Hazard Warnings in Sri Lanka: Challenges of Internetworking with Common Alerting Protocol

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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 commercial satellite and terrestrial network technologies (C/L/X-Band, GSM, and CDMA in modes of voice and text). 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 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.

KEYWORDS

All-Hazard, Last-Mile, Public Warning, Common Alerting Protocol, 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 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 donar 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 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 responsible for monitoring messages delivered by 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.

Because the Government of Sri Lanka (GoSL) has the exclusive responsibility for issuing “public warnings”, the HazInfo project has confined it’s messaging to issuing “Alerts” in a Closed User Group” environment; namely the members of 32 strategically selected[3] tsunami affected Sarvodaya villages. The advantage of this approach is that in the event the GoSL issues an official warning the HazInfo network will be available to relay the GoSL warnings to the Sarvodaya Last-Mile communities.

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.

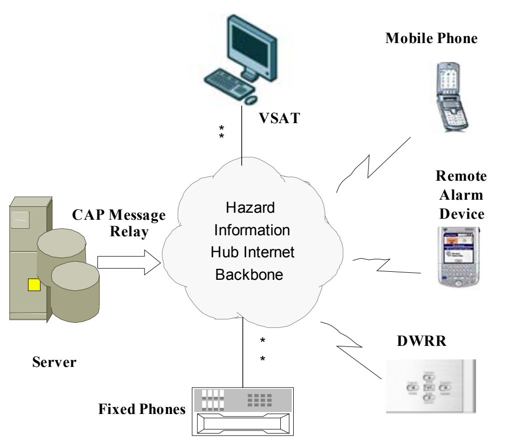

Figure 1 - Sarvodaya Hazard Information Hub Common Alerting Protocol Message Relay and the Information Communication Technologies that receive the CAP Alerts

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

[3] The Lanka Jatika Sarvodaya Shramadana Sangamaya (Sarvodaya) is Sri Lanka’s largest and most broadly embedded people’s organization, with a network covering: 15,000 villages, 345 divisional units, 34 Sarvodaya district offices; 10 specialist Development Education Institutes. http://www.sarvodaya.org/aboutSelected Sarvodaya Villages were affected by the December 2004 Indian Ocean Tsunami and uniformly represent the 10 Tsunami

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[4] 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.

Addressable Radio for Emergency Response (AREA)

Addressable Radio for Emergency Response or AREA is a class of WorldSpace[5] Disaster Warning, Recovery, and Response (DWRR) systems that can disseminate hazard information directly to those communities at risk. Global Positioning System (GPS) technology incorporated into the radio set, along with the unique code assigned to every satellite radio receiver, allows for hazard warnings to be issued to sets that are within a vulnerable area or just to radio sets with specific assigned codes. This solution communicates UDP/IP data packets channeled up to a Satellite through X-Band and down to the DWRR devices through L-Band communication pipes. The AREA devices feature a small alpha-numeric display screen, audio speaker and alert beeper. An optional USB connectible device is available to provide expanded message display capability [10].

Wireless Mobile Phone (MP)

The MP is powered by a 104MHz ARM processor, and is based around Symbian's Series 60 platform. Microimage[6] 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.

Wireless Fixed Phones (FP)

Code Division Multiple Access (CDMA) FP was used in the research. These FPs are a Sri Lanka Telecom[7] solution for telephony mainly for Rural Sri Lanka. The phone sets also provide 1xRTT capabilities with Voice, SMS, and Internet connectivity (54Kbps), which transmit on the 8.5 KHz and 18.5 KHz frequency spectrums. CDMA Fixed Wireless Phones with built-in speakerphones to provide voice communication via the public switched (FPs).

