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The application of location based services in national emergency warning systems: SMS, cell broadcast services and beyond

Anas Aloudat
University of Wollongong

Katina Michael
University of Wollongong, katina@uow.edu.au

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Abstract
Location-based services can be broadly defined as any service that provides information pertinent to the current location of an active mobile handset at a specific window of time, regardless of the underlying delivery technology used to convey its information. To date, the short message service and cell broadcast service have been utilised by several countries during emergencies, however the future indicates that these services while cost-effective today, will almost certainly be superseded in the next five to ten years by newer more powerful capabilities. The path forward in location-based emergency services in Australia is given against a backdrop of the E911 experience in the United States, and supplemented with additional mini-cases of other national LBS deployments for emergency services also presented. Of particular importance is how location-based public alerting and warning systems are implemented using legislation or contractual service level agreement instruments or a hybrid approach. Of relevance here is also whether or not governments who deploy LBS for emergencies will carry the cost of the deployment during an emergency or disaster and whether or not carrier participation is mandated by the government. Finally a comprehensive list of general requirements for location-based emergency services is shown. In essence these are recommendations to be adhered to if robust solutions are to be deployed in a nation state.

Keywords
location, services, beyond, warning, systems, sms, cell, broadcast, application, emergency, national

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The Application of Location Based Services in National Emergency Warning Systems: SMS, Cell Broadcast Services and Beyond

Anas Aloudat, Katina Michael

School of Information Systems and Technology, University of Wollongong

Summary

Location-based services can be broadly defined as any service that provides information pertinent to the current location of an active mobile handset at a specific window of time, regardless of the underlying delivery technology used to convey its information. To date, the short message service and cell broadcast service have been utilised by several countries during emergencies, however the future indicates that these services while cost-effective today, will almost certainly be superseded in the next five to ten years by newer more powerful capabilities. The path forward in location-based emergency services in Australia is given against a backdrop of the E911 experience in the United States, and supplemented with additional mini-cases of other national LBS deployments for emergency services also presented. Of particular importance is how location-based public alerting and warning systems are implemented using legislation or contractual service level agreement instruments or a hybrid approach. Of relevance here is also whether or not governments who deploy LBS for emergencies will carry the cost of the deployment during an emergency or disaster and whether or not carrier participation is mandated by the government. Finally a comprehensive list of general requirements for location-based emergency services is shown. In essence these are recommendations to be adhered to if robust solutions are to be deployed in a nation state.

1 Introduction

Emergencies and disasters have been part of our existence since time began. But even today, the risks of a wide range of known and previously unknown hazards continue to challenge society. The New York terrorist attacks (2001), the Indian Ocean Tsunami (2004), Hurricane Katrina (2005) and the Black Saturday bushfires in Australia (2009) are just a few examples of large-scale hazards. Despite the technological advancements nations are achieving, they still remain at the mercy of large-scale disasters. Emergencies are generally hard to predict, control or manage. Their complexity, surrounding uncertainty, timing, consequences and potential severity always pose significant challenges to governments, aid agencies and the affected population at every stage of their occurrence. Accordingly, these extreme situations are unique contexts in which people are in continuous need of information. The lack of timely safety information where it is most needed has the potential to turn an ordinary hazardous event into a serious situation that could result in major consequences. This is especially true now, with the increased prevalence of emergencies and disasters in recent years not only in Australia but also worldwide (Coyle and Meier, 2009, United Nations News Centre, 2010). According to the United Nations’ International Strategy for Disaster Reduction (UN/ISDR Platform for the Promotion of Early Warning, 2005), one of the main reasons for losing lives in emergency events is the lack of alert information just in time. Unfortunately, this same issue has been amongst the main reasons that played a role in the bushfire disaster on February 7th 2009 in Australia, which left 173 dead and destroyed well over 2000 homes and businesses (The Victorian Bushfires Royal Commission, 2009).

2 Emergency management and mobile phone services

In response to emergencies and disasters, emergency management activities have long been practiced by people and governments. Such activities evolved from simple precautions and scattered procedures into
more sophisticated management processes and systems that include preparedness, protection, response, mitigation and recovery strategies (Canton, 2007). In this regard, governments have long been utilising various techniques and technologies, such as signage, sirens, speakers, radio, television, landline telephones and the internet, to communicate and disseminate critical time-sensitive information to people about impending dangers, as events have occurred and immediately following events.

It has long been known that not all technologies can reach everyone in the event of an emergency. In addition, different methods of warning are not equally effective at providing an alert or notification in different physical and social settings (Mileti and Sorensen, 1990). Governments around the world have also been exploring the utilisation of new feasible channels including proprietary solutions and private infrastructure to communicate with people during emergencies. In this sense, mobile telecommunications networks have been exploited in the past few years as a means to provide an additional flow of information to people beside the conventional channels. Fortunately, there have been dramatic advances in these networks, specifically in their spread, range and functionality (Kolodziej and Hjelm, 2006) to allow some specific technologies and services to be effectively employed in the domain of emergency management.

Amongst these, location-based services (LBS) have been suggested, trialled or implemented in several countries around the world. LBS in these scenarios is used to find the pinpoint geographic location of a mobile handset, after the handset user has initiated an emergency mobile phone call or a distress short message service request for help. LBS can also be used to disseminate warning messages and relevant safety information to people via their active mobile handsets located within a defined geographic area of the emergency in regard to severe weather conditions, an act of terrorism, an impending natural disaster or any other extreme event (Krishnamurthy, 2002, Weiss et al., 2006, McGee, 2008).

It is quite true that mobile telecommunications services are highly dependent on infrastructure and large-scale emergencies or disasters can significantly impact the effectiveness of their underlying infrastructures. Nonetheless, the availability and pre-positioning of mobile cell towers and generators have greatly increased the resilience of the cellular networks in recent years, and the persistent transmission technologies in these networks have also proven to be reliable in areas devastated by severe events (Kiefer et al., 2008). As a result, LBS can be utilised within these networks to provide information across all phases of an emergency. Before a specific event, critical information messages about the risk or evacuation measures can be disseminated to people who are in the vicinity of that risk. During the event, experience has shown that safety messages often have the best chance of working, despite damaged infrastructure, because these messages rely on persistent transmission technologies (Kiefer et al., 2008). After the event, messages can also be provided, even in an environment where much of the critical infrastructure remains dysfunctional (Kiefer et al., 2008, McAdams, 2006).

2.1 Gap in the Research

To a large extent, research into public offerings of location-based mobile phone emergency services i.e. government to citizen for emergency purposes have been limited. Save for technical feasibility studies worldwide about these electronic services there is a marked scarcity in theoretical and empirical research that specifically touches on the issues surrounding the utilisation of LBS for emergency management. Accordingly, there is an apparent gap in the current body of knowledge directed towards establishing the viability of location-based mobile phone services. This book chapter reviews the current state of play in the LBS emergency management domain with a view to informing Australian emergency management arrangements and practices.

3 Defining location-based services
Terms such as location-based services, location-dependent services, location-related services, location-enabled services, location-sensitive services and location services have been used interchangeably to describe the same type of services. See for examples Hjelm (2002), Jensen (2002), Holma et al. (2004), Lopez (2004), Spiekermann (2004), Bernardos et al. (2007) and Uhlirz (2007). Küpper (2005) has commented previously that one possible reason for this mixing of terminology might be due to the fact that the character and appearance of location-based services have been specified and implemented by different communities and industries, especially in the telecommunications sector and the ubiquitous computing area for a variety of applications.

