Designing an Emergency Information System for an Emergency Information System for Catastrophic Natural Situations

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Abstract

Natural disasters have brought about irreparable damage to humans, human activity, society, and the economy, and their effects will probably be increased in the future due to climate change. However, the extent of a natural disaster could be diminished if both individuals and authorities are informed of an impending emergency situation. Therefore, the research interest has been directed into developing robust Emergency Information Systems. This paper demonstrates the way a specific Emergency Information System could be designed to deliver alert messages. The system was designed on the base of the DRM standards and was put into action in the region of Vigla, an area located in Symi, one of the Dodecanese islands. The coverage test proved that the system operates well in remote areas that are characterized by rough geographic terrain.

Keywords: warning system, emergency, emergency information system

Diseño de un Sistema de Información de Emergencia para Situaciones Naturales Catastróficas

Resumen

Los desastres naturales han provocado daños irreparables a los seres humanos, la actividad humana, la sociedad y la economía, y

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probablemente su efecto se verá incrementado en el futuro debido al cambio climático. Sin embargo, el alcance de un desastre natural podría disminuir si se informa tanto a las personas como a las autoridades de una situación de emergencia inminente. Por lo tanto, el interés de la investigación se ha dirigido al desarrollo de Sistemas de Información de Emergencia robustos. Sobre esta base, este documento demuestra la forma en que se podría diseñar un Sistema de Información de Emergencia específico para enviar mensajes de alerta. El sistema fue diseñado sobre la base de los estándares DRM y se puso en marcha en la región de Vigla, un área ubicada en Symi, una de las islas del Dodecaneso. La prueba de cobertura demostró que el sistema funciona bien en áreas remotas que se caracterizan por un terreno geográfico accidentado.

Palabras Clave: Sistema de Alerta, Emergencia, Sistema de Información de Emergencia

为自然灾害场景设计应急信息系统

摘要

自然灾害已为人类、人类活动、社会和经济带来了不可修复的破坏，并且由于气候变化，其灾害影响将在未来增加。不过，如果个体和当局能知晓即将到来的紧急情况，气候灾害程度则能减少。因此，研究兴趣聚焦于开发稳健的应急信息系统。基于此，本文证明了一个具体的应急信息系统能如何通过设计来交付预警信息。该系统的设计基于灾害风险管理（DRM）标准，并在锡米岛（多德卡尼斯群岛之一）的Vigla区域中投入使用。覆盖范围检测证明，该系统在偏远区域（崎岖地形）中运行良好。

关键词：警报系统，紧急情况，应急信息系统

Introduction

In recent years, we have been witnessing many natural disasters such as earthquakes, floods and fires that have necessitated the development of Emergency Information Systems, aiming to inform the public and authorities of an impending emergency situation. A critical issue that pops up when tackling such disasters is the loss of communication systems. However, such loss could be counterbalanced by a competent emergency information system which could be available and well operated in case of emergency.

The technology which could be employed in order to develop an Emergency Information System should compensate for the system stability in the case of a disaster. Various technologies could be used for this purpose. Tarchi et al. (2009) have presented an emergency information system which incorporates the mobile network model into the communication infrastructure. Bai et al. (2010) has proposed an integrated communication system that consists of heterogeneous wireless networks pointing upward; in the case of remote areas, a satellite gate is needed to achieve the connection with the satellite mobile network. Lien et al. (2009) have demonstrated an emergency information system based on ad-hoc networks (MANET). Choi & Lee (2008) point out that satellite communication networks are considered to be the best solution to the radio broadcasting of the emergency content. Bartel et al., (2009) suggest that an emergency information system should be a part of an integrated information system (EMIS), which incorporates dynamic GIS databases, so that the emergency information could be processed and transmitted in real time.

However, Kang & Choo (2016) state that Emergency Information Systems based on the capabilities of cellular phones, emails, and text messaging services cannot send the requisite alert message to all individuals, nor are they effective for a location-oriented emergency. Proloy et al. (2017) direct attention to the need for secure and reliable transmission through wireless networks, laying stress on the use of modulation techniques to combat the bits error. Forstmann et al. (2011) argue that networks such as Ethernet and WIFI will be susceptible to failure in times of emergency, especially in the case where the electrical power goes out.