Very Small Aperture Terminal (VSATs)

The VSATs installed by the project operate on the C-Band International Telecommunication Union (ITU) frequency spectrum. Ku-Band frequency spectrum VSATs have been proven to have substantial down town as a result of the tropical weather that creates cloud cover quite often in Sri Lanka. Therefore, the HazInfo project opted to adopt C-Band instead of Ku-Band. VSAT terminals are being installed in two communities and at the HIH. These facilities will provide up to a 512 kbps Internet connection and enable testing of the Internet Public Alerting System (IPAS). An IPAS client application installed on a computer enables pop-up messages to appear on a PC screen and an audio alert tone to be played on the computer's sound system. This part of the project will also evaluate the extent to which end-user devices can be used to report observations from villages to the Hazard Information Hub in order to

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affected Coastal Districts of Sri Lanka. These Villages also represent the different ethnic communities in the country.

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

[5] WorldSpace Addressable Satellite Radio url – http://www.worldspace.com

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

[7] Sri Lanka Telecom url – http://www.slt.lk

improve situational awareness. These evaluations will therefore have downstream (warning) and upstream (reporting) components. TCP/IP based Internet Public Alerting System (IPAS) software was developed by Solana Networks[8] in Ottawa, Canada. The software uses a dedicated port on the client's PC to communicate the alerts through a non CAP compliant Simple Object Access Protocol (SOAP) based text messaging technique.