In the context of LBS, location always refers to a spatial geographical location that is associated with a physical point or region relative to the surface of the Earth (Dawson et al., 2007). Accordingly, LBS are classified as a subset of a larger set called context-aware services, which are electronic services that automatically adapt their behaviour (e.g. filtering or presenting information) to one or more parameters (time, location, identity or activity) so as to reflect the context (personal, technical, spatial, social, or physical) of a target (person, animal or object) (Küpper, 2005). See Figure 1.

![Figure 1: Context-aware and location-based services. Adapted from Küpper (2005).](image)

LBS as a concept denotes applications that utilise the available geographic location information of a target device, being fixed, handheld, wearable or implantable, in order to add value to the provided service (The 3rd Generation Partnership Project, 2009, Perusco and Michael, 2007). Astroth (2003) defines a location-based service as “any application that offers information, communication, or a transaction that satisfies the specific needs of a user in a particular place”. Harvey (2008) simply defines LBS as “technologies that add geographical functions to other technologies”. Gruber and Winter (2002) state that an LBS is “any value-added service that takes into account a mobile agent’s actual location” while Shioe et al. (2002) delineate LBS as “services that provide geographically-orientated data and information services to users across mobile telecommunication networks”. Samsioe and Samsioe (2002) argue, however, that an electronic service that has location capabilities, should be able to fulfil the following three separate activities to be accurately defined as an LBS:

- Estimate the location of the device;
- Produce a service based on the estimated location; and

- Deliver the location-enhanced service to that device.

This strict definition excludes several services that employ location technologies in mobile telecommunications networks such as cell broadcasting services since these services cannot change their content when the physical location of a mobile handset changes. However, in the emergency management context, it should be understood that any service that provides information pertinent to the current location of the active mobile handset at a specific window of time can be viewed as a location-based service, regardless of the underlying delivery technology used to convey its information. Although this understanding may extend to other types of services as well, it is, nonetheless, an understanding that greatly harmonises several interpretations of LBS such as those depicted by Holma et al. (2004), Grothe et al. (2005), Guan et al. (2007), Oh and Haas (2007), Stojanović et al. (2007) and Aitenbichler (2008).

The text-based message is the most realised form of LBS, but there are several other possible forms where the service could be received including as a bitmapped image, voice message and multimedia message with rich content such as animated image formats, interactive maps or video. However, the final form of the delivered LBS depends on several factors that include existing and dedicated network resources, underlying technologies and protocols, market trends and handset capabilities/limitations (Spiekermann, 2004).

3.1 The role of geographic information systems in location-based services

Geographic information sciences (GI Sciences) are generally concerned with “the capture, storage, integration, management, retrieval, display, analysis, and modelling of spatial data” (Fotheringham and Wilson, 2008). Geographic information systems (GIS) are a set of hardware and software systems used to create, manage, analyse and display spatial data (Zadorozhny and Chrysanthis, 2004). GIS combine data about the geographic location that are associated with several attributes of natural and man-made features of a given location (The Australian Government: Department of Defence, 2008).

GIS tools have been available for years but their price and sophistication limited their availability to only specialists and scientists. However, recent product deployments, such as Google Earth, Microsoft Live Search Maps and Yahoo!Maps, have helped put these tools into the hands of a much larger audience of non-specialists (Drummond and French, 2008). These online tools currently offer new possibilities to people to gain free access to satellite imagery, aerial photography and street views with resolutions that are high enough to identify detailed attributes of any structure on the Earth’s surface (Michael and Masters, 2006).

GIS play an important role to the operation of location-based services. LBS content providers depend greatly on these systems as they provide efficient means to model the real world structures (e.g. buildings, streets, mobile cell towers) and terrain (e.g. mountains, rivers) into digital geographical data format, provisioning LBS users with relevant information, such as maps or spatial reference points, to match the user query and/or his or her particular location (Kang et al., 2007). GIS also aid in the deployment of location-based emergency services by providing the means to map several contexts of the same area over a period of time, presenting it as a uniquely viewable spatial data set that helps identify environmental changes and patterns about local risk levels and natural disasters in that area (Fritsch, 2008, Elias et al., 2008).

Michael and Michael (2009) postulated that without GIS much of location-based services functionality would not be plausible. Nonetheless, Michael and Michael argue that, while GIS is about maps, places, and points of interest, LBS assign a meaning to this geographically referenced information through linking it to a particular person’s need within a specific period of time.
3.2 Classifying location-based services

LBS can be classified into reactive (pull) and proactive (push) services. Reactive LBS are always initiated by the user, when he or she invokes the service via a device, whether fixed or handheld, to request certain functions or information. In this case, the service gathers locational data (either of the requestor or of another target person or object), processes it, integrates it with other information pertinent to the desired location then returns the location-dependent result to the user. For example, as an information list of nearby points of interest (e.g. restaurants or theatres) including relevant information such as the distance from the current location, directions, contact numbers or postal address (Küpper, 2005).

Proactive services are the other classification of LBS, in which the services are automatically initiated as soon as a predefined location event occurs, for example, if the user enters, leaves or comes into the vicinity of a certain area. The collected locational information could be stored by the service provider for the purpose of further processing or future requests, or it could be directly sent to the user, once it has been processed, in a value-added form (Küpper, 2005, Scott-Young and Kealy, 2002).

In contrast to reactive LBS, where the user is only located once, proactive LBS requires the constant tracking of the mobile handset to detect changes in location events (Junglas and Spitzmuller, 2005). Accordingly, it is still unclear to what extent proactive services can be widely used in mobile telecommunications networks since this type of service takes up disproportionate amounts of network resources as they require continuous updates of device locations. For example, in order for a service provider to be able to push updated traffic reports to its subscribers, the service provider needs to keep querying location activities of all devices entering, roaming or leaving the respective cell area (Spiekermann, 2004).

3.3 The location-based services value chain: key stakeholders

Effective deployment of location-based services requires the coordinated effort of multiple stakeholders in the LBS value chain, each of which provide specific components of the total solution (Astroth, 2003). A stakeholder represents an autonomous entity like a person, a company or an organisation, each maintaining or performing one or several roles that characterise either the interests or functions it fulfils from a technical perspective, or the impact it exercises on LBS from an economic or regulatory position (Küpper, 2005).

Roles of LBS stakeholders can be classified as operational and non-operational. The operational roles define the players that cooperate during the operation of the services which require each stakeholder to maintain technical infrastructure, ranging from the user’s mobile handset to the service provider’s farm servers to the carrier’s telecommunications network, so as to facilitate the request and the provision of sub-services during LBS execution (Küpper, 2005). During an LBS operation the interaction between the actors in the value chain takes place through reference points that are defined by a set of protocols and connectivity services offered by various networks and are often determined by Service Level Agreements (SLAs). SLAs are agreed upon and adopted between the participating parties, prior to the provisioning of the services, for agreed quality of service and accounting conditions (Küpper, 2005).

A non-operational stakeholder is one that does not directly engage in the technical operation of LBS but has an indirect impact on the services, either by dictating economic or regulatory circumstances of LBS operation or through the influence it exercises on the adoption of LBS technical standards (Küpper, 2005). An example from the Australian context could be the Australian Communications and Media Authority (ACMA), which exercises a direct influence in regulating, by law, the utilisation of location data to protect
the privacy of individuals and for other purposes such as lawful interception (The Australian Communications and Media Authority, 2004).

4 Geographical positioning techniques for location-based services

In the world of LBS, global navigation satellite systems (GNSS), Internet Protocol (IP) technologies and radio frequencies are the main access media used to determine the geographic location of a device (Perusco and Michael, 2007, Michael, 2004, Dawson et al., 2007).

