Common Alerting Protocol Message Broker for Last-Mile Hazard Warning System in Sri Lanka: An Essential Component

Gordon Gow, (PhD)
Faculty of Extension
University of Alberta, Canada
email: ggow@alberta.ca

Peter Anderson
Department of Telematics
Simon Fraser University, Canada
email: anderson@sfu.ca

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

ABSTRACT

Last-Mile Hazard Warning System (LM-HWS) is an Innovation aimed at providing the Communities in Sri Lanka a system to receive hazard information for early warnings. A major component of the LM-HWS is the Hazard Information Hub (HIH) disseminating CAP Message in the 3 national languages: Sinhala, Tamil, and English. These CAP Messages are sent to the Last-Mile Communities in the content-forms of audio and text. Reliability of the HIH performance must not be any less than a 95%. Such a high reliability is expected in order to give the Community First-Responders time to complete their Emergency Response Plans. The Live Exercises gave the HIH a Reliability score of 78%. For example an event such as the December 2004 Tsunami that had a minimal 90 minute duration between time of hazard starting and the time of impacting Sri Lanka; with a 78% Reliability, the function: Relaying of Message to the Last-Mile alone would take 20 minutes. Analysis also shows the Reliability to drop significantly when the combination of SISO relaying Applications increase. A MIMO Alerting Application such as a Common Alerting Protocol (CAP) Message Broker would increase the performance of the HIH and give the hazard impacting Communities additional time to execute their ERPs.

KEY WORDS

Last-Mile, All-Hazard, Disaster, Emergency, Warning, System, Information Communication Technology, Localization, Relay, Common Alerting Protocol, Message Broker

INTRODUCTION

In December 2005, LIRNE*asia*, 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 Center[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 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.

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

For purposes of the HazInfo project, the research would focus on the non-government organization (NGO) contribution and be designed around a governance structure whereby a non-profit NGO, Sarvodaya, would provide oversight, training, and a Hazard Information Hub (HIH) for the monitoring of hazard threats and dissemination of alert messages to local communities within the Sarvodaya network of villages utilizing combinations of different ICTs. Designated first-responders selected from the local communities would be responsible for monitoring messages received by to the ICTs, overseeing emergency preparedness, message dissemination, and emergency response at the local level. The research findings from the simulated tests and exercises of the ICTS and integrated risk management processes are intended to provide a guide to implementing an early warning system for the 15,000 plus Sarvodaya embedded villages[2] in Sri Lanka.

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.

METHODOLOGY

Common Alerting Protocol

A major feature of the HazInfo Project employs the use of a standard data interchange known as the "Common Alert Protocol" (CAP) between the Hazard Information Hub (HIH) and the end-user technologies. Project is specifically interested in researching the use of CAP in a Multi language environment as in Sri Lanka [13]. CAP was integrated into the project because it is an open source, XML-based protocol with clearly defined elements, is 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.

5 Information Communication Technologies

The CAP messages were delivered to the last-mile via 5 ICTs – Remote Alarm Device, Wireless Mobile Handheld Phones, Addressable Radios for Emergency Alert, Wireless Fixed Phones, and Personal Computer coupled with Very Small Aperture Terminals. A description of the 5 ICTs is well illustrated in [15]. Since the focus of this paper is on the HIH Monitor Activities and the CAP Message Dissemination Applications the reader is expected to refer to [15] for an illustration of the ICTs as well as their Performance.