INTERNETWORKING PIPES, GATEWAYS and CONTENT

HazInfo Communication Architecture

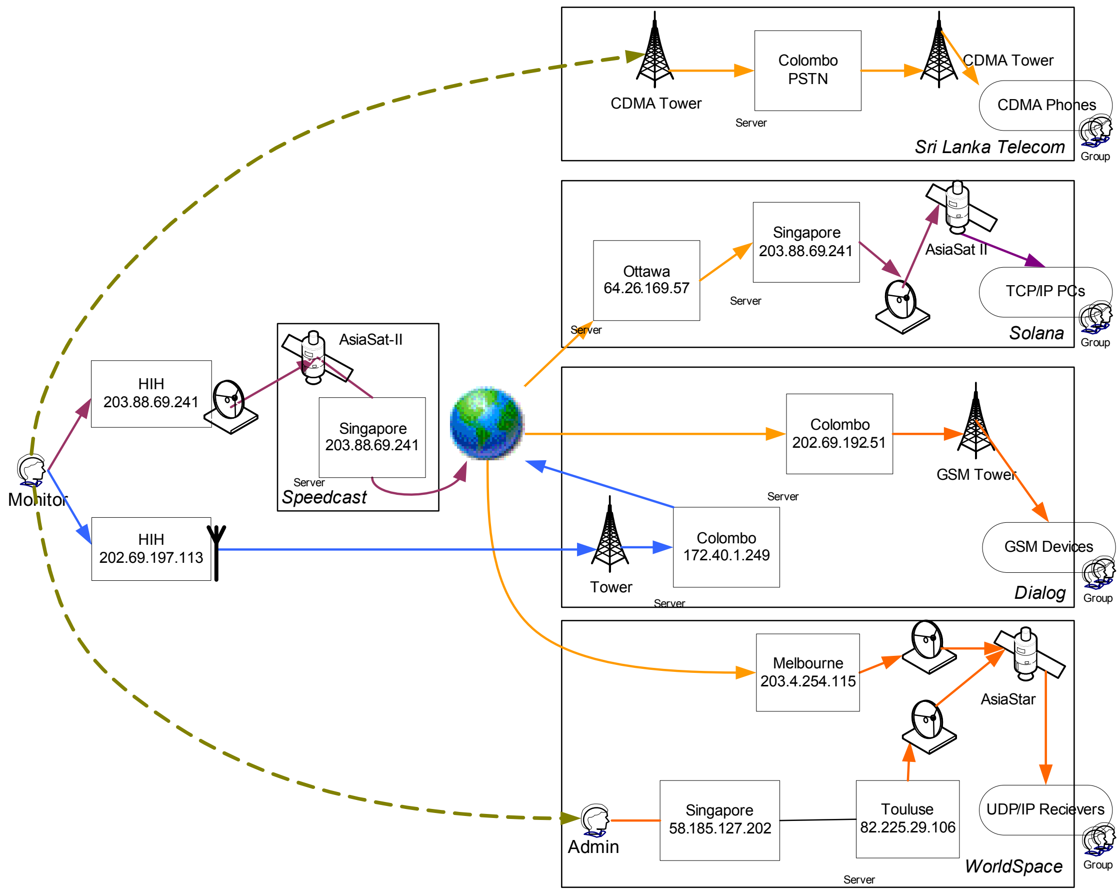

Figure 2 - CAP Message Structure for LM-HWS

Initiating point of internetworking is HIH. The message composed by the authorized user: HIH Monitor is delivered by an Internet Browser based application through the Layer 3 switch at the HIH to the WorldSpace, Dialog and Solana Systems either via the 203.888.69.241 or 202.69.197.113 Gateways the VSAT C Band Link or Microwave Link respectively. The CDMA alerting message is a voice call, which works independent of the two TCP/IP gateways, uses a CDMA2000 1xRTT system to deliver the message via the 8.5 KHz and 18.5 KHz frequency spectrums Sri Lanka Telecom System. The Systems: Sri Lanka Telecom, Solana, Dialog, and WorldSpace, deliver the message to CDMA2000 1x_RTT fixed wireless telephone, Personal Computer (PC), RAD or Nokia 6600, and AREA A or B or C devices respectively.

[8] Solana Networks Internet Public Alerting System – http://www.solananetworks.com

Content Standard to Test the Effectiveness of ICTs

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. CAP is a simple, flexible data interchange format designed for collecting and distributing "all-hazard" safety notifications and emergency warnings over information networks and public alerting systems [8]. Essentially, as a content standard, CAP is deliberately designed to be transport-neutral.

In web-services applications, CAP provides a lightweight standard for exchanging urgent notifications. It can also be used in data-broadcast applications and over legacy data networks. CAP provides compatibility with all kinds of information and public alerting systems, including those designed for multilingual and special-needs populations. CAP incorporates geospatial elements to permit flexible but precise geographic targeting of alerts. Futher, CAP provides for associating digital images and other binary information with alerts and supports various mechanisms for ensuring message authenticity, integrity and confidentiality where required.

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

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

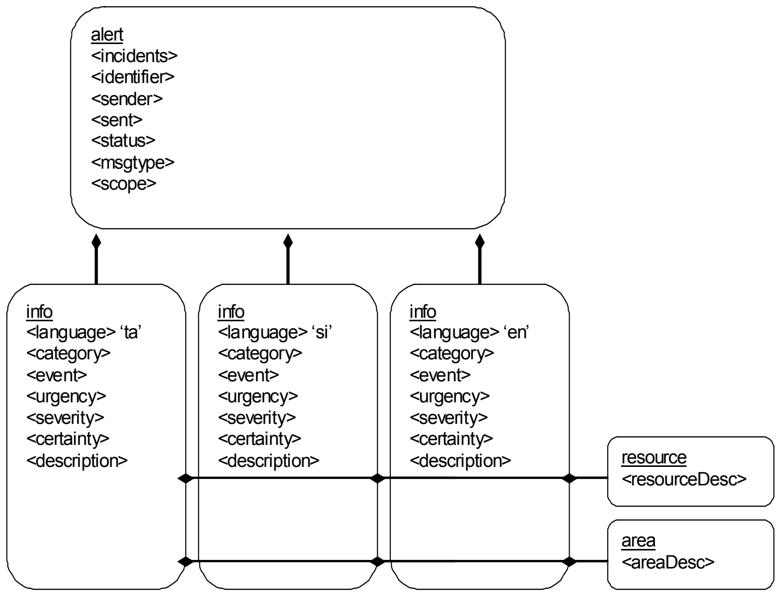

Figure 3 - CAP Message Profile defined for Sri Lanka

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 defined in the Profile for Sri Lanka, which are the sub elements of the <Info> element <urgency>, <severity>, <certainty>, and <description>
0.85	Mandatory sub elements of the <alert> element and the sub element <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[9] 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

[9] 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

(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*
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.