The first global location system in use was the satellite-based Global Position System (GPS) created, funded and controlled by the U.S. Department of Defence. The system was built and conceived primarily to serve military purposes but since the late 1990s the system was upgraded with new civilian signals making it freely available to the public and for commercial use (Kaplan and Hegarty, 2006). The result of this free availability of satellite positioning capabilities led to a real revolution in a wide range of applications that included air, sea and land traffic control, navigation solutions, freight management, and emergency services (Spiekermann, 2004). Other comparable global navigation satellite systems are currently also in use or scheduled to operate in the very near future. Some of these include: the European Union satellite system called Galileo, the Global Orbiting Navigation Satellite System (GLONASS) of the Russian Federation, the Compass system of the People’s Republic of China, India’s Geo Augmented Navigation system (GAGAN), and the Quazi Zenith Satellite System (QZSS) of Japan (Samama, 2008).

Global navigation satellite systems provide high levels of accuracies usually within 10 to 20 metres, but their availability is not guaranteed, especially indoors, in urban canyons (i.e. in dense blocks of structures between tall buildings), in tunnels, and in mountainous regions, as a clear line of sight (LoS) to the satellite is always required (Samama, 2008). In addition, to receive signals from a GNSS system, a dedicated receiver is required or a specialised chip is needed to be equipped within the device (Rizos, 2005).

Currently, location data can be obtained by utilising one or more of many indoor and/or outdoor positioning determination technologies, classified as network-centric, terminal/user-centric, and hybrid solutions, used to get an estimate of the geographic coordinates of the device’s location. Each method differs in its market, range, coverage, continuous availability, precision, purpose and functionality (Samama, 2008, Rizos, 2005). Some of the prominent examples of positioning technologies include the terrestrial radio measurement systems in mobile telecommunication networks and wireless location area networks (WLANs), radio frequency identification (RFID) systems, Bluetooth and Wi-Fi access points, and several available hybridisation solutions (e.g. GSM with GPS) (Rizos, 2005, Samama, 2008, Aitenbichler, 2008).

4.1 Radio-based positioning systems

Radio-based positioning systems are used in several domains but the well-known terrestrial cellular mobile-radio networks are by far the most prominent (Spiekermann, 2004). In these networks, the location of the mobile handset can be identified by one or more positioning determination technique that include GPS, Assisted-GPS (A-GPS), Cell Identification (Cell-Id) or Cell of Origin, Enhanced Observed Time Difference (E-OTD), Observed Timed Difference of Arrival (OTDOA), Multipath Pattern Matching (or fingerprinting), and several possible combinations from this list (Küpper, 2005, Samama, 2008, Rizos, 2005). However, due to the fact that installing a positioning system is often a significant investment and can be quite expensive to maintain and operate, most of the telecommunications carriers around the world were and are still heavily relying on Cell-ID related technologies for mobile positioning purposes. These technologies are by far the most cost effective to apply (Spiekermann, 2004), especially when high levels of location accuracy are neither mandatory nor necessary (Agrawal and Agrawal, 2003).
Under Cell-ID technologies, the location is simply the identification of the base station communicating with the targeted active mobile handset. See Figure 2. Therefore, the accuracy differs according to the size of the cell itself, ranging from 100 metres in densely populated urban areas to 20 or 30 kilometres in rural areas (Samama, 2008). In general, the accuracy of Cell-ID positioning results could be improved up to 50 percent by using one of several different techniques like the Angle of Arrival (AOA) or Time of Arrival (TOA), which both do not require any handset modifications but require modifications to base stations, making them also costly to implement in later stages (Samama, 2008).

Figure 2: The Cell-ID concept (BS: Base Station). Adapted from Samama (2008).

High levels of accuracy are certainly a quality that is desired in many LBS applications, especially in emergency services. Table 1 provides a general overview of the needed accuracy levels for most of the current LBS applications offered in today’s cellular networks.

Table 1: Overview of LBS applications and level of accuracy required. Adapted from Bellocci et al. (2003).

<table>
<thead>
<tr>
<th>Application</th>
<th>Requirement of accuracy level</th>
</tr>
</thead>
<tbody>
<tr>
<td>News, Traffic Information, Fleet Management, Remote Workforce Management</td>
<td>Low</td>
</tr>
<tr>
<td>Yellow Pages, Local Advertisement, Location-Sensitive Billing</td>
<td>Medium to Low</td>
</tr>
<tr>
<td>Gaming</td>
<td>Medium</td>
</tr>
<tr>
<td>Point of Interest, Car Navigation, Directory Assistance, Car Tracking, M-Commerce, Child Tracking, Pet Tracking, Electronic Toll Collection, Public Management System, Local Advertisement</td>
<td>Medium to High</td>
</tr>
<tr>
<td>Directions, Personal Navigation, Asset Tracking</td>
<td>High</td>
</tr>
</tbody>
</table>
Sensitive Goods Transportation, Emergency, Parolees on Extended Supervision Orders,

5 Feasible technologies for the delivery of warning notifications today

Several technologies have emerged as feasible options capable, in theory, of delivering warning notifications and safety alert information based on the geographic location of the recipient. The 3rd Generation (3G) network standard multimedia broadcast/multicast service (MBMS), for example, can be used to broadcast (push) emergency messages to defined areas with rich multimedia content such as voice instructions and detailed evacuation maps (Ericsson Company, 2007). However, as much as this technology is promising, it is not supported by all mobile telecommunications networks currently operating, making it unfeasible to be utilised, at least not for several years to come (Bakaimis, 2005). Other comparable technologies might also provide promising platforms to deploy geo-specific emergency systems. Examples include, the Enhanced Message Service (EMS) and Multimedia Messaging Service (MMS), which both became extremely popular, especially with the rapid proliferation of mobile handsets that support digital pictures and internet functionalities (The National Communications System, 2003). The main problem however with these technologies is that legacy handsets, which are largely still in use, do not support advanced messaging functionalities, which rule out these technologies from being widely deployed as well.

It is noted, that all of the usage examples which have been identified worldwide were deployed using the Short Message Service (SMS) technology, the Cell Broadcast Service (CBS) technology or a combination. The two technologies do fulfil most of the basic and current requirements of emergency alerting and warning systems. Both could be utilised for geo-specific emergency purposes and both would operate with almost all mobile handsets available today (The European Telecommunications Standards Institute, 2006).

5.1 Short message services (SMS)

SMS is a well-known and accepted asynchronous protocol of communication. It is capable of transmitting a limited size of binary or text messages to one or more recipients. SMS offers a virtual guarantee for message delivery to its destination (The European Telecommunications Standards Institute, 2006). In case of unavailable network coverage or temporary failure, the message is stored in the Short Message Service Centre (SMSC) network component and delivered when the destination becomes available. Also, the message is delivered if the mobile handset is engaged with a voice and/or data activity. SMS messages do not consume much bandwidth although the network resources might become overloaded if an immense number of SMS messages and/or phone calls have been initiated simultaneously. It should be noted that delays can occur and may result in delivery failure, especially during emergencies.

SMS does not provide any geo-specific location information by itself. However, such information can be obtained from other resources in the telecommunications network (e.g. the Cell-ID). SMS has the potential to be used in location-based emergency services, where mass SMS messages can be directed to specific mobile numbers when they have been identified to exist in designated area(s).

5.2 Cell broadcasting service (CBS)

Cell broadcasting technology is a service delivered by mobile service providers where uniform text messages are broadcast indiscriminately to all mobile handsets in a specific geographic area. The messages can be broadcast to one cell tower or all cells in a carrier network (The European Telecommunications Standards Institute, 2006). Unlike SMS, the nature of CBS does not allow for two-way interactive communication which largely explains why the technology has not been widely deployed for commercial
applications (Celltick Company, 2003). Some few proprietary solutions however exist today which allow
two-way communication but they all require specific Subscriber Identity Module (SIM) toolkits and special

The cell broadcasting spectrum has the capacity of about 64000 different logical channels, with the
potential to use each channel for different types of service messaging, e.g. weather updates, traffic reports,
public health advice, commercial advertisements (Chochliouros et al., 2009). Some channels however are
reserved to broadcast specific messages, for example, the “cell/area info display” service that allows a
serving cell to broadcast its geo-specific information (Name or ID) directly to its mobile handsets by
utilising channel 050.

