DEWN II: A TRILINGUAL DISASTER AND EMERGENCY WARNING NETWORK
Lanka Wijesinghe¹, Prasanga Siriwardena¹, Sinnathamby Shanmugarajah³, Sameera Wijeratne², Randinee Wijesinghe², Michael de Soyza², Harsha Purasinghe³, Dileeka Dias⁴
¹Dialog-University of Moratuwa Mobile Communications Research Laboratory
²Dialog Telekom PLC, ³Microimage (Pvt.) Ltd., ⁴Department of Electronic and Telecommunication Engineering, University of Moratuwa
Email: lanka@ent.mrt.ac.lk

Abstract – The paper describes the design and development of an emergency warning network that can disseminate disaster early warnings in three languages, to vulnerable communities over the GSM network. The Disaster Early Warning Network (DEWN) is a last-mile solution for early warning of disasters, and consists of a server at a warning dissemination centre, the GSM network and user terminals. The user terminals are mobile phones with the DEWN application and electronic alarm devices capable of generating audible, high-volume alarms and flashlights. The user devices generate alarms in response to a warning message from an authorized entity via GSM’s short message service (SMS) or cell broadcast (CB). The design of DEWN follows international guidelines on emergency communications, such as the ability to reach a large number of people very fast, awaken sleeping communities, and be able to acknowledge warning messages.

I. INTRODUCTION

Following the natural disaster that engulfed the Sri Lankan coastal belt on the 26th of December 2004, Dialog Telekom Ltd., the Dialog-UOM Mobile Communications Research Laboratory and Microimage (Pvt) Ltd. initiated a collaborative effort to develop a reliable early warning dissemination system for the country, as part of their contribution towards the national effort to avert loss of life in future emergency situation.

The December 2004 Tsunami claimed the life of 1 in 500 Sri Lankans, and over 350,000 across South Asia. It is now known in hindsight, that though a Tsunami warning was generated, there was no mechanism in place for this to be relayed to the vulnerable communities. Of particular significance is the fact that there was ample time for the people along the Southern and South-Western coast of Sri Lanka to be warned and evacuated after the Tsunami strike on the Eastern coast, had there been a mechanism for dissemination of warnings.

Requirements for emergency communications, have been identified internationally through standardization activities [1,5,8]. International standardization activities have also gained momentum after the 2004 Tsunami.

In each country, information on an emergency situation is received by a relevant authority, currently; the modes of disseminating the warning are Television, Radio, Cellular Phones, PSTN, and Satellite-based systems.

If the warning arrives late at night when people are asleep, media such as television and radio will be ineffective.

Alternatively the warning message can be delivered by fixed or mobile phones. This is not practical as a mass-alert system due to the large number of calls that would have to be generated, and the resulting network congestion.

A novel approach for such a system has been adopted by WorldSpace Inc in collaboration with Raytheon Corporation [3], which utilizes a combination of satellite technology and radios for warning. Warning messages are transmitted by satellites, which are in turn picked up by the satellite radio units. This would trigger a radio to be turned on, which will then be heard by the public.

In the development of DEWN (Disaster Early Warning Network), research and development is focused on the GSM family of technologies with a view to harnessing the strengths of Cell Broadcast (CB), SMS, and Location Based Technologies. Java and Symbian based device-interfacing technologies, and Modern microprocessor-based embedded systems technologies form the user end of the system.

DEWN was thus designed to deliver a cost effective and multi-modal mass alert system which can be deployed for the purpose of warning key stakeholders in disaster management as well as the general public in advance of the occurrence of life threatening situations.

The paper describes the 2nd generation DEWN technology, which improves on the original version [9] in terms of multiple language support, more efficient message delivery and better user-friendliness in the end-user devices.
II. MOBILE NETWORKS FOR WARNING

In an emergency situation, fixed or mobile phone networks will get congested within a short period of time. Therefore congestion problem is a very serious weakness of the PSTN/PLMN in any emergency situation. Therefore on no account should the PLMN or PSTN be considered the primary communication medium for any disaster management system.

However, the ubiquitous nature of mobile networks make it an excellent choice for early warning without the need for specialized infrastructure, if technologies available are properly adapted to the requirements.

