Challenges of Optimizing Common Alerting Protocol for SMS based GSM Devices in Last-Mile Hazard Warnings in Sri Lanka

~ Working Paper ~

Dileek Dias, PhD
Dialog Mobile Communication Research Lab
University of Moratuwa, Sri Lank
Email: dileeka.dias@ent.mrt.ac.lk

Peter Anderson
Telematics Research Laboratory
Simon Fraser University, Canada
Email: anderson@sfu.ca

Nuwan Waidyanatha
Last-Mile Hazard Warning Systems
LIRNEasia, Sri Lanka
Email: waidyanatha@lirne.net

ASTRACT

There is a growing call for the use of open source content standards for all-hazards, all-media alert and notification systems. This paper presents findings on the implementation of Common Alerting Protocol (CAP) as a content standard for a community-based hazard information network in Sri Lanka. CAP is being deployed as part of the HazInfo project, which has established last-mile networking capability for 32 tsunami-affected villages in Sri Lanka in order to study the suitability of various Information Communication Technologies (ICTs) for a standards-based community hazard information system. Results to date suggest that the basic internetworking arrangement at lower technical layers has proven to be reasonably robust and reliable but that a key challenge remains in the upper layers of application software and content provision. This is evident in the apparent difficulties faced when implementing CAP messaging over multiple last-mile systems that include GSM Technology in modes of text messaging. Lessons learned from silent tests and live exercises point to several key bottlenecks in the system where the integrity of CAP messages is compromised due to problems associated with technological boundaries, technical difficulties, software interoperability or direct human intervention. The wider implication of this finding is that content standards by themselves are not sufficient to support appropriate and timely emergency response activities. Those working with content standards for hazard information systems must consider closely the interoperability issues at various layers of interconnectivity. It is also evident that before Cell Broadcasting only solves the congestion problem. As field trials suggest, CB can not be introduced for public alerting until a common content standard is agreed upon that takes into consideration the restrictions imposed as a result of miniaturization of mobile handheld devices that prevent from displaying unambiguous alert messages in the last-mile of all-hazard warning system in Sri Lanka. Otherwise, ambiguous messages can cause unnecessary problems in the last-mile communities.

KEYWORDS

All-Hazard, Last-Mile, Public Warning, Common Alerting Protocol, Global Standard Mobile, Information, Communication, Short Message Service, Cell Broadcast, Technology, Sri Lanka

INTRODUCTION

In December 2005, LIRNEAsia, an ICT policy and reform research organization, initiated a research project to evaluate the "last-of-the-mile" communication component of an all-hazards warning system for Sri Lanka. The project entitled, "Evaluating Last-Mile Hazard Information Dissemination", or the "HazInfo Project", was funded by the International Development Research Centre[1] of Canada (IDRC). Its research design was based on recommendations of a "participatory concept paper" for a national early warning system (NEWS:SL) completed in the months following the

[1] International Research and Development Center (IDRC) of Canada is donar agency url – www.idrc.org .

2004 tsunami – [11]. The paper noted that although the issuing of public hazard warnings was the responsibility of the government, it is unlikely that the Last-Mile of such a system can be provided solely by government. Rather, it requires a partnership of all concerned including government, private and non-government sectors.

The general objective is to evaluate the suitability of 5 ICTs deployed in varied conditions for their suitability in a last-mile of a national disaster warning system for Sri Lanka and possibly by extension to other developing countries. Specific objectives are to measure the system design and performance for: reliability of the ICTs; effectiveness of the ICTs; effectiveness of the training regime; contribution of organizational development; gender specific response, and integration of ICTs into everyday life. These factors have been assigned a set of corresponding indicators that will form the basis for observations and evaluations of the technology and training.

This paper discusses 2 of the 5 ICTs used in the research project, namely the Nokia 6600 Mobile Handset and the Dialog-University-of-Moratuwa Remote Alarm Device. The CAP messages were delivered to the last-mile via these 2 GSM Devices and Wireless Mobile Handheld Phones. In the case of the Nokia 6600 the messages were delivered in all 3 National Languages: Sinahala, Tamil, and English.

