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Application of satellite navigation system for emergency warning and alerting

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ABSTRACT

One of the key responsibilities of any government is to communicate and disseminate safety information and warnings to the general public in case of an emergency. Traditionally, warnings are issued by the government through a broadcast approach using communication channels such as TV and radio. However this monopolistic approach is now challenged by new technologies and media capable of providing individualised warnings to personal mobile devices. Location-based emergency services and mobile alerts are becoming increasingly prevalent in the provision of emergency warnings. These new modes of emergency services have been adopted by several countries worldwide including Australia. One example is the Australian National Emergency Alert (EA) which is a telephone-based service enhanced with location-based capabilities. This paper introduces the concept of applying global satellite navigation systems such as the Japanese satellite system in the domain of emergency warning and alerting. The Japanese satellite warning system can be tailored to transmit real-time location-based emergency warnings to people's mobile devices while not being constrained by the limitations of ground-based communication technologies. A key advantage of satellite based communication is its high resilience to communication network overload and failure of ground systems and network infrastructure during a disaster. This enables people to obtain necessary information anywhere (outdoor) and anytime during times of disaster. A satellite-based warning system could also be integrated with existing warning services and be used as a complementary technology. This paper examines opportunities and challenges for using satellite navigation systems to deliver warnings and safety messages during emergencies and disasters.

1. Introduction

The catastrophic consequences of emergencies and disasters are universally recognised bearing devastating human, economic and environmental losses. The Indian Ocean Tsunami in 2004, the 2009 Victorian bushfire disaster in Australia, and the 2011 Tohŏku Earthquake and Tsunami in Japan are just a few cases of tragedy, which highlighted the critical importance of preparedness, early detection and warning communications in order to mitigate losses of life, property and ecological damage. A 'warning system' is a means of 'getting information about an impending emergency, the nature of the threat, communicating that information to those who are likely to be affected by it, and facilitating informed decisions and timely response by people in danger' (Mileti & Sorensen, 1990). Several studies have shown that functional warning systems can be a highly effective tool for saving lives and reducing property losses (Golnaraghi, Douris, & Migraine, 2009).

The early warning and preparedness phase is crucial in the emergency management process for reaching an adequate level of readiness to react to potential threats. During this phase, emergency plans are developed to establish, among other procedures, evacuation and emergency escape routes. The United Nations International Strategy for Disaster Reduction identifies four interdependent elements for the provision of early warnings, including dissemination of information via communication systems that deliver timely and accurate warning messages (United Nations International Strategy for Disaster Reduction, 2005). To function effectively, warning systems must be supported by robust communication networks comprised of reliable infrastructure and effectual interactions between key stakeholders, decision makers and the general public. The range of information communication technologies used by state emergency services authorities to disseminate warnings has conventionally involved one-way, top-down communication flows (Handmer, 2000; Parker & Handmer, 1998). Technologies such as sirens, radio and television are commonly used to deliver warnings and safety information. However, a recent re-examination of

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emergency warning systems demonstrates a steady progression toward incorporating two-way participatory approaches leveraging new technologies and collaborative information sharing tools such as the powerful combination of the Internet, mobile, crowd-sourcing and social networking technologies (Crowe, 2012; Keim & Noji, 2011; White, 2011). Mobile location-based services in emergency management are now an established part of government strategies in an increasing number of countries worldwide including Australia. This marked shift from command to dialogue communication functions reflects the remarkable pace of change within contemporary communication patterns and information sharing systems.

Utilisation of satellite navigation systems for emergency warning and alerting is a relatively new and emerging technology (Handmer, Choy, & Kohtake, 2014; Iwaizumi, Ishida, Iino, Kohtake, & Buist, 2014; Mathur et al., 2005; Olla, 2009). There has been little research to investigate its feasibility and application. The value of such capabilities could be foreseen in the case of critical situations where ground-based communication channels are limited or unavailable; and the coordination of emergency procedures with location-awareness activities is paramount. In mid-2014, the Japanese and Australian Governments formally agreed to cooperate to promote utilisation of Information and Communications Technology (ICT) as well as strengthen cooperation for the promotion of geospatial information projects using the Japanese satellite navigation system (Prime Minister of Australia, 2014). The Japanese Quasi-Zenith Satellite System or (QZSS) is an example of a satellite-based navigation system. While primarily built for users in Japan, the satellite trajectory design offers significant advantages to neighbouring East Asian countries as well as Australia. This paper introduces the concept of utilising a satellite navigation system in the domain of emergency warning and alerting. The proposed system is capable of providing real-time alerts enhanced with location-based information enabling users to take appropriate risk mitigation actions during events of disaster. It builds on and extends Handmer et al. (2014) which covered warning systems and the potential of satellite technology in Australia, by focusing instead on emerging mobile technologies, and the details of the new QZSS satellite technology for emergency warnings.

