uses VoLTE, the users will receive a notification of an incoming alert message.	Users receive a notification of incoming alert message.
7. Alert attention signal.	Configured by the wireless service provider.	Configured by the user.

***Table 1**: Comparison of key attributes between CBS and SMS-based public alerting.*

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References

[1] DRDC-CSS Technical Advisory Note, "Public Alerting over Long Term Evolution (LTE) Wireless Networks: Technology Overview", TAN Z43, April 22, 2015.