Remote Alarm Device (RAD)

RADs are stand-alone units that incorporate remotely activated alarms, flashing lights, a broadcast FM radio receiver to be turned off or on and SMS messages to be displayed, as well as self-test, message acknowledgement and hotline GSM call-back features. The devices work on the 9.5 KHz and 19.5 KHz frequency Mobile and Fixed spectrums. Dias et al developed a Global System for Mobile (GSM) Communication Alarm Device at the University of Moratuwa Dialog [2] Communication Research Lab. The innovation of the design is best described in the journal article [3] in the reference section. RAD units are operational in 6 communities. Individual units are also operational in 4 Districts of the Government Disaster Management Centers.

Wireless Mobile Phone (MP)

The MP is powered by a 104MHz ARM processor, and is based around Symbian's Series 60 platform. Microimage[3] developed a J2ME applet for the MPs that can be activated by a Short Messaging Service Message (SMS) sent from a Microsoft Internet Application that can be configured to send alerts to all or a group of MP handsets. The GSM Java enabled SMS mobile phones receive text alerts in Sinhala, Tamil and English, sounds an alarm, and has a hotline GSM call-back features.

Encoding and Transmission of CAP Messages

CAP message is entered via the DEWNS HTTP Software Application. The SMSC takes information form the <msgType> and <Description> elements of the CAP message by the Short Message Service Center (SMSC). This truncated CAP message is then forwarded to the GSM Terminating device: RAD or MP. The software in the devices activates the alarms and displays the text.

Reception and Decoding of CAP Messages

The 140 character 8 bit special SMS text message contains a header code of 10 characters, which is decoded by the RAD's Microcontroller and MP's J2ME Applet. Remaining 130 characters contain the English portion of the alert text message in the RAD and equal truncated parts of the Sinhala, Tamil, and English portions of the text message for the MP.

DEWNS Devices Operational States

Power On, the RAD is powered by 240v 60Hz AC and when the main power is down it is run by a Matrix 7v DC Lithium Battery. The Nokia 6600 has a rechargeable 9v Battery. At this point the GSM Module will in both devices listen to SMS of the type that are Alerts and be on *Standby*. SMS Alert is a specific SMS with a known header that triggers the device to initiate the Alerting Sequence. The total message is the size of 2 SMS messages; i.e. 2 x 160 7bit characters. Siren On, Light On, and *Text Display* are instantaneous. The User can press the "Acknowledge button" (see Appendix) to turn the *Siren Off* and *Light off*. The User can use GSM *Telephony* by pressing the "Callback button" to dial the Alert Sender for direct conversation or to receive a voicemail of the CAP message. Final step is

[2] Dialog Telekom url – http://www.dialog.lk

[3] Microimage url – http://www.microimage.com

pressing the *Radio On* to listen to an FM Emergency Broadcast Station. This completes the cycle of operational states in the Micro-Controller of the DEWN devices.

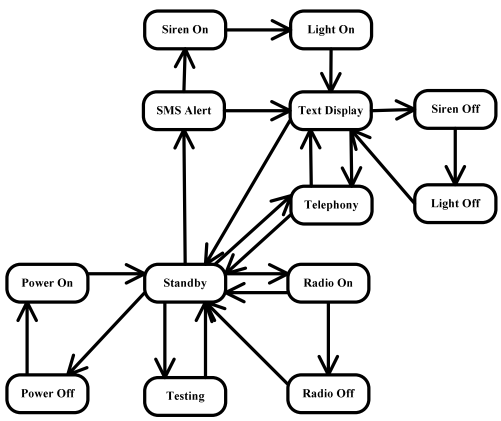


Figure 1 - Operational States of the DEWN devices: RAD and MP

The states described above are essential for the functionality of alerting which requires a "wakeup" function and a "radio broadcast receiver for response and recovery stages in disaster management.