ESSENTIAL FIRST-RESPONDERS

Human Resource described in this section is vital to ensuring the propagation of the CAP message from the HIH to the people in the Last-Mile. The CAP Message can get mutated by anyone of the Key Resources or by the Communications Providers due to limitations on the Technologies and Devices. Without these Key Players filling the void of the partially automated communication architecture the LM-HWS will be dysfunctional.

HIH Monitors

Sarvodaya Hazard Information Hub 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 to enter the CAP Message

collective.

to be transmitted to the ICT Provider Gateways. Authorized Personnel: HIH Monitors are first trained and certified. The certification requires written assessment and a practicum; similar to other emergency management units.

ICT Guardians

An ICT Guardians (ICT-Guardian) should be able to clearly interpret the Event, Priority, and Description of a CAP Message. Thereafter, be able to activate community ERP as a function of the received CAP Message. ICT Guardians are the community resources that maintain and operate the ICTs around-the-clock. When an Alert is received the Guardians communicate the information to the community ERP Coordinators (a.k.a Community First-Responders). During the hand-off the ICT-Guardian receive in-house training on operational instructions, fault handling procedures, alert recording/dissemination procedures.

ERP-Coordinators

The HazInfo participating communities have developed a Community Emergency Coordination Unit (CECU). All members of the CECU are ERP Coordinators who engage in coordination activities during an emergency such as relaying threats to the people in the community and ensuring the community executes the correct ERP.

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.

Participated Sarvodaya Communities

The Sri Lanka "North-East" Conflict between the Liberation Tamil Tigers for Elam and the Sri Lanka Government has forced the project from running Live-Exercises in Jaffna. Similarly, the Hambantota District was affected by floods and damn breaks, giving people enough to worry about than concentrate of Live-Exercises. Therefore, the sample size was reduced to 26 villages instead of 32 villages in 07 Districts instead of the original 09 Districts. At least 1 Silent-Test with the ICT-Guardian was conducted by the HIH-Monitor initiating the Silent-Test. Table 6 below defines the allocation of ICTs and the participating communities with the specific ICT.

Table 5 – Village categorization relative to the training regime and organizational ranking

Quadrant	***Village characteristics***
Upper Left	- Trained and Less Organized

Upper Right - Not Trained and Less Organized

Lower Left - Trained and Organized

Lower Right - Not Trained and Organized

Table 6 - The distribution of ICTs in the 32 Sarvodaya Communities (District defined in parenthesis) that participated in the Last-Mile HazInfo Project. Table is subdivided in to 4 quadrants with 8 villages in each.

VSAT Urawatha (Galle)	MP Nidavur (Batticalo)	FP Thirukadalar (Trincomalee)	AREA-B Moratuwella (Colombo)	MP Meddhawatha (Matara)	PM Ulla 1 (Kalmunai)	FP Oluville (Kalmunai)	AREA-B Maggona (Kalutara)
AREA-B + RAD Modara-pallassa (Hambantota)	AREA-B + FP Wathegama North (Matara)	AREA-B + MP Palmunnai (Batticalo)	Control Village Abeyasinghe Pura (Ampara)	AREA-B + RAD Thondamanar (Jaffna)	AREA-B + Fixed phone Shithani-kudipuram (Kalmunai)	AREA-B + Mobile Phone Munnai (Jaffna)	Control Village Modara (Colombo)
VSAT Modaragama (Hambantota)	MP Diyalagoda (Kalutara)	FP Periyakallar (Batticalo)	AREA-B Panama North (Ampara)	MP Satur-kondagnya (Batticallo)	MP Samodhagama (Hambantota)	FP Indivinna (Galle)	AREA-B Brahamana-wattha (Galle)
AREA-B + RAD Kalmunai II (Kalmunai)	AREA-B + FP Samudragama (Trincomalee	AREA-B + MP Valhengoda (Galle)	Control Village Mirissa South (Matara)	AREA-B + RAD Venamulla (Galle)	AREA-B + Fixed phone Kottegoda (Matara)	AREA-B + Mobile Phone Thallala South (Matara)	Control Village Thalpitiya (Kalutara)

Note that the four quadrants with 8 communities per quadrant have ICTs identically distributed.