Message Dissemination Methods

At this stage of the project, both WorldSpace[3] and MicroImage[4] have developed web browser based CAP GUIs for the HazInfo project. The WorldSpace CAP GUI (Anny Network Early Warning System or Anny) interfaces with the AREA component and the MicroImage (Disaster Early Warning Network or DEWNS) with the Dialog[5] Remote-Alarm-Device/Java-Phone components. Presently, the ANNY and DEWN CAP software operate independently of each other, but in the future, could be integrated and controlled by a single software application; namely the a CAP broker. The VSAT satellite alerting message software also uses web browser based GUI called Internet Public

2 Sri Lanka has more than 23,000 villages comprising, predominantly, Sinhala, Tamil, Muslim, and Burger ethnic groups.

3 WorldSpace Global Data Solutions provider of Addressable Satellite Radios; website – http://www.worldspace.com

4 Microimage (Pvt) Ltd provider of SMS based Mobile Phone localized alerting; website – http://www.microimage.com

5 Dialog Telekom largest Telco in Sri Lanka; website – www.dialog.lk

Alerting System (IPAS). IPAS in its current form is not CAP-compliant but provides a simple and effective means to test sending IP based alerts to PC screens. A simple voice CALL was made and the CAP Message was read-out over the CDMA Wireless Fixed Phones.

The Alert application of WorldSpace is a WebApp that allows authorized personnel to generate messages which may either be specifically directed at one or more WorldSpace Receivers, or groups of receivers or broadcast to all receivers covered by a specified satellite. The application provides a User Interface from creating / editing a message, and for selecting the intended recipients.

Once logged in to the DEWN web-based system, the HIH monitor can create new and view existing users, view and delete existing messages and/or create new ones in Sinhala, Tamil and English, assign a Hot-line number, create new and view exiting recipients, create and configure alarms and send SMS and Alarm messages. To enable Sinhala and Tamil functionality, corresponding drivers must first be installed on the HIH First-Responder's (or HIH Monitor's) computer.

One advantage of IPAS is that it appears capable of carrying the equivalent of the entire CAP "description" field. IPAS alerts can also be received on any Internet enabled MS Windows computer and is not dependent on a dedicated network. IPAS Alerts are targeted by Area and a Priority level; where IP packets are transported through a dedicated IO port in a PC.

Functions of a CAP Message Relay

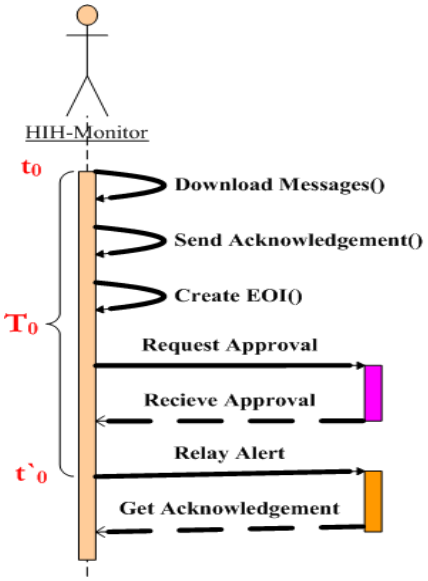

Figure 1: Functions carried out by an HIH Monitor when Relaying a CAP Message to the Last-Mile Communities

HIH is a round-the-clock operation. Authorized personnel who keep an eye on the information feeds and disseminate CAP messages are the *HIH Monitors*. Monitor responsibility are to check the email, websites, and newscasts frequently for EOIs. Monitor will use the web interfaces and Telephony to transmit the CAP message to the ICT Provider Gateways. The ICT Providers in return relay the messages to the Last-Mile Community First Responders known as ICT Guardians.

Download Message () – The Exercises were initiated by an official issuing an email to hih@sarvodaya.lk . This email is downloaded in to the inbox and read by the HIH Monitor. *Send Acknowledgment ()* – The HIH Monitor then replies to the email bulletin indicating receipt of message. *Create EOI ()* – Event of Interest is a form that is filled by the HIH Monitor to decompose the email and structure the message to fit the CAP Profile designed for Sri Lanka. This document will also be used as a paper-trail for accountability. *Request Approval ()* and *Receive Approval ()* –

The EOI is approved by a Sarvodaya Executive. In the Live-Exercises the Director Sarvodaya Community Disaster Management Center acted as approving person. *Relay Alert ()*– Task of accessing application, entering CAP text message in to a Web based software application and disseminating to community ICT or speaking-out CAP as a voice message in the form of a Telephone Call. Get Acknowledgement () – All the ICTs except for the AREA have mechanisms to send an acknowledgment to the HIH.