Given it is a broadcasting service, CBS does not require the identification or the foreknowledge of any
mobile handset number. Comparable to the known radio service, only the activated channel would receive
the broadcast. The handset has to be switched on to a specific CBS channel to start receiving messages. A
message will not be received if the handset is switched on after broadcasting.

CBS is conveyed on dedicated channels using a fraction of the bandwidth that is normally used for mobile
phone calls and SMSs. Therefore, it does not place additional demand on carrier resources or suffer any
degradation when the network becomes highly congested during emergency events (The International
Federation of Red Cross and Red Crescent Societies, 2009).

5.3 Comparing SMS and CBS for location-based emergency services

Table 2 provides a comparison between the characteristics of SMS and CBS, the two main technologies
utilised for location-based emergency services. The characteristics were for the greater part adapted from
documentation provided by The National Communications System (2003) and The European

Table 2: Characteristics of SMS and CBS for location-based emergency systems.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Short Message Service</th>
<th>Cell Broadcast Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission form</td>
<td>Unicast and multicast communication.</td>
<td>Broadcast service. Message received indiscriminately by every mobile handset within the broadcasting range.</td>
</tr>
<tr>
<td>Transmission capacity</td>
<td>Depends on network infrastructure. Usually the SMS warning system has the capacity to send 300 messages per second (The Office of the Emergency Services Commissioner, 2009).</td>
<td>Being broadcast, it is independent of the number of mobile handsets that receive the message.</td>
</tr>
<tr>
<td>Handset compatibility</td>
<td>All handsets support SMS.</td>
<td>Most handsets support CBS except few legacy devices (e.g. Nokia 3310) (Celltick Company, 2003).</td>
</tr>
<tr>
<td>Handset number dependency</td>
<td>Dependent. Foreknowledge of mobile number(s) is essential.</td>
<td>Independent. Message is received on the activated broadcasting channel.</td>
</tr>
<tr>
<td></td>
<td>Only pre-registered numbers notified.</td>
<td>All handsets within a cell notified.</td>
</tr>
<tr>
<td>Location dependency</td>
<td>Independent. User receives the message anywhere.</td>
<td>Dependent. Only targeted cell(s) receive the message.</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>Geo-location information</td>
<td>Obtained by identifying the location for each handset separately.</td>
<td>No handset location identification. The location of the target serving cell(s) is known for the broadcaster beforehand.</td>
</tr>
<tr>
<td>Geo-Scalability</td>
<td>Determining the physical location of each mobile handset can be done, but it is quite complex and time consuming (The 3rd Generation Partnership Project, 2008).</td>
<td>Geo-scalable from a single cell site coverage area to a whole country.</td>
</tr>
<tr>
<td>Delivery time</td>
<td>Under normal conditions, delivery can be almost instantaneous, but a large number of messages take considerable time.</td>
<td>20 seconds to 2 minutes to all mobile handsets (The Japanese Government even requires an alert to arrive on all mobile handsets within 4 seconds, of which 35 million persons are in Tokyo alone) (Sanders, 2009).</td>
</tr>
<tr>
<td>Service barring</td>
<td>No barring.</td>
<td>Received only if the broadcast reception is set to “ON” status.</td>
</tr>
<tr>
<td>Reception</td>
<td>Message is received once the mobile is switched on.</td>
<td>No reception if the handset is switched on after broadcasting.</td>
</tr>
<tr>
<td>Congestion and delay</td>
<td>Subject to network congestion. Immense number of SMS may produce delays even for SMS priority messages (One2many Company, 2009).</td>
<td>Congestion is unlikely as CBSs are sent on dedicated channels. Almost no delays except if received in poor coverage area.</td>
</tr>
<tr>
<td>Delivery failure</td>
<td>Network overload might cause delivery failure.</td>
<td>Busy mobile handsets might fail to process a CBS message.</td>
</tr>
<tr>
<td>Delivery confirmation</td>
<td>Delivery confirmation is supported.</td>
<td>Delivery confirmation is not supported.</td>
</tr>
<tr>
<td>Repetition rate</td>
<td>No repetition rate.</td>
<td>Can be repeated periodically within 2 to 32 minute intervals.</td>
</tr>
<tr>
<td>Language format</td>
<td>Identical to all recipients.</td>
<td>Messages with different languages can be broadcast on multiple channels simultaneously.</td>
</tr>
<tr>
<td>Message content</td>
<td>Identical to all recipients.</td>
<td>Different messages can be sent to different areas.</td>
</tr>
<tr>
<td>Message length</td>
<td>140–160 characters in length. Can concatenate up to five messages.</td>
<td>93 characters. Can concatenate up to 15 ‘pages’ to produce a single message of up to 1200 bytes of data.</td>
</tr>
<tr>
<td>Message retrieval</td>
<td>Can be retrieved from the handset inbox.</td>
<td>If the user does not save the message manually they may not be able to retrieve it again (Kidd</td>
</tr>
<tr>
<td>Support for people with special needs</td>
<td>Does not accommodate any disability related technologies.</td>
<td>Accommodates disability related technologies (Kidd et al., 2008).</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>--------------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Spamming</td>
<td>Some mobile service providers support internet connectivity. Internet-based SMS spamming is possible.</td>
<td>Not possible for an outsider except through uncontrolled access to mobile network infrastructure and the lack of implemented safeguards by an irresponsible service provider.</td>
</tr>
<tr>
<td>Availability</td>
<td>Available but lacks rapid and scalable geo-location mechanisms.</td>
<td>Available but needs modifications in most cases.</td>
</tr>
<tr>
<td></td>
<td>Needs to overcome loading and delay issues in sending SMS to mobile handsets in target areas (Kidd et al., 2008).</td>
<td>Needs to overcome issues related to international standardisation of emergency channel addresses.</td>
</tr>
<tr>
<td></td>
<td>Subject to inter-carrier agreements.</td>
<td>User requirements need further work (e.g. some people may be particularly less inclined to work with this technology due to lack of familiarity) (Kidd et al., 2008).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Subject to inter-carrier agreements.</td>
</tr>
</tbody>
</table>

6 Location-based emergency services in mobile networks

Emergency services represent one of the most obvious and reasonable application areas where the deployment of location technology not only makes sense (Küpper, 2005) but can also be a life-sustaining tool. Still, location-based emergency services are in their infancy in several countries around the world including Australia (Küpper, 2005). Problems related to technical issues including location determination mechanisms and accuracy standards, and also issues related to identifying different requirements for these emergency services still need to be resolved (Togt et al., 2005, The European Telecommunications Standards Institute, 2010)

In general, there are two types of location-based emergency service applications in mobile telecommunications networks (The European Telecommunications Standards Institute, 2006). The first is initiated by a person in the form of a phone call or a distress Short Message Service (SMS) in a life-threatening or time-critical situation. The second type is initiated usually by the government in collaboration with telecommunications carriers, in which safety alerts and early warning messages are disseminated (pushed) to all active mobile handsets located in designated threatened area(s) before, during or after a large-scale event. The fundamental idea behind the first type of LBS is for an emergency service organisation (ESO) (i.e. police force, fire brigade or ambulance service) to reach the caller (or the message sender) with some precision, based on the location information provided by the caller’s mobile service
provider. In many cases the person will be unable to communicate his or her current location or simply does not know it, so the ESO relies on handset data (Küpper, 2005). The premise behind the second type of emergency service application is to utilise the mobile handset as an additional information channel that is capable of reaching people wherever they are but within the threatened area.