ICT Deployment

Before distributing equipment to participating villages, all ICTs were tested at the Sarvodaya Head Quarters. Thereafter, the equipment (except the VSAT) was handed over to the ICT-Guardians to take back to their communities. At the time of hand-over, a workshop was conducted to provide an introduction to CAP and formal training of use and maintenance of the ICTs.

Next a series of "Silent-Tests" (see below) were conducted as soon as the ICTs were deployed in the villages to determine whether the ICT-Guardians were able to properly install and operationalize them. However, due to a poor response, Sarvodaya HIH staff made a follow up visit to each location to assess and, if necessary, re-configure the ICTs to maximize the signal reception gain and test the alerting functions.

Finally, the ICT-Guardians were given datasheets to help them maintain utilization and maintenance log. Another form focused on the ICT-Guardians recording their perception of the CAP messages received in an alert.

"Stage[10] 4 & 5 Sarvodaya villages that are more "organized", i.e., have a formal structure that enables coordination and direction of activities did not respond more effectively to hazard warnings than less organized stage 1, 2 & 3 villages". The devices are distributed to cover the ethnicity of coastal communities. In some instances the a pair of ICTs were given to the village to determine the shortcomings of two-way communication in the AREA-B system.

Silent-Tests

A "Silent-Test" is a system test whereby the message *recipient* terminates the message upon receipt by the HIH-Monitor, ICT-Guardian, or ERP-Coordinator rather than seeking any further action. These tests were used to check the functioanlaity of equipment as well as enable First-Responders to rehearse situations. The message is recorded and acknowledged by each participant. The message *initiator* is either the HIH-Monitor or an ICT-Guardian. The initiator waits to receive an acknowledgement from the message recipient. A range of these test were conducted between between June and December 2006.

Live-Exercises conducted between December 2006 and March 2007

A "Live-Exercises" is a sequence of planned exercises to evaluate the interoperability between processes. Unlike in a Silent-Test where the test involves a single, "hand-shake"; the Live-Exercise is a sequence of independent hand-shakes; where the Live-Test is the chain of processes: relaying CAP message, acknowledging CAP message, and disseminating message to Last-Mile. LM-HWS processes were simulated in 26 of the 32 villages.

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."

[10] Sarvodaya follows a development model that come under its purview to develop through five evolutionary stages. Half of the 32 villages selected, will be composed of highly developed stage 4 and 5 villages and the other half would be composed of less organized stages 1, 2 and 3 Sarvodaya villages.

Behavior of ICTs and Resultant Last-Mile Outcomes

Table 7 – 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

Interface	*HIH Monitor issued CAP Message*	*Receiver Device and {Medium}*	*ICT Guardian received Message elements*	*Community Executed ERP*
DEWN Internet Browse	<info> sub element with <Language[11]>en <Description> … {no size restriction}[12] <Language>si <Description> … {no size restriction} <Language>tm <Description> … {no size restriction}	MP {Text} RAD {Text}	"Warning" <info> <Language>en <Description> A SEVERE CATEGORY 4 CYCLONE… <Language>si <Description> …{sinhala} <Language>tm <Description> … {tamil} {restricted by 130 characters}	Tsunami Evacuation
ANNY Internet Browser	Full CAP message with <Language>en only.	AREA – B {Text}	<msgType>Alert <Scope>restricted <Sender>hih <Status>exercise <Category>met <Urgency>expected <Severity> sever <Certainty>observed <Event>A SEVERE CATEGORY 4 CYCLONE	Tsunami Evacuation
Internet Public Alerting System	<Description> with <Language>en only … {no size restriction}	Personal Computer {Text}	<Description> A SEVERE CATEGORY 4 CYCLONE … {no size restriction}	Not Applicable
CDMA 2000 1x_RTT	<Description> … {no size and language restriction}	CDMA2000 1x_RTT Telephones {Audio}	<Description> A SEVERE CATEGORY 4 CYCLONE …{no size restriction}	Tsunami Evacuation