SMS (Short Message Service) doesn’t use voice traffic channels to deliver the message. The bottleneck in this case would be the message handling capacity of the SMS Center (SMSC). Since a store-and-forward mechanism is employed, in a high load scenario, the delay of the SMS may vary from a few seconds to few hours. By employing a priority scheme, this delay can be minimized up to a few minutes, thus making SMS more reliable than voice calls under emergency situations.

Cell Broadcast Messages (CBM) is a useful feature found in cellular networks [5]. With CBM, a text message is transmitted (broadcast) on a downlink only stream to all mobiles registered with the target base station. The potential of CBM for emergency communications has attracted a great deal of worldwide interest in recent times [5].

Since CB does not use regular traffic channels, it is not prone to blocking, and is therefore very useful for mass messaging, for example warning the public on a mass scale. CB has the ability to reach 95% of users within 20-30 seconds, even in overload situations.

Unlike SMS, CB can only be generated by authorized users from a CBM Center. Hence the security and reliability of a CBM based mass alerting system is far superior to SMS. The disadvantage of CBM’s broadcast nature is that messages received could create mass hysteria if people are not properly trained in disaster response.

III. THE DEWN SYSTEM

DEWN is an innovation based on widely available mobile communications technologies such as short messages (SMS) and cell broadcast (CB), aimed at rendering a cost effective and reliable mass alert system. It is capable of generating directed, mass or location-based alerts using the above technologies. The network connects mobile subscribers, police stations, identified religious/social community centers and even the general public to a national emergency alarming centre.

DEWN comprises of two basic elements – i.e. the DEWN Server and DEWN Clients. The DEWN Server will reside in a secure facility and will be used by authorized persons to generate warning messages via SMS or CBM. The DEWN Clients are the intended recipients of the above mentioned messages. Upon reception of the messages the clients will generate textual, audible and/or visible alerts. There are two types of DEWN Clients: a Java/Symbion application for mobile phones the DEWN Alarm Device [7, 9].

A responsible authority would generate an alarm message from the alarming centre, which would be received by mobile phones as well as specialized alarm devices. The message could be selectively sent based on area, to identified individual/group of receivers, or to the general public as decided by the authority generating the message.

The clients may be installed at central locations such as police stations and community centers, and with identified government representatives and community leaders. Figure 1 shows the overall architecture of DEWN.

IV. DEWN CLIENTS

The end-user devices of DEWN are normal cellular phones (handset-resident applications) and special-purpose alert devices. Figure 2 shows the client devices.

In developing these components, the following requirements accepted by the global community working on emergency communications were considered:

a) The necessity to reach a large community very fast
b) Multiple wake-up mechanisms
c) Back-up power for operation
d) Ability for recipients of warning messages to acknowledge and/or respond to messages.
e) The need for warning devices to be used in day-to-day life, and not only in emergencies.

SMS Based alerting is used to activate selected Alarms/mobile phones, while the CBM is used to activate all Alarms/mobile phones in a selected area.
The Alarm device has the following functionalities:

a) Audible alarm with user selectable tones.
b) Visual light alert with user selectable patterns.
c) Remotely and locally tunable FM receiver.
d) Callback facility to a dynamic hotline number.
e) On site functionality verification.
f) Multilanguage support.
g) Unauthorized trigger protection
h) Backup battery.
i) Portability.
j) Debug information output.
k) Ability to be used as a radio in day-to-day operation.

The handset resident application has the following functionalities:

a) Translates SMS and CB messages into penetrative screen flash messages and audible alarm tones capable of waking a sleeping subscriber.
b) Presenting screen messages in tri-lingual form encompassing Sinhala and Tamil characters hitherto not available on handset language packs.

It is likely that entities authorized to generate warning messages through the DEWN, will be informed of impending of emergency situations early. Thus it is reasonable to expect that early warning messages will be disseminated to the client devices before the network gets congested or, perhaps physically destroyed.