6.1 The E911 location-based emergency call service in the United States of America

In 1996, the Federal Communications Commission (FCC) in the United States launched the first initiative in the world, in which the Commission sought to enhance the quality and reliability of the American 911 emergency call service by requiring the telecommunications carriers to locate a person and to deliver the geographic position of his or her mobile handset to the nearest Public Safety Answering Point (PSAP). PSAP is the answering centre for calls to 911 that originate within specific geographic areas. The initiative is now a mandate that is known as the Enhanced 911 (E-911) after the distinctive emergency number 911 of North America (Kaplan and Hegarty, 2006, Küpper, 2005).

However, since the mandate needed the telecommunications carriers to do a lot of work to meet required accuracy levels far beyond what was possible with existing mechanisms of location management at that time. The FCC adopted a phased approach to implementation to give enough time to all parties, specifically the carriers, to realise the needed enhancements (Küpper, 2005, Spiekermann, 2004). The implementation of E911 required considerable coordination amongst various stakeholders including public safety agencies, mobile carriers, technology vendors, equipment manufacturers and local exchange carriers. The enhancements were ruled to be carried out in two phases:

Phase I: This phase was implemented in April 1998. The requirements stipulated that a person’s location based on the geographic coordinates of the serving cell from where the emergency call originated, and also to forward the person’s handset number to the nearest PSAP centre allowing the centre to call back if the call is unintentionally interrupted. However, since the positioning mechanisms were mainly relying on Cell-ID technologies, accuracy levels were rather poor during this phase (Küpper, 2005, Samama, 2008).

Phase II: Phase two began in October 2001. The requirements in this phase ruled that each carrier be able to locate a person accurately within 50 to 100 metres in 67% of the received emergency calls, and 150 to 300 metres in 95% of all emergency calls in the carrier’s coverage area depending on the location technology used since the mandate did not specify which technology to use. As these accuracy levels were difficult to meet using the cell-based approach, more enhancements on network infrastructures became inevitable and carriers started to switch to alternative positioning technologies to meet the requirements ruled by the FCC (Küpper, 2005, Kaplan and Hegarty, 2006).

In all cases, the FCC’s E-911 mandate was proven to be the pivotal driver behind the development, enhancement and deployment of very accurate location technologies that advanced the introduction of various location-based applications in mobile telecommunications networks including the overturing to location-based emergency services not only in the United States but in several other countries around the world (Rizos, 2005, The Australian Communications and Media Authority, 2004, Kaplan and Hegarty, 2006).

6.2 Implementing the Warning, Alert, and Response Network Act in the U.S.

Several location-based systems for public alert and warning purposes are currently being implemented or on the way to deployment in several countries worldwide. In the United States for example, and in response to a requirement in the Warning, Alert, and Response Network (WARN) Act, now signed into law, the FCC worked with commercial mobile service providers to create a specific addition to the Integrated Public Alert and Warning System (IPAWS). The system was called the Commercial Mobile Alert System.
(CMAS), which enabled federal, state, local, and other non-federal authorities to broadcast geographically targeted alerts through mobile handsets within the area of an emergency (Moore, 2009).

Basically, CMAS is intended to facilitate the dissemination of three types of alerts through mobile telecommunications networks: Presidential, imminent threats, and America's Missing Broadcast Emergency Response (AMBER) Alerts (Penn, 2009). The WARN legislation requires CMAS to provide individuals with instructions about what to do in response to a threat and to ensure the transmission of alerts in response to all threats to public safety, including natural disasters and human-made incidents, but only for threats that may pose a serious risk to public health and safety (Francica, 2006).

The National Continuity Programs Directorate, within the Federal Emergency Management Agency (FEMA), has the responsibility of acting as the gateway and aggregator of alerts (i.e. receiving, verifying, and transmitting non-federal alerts) to be disseminated through CMAS. The National Continuity Programs Directorate is also responsible for implementing the IPAWS (Moore, 2009).

IPAWS accepts alert and warning messages generated by emergency managers, mainly using an IPAWS web interface in a standards-based format known as the Common Alerting Protocol (CAP). CAP is an XML-based general data format for exchanging all-hazard emergency alerts and public warnings over all kinds of networks including cellular networks (Organisation for the Advancement of Structured Information Standards, 2010). CAP formatted messages are then forwarded to FEMA’s aggregator to be disseminated through all possible means as stipulated by the WARN legislation (Penn, 2009).

Although the WARN legislation has set a timetable for developing CMAS, there are however no deadlines to enforce this on the mobile telecommunications industry (Harkins, 2007). Mobile service providers are not required by law to participate, however the legislation obligates each service provider who does not plan to participate to clearly indicate it to its potential customers at the point of sale (Mollman, 2009). Participation is mandatory only when the President of the United States sends a message. In that case all telecommunications services providers must broadcast the Presidential message (Harkins, 2007).

In the United States and in several other countries, the implementation of location-based public alerting and warning systems by the telecommunications carriers have been supported by a variety of measures, including legislation, contractual agreements and compensation mechanisms (Kidd et al., 2008). Table 3 summarises these measures by country.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Country</th>
<th>Technology</th>
<th>Carrier Participation</th>
<th>Compensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yet to be determined</td>
<td>Australia</td>
<td>Yet to be determined</td>
<td>Voluntary</td>
<td>Possibility of government financing</td>
</tr>
<tr>
<td>Legislation</td>
<td>Finland</td>
<td>Any technology may be used</td>
<td>Compulsory</td>
<td>Some financial compensation</td>
</tr>
<tr>
<td>Legislation and contractual agreement</td>
<td>USA</td>
<td>Cell broadcast + SMS</td>
<td>Proposed to be voluntary</td>
<td>Possibility of government financing</td>
</tr>
</tbody>
</table>

Table 3: Location-based public alerting and warning system implementation mechanisms. Adapted from Kidd et al. (2008), The Victorian Bushfires Royal Commission (2009) and Weiss (2009).
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Country</th>
<th>Technology</th>
<th>Carrier Participation</th>
<th>Compensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractual</td>
<td>Japan</td>
<td>Cell Broadcast + other technologies (e.g. Paging Channels)</td>
<td>Voluntary</td>
<td>No financial compensation</td>
</tr>
<tr>
<td>agreement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contractual</td>
<td>The Netherlands</td>
<td>Cell broadcast</td>
<td>Voluntary</td>
<td>No financial compensation</td>
</tr>
<tr>
<td>agreement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contractual</td>
<td>Italy</td>
<td>SMS</td>
<td>Voluntary</td>
<td>No financial compensation</td>
</tr>
<tr>
<td>agreement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contractual</td>
<td>South Korea</td>
<td>Cell broadcast</td>
<td>Voluntary</td>
<td>No financial compensation</td>
</tr>
<tr>
<td>agreement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral agreement</td>
<td>India</td>
<td>SMS and cell broadcast simultaneously</td>
<td>Voluntary</td>
<td>No financial compensation</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral agreement</td>
<td>Malaysia</td>
<td>Cell broadcast</td>
<td>Voluntary</td>
<td>No financial compensation</td>
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</table>

7 Example LBS deployments in emergencies: lessons from the field

The following cases have been acquired from attainable news and media resources. The extent of location-based mobile phone services deployment for managing emergency differs from case to case. While in some cases LBS are utilised to manage all types of emergency events that may affect a whole country, others are limited to either a small geographic area (i.e. to province or jurisdiction) or to a specific type of emergency. The main objectives in presenting them is to provide a proof of concept and concrete examples that location-based services are successfully utilised to manage different and emergency event types and hazardous situations worldwide.