Calculating the Reliability of Composing and Relaying

"*Relay time*" in this case is the first process of three processes that are associated with the LM-HWS. The other two processes involve first-responders (actors) in the community. In this particular scenario it concerns the time taken from the moment a warning is received at HIH, transformed into a CAP message by filling the EOI form, getting the required approval, and disseminated to the Last-Mile Communities. In refernce to Figure 1, let t_0 be the time the alert message is available in the form of an email bulletine for the HIH Monitors to download; t_0' is the time the CAP Message is relayed via the minimum set of relay application. Further introduce a varaible $T_0 = t_0' - t_0$ is the time interval taken to complete CAP Message Composition and Relaying Process. The difference between the hazard initiating time and the hazard impact time is defined as the period T, which varies for the combination of each hazard-category and event. Usually the event message will carry the hazard travel timeas well as the vector (speed and direction) of hazard. The initial information suh as the the time event occuring and location event happened is also given. The minimal allowable period: $T = d/s$; where d is the minimum distance between epicenter and first impact area and s is the speed at which the hazard is travelling. Then Reliability is calculated: $R_0 = 1 - \left(\frac{T_0}{T}\right)$; where $R_0 \in [0,1]$.

RESULTS FROM LIVE EXERCISES

Date of Live Exercise	*Dissemination Sequence*				*Remarks*
	1	*2*	*3*	*4*	
04-Apr-2006	ANNY	DEWN			Observer not present to record HIH Activities (Kalutara District)
26-Nov-2006	DEWN	ANNY			Observer not present to record HIH Activities (Galle District)
11-Dec-2006	CALL	DEWN	ANNY	CALL	HIH Monitor did not Downloaded Email, did not generate n EOI, did not get Approval (Ampara and Matara District)
25-Feb-2007	ANNY	CALL	DEWN		Observer not present to collect HIH Activities (Galle District)
04-Mar-2007	ANNY	DEWN			Performance Good (Colombo District)
10-Mar-2007	ANNY	CALL	CALL		Delayed due to the multiplicity of telephone calls (Trincomalee District)
11-Mar-2007	ANNY	CALL	DEWN		Performance Good (Kalutara District)
17-Mar-2007	CALL	DEWN	ANNY	DEWN	HIH Monitor had to use 2 different modules in DEWN Application to Alert the Mobile Phones and RADs respectively
09-May-2007	DEWN	DEWN	ANNY		HIH Monitor had to use 2 different modules in DEWN Application to Alert the Mobile Phones and RADs respectively

Table 1 - Live Exercise conducted between November 2006 and May 2007, Relay Application Sequence used by the HIH Monitor, and important remarks. Refer to section titled "Message Dissemination Methods above for definitions of ANNY, CALL, & DEWN used in table.

After aplying the function described in the section *Calculating the Reliability of HIH Monitors* the results below were obtained. The average for the data is rounded up to 78% with a 3% variance. It is a comparison of the human and technology components of the HIH Functions. The other functions that lead up to the Relaying function score a Reliability average of 94% with a 0.08% variance.