Another issue is related to the quality of the emergency information provided. Endsley et al. (2011) and Jennex (2007) argue that emergency information should be provided rapidly and accurately. In addition, Endsley, Bolte, & Jones (2011) and Jennex (2007) suggest that emergency information should be provided immediately after the onset of the emergency.

A further important issue focuses on the extent of the availability of the technologies that could be used to develop an Emergency Information System in remote areas. Jang et al. (2009) have underlined that a critical issue which arises when coping with disasters is the loss of communication systems. It is important to emphasize that technologies such as the internet and wireless networks are not always available in remote areas. This holds true especially in the case of remote islands. In spite of the fact that some remote areas are served through such technological facilities, the service provided frequently lacks quality and therefore it is not feasible for an Emergency Information System developer to use such a service. In such cases, other potential technologies such as Digital Radio Broadcasting, Digital Television, and GIS systems could offer more efficiency to the final emergency information system

This paper takes up the issue of emergency information system development by focusing attention on the technologies that could be employed, laying stress on DRM technology (Section 2). The paper also demonstrates a competent emergency information system which works well in remote areas (Section 3.1). A specific methodology was used to test the coverage potential of our system (Sections 3.2). The system was put into action and the results were promising (Section 3.3) The final Sections 4 and 5 include the discussion on the results and the concluding remarks.

Literature Review

There are a lot of studies related to an Emergency Information System Development that we find in Literature. Kang & Choo (2016) have developed an Emergency Information System for car accidents and natural disasters based on a respective warning system by employing a deep-learning technology. Specifically, an emergency warning system was developed relying on deep-based real time videos on CCTV devices in order to detect car accidents and natural disasters. Also, an Information System was developed in order to inform authorities of an impending car accident or an impending natural disaster.

The study of Siergiejczyk (2015) refers to an Emergency Information System that could be used in railway stations in order to inform the personnel of impending dangers that could necessitate the stoppage of train movement. This Emergency Information System takes advantage of the GSM-R service capabilities and, at the time a specific danger is being noticed, an alarm signal is being sent to the railway personnel through the use of a voice group call service (VGCS).

The work of Khalid & Shafiai (2015) places emphasis on an Emergency Information System based on a respective warning system for floods in Malaysia. The information delivery process focuses on publishing the information of an impending flood, derived from a corresponding warning system online, so that people could get access to this information. Simultaneously, at the time a flood is being predicted, short text messages (SMS) are being sent to authorities in order to take the requisite action.

The American Patent (2018) suggests using Digital Radio Broadcasting in order to develop an emergency vehicle proximity sensing system. This system prepares the alert messages, an emergency vehicle transmitter, an antenna for digital radio broadcast transmission, and a digital radio broadcast receiver. It is important to denote that the vehicle transmitter attains a digital radio broadcast transmission at a predetermined FM or AM frequency.

Additionally, an Emergency Traffic Information System is demonstrated in the work of Kubat et al. (2012). The major feature of this system is that the alert messages are sent within the FM broadcast band using RDS (Radio Data System) technology.

Finally, a DRM emergency information system is presented in the study of Shabrina (2017). The study doesn't direct attention to system design, but focuses attention on the system's coverage in the light of a specific methodology. It is essential to point up that the respective DRM emergency information system achieved a 99% coverage percentage.

The studies mentioned refer to emergency information systems which deliver emergency messages digitally despite the technology used for signal transmission. In the light of these technologies, our approach focuses on developing an emergency information system taking advantage of the avails of the DRM digital transmission and digital message delivery process.

Emergency Information System Development

The Uniwa-EIS System

We are currently working on developing an Emergency Information System by the use of appropriate technology which is available in remote areas. On account of the problems related to digital means and the need for modulation techniques (Kang & Choo, 2016; Proloy et al., 2017; Forstmann et al., 2011), we are working on developing an emergency information system based on the avails of DRM technology (Ellingson, 2016). It is important to highlight these avails, stressing the great signal coverage (no radio broadcast repeaters are required) and the economically affordable signal reception (no providers needed). In more detail, our approach is focused on designing an Emergency Information System in a way that the emergency content will be delivered accurately and rapidly (Jang et al., 2009). Our objective is also centered on designing a stable system which will achieve the maximum coverage percentage in areas featured by rough geographical terrain. To this end, our system design was based on the DRM EWF standards. Our system, which is called "UNIWA-EIS," is illustrated in Figure 1.