2. Mobile warning systems

Multiple, redundant communication channels are required for the dissemination of critical safety information and warning messages to people about impending danger and risk of disasters. Multiple communication channels increase the effectiveness of emergency warnings by extending their reach so that if one would fail, others may get through. Furthermore, multiple means of delivering emergency information could also service as a means of confirmation reinforcement. When people receive news of an unexpected event, they often seek confirmation from other sources (Auf der Heide, 1989).

Traditional communication channels such as door-to-door, signage, sirens, loudspeakers, radio, television, fixed phone network and internet can only fill the information function of warnings and convey them in a passive manner. The public needs to tune to specific channels of communication. Door-to-door notification and fixed phone network can actively notify and warn people of the impending danger but the coverage is limited to a local scale thus is not operationally effective. These different methods of communicating warning and safety information are not equally effective at providing an alert in different physical and social settings (Mileti & Sorensen, 1990).

New media and communication technologies have emerged in the past decade as viable tools for delivering warning messages and safety information (Handmer et al., 2014). Mobile telecommunication or cellular network technologies have become ubiquitous technologies in today's society and the proliferation of mobile handsets presents an opportunity to provide 'personalised' lifeline information during emergencies and disasters. Mobile telephone warning systems have been embraced and used effectively by several governments around the world as complementary systems to the conventional well established warning channels. Perhaps the two most practical mobile telecommunication technologies that fulfil the requirements of mobile phone emergency alert information service are the common Short Message Service (SMS) and Cell Broadcast Services (CBS). With CBS, uniform text messages are sent point-to-area to potentially all users within a specific geographic area defined by cell towers. It could also be sent to all cells in a carrier network and has a large spectrum of channels which can be used to broadcast different type of service messaging (such as weather updates, public health advice etc). However users of CBS must tune their mobile phones to the specific channel in order to receive messages, just like radio signal. As a result, CBS is not susceptible to network overload. The Netherlands is the first country in the world to introduce this emergency alert system nationwide (Government of the Netherlands, 2012). Wireless Emergency Alert (WEA) from the U.S. is another example of CBS.

With SMS, the text message is sent from point-to-point to a specific predefined set of phone numbers. Unlike CBS, this channel is therefore an individual addressable channel, i.e., it is known to whom the messages are addressed to. However, SMS is susceptible to network overload and message delivery failure if an immense number of SMS messages and/or phone calls have been initiated simultaneously. Delays can occur and may result in delivery failure especially during times of emergency. Nonetheless SMS is a well-established and widely accepted protocol for communication. The benefits of SMS are that it supports delivery confirmation and has a 'store and forward' mechanism. During times of an unavailable network coverage or temporary failure, the message is stored in the Short Message Service Centre (SMSC) network and delivered when the recipients becomes available (Aloudat, 2010).

In Australia, in the wake of the 2009 Victorian bushfire disaster, the Council of Australian Governments agreed to take immediate steps to enhance the nation's emergency management arrangements through the development of a telephone-based emergency warning system. Emergency Alert (EA) a telephone warning system that emergency management agencies can use to send alerts to community members via landline and mobile phones based on the service address information of the subscriber. The EA system became operational on 1 December 2009 and has since been used to disseminate warnings for flood, tsunami, bushfire, storm surge, chemical incidents and missing person emergencies (Torrens Resiliences Institute, 2011). The EA system is based on SMS technology.

The EA system is an official warning approach currently in use in Australia during times of likely or actual emergencies. In severe emergencies, warnings are "pushed" via SMS text messages to all active mobile phones and voice messages to landlines within a threatened area based on their registered addresses. However delivery of messages cannot be guaranteed if telecommunications networks are compromised during events of emergency (Australian Government, 2009) or the mobile phones are outside of the coverage area. Although EA has been relatively successful since its nation-wide operational implementation (Handmer & Ratajczak-Juszko, 2011), its reliance on ground telecommunications network including network coverage issues in Australia reduces its effectiveness.

3. Proliferation of smartphones and location-based services

Australian society is becoming increasingly mobile not only in the way people communicate but also in the way they acquire information (Aloudat, 2010). According to a survey undertaken in 2013, there has been an increase in the proportion of Australians who own smartphones. 88% of respondents owned a smartphone compared to 76% of respondents in the previous year (Mackay, 2013). In 2015, it has been estimated that there were roughly 1.9 billion smartphone users in the market with the number expected to increase in 2016 to 2.16 billion people globally (Kissonergis, 2015). Virtually all smartphones now include a built-in