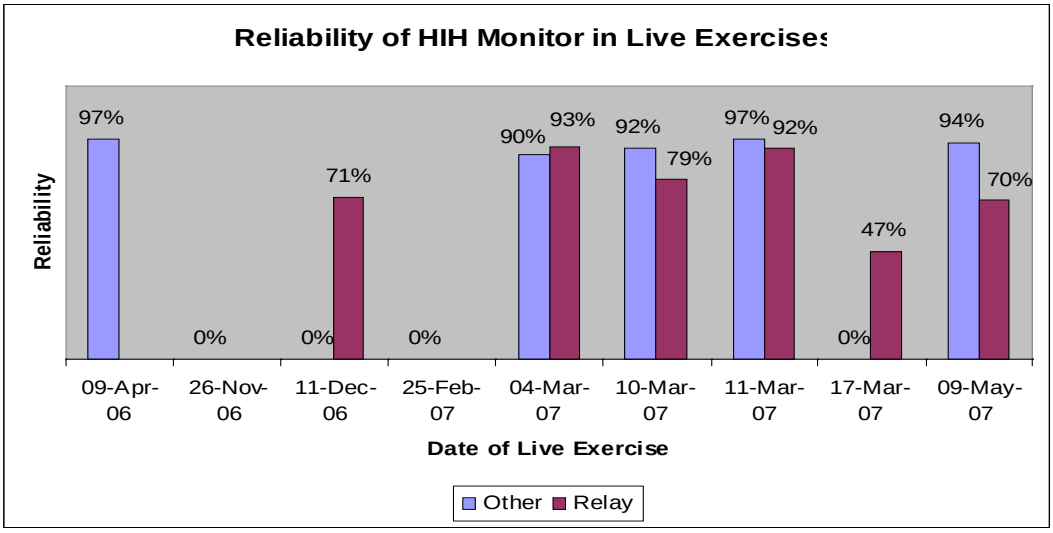

Figure 2: Reliability of HIH Monitor Disseminating CAP Messages via a series of SISO Applications during the Live Exercise. Graph shows Relay – relaying of message using application and other – function: download, acknowledge, EOI, & approval that must be completed prior to issuing message.

The same results above in Figire 2 summarized as an average to look at the overall perfromance of the HIH Montiors during the Live-Exercises conducted between November 2006 and May 2007, as seen in Figure 3 below.

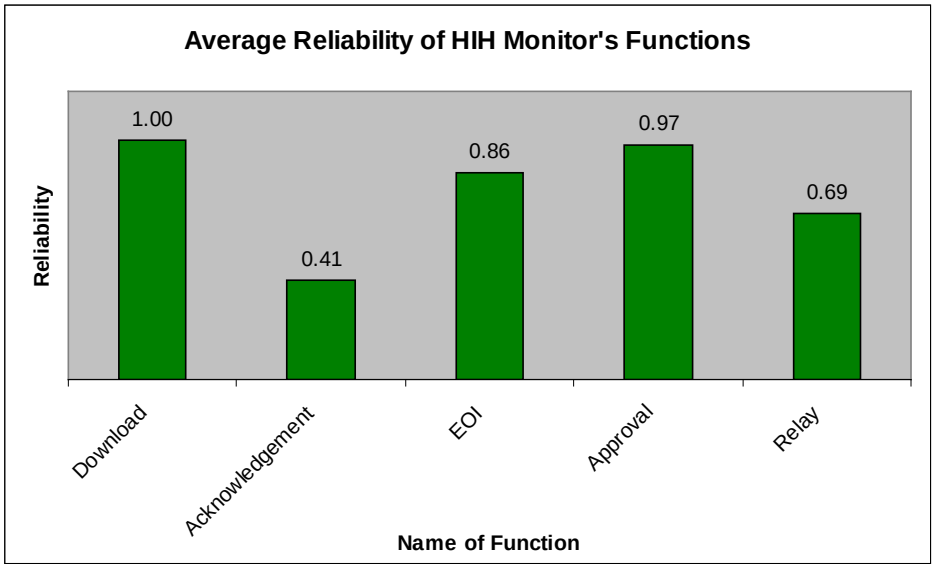

Figure 3 - Average reliability of HIH Monitor's Functions observed during the Live

DISCUSSION

The set of functions up to the point of relaying the CAP Message, with a little improvement and training, can be made to perform with over 95% Reliability. The bottleneck is in the independednt set of Message Relay Applications, which need to be consolidated to one Relay Application.