Content Standard to Test the Effectiveness of ICTs

CAP was integrated into the project because of the following perceived benefits and advantages:

- Since it is an open source, XML-based protocol with clearly defined elements, CAP should be capable of supporting data interchange across multiple dissemination channels.
- With CAP, one input at the central information hub can be translated into multiple outputs for downstream alerting.
- CAP provides a standardized template for submitting observations to the central hub (upstream) and thereby supports situational awareness to improve overall management of a critical incident.
- A CAP-enabled system will more easily integrate with other national and international information systems.

CAP standardizes the content of alerts and notifications across all hazards, including law enforcement and public safety as well as natural hazards such as severe weather, fires, earthquakes, and tsunami. This paper will specifically discuss the research findings of using CAP in a Multilanguage environment (Sinahala, Tamil, and English).

Botterell et al [2], designers of CAP, have given the message recipients full autonomy to take action based on the information they receive. It is expected that the community has an emergency response plan (ERP) that is executed on the basis of the content in the CAP message. Therefore, it is important to avoid ambiguity in the alerts (for example, if the message indicates that the particular community is at no threat, then the community plan should be simply to acknowledge and record the message and do not relay it any further).

CAP Profile for Sri Lanka

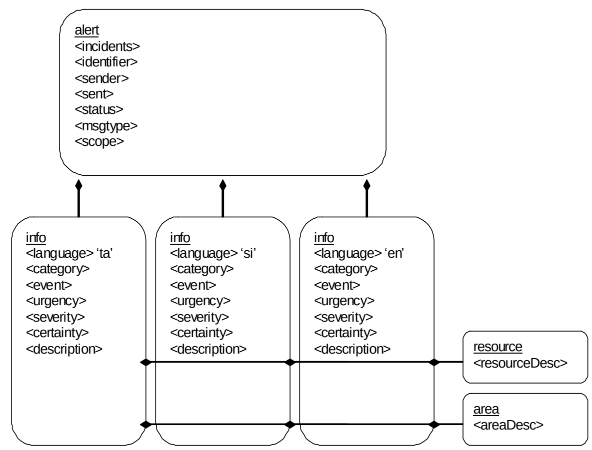


Figure 2 - CAP Message Profile defined for Sri Lanka

CAP adopts a Document Type Definition (DTD) Extensible Markup Language (XML) data structure that consist of a main element <Alert> and subelements <Info>, <Area>, and <Resources> as illustrated in Figure 2 below.

<*urgency*> Code that denotes the time to impact of the event. <*severity*> Codes that denotes the scale of impact of the event. <*certainty*> Code that denotes the probability of the event. These 3 elements define the Priority of the <*event*>. The Priority is a higher order function that maps Urgency, Severity, and Certainty values to a distinct Priority: Urgent, High, Medium, or Low. The mapping is discussed in Table 1 below.

Table 1 - Matrix to determine Message Priority with CAP elements

Priority	<urgency>	<severity>	<certainty>
Urgent	Immediate	Extreme	Observed
High	Expected	Severe	Observed
Medium	Expected	Moderate	Observed
Low	Expected	Unknown	Likely

ASSESSMENT METHODOLGY

Indicators of the overall ICT Performance will be assessed against a point system based on the composition of a set of scaling functions. Simulated drills took place over 6 month period to gather information pertaining to a number of stated propositions (hypotheses).

"*Reliability*" is an indicator of effectiveness to obtain data on whether or not the technology functioned on the day of the hazard event or exercise. There are a number of questions to be considered for the design of an evaluation instrument for this indicator.

"*Relay time*" is an indicator that is divided into three distinct processes. The first process concerns the time taken from the moment a warning is issued from the HIH to it being received at device located in the community. The second process concerns the time taken from the moment the first responder in the village receives the message from the HIH and delivers to the local community first-responders. The third process is measured by the time taken for the local community first-responders to then activate the local response plans. The design of an evaluation instrument will need to consider a number of questions pertaining to this indicator.

"*CAP Message Interoperability*" was subjectively studied by assessing the "action taken" by the message recipient. For this assessment, the CAP message relayed from the HIH and actions taken were recorded by each First-Responder.