V. MULTILINGUAL SUPPORT

Multilanguage support is necessary for a multi-cultural country such as Sri Lanka. It is essential that multilingual messages are supported in any system designed emergency communications. As the length of the SMS is limited to a small number of characters all languages cannot be supported by a single message to convey meaningful information. Sending multiple messages is not only inconvenient at the server, but also increases the load on the network and could hence cause delays.

Hence an innovative approach was adopted to support trilingual messaging in DEWN.

MESSAGE TEMPLATES

Since the messages are to be concise, their structure should be well planned to provide unambiguous information. To satisfy this requirement, messages are categorized according to the type of disaster, and a template is created for each category. The templates have been designed to improve the quality of the messages and to make them transparent to the originator. They have fixed text fields and blanks fields. The latter are to be filled at the time of sending.

After the blank fields are filled by the sender, a message for the current requirement is created. For example, the area where the disaster is expected, and the time could be the dynamic information which customizes the message to the current situation.

The templates for each disaster are divided into four groups. They are,
a) Alert: Only to inform the community of a possible disaster but not to take any action until the evacuation order is sent.
b) No threat: To inform the community that the danger from the disaster is over.
c) Evacuation order: The disaster is about to happen and to take preventive action.
d) Withdrawal: The disaster time is over and safe to return.

The templates are stored in the client devices with a given reference number and a language key. The former is to identify the template and the latter is to identify the language of the respective template. The reference number and the language key, along with the information are sent in the SMS or CB messages.

INTEGRATED SHORT MESSAGES

With the templates stored in the client devices, the warning message carries only the disaster-specific information (to be filled in the blanks) and reference number and the language key. Thus, the message is short and can be sent efficiently over the mobile network. However, the information is displayed clearly and comprehensively at the client devices.

Since the message sent over the network is small in size, information in all three languages are integrated into a single SMS.

The items of information are separated by character delimiters so that the client devices can decode and find correctly, the contents to be substituted in the appropriate blanks to create the complete message for the user. The message also contains other information to trigger the sound, light, radio, and a call-back hotline as well as a header and a footer.

Storing templates in the client devices is also done using SMS. The header part of the message is to identify the message as a template. The template number and the language key is sent in the header. For the three languages three SMSs are sent. The client device saves them in the correct locations in its memory indicated by the template number and the language key. The templates are sent at the time of configuration of the network, so that they can be used in an emergency. After saving the template, the client device sends an acknowledgement to the sender, confirming the successful storage of the template.
Templates may be updated by resending the updated template with original template number and the language key. Then the Alarm replaces the existing one with the new one in that location. Additional templates may also be sent to devices to enhance the already existing set.

**NON TEMPLATE MESSAGES**

DEWN also supports non-template messages (general messages). A general message is used to convey any information relevant to the disaster which cannot be put into a template, such as precautionary measures. They are delivered over the mobile network in the same way as warning messages, but in one language only. Trilingual support for this type of messages is achieved with three separate general messages.

Examples of where general messages are used may be to send precautionary advice and reminders to test client device functionality

**MESSAGE TYPES**

Following are the different types of messages exchanged by the alarm and the Sender (DEWN server)

a) Template messages.
b) Warning messages.
c) General messages.
d) Administrative messages.
e) Acknowledgement messages.

All the messages follow the common format depicted in the following string.

<Header><Message><footer>

The header part of the message changes depending on the type of the message. The arguments in a particular field are separated by delimiters so that the devices can extract the arguments from the message and insert into the appropriate position in the template. The Footer marks the end of the message.

Following is a concise description of the headers and message parts of each message.

**Template messages**

Template messages are sent to deliver templates to the client devices. The template messages so stored are used to generate warnings together with the information delivered by the warning messages.

The template header contains the following information.

i. **Template message identifier**: to identify template messages uniquely.

ii. **Dynamic reference number**: to acknowledge a message uniquely.

iii. **Language key**: to identify the language.

iv. **Template Number**: to identify the template.

The Message part of contains the template text to be stored in the memory. Template contains fixed text fields and a marker for the fields to be filled.

**Warning messages**

Warning messages carry information regarding the impending disaster to be filled in the relevant template to provide a meaningful message to the end user. A single warning message contains all the information to fill templates of all three language pertaining to the disaster.