Some of the delays were caused by login failures. Having to operate a multiple of SISO Relay Applications forces the user: HIH Monitor to remember that many user names and passwords. A CAP broker would remember the security access information to all of the teleports. Hence, the HIH Monitor will need only the CAP broker access information.

The data on 10-Mar-2007, 17-Mar-2007, and 09-Mar-2007 shows that the Reliability drops significantly as the number of Relay Application need be used to disseminate the messages.

The Messaging in the Live Exercises were conducted mainly in English language. Therefore, the complexity of translating the CAP Messages is not reflected in the data. However, it is intuitive that without any intelligent real-time translator it would be very difficult for the HIH Monitors to achieve the 95% Reliability benchmark.

RECOMMENDED LM-HWS CAP BROKER

An early challenge faced by the project was whether or not the project would need to build a CAP user interface (GUI) from scratch, or whether there was an application available that could be borrowed. The CAP GUI provides a method (a template) for authorized users to enter data into a computer at the HIH and for the transformation of that data into the appropriate CAP XML elements to enable standardized content creation and passage to the various ICTs. The results show the need for a CAP broker.

For the HazInfo CAP Broker, the current inputs will come in the form of text and/or voice. The message editor should be capable of transforming the audio and/or text to fit the defined CAP format. In most cases the message will be entered by the user. In a few cases the interface to external sources will be direct without any user interference. Figure 4 below shows the necessary and sufficient software components of the CAP Broker.

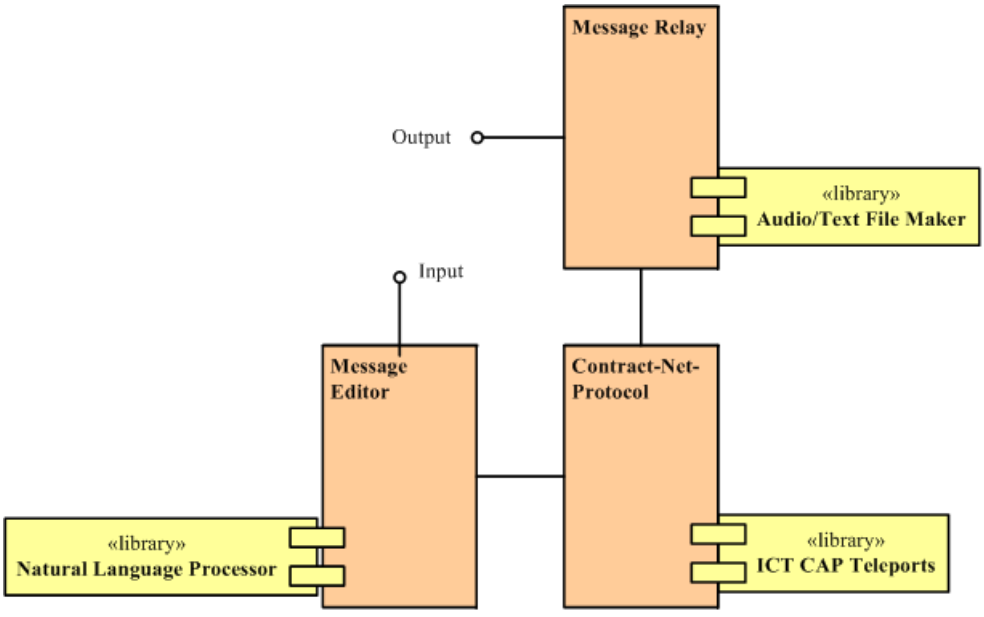

Figure 4: Modules and Knowledge bases (libraries) associated with CAP Message Broker

A *natural language processor* will take a CAP input in any language and translate the message to chosen other languages. The user should be able to switch between languages as and when needed. Hence, the GUI must also change to fit the localization requirement; i.e. switch to the selected language. The user can then enter the CAP message in their language of choice. Thereafter, the translator in the Message Relay component will convert the message to the specified languages and file formats.