Compulsory Elements of the CAP Profile

A CAP message is defined to have a high effectiveness value of 1 if the message contains the mandatory CAP elements as described in the section titled CAP Profile for Sri Lanka and Figure 3 above. The lower end value 0 is when the message is an empty CAP message; i.e. dead air or text elements with null values. The compulsory Elements of the CAP Profile include elements in the <Alert> "qualifier" elements: <Incident>, <Identifier>, <Sender>, <Sent>, <Status>, <msgType>, <Scope>, and the "sub" elements: <Info>, <Resource>, and <Area>

Table 2 – Sigmoid Scaling function for Full-CAP Capabilities

Value	*Fuzzy Rules*
1.00	All sub elements that are contained in the <Alert> element, which includes all the qualifier and sub elements
0.95	Mandatory sub elements of the <alert> element and the sub element <description>
0.85	Mandatory defined in the Profile for Sri Lanka, which are the sub elements of the <Info> element <category>, <event>, <urgency>, <severity>, <certainty>, and <description>
0.70	<description> only
0.50	Mandatory sub elements of the <alert> element only
0	Otherwise

Language Diversity in Sri Lanka

The rules for Table 3 below were defined from the Ethnicity Statistics[4] obtained from the Census Bureau of Sri Lanka; approximately 82% are Sinhalese, 9.5% are Tamil (Sri Lanka and Indian Tamil), and the rest, 8.5% are Other (Sri Lanka Moor, Burgher, Malay, Sri Lanka Chetty, Bharatha, etc. "Other" ethnic groups are literate in English and in a major portion of them can speak and read either Sinhala or Tamil. Ideally, the CAP messages should be disseminated in all three languages or at least in Sinhala and Tamil.

Table 3 - Sigmoid Scaling Function for Language Diversity

Value	*Fuzzy Rule*

[4] Statistics used in the explanation was obtained from -- http://www.statistics.gov.lk/census2001/population/district/t001c.htm ; the values used for Rural and Urban as a collective.

1.00	Sinhala, Tamil, & English
0.95	Sinhala & Tamil
0.85	Sinhala & English
0.70	Sinhala Only
0.50	Tamil Only
0.20	English Only
0	Otherwise

Mix of Audio and Text Communication Mediums

The project used Table 4 to weight the ICT as a function of the capability to disseminate audio or text messages. The RAD and MP have build in fm radios the user can tune into. AREA use MP3 files to broadcast alerts over an emergency channel.

Table 4 - Sigmoid Scaling Function for Audio and Text Communication Mediums

Value	*Fuzzy Rule*
1.00	Audio and Text
0.95	Audio only
0.85	Text only
0	Otherwise

A Complete Full-CAP Message

In this project we define a Complete Full-CAP Message to be one that complies with the CAP Profile for Sri Lanka, contains all three languages: Sinhala, Tamil, and English, and also is disseminated in modes of Audio (i.e. Voice) and Text. The final rating is the multiplication of the values obtained from Tables 2, 3, & 4.

SIMULATION RESULTS

The Alert Message

The simulations began at the HIH with the receipt of an email containing the critical information pertaining to a Cyclone hazard. The following abstract of the entire message contains the critical information and Table 7 below illustrates the composition of message transformations.

> "A SEVERE CATEGORY 4 CYCLONE is now current for HAMBANTOTA District coastal areas. At 10:00 am local time SEVERE TROPICAL CYCLONE MONTY was estimated to be 80 kilometers west of Hambantota and moving southeast at 10 kilometers per hour."

Behavior of ICTs and Resultant Last-Mile Outcomes

Table 5 – Summary of the messages being received, generated, and relayed by the actor: HIH Monitor, Communications Provider, ICT Guardian, ERP Coordinators during the Live Exercises over the 5 ICTs

HIH Monitor issued CAP Message	***ICT Guardian received Message elements***
<info> sub element with <Language>en <Description> … {no size restriction} <Language>si <Description> … {no size restriction} <Language>tm <Description> … {no size restriction}	"Warning" <info> <Language>en <Description> A SEVERE CATEGORY 4 CYCLONE… <Language>si <Description> …{sinhala} <Language>tm <Description> … {tamil} {restricted by 130 characters}

In all of the simulated drills the communities the "server category 4 cyclone …" as a tsunami evacuation drill. The limitation in the message absconded from exposing important information necessary for a community to execute their ERPs.