The warning header contains the following information.

i. **Warning message identifier**: to identify the message uniquely

ii. **Message reference number**: to be used in identifying a message uniquely in acknowledging

iii. **Flashlight pattern**: off, continuous, blinking

iv. **Audible alarm pattern**: off, continuous, beeping

v. **Radio state**: on/ off

vi. **Radio channel frequency**

vii. **Hotline number**: the number to call back to get more information.

viii. **Template number**: the template for which the information in the message part has to be inserted

The Message part contains the information to be filled into the templates. They are separated by language delimiters for each language.

**General messages**

General messages are warning messages that do not use templates. Their content is directly displayed in the specified language. But they also contain a similar header as warning messages to trigger the alarm devices.

The general header contains the same details as the warning header except the template number. Instead, a general message identifier and a language key is inserted.

The general message content is just text in a single language. The client device displays the text in the specified language.

**Administrative Messages**

Administrative messages are used to configure the client devices remotely.

**Acknowledgement Messages**

Acknowledgement messages are sent to inform the sender (DEWN server) the receipt of the message and correct execution.

Acknowledgement header contains the identifier to identify it. And it contains the message reference number sent with the message to which the acknowledgement is sent.

The acknowledgment content depends on the message being acknowledged. It may contain any information necessary to the sender.

Figure 4 shows the message processing in the DEWN client devices.
VI. THE DEWN SERVER

A server with a user friendly web interface is developed to communicate with the DEWN client devices which are distributed countrywide. This interactive web interface has the ability of communicating with all the DEWN Alarm devices through SMS or cell broadcast messages. Therefore the devices can be controlled and configured remotely provided that they are located within the coverage area of a mobile network. The server has the following capabilities:

a) Send warning messages as SMS or CB
b) Alarm Configuration
   a. Create Alarm templates
   b. Alarm reset
   c. Change SMSC
d. Change Sender etc.
c) Security and Authentication
d) Keep activity logs and create reports

The web interface supports creating templates and sending messages in three languages namely, Sinhala, Tamil and English.

All the messages are previewed before sending for prior approval of the relevant authorized persons.

The server interface is shown in Figure 5.

VII. CONCLUSION

The paper presents an early warning network built on the existing mobile network infrastructure, DEWN. The proof of concept has been successfully installed and demonstrated in partnership with the Government of Sri Lanka, and deployment is planned in the near future. It has also been installed and evaluated as a candidate for last-mile hazard warning in a study by Sarvodaya/LIRNEAsia [4, 10].

DEWN, being the first early warning network demonstrated through practical implementation, has enormous impact on the evolution of an effective technology for this purpose. Therefore, the benefit is tremendous, both from social and economic standpoints. Mobile networks cover a significant part of the country, while all operators are expanding their coverage at this time. Very soon, the country will have almost 100% coverage.

Capabilities of DEWN may be summarized as follows:

a) The ability to use the ubiquitous mobile network as one method of disaster warning. There is no known emergency early warning network of this nature.
b) The ability to send warning messages to a selected group or as mass warnings.
c) The ability to wake up sleeping people in the event of an impending disaster, which is not a characteristic of traditional warning methods such as radio and television
d) Use of cell broadcast in emergency situations where normal voice calls or SMS may fail due to congestion
e) Support for trilingual messages within a compact, efficient communication means.

Though the DEWN is a response to the Tsunami disaster of December 2004, it is by nature general purpose. Many countries around the world are seriously affected from time to time by natural disasters such as floods and landslides, cyclones and earthquakes. No effective early warning system is yet in place, and loss of life and property results every time. Thus, the potential of using DEWN for natural disasters is significant.

VIII. ACKNOWLEDGEMENTS

The authors are thankful of Dialog Telekom’s sponsorship of this research, as well as their guidance towards developing and promoting an innovative, timely and relevant technology. The support of the 118 Centre of the Ministry of Public Security and Law and Order, the Ministry of Disaster Management, LIRNEAsia, and Sarvodaya, have been of great value in implementation, testing and improvement of our efforts.
IX. REFERENCES


[7] GSM Mobile Equipment (ME) (GSM 07.05 & 07.07)


Figure 5. The DEWN Server Interface