Nonetheless, one obvious point should be stressed here is that the success of LBS utilisation in one country does not necessarily mean similar success in another country as there are many influencing factors. As shall be discussed in the following chapters, we need to determine the applicability and viability of these services, which include government support, legislative frameworks, telecommunications carriers’ participation and people’s acceptance of LBS within the Australian context.

7.1 Text messages to allay SARS fears in Hong Kong

On April 2003, Sunday, a mobile phone operator in Hong Kong, launched a location-based service that was capable of alerting its subscribers who happened to be in the vicinity of buildings where the deadly Severe Acute Respiratory Syndrome virus (SARS) had been reported. Those who opted in to the service had their mobile phones tracked continuously. The subscriber was informed via SMS which buildings, within a kilometre of his or her last known location, had SARS cases as declared by the Hong Kong Department of Health. The subscriber also received updated information about the location of potential infected places the SARS patients were suspected to have visited (Lui, 2003). The Sunday Company is one of several mobile phone operators in Hong Kong; a highly competitive market with one of the highest mobile penetration rates in the world (The International Telecommunication Union, 2003). Hong Kong was one of the most
SARS affected countries in the world with more than 700 places put under quarantine and around 1,425 SARS infections registered including 61 deaths. Worldwide, there were around 8,422 cases that had been reported with SARS infections, with 916 deaths recorded in total according to the World Health Organisation (2003).

7.2 California’s Contra Costa County emergency alerts

As part of its community warning system, the County of Contra Costa in California and in collaboration with Sprint, a US based mobile service provider, began to provide a free public safety emergency alert messaging service regarding impending and existing extreme events such as urban structure fires or wildfires. Sprint’s subscribers who happened to be in the County’s jurisdiction at the time of an emergency received a warning SMS if they were in the vicinity of a threatened area. However, in order to start receiving warning messages Sprint customers needed first to opt in to the service via a dedicated website that was established by the County. Sprint utilised a proprietary solution from the SquareLoop Company that enabled the location identification of the subscriber’s active mobile handset within the designated emergency area and then the delivery of the warning message to that handset (McGee, 2008).

7.3 Natural disaster information system in India

With the aim of preventing loss of life in disasters such as the case in the 2004 Tsunami, a Bangalore-based company developed an alert system which could disseminate warning messages to people in designated areas and in their local languages. The system, called Geneva Natural Disaster Information System (NDIS), is the result of a joint effort between Geneva Software Technologies and the Ministry of Science and Technology, with a close partnership with the Indian Meteorological Department and Bharat Sanchar Nigam Limited (BSNL) Company.

The system is a multi-lingual cell broadcast service that is capable of sending text alerts in the event of an emergency through mobile handsets in over 100 languages including English and all regional languages of India. It can be configured to send text alerts followed by voice messages to mobile handsets and can be used also to send voice warnings to fixed landline telephones when necessary.

The system was basically designed to disseminate warnings in the case of a tsunami within 30 seconds of a weather satellite or an earthquake observatory giving an alert signal but the system could also be used to warn for other types of emergencies such as cyclones or epidemics.

After generating a warning by the meteorological department alert system, the warning would be sent to the company’s server where it is converted by NDIS into a text message in two seconds. Within 19 seconds, the system translates the text into a predefined set of languages and converts the text into voice, if needed, using a Dynamic Voice Translation System (DVTS) component. Within only 30 seconds from receiving the meteorological department warning, the text message would be sent to its recipients or streamed as voice to handsets or fixed telephones.

The multi-lingual messaging software used by NDIS is based on a patented technology called VIVID. The software is compact enough to be stored on a subscriber identity module (SIM) card and compatible with almost all types of handsets used in India. The SIM software component is needed to present the message in the desired language based on its standard text messaging Unicode embedded technology. Users do not need to subscribe to the service but they need to equip their devices with a SIM card that is compatible with NDIS.
The system has also core LBS functionalities as it has the capability to track people during sudden events such as bomb blasts or those events that span over a long period of time such as epidemics (Geneva Software Technologies Ltd., 2006, The Statesman Newspaper, 2006).

7.4 Early warning missile alert system in Israel

Israel is a country that is continuously threatened by rocket attacks. In its last two conflicts with Hezbollah (Lebanon) and Hamas (Gaza), 90 percent of the Israeli casualties involved people who were hit by projectiles while being in open areas away from any building.

Individuals who seek shelter in designated safe buildings during rocket attacks are likely to avoid being wounded or killed. As a result, the Military Home Front Command of Israel has been working on warning civilians of rocket attacks by utilising mobile telecommunications technologies amongst other things driven by the excellent mobile phone coverage in Israel with nine million active mobile phones for only seven million civilians. An early warning missile alert system is set to be ready in 2011, designed with rocket sensors capable of creating a virtual ellipse of the precise location of an impact zone. Based upon the calculations all active mobile handsets within the affected zone will be given an early 10 minute warning to evacuate through their mobile handsets. The system is meant to be an addition to traditional warning systems such as the television, radio and sirens, not a replacement.

The alert will be received as a free service but the system’s design requires the individual to sign up first to the service through a dedicated website and then to choose how he or she wants to receive the warning information. The alert can be obtained by logging onto the website, via email or pushed to the subscriber’s mobile handset in one or a combination of four possible forms: text message, audio alert, a handset vibration or light flash which will be especially useful for people with hearing or vision impairment. At some stage, the system will be able to deliver the alert with a map of the affected area.

The system is the result of an agreement between Nixle, a San Francisco based company and Safe Cities Solutions Israel, a Homeland Security company specialising in security design and planning for governments worldwide. The system utilises Nixle’s proprietary technology and its secure text messaging platform to disseminate geo-targeted information from the Israeli government to the general public. The platform is mainly based on cell broadcast technology and will be able to send around 500 alerts per second from each single server used in the system.

Cell broadcast technology is already supported by the three main mobile companies and almost all mobile handsets currently in use in Israel. However, the Command is working with the Israeli Ministry of Communications to restrict the importation of mobile handsets to only those devices that support cell broadcasting. With the rate in which most Israelis upgrade their mobile handsets, a two year waiting time is necessary for each individual to have a compatible handset with the technology. The waiting time will be spent testing the system extensively with the first test held successfully in May 2009 in a nationwide exercise. The time is also needed to work on the system’s regulatory aspects that would shape the collaboration between the three mobile phone companies, and also guide the partnership between the Command and the Ministry of Communications on one side, and between the private mobile telecommunications companies on the other side (Lappin, 2009a, Lappin, 2009b, Sneh, 2009, Nixle Media, 2009, World Tribune, 2009).

7.5 Earthquake and tsunami early warning system in Japan

Japan is one of the most natural disaster-prone countries in the world with more than 10 percent of the world’s magnitude 6, or greater, earthquakes recorded every year. Administered by the Japan Meteorological Agency (JMA), the country launched its Earthquake and Tsunami Warning System
(ETWS) that disseminates warnings over television and radio. On November, 2007, the NTT Docomo Company started to simultaneously provide location-specific earthquake and tsunami warnings to its customers. The company supplies its own mobile handsets with specific configuration menus from which the user chooses to receive earthquake warnings and/or tsunami warnings based on their geographic location at any given time. The user can also define the volume and duration of the dedicated alert tone.

The NTT Docomo system is based on cell broadcasting technologies and designed to send multiple Message Indicators (MIs), where each MI is assigned for a specific type of emergency or language. Every broadcasted warning message has a serial number that can be repeated every two seconds for new handsets entering the affected area, without appearing on handsets which have received the message already.