Final Rating of ICTs for CAP Completeness

Real values given for each indicator for the ICTs are a based on mostly perception and the values are in Table 8. In some cases an actual formula is applied to calculate the indicator's value.

Table 6 - Rating for the ICTs for effectiveness of relaying a Complete Full CAP message

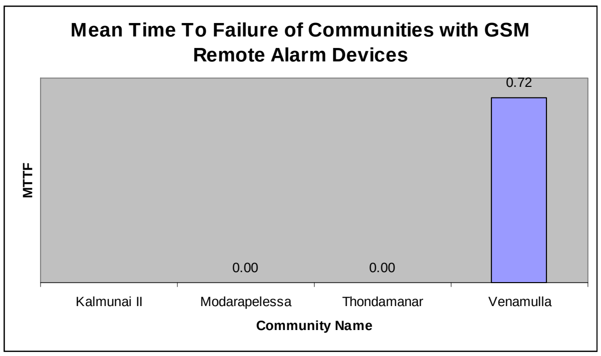
ICT / Measure	***RAD***	***MP***

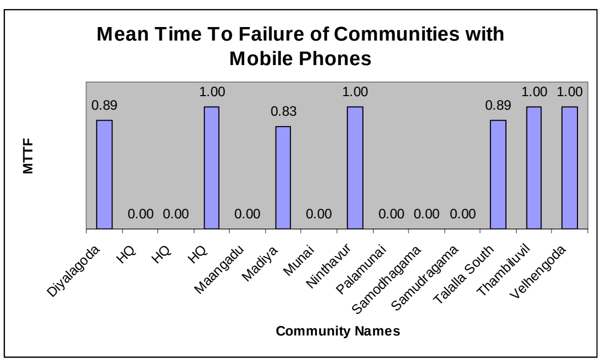
Language Diversity (‘si’, ‘tm’, ‘en’)	0.20	1.00
Full CAP (‘XML’)	0.80	0.80
Mediums (audio, text)	0.85	0.85
Rating	0.14	0.68

DISCUSSIONS

Reliability and Effectiveness of ICTs

Test initial results show all devices to take less than 1 minute to push the alert messages to the end user devices. The alert tests conducted on 4 – 10 units of each of the 2 types of GSM Devices for any given trial. Therefore congestion is not taken in to consideration here.





The Mean Time To Failure (MTTF) are very high an in some cases where the community failed 100%. Therefore, it is evident that unambiguous alert messages must be issued to ensure failure of community executing the ERP with a lower MTTF.

Table 7 - Rating of ICTs based on Reliability and Effectiveness

ICT / Measure	RAD	MP
Reliability	0.78	0.99
Effectiveness (Complete CAP Messaging only)	0.14	0.68
Rating	**0.11**	**0.67**

Shortcomings of ICTs

Presently, both GSM devices used in the HazInfo project does not employ a multi-langauge device that is capable of displaying the entire CAP message. However, it is currently configured for English language character only. Therefore, ICT-Guardians have had to learn to interpret the English partial CAP Messages. Considering the low level of English language usage especially in rural Sri Lanka, ideally, the devices should enable the ICT Guardians to select the message language of choice (i.e. Sinahala, Tamil, or Englsh).

Disregarding the CAP Profile

The 2 GSM ICTs used in the project make use of the CAP message format. However, each is only capable of displaying a limited number of the CAP elements, limiting the amount of alert message content. Consequently, during simulations first-responders restricted their CAP message content recording to only a few elements such as the <*msgType*> and <*Event*> because that’s all they received. Message did not include <*urgency*>, <*severity*>, and <*certainty*> to enable ICT-Guardians to gage the Priority. Although, the RAD and MP devices use the <Description> element that could also carry this information, they are restricted to an overall message content limit of 130 characters, which is insufficient to carry a meaningful unambiguous alert message.