After the messages are generated using the *CAP Message Editor* is saved, then the *Message Relay* component will generate the necessary outputs in the specified file formats as subscribed by the Message Recipients and ICT Providers. Thereafter, these files will be relayed to the registered gateways. In most cases it will be a TCP/IP file transfer that will be picked up by the provider. The module will provide means to configure the message relay component. This will entail mapping the CAP message file formats with the respective Gateways. Hence, this component will also allow the user to register and configure the gateway (teleport). The providers will deliver the messages to the last-mile through the subscribed gateway.

The CAP Message Broker (abbreviated as CAP Broker) is a server application that provides an intermediary point of interconnection between the Information Hub and the relay network to facilitate interconnection of all ICTs and passage of CAP-compliant messages through a single software application. ***"Message broker"*** is an intermediary program that translates a message from the formal messaging protocol of the sender to the formal messaging protocol of the receiver in a telecommunication network where programs communicate by exchanging formally-defined messages."[6] The HazInfo Project defines a CAP Message Broker to be a Multiple Input Multi Output System that builds a multilateral contracting scheme between the CAP Message issuing Actors: HIH Monitors, CAP Message Transporting Actors: ICT Providers, and CAP Message receiving Actors (Emergency First Responders). HIH Monitors must have the capability to generate a single message for a targeted set of Geo Spatial Coordinates (i.e. Area). The *Contract-Net-Protocol* is the module that maintains the contracts between the 3 Actors and ensures the delivery of CAP Message is completed. A major article in the Contract is the association of Geo Spatial information, mainly, with respect to the CAP Message recipients.

CONCLUSION

Build an MIMO System such as a CAP Message Broker, which is an essential component in a LM-HWS to disseminate the CAP Messages to the various ICTs in Sinhala, Tamil, and English. It is recommended that a free and open source software program (CAP Broker) be developed to integrate the project's individual CAP message generators and processors to serve as a single non-repetitive data input and import/export function. Supplementing the deficiency in a LM-HWS with additional with human capacity is very costly. Therefore, most of the deficiencies must be remedied with Efficient Software such as a CAP broker. Extending the software to work for other Message Relays in the Region will be easy, after it is proven to work for a Nation with 3 languages such as Sri Lanka.

REFERENCES

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]

5. 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

6 Definition of a Message Broker is as defined in the wikipedia -- http://en.wikipedia.org/wiki/Message_broker .

Public Warning ITU Headquarters, Geneva

6. 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/

7. 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

8. 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

9. 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]

10. Rangarajan, S (2007), "Synchronous and Asynchronous Education Delivery", On-line Journal of Space Communication article can be found here -- http://satjournal.tcom.ohiou.edu/ (Published)

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.

13. Waidyanatha, Nuwan, Gow, Gordon, Anderson, Peter (2007 May). "Hazard Warnings in Sri Lanka: Challenges of Internetworking with Common Alerting Protocol". Accepted paper for the Proceedings of the 4th International ISCRAM Conference ((B. Van de Walle, P. Burghardt and C. Nieuwenhuis, eds.), Delft, the Netherlands, May 2007 (Published)

14. Waidyanatha, Nuwan, Dias, Dileeka, Anderson, Peter (2007 September). "Challenges of Optimizing Common Alerting Protocol for SMS based GSM Devices in Last-Mile Hazard Warnings in Sri Lanka" ~ working paper ~, *Proceedings of the IEEE 1st International NGMAST Conference and Exibition, Cardiff, Wales*. (Paper being reviewed)

15. Waidyanatha, Nuwan, Gow, Gordon, Anderson, Peter (2007 September). Community-based Hazard Warnings in Rural Sri Lanka: Performance of Alerting and Notification in a Last-Mile Message Relay", *Proceedings of the IEEE 1st International WRECOM Conference and Exhibition, Rome, Italy*. (In Press)