Led by NTT Docomo, the ETWS is currently being standardised in The 3rd Generation Partnership Project (3GPP), the main international telecommunications standards body, upon strong request from the Japanese Government. It is expected that once the standardisation has been concluded other tsunami and earthquake prone countries, mostly in Southeast Asia, may deploy the same service on their national mobile telecommunications networks (Coyle and Childs, 2005, One2many Company, 2009, Sanders, 2009).

Finally, as there is scant documented literature in the investigation of cases where location-based mobile phone technologies have been used in the realm of emergency management, presenting the above cases served to provide evidence that the coordination of emergency management procedures with location-awareness activities can truly act as a life-saving tool when these technologies are utilised by governments.

8 The Australian LBS experience and the way forward

8.1 The national emergency warning/alerting system in Australia

Not until recently was the standardisation of a national emergency planning and alerting approach to public warning across Australia considered for actual implementation. A national emergency warning system has been the subject of discussions between the Commonwealth, States and Territories since 2004. In 2005, there was a prevailing view of the need to introduce a warning system at a national level but it was not subject to agreement by all States and Territories (The Victorian Bushfires Royal Commission, 2009). However, by July 2008, the Council of Australian Governments (COAG) finally reached an agreement to establish a national telephone-based emergency warning system in Australia (The Australian Government: Attorney General’s Department, 2009). But according to the Prime Minister of Australia, privacy and data security restrictions in the Telecommunications Act 1997, combined with interstate disagreements over funding schemes, were the main reasons for delaying the system’s introduction till after the bushfires in Victoria in February 2009 (Bita and Sainsbury, 2009).

Following the worst bushfire season in Australia’s history in 2009, the Federal Australian Government, COAG and the States and Territories Governments identified the compelling need for the immediate deployment of the national warning system, which would enable them to deliver warnings to landline and mobile telephones based on the billing address of the subscriber (The Australian Government: Department of Broadband Communications and the Digital Economy, 2009).

The National Emergency Warning System (NEWS) was operational by October 2009 in all States and Territories except Western Australia (WA) which delivers its emergency warning messages through the use of its own WA StateAlert system (The Victorian Department of Treasury and Finance, 2009). Under the COAG agreement, States and Territories retain autonomy about the warning systems they choose to implement (The Australian Government: Attorney General’s Department, 2009).
NEWS is meant to supplement, and not to replace, the range of traditional measures currently used to warn the public of emergencies, including the television and radio, public address systems, door knocking, sirens, signage and the internet (Gibbons, 2009).

The second stage of NEWS is presently under deliberation, in particular the ability for Australian telecommunications carriers in meeting the long term requirements for a national emergency alerting and warning system utilising location-based technologies to identify active mobile handsets, of all carriers, within a defined emergency area (The Victorian Department of Treasury and Finance, 2009). With regard to the location-based emergency services phase of NEWS, the bill clarifies the Telecommunications Act by explicitly allowing carriers and service providers supplying LBS to access listed public number information in the IPND (Integrated Public Number Display). It is important to note that the current Telecommunications Act does not contain express authority for use of information in the IPND for the purpose of providing LBS on a large scale (Gibbons, 2009). The Bill seeks to explicitly permit access to IPND data for the purpose of providing location-based emergency services and only limited to that information necessary to provide such services. The amendments also extend the existing secondary usage provisions of the Telecommunications Act to prohibit the use or disclosure of IPND data obtained for the purpose of providing the services, save for the purposes permitted under the Act. The prohibition against secondary usage applies to either the carrier or service provider, which initially requested the data and to any other party who may receive the information (The Australian Government: Department of Broadband Communications and the Digital Economy, 2009).

8.2 Location-based emergency services in Australia

Unlike the United States, technical feasibility in the context of location accuracy standards for emergency purposes does not exist yet in Australia. In addition, the commitment for telecommunications carriers are less restrictive since Australian regulators, primarily the ACMA, do not enforce any accuracy levels on carriers (The Australian Communications and Media Authority, 2004). At present, a call from a mobile handset to an emergency call service is accompanied by very broad mobile location information (MoLI) relating to what is known as a standardised mobile service area (SMSA). These SMSAs can range in size from 2,000 to 500,000 square kilometres, according to the cell’s size from where the emergency call is originated, and are thus too broad to assist ESOs to find someone in an emergency. Rather, the SMSAs are used by the emergency call person to identify the requested ESO answering point that is closest to his or her location, a process known as jurisdiction determination (The Australian Communications and Media Authority, 2004).

Many aspects of these services are regulated and monitored by ACMA under primary legislation, namely the Telecommunications (Consumer Protection and Service Standards) Act 1999 and Telecommunications Act 1997, and through two subordinate legislative instruments: (i) Telecommunications (Emergency Call Service) Determination 2002; and (ii) Telecommunications (Emergency Call Persons) Determination 1999 (The Australian Communications and Media Authority, 2004).

The primary emergency service number in Australia is 000, which is equivalent to the American 911. Two other secondary emergency service numbers are also used in the country: 106 and 112. The 106 emergency call service number is for the exclusive use of text-based telecommunications users, allowing people who are deaf or have hearing or speech impairment to text the emergency call service and request assistance from an ESO. The 112 number can be used by a user with a GSM mobile handset. The 112 emergency number is an international GSM standard developed mainly through ETSI and can be used with any GSM network around the world. The number also became the European Union standard emergency service number (The Australian Communications and Media Authority, 2004).
Highly accurate location techniques to provide accurate MoLI in emergency situations are yet to be implemented in Australia but one future aim is to reach accuracy levels within 50 to 500 metres (The Australian Communications and Media Authority, 2004). Currently, location methods that can identify the mobile base station being used to carry an emergency handset call, thus providing MoLI generally within 500 metres to 30 kilometres of accuracy, are available and ready to be used in Australia but prior to 2009 were not extensively deployed by the country’s telecommunications carriers (The Australian Communications and Media Authority, 2004). However, this is expected to change as the feasibility of high accuracy location methods are currently under investigation after the Federal Australian Government, and the Council of Australian Governments (COAG) identified the compelling need for these methods in Australia following the tragic 2009 bushfires season (The Victorian Bushfires Royal Commission, 2009). The delivery of warning messages to mobile handsets based on the physical location of the handset at the time of the emergency is scheduled to be investigated in the second stage of a recently deployed National Emergency Warning System (NEWS), with a view to implementation for the 2009–2010 bushfire season (The Victorian Bushfires Royal Commission, 2009).

Accordingly, with respect to the second type of location-based emergency service application, which is initiated by government agencies to people in the case of an emergency, The Government of Victoria on behalf of COAG sought in an August 2009 tender, responses from the mobile phone industry in Australia for determining the capacity and capability of the Australian telecommunications carriers in meeting the long term future requirements for a national emergency alerting and warning system utilising location-based mobile phone technologies to identify active mobile handsets, of all carriers, within a defined emergency area (The Victorian Department of Treasury and Finance, 2009). The tender document stated that the underlying technology should be capable of the following:

“The technology will have the ability to receive notifications about any new mobile devices entering a previously specified emergency area to alert the user that, for example, an emergency services vehicle has arrived at a location, or a civilian has entered the area and may be unaware of the emergency.

The technology will include the ability to receive notifications for any mobile devices exiting the defined emergency area. This could facilitate the creation of an evacuation list of people who are still remaining in the emergency area.

The technology will be able to locate specific mobile devices in both 2G and 3G networks, and overlay their position onto a map.

The technology will have the ability to provide sufficient privacy and authentication checking mechanisms to ensure mobile location security” (The Victorian Department of Treasury and Finance, 2009).