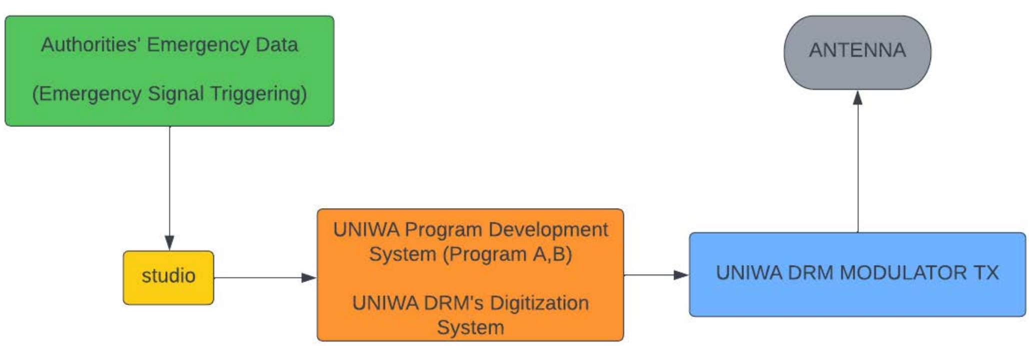

Figure 1. The UNIWA-EIS system.

The principal units of our system are:

1. A Program Development System which is a remotely controlled system that develops the respective programs based on the emergency content;
2. A DRM Digitization System which encodes the emergency content;
3. A DRM Modulation/ Broadcasting System which broadcasts the encoded emergency content.

It is also important to emphasize that our system is facilitated with fixed-line internet, mobile internet living up to 4G and 5G standards along with satellite internet. Additionally, our system uses alternative, environmentally-friendly power sources.

As depicted in Figure 1, the entire process includes the following stages:

1. The signal which is triggered by authorities is transferred into the studio and is activated at the UNIWA-Content Server.
2. The UNIWA Content Server develops the respective program which is about to be broadcast by a proper DRM modulator. It is essential to explain that the Program Development System is incorporated into the Content Server, and it is held responsible for developing the appropriate program with respect to the selected DRM service. It is important to denote that the DRM Digitization System is also a part of the Content Server and it encodes the emergency content.

It is vital to point out that the 'SPARK' software which meets the DRM's standards has been used in the program development process on the content server.

Testing our system

Our objective was to test the coverage of our system in areas featured by rough geographical terrain. For this purpose, our system came into effect in the region of Vigla, an area located on the island of Symi. Vigla was selected due to its specific morphology. The coverage study was based on the philosophy of a standard methodology called "LEGBAC" (Mattson, 2005). This methodology provides coverage results by analyzing valuable data such as those listed below:

- Site longitude;
- Site latitude;
- Transmitter Power;
- Carrier Wave Frequency.

The area of Vigla is defined as the 'Site' in our case. The respective data was collected and analyzed by means of proper software. It is important to point out that transmitter power and site longitude and latitude were parameters which were also used in the study of Shabrina (2017) to test the coverage of a DRM emergency information system.

It is vital to illustrate that, in line with the study of Shabrina (2017), we carried out the coverage test in four phases. These phases were different in terms of the antenna central frequency and the antenna polarization (horizontal/vertical). However, the transmitter power value was the same in all phases (586 Watt). The results proved that a slight adjustment to these antenna characteristics didn't significantly alter the coverage percentage.

Results

The analysis outcome is well depicted in Figure 2. The map illustrated in this figure shows the coverage calibration (phases). Table 1 presents the antenna adjustment in each phase.