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.

[11] Language identifiers used in the text: 'si', 'tm', and 'en' refer to 'Sinhala', 'Tamil', and 'English' respectively.
[12] {no size restriction} implies that the input or output text display or audio is not truncated as it would by the SMS based system that is restricted by the 130 character length.

Table 8 - Rating for the ICTs for effectiveness of relaying a Complete Full CAP message

ICT / Measure	*AREA*	*RAD*	*MP*	*FP*	*VSAT*
Language Diversity (‘si’, ‘tm’, ‘en’)	0.20	0.20	1.00	1.00	0.20
Full CAP (‘XML’)	0.85	0.70	0.70	0.80	0.20
Mediums (audio, text)	0.95	0.85	0.85	0.95	0.85
Rating	0.16	0.19	0.56	0.76	0.03

DISCUSSIONS

Reliability 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 ICTs for any given trial. Therefore congestion is not taken in to consideration.

Shortcomings of ICTs

Presently, the HazInfo project does not employ a multi-langauge device that is capable of displaying the entire CAP message. The WorldSpace optional Alert Box is the only device that can display 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).[13]

Disregarding the CAP Profile

Of the five ICTs used in the project, only three make use of the CAP message format (AREA, RAD and MP). However, each is only capable of displaying a limited number of the CAP elements, limiting the amount of alert message content. Consequently, during simulations ICT-Guardians restricted their CAP message content creation to recording only a few elements such as the <*msgType*> and <*Event*> and did not include <*urgency*>, <*severity*>, and <*certainty*> to enable ICT-Guardians to gage the Priority. One reason particular reason for doing so was that only the WorldSpace AREA units could display these qualifier elements. 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.

CAP Interoperability

Global hazard monitoring organizations such as United States Geological Survey (USGS) and Pacific Tsunami Warning Center (PTWC) also issue CAP messages. However, throughout the project, it was discovered that not all organizations, including USGS and PTWC, use the same OASIS CAP version making it difficult to automatically import their CAP Messages into the HazInfo CAP readers and thus requiring manual transfer of data for relaying timely Events of Interest.

CONCLUSION

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

[13] A report by Anderson, Peter [1] describes in detail the shortcomings of the ICTs and recommends enhancements to make the ICTs usable in the last-mile of Sri Lanka. The report further proposes an integrated software system that can automate some of the HIH processes to make it easy on the HIH Monitors to minimize the dissemination times.

multiple last-mile systems that include commercial satellite and terrestrial network technologies (C/L/X-Band, GSM, and CDMA in modes of voice and text). Except for the voice only component of Fixed CDMA phones, all other ICTs used in the HazInfo Pilot must be upgraded to receive complete CAP Messages and in all working languages before they can be effectively used in the Last-Mile communities of Sri Lanka. However, community simulations demonstrate that all 5 ICTs can be easily incorporated into the community with the recommended enhancements. 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 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. Finally, the implementation of an effective last mile warning system cannot be dependent upon ICT alone. An effective system must first include development of the necessary human capacity: HIH-Monitors, ICT Guardians, and ERP Coordinators, along with proper local risk management and public education to supplement the deficiencies of an end-to-end fully-automatic early warning system. Thereafter, simulated drills must be conducted regularly to develop the cognitive framework to ensure all ERPs can be carried out smoothly and without confusion.

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