9 Requirements for Location-based Emergency Systems

Location-based emergency systems are part of all-hazard alert and warning systems that include other emergency notification mechanisms (The Federal Communications Commission, 2005). Several national authorities, international standards organizations, and a number of specialist researchers have undertaken extensive studies to identify and document different requirements for different public emergency warning systems that should in principle allow support for all current and future emergency event types. In these studies, many aspects were given attention, including legislative, regulatory, administrative, operational, technical, organizational and ethical requirements. Some of these contributions have been by Mileti and Sorensen (1990), the Cellular Emergency Alert Systems Association (2002), ETSI (2003; The European Telecommunications Standards Institute, 2006a, 2006b, 2010), Tsalgatidou et al. (2003), FCC (2005), McGinley et al. (2006), the International Telecommunications Union (2007), The 3rd Generation
Partnership Project (2008; The 3rd Generation Partnership Project, 2009), Fernandes (2008), The Victorian Bushfires Royal Commission (2009), The Victorian Department of Treasury and Finance (2009), and Jagtman (2009), Sanders (2009), and Setten and Sanders (2009) under the European Commission’s CHORIST Project (2009).

In general, defining requirements serves several objectives such as establishing a standardized way of developing and implementing a system, prioritizing the system’s future functionality while providing guidance on the system’s expected performance levels, preventing duplicative reporting for the system’s stakeholders (The United States Department of Homeland Security, 2008), and ensuring that people who want access to LBS services during emergencies can have them in addition to other mechanisms they have traditionally enjoyed. With regard to location-based emergency systems, no explicit requirements, specifically legal and administrative requirements, currently exist anywhere in the world (Togt, Beinat, Zlatanova, & Scholten, 2005). Nonetheless, based on the concepts and principles outlined in the above-mentioned works, the following specific requirements have been drawn from the literature for location-based emergency warning and alerting systems. These requirements include, but are not limited to:

1. Ability to be integrated or used along with other alerting and warning systems.
2. Be fully accessible to the right authorities.
3. Be only accessible by the right authorities.
4. Be flexible to allow support for all current and future types or categories of emergency events and not to be designed to support specific type(s) of emergencies or events requiring notification.
5. Ability to operate independently of a specific telecommunications carrier network.
6. The underlying technology should be supported by all telecommunications carriers in the country.
7. Be able to accommodate newer technologies to enable futuristic enhanced transfer modes (e.g. messages with large data content such as video within the warning notification in order to send, for example, a map of safe area or emergency facilities).
8. Have the ability to provide sufficient privacy and authentication checking mechanisms to ensure mobile location security.
9. Support both pre-planned and dynamic notification events.
10. Reach an unrestricted number of people, ranging from hundreds in rural areas to millions in urban and metropolitan cities.
11. Deliver messages simultaneously to a large number of recipients.
12. Deliver the message in near real-time or within a planned specified time.
13. Reach the appropriate recipients, as efficiently as possible, through the ability of the underlying technology to segment the message recipients by geographic locations.
14. Allow the opportunity to send different messages to different groups of people (e.g. recommend different safety areas for different groups or messages can be targeted at people in the immediate vicinity of an emergency to do one thing, and people traveling to an affected area to do another).
15. Reach all kinds of existing mobile handsets including legacy devices that are largely still in use.
16. Support delivery of messages to those with special needs and unique devices, such as handsets for hearing and vision impaired persons.

17. Reach the residents of remote areas, and people roaming from other mobile telecommunications networks, including visitors from other countries.

18. Support the transmission in languages in addition to English to the extent where it is practical and feasible.

19. Be able to deliver the message under network-congested conditions.

20. Have a message redelivery mechanism when the initial message delivery fails.

21. Have a message reiteration mechanism for as long as the message is valid.

In addition to the base requirements for the location-based emergency system, the requirements for the service/message itself should consider, but are not limited to, the following:

1. Message creation is driven by the country’s specific characteristics and its own list of emergencies.

2. Message template is consistent across different warning sources from different emergency authorities.

3. Message is based on standardized digital format for expressing and disseminating a consistent warning message simultaneously over different informative and media channels.

4. Specifically recognizable as being an emergency message that cannot be mistaken for an ordinary message.

5. Credible, secure and authentic.

6. Location-specific, to minimize social anxiety.

7. Relevant, to ensure that recipients realize that the warning relates to their personal situation.

8. Timely, to prevent wrong actions and to provide those at risk with enough time to take protective action.

9. Accurate, to indicate the degree severity, or the predicted severity, of the event.

10. Complete, to offer sufficient details about the situation.

11. Concise, to avoid lengthy messages.

12. Provide adequate instructions to recipients regarding what should and should not be done to protect them.

13. Fully clear and comprehensible to all people including young and senior recipients.

14. Positive, rather than negative to advocate people on what to do.
Conclusion

This paper presented the role of location-based services in emergency situations. It began with an overview of location-based services, and was followed by an explanation of geographic information science. Different LBS classifications and stakeholders were discussed as well as how geographic positioning techniques are used in the LBS domain. This was followed by a comprehensive review of the use of LBS in mobile telecommunications networks for emergency calling/messaging and public alerting purposes. In particular, two main technologies used to deliver location-based services to mobile handsets today were identified, described and compared. The use of the short message service and cell broadcasting service in public warning was discussed and the advantages and disadvantages of each method presented. A small number of mini cases illustrates the adoption and deployment of LBS in emergency management since 2003, and demonstrates the value of the technology since its inception. An extended emphasis is given to the Australian experience. Finally a basic requirements analysis for a location-based mobile phone emergency system, as part of a larger public warning and alerting system, was presented based on pertinent studies and projects. The requirements covered different aspects of the system, including the design, deployment and implementation. The requirements also covered some of the fundamental characteristics that should be considered in the provided service/message. These requirements are particularly useful for markets where LBS has not yet been fully exploited, especially for government mandated emergency services.

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Biography

Mr Anas Aloudat is a PhD candidate in the School of Information Systems and Technology, at the Faculty of Informatics, at the University of Wollongong. His thesis is investigating the utilization of nationwide location-based services for emergency management within Australia from social and behavioural perspectives. Mr Aloudat holds a Master of Science in Computing from the University of Technology, Sydney (‘03) and a Bachelor of Science in Computer Science from Mu'tah University, Jordan (‘93). He is presently a sessional lecturer/tutor and research assistant at the University of Wollongong. He is a member of the following associations: IEEE Society on Social Implications of Technology, the Civil Emergency Alert Services Association, the Disaster Preparedness and Emergency Response Association and the Research Network for a Secure Australia.

Associate Professor Katina Michael (MIEE’04, SMIEEE’06) holds a Doctor of Philosophy in Information and Communication Technology (ICT) from the Faculty of Informatics at the University of Wollongong, NSW, Australia (‘03); a Master of Transnational Crime Prevention from the Faculty of Law at the University of Wollongong (‘09) and a Bachelor of Information Technology from the School of Mathematical and Computing Science, NSW, Australia at the University of Technology, Sydney (‘96). She is presently an Associate Professor at the University of Wollongong in the School of Information Systems and Technology (‘02-’10) in Australia, and has previously been employed as a Senior Network Engineer at Nortel Networks (‘96-’01). She has also worked as a Systems Analyst at Andersen Consulting and OTIS Elevator Company. Michael has published several edited books, but more recently co-authored a 500 page reference volume: Innovative Automatic Identification and Location Based Services: from Bar Codes to Chip Implants (Hershey, PA: IGI, 2009). She has published over 85 peer reviewed papers. Michael researches predominantly in the area of emerging technologies, and has secondary interests in technologies used for national security and their corresponding social implications.