Table 1: Antenna's Adjustment

Phase	Antenna Central Frequency	Antenna Polarization
Phase 1	107.9	Horizontal
Phase 2	100	Vertical
Phase 3	104.6	Horizontal
Phase 4	88.2	Vertical

Each phase is depicted on the map by the use of a different color. The red color depicts phase 1, the yellow color illustrates phase 2, the light blue color depicts phase 3 and the light magenta color illustrates phase 4. The coverage percentage in each phase is shown in the table on the right-hand side of the map. The system achieved the following coverage percentage according to the antenna settings in each phase. The coverage outcome is shown in Table 2.

Table 2: Coverage Percentage

Phase	Coverage Percentage
Phase 1	99.7
Phase 2	98.3
Phase 3	99.2
Phase 4	98.1

Thereby, our system reached a 98.8 coverage percentage.

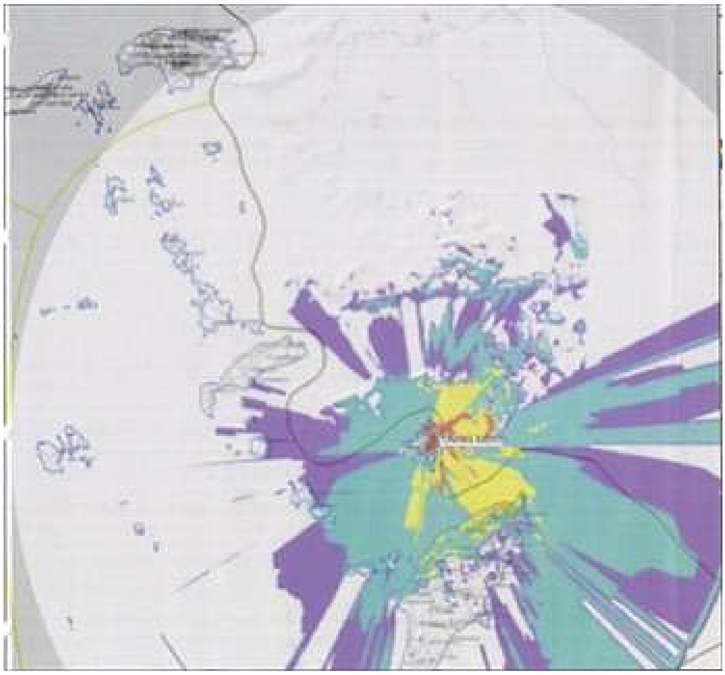

Figure 2. Coverage details.

Discussion

It is important to stress the fact that the study of Shabrina (2017) has tested the coverage of a DRM emergency information system in the area of Indonesia and the coverage score (99%) proved that this system works well in that region. It is also essential to stress the fact that in this study the coverage percentage varied according to the antenna adjustment and the antenna type. In particular, the coverage percentage was significantly altered with the antenna adjustment. It is essential to indicate that in the stages where the antenna central frequency changed noticeably, the coverage percentage dropped to 93%. In our case, the coverage outcome proved that our system achieved a high coverage percentage in each antenna features adjustment phase, indicating that the coverage percentage was not significantly affected by the antenna calibration. Even in stage 4, where the lowest coverage percentage was observed, the respective percentage didn't drop significantly (98.1). Additionally, the coverage test in the study of Shabrina (2017) was not based on the ground morphology of Indonesia and the system was not tested in cases of remote areas. On the contrary, our system has been tested in an area featured by rough geographical terrain, proving its robustness. Finally, the high coverage percentage proved that our system works well in remote areas with rough geographical features, indicating that such a system could be used to efficiently transmit the emergency content in the respective areas offsetting a liable internet failure (Jang et al., 2009). Our team is currently working on testing the coverage potential of our system by making further adjustments to the antenna in order to come up with extra parameters in view of examining their effect on the system coverage.

Conclusion

This paper focuses on the technologies which could be employed in order to develop emergency information systems and places emphasis on the design of a competent DRM emergency information system which works well in areas featured by rough geographical landscape. The paper also demonstrates a specific framework to test the coverage of such a system. The system was put into action and the results were promising. The high coverage score indicates that DRM emergency information systems appear to work well in remote areas. Nevertheless, more studies are needed to display the defects of such systems in these areas.

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