Next Generation Alerting

Cell Broadcasting solves the congestion problem faced in SMS. Moreover, it will not be affective for alerting unless it can provide a Complete Full CAP Message. Until then it is suggested that the experimented SMS based technologies be used with capabilities to activate and listen to a broadcast radio frequency. Without proper emergency response plans and a set of clear messages to it will be chaotic.

CONCLUSION

The 2 GSM devices used in the HazInfo Pilot cannot be upgraded to receive Complete Full CAP Messages; i.e. cannot score a value 1.0 in Table 2. However, could score a value at most 0.80 or 80% CAP Compliant. This is achieved by strictly using the <event>, <urgency>, <severity>, and <certainty> elements of the <info> section in a single 8 bit 140 character SMS or 8 bit 93 character CB message. A single 8 bit character is used to enumerate the combination of <urgency>, <severity>, and <certainty> to determine the Priority and the remaining characters of the SMS or CB message can be used to carry the <event> information, which will be sufficient in length to carry an unambiguous alert message in the last-mile languages at the first alerting instance before network congestions starts and all GSM means of communication such as GPRS, Voice, and SMS will cease. Therefore, coupling GSM Mobile devices with FM radios have proven to be essential for receiving emergency broadcasts during disasters.

REFERNCE

1. Anderson, Peter (2006) Last of the Mile Warning System ICT *Assessment and Community Simulation Observation Report*, LIRNEasia HazInfo Project [Available from author]

2. CAP Cookbook (Wiki). (2006) Welcome to the CAP Cookbook. 2006. Available http://www.incident.com/cookbook/index.php/Welcome_to_the_CAP_Cookbook

3. Dias, Dileeka, Jayasinghe, Gamini, Fahmy, Farazy, Galaweera, Nuwan (ICIIS 2006). *A GSM Alarm Device for Disaster Early Warning*. First International Conference on Industrial and Information Systems, Peradeniya, Sri Lanka.

4. Gow, Gordon A. (2006, July 12). Last-Mile Hazard Warning System: Guidelines for HIH *Procedures, System Activation, and Testing*, LIRNEasia HazInfo Project [Available from the author]

6. Gow, Gordon A. (2006, October 19). Implementing Common Alerting Protocol for Hazard Warning in Sri Lanka, ~Working Paper ~ Presented at ITU/OASIS Workshop and Demonstration on Advances in ICT Standards for Public Warning ITU Headquarters, Geneva

7. LIRNEasia. (2006). Evaluating Last-Mile Hazard Information Dissemination (HazInfo). 2006. Available http://www.lirneasia.net/projects/current-projects/evaluating-last-mile-hazard-information-dissemination-hazinfo/

8. OASIS. (2005, October). Common Alerting Protocol v1.1 (CAP -V1.1). 2006. Available http://www.oasis-open.org/committees/download.php/15135/emergency-CAPv1.1-Corrected_DOM.pdf

9. Othman, Zalinda, Subari, Khairanum, Morad, Norashima, *Applications of Fuzz Inference Systems and Genetic Algorithms in Integrated Process Planning and Scheduling* www.journal.au.edu/ijcim/2002/may02/article5.doc

10. Rangarajan, S (2006), Addressable Radios for Emergency Alerts, *Proceedings of presentation at the ITU/ESCAP Joint Regional Workshop on Disaster Communications*, Bangkok, Thailand, srangarajan@worldspace.com [Available from the author]

11. Samarajiva, Rohan, Knight-John, Malathy, Anderson, Peter, Zainudeen, Ayesha et al. (2005, March 17). National Early Warning System Sri Lanka: A *Participatory Concept Paper for the Design of an Effective All Hazard Public Warning System* Version 2.1, LIRNEasia and Vanguard Foundation, 2006. Available http://www.lirneasia.net/projects/completed-projects/national-early-warning-system/

12. Samarajiva, Rohan. (2005). Mobilizing information and communications technologies for effective disaster warning: lessons from the 2004 tsunami. *New Media and Society*, 7 (6), 731-747.