Challenges of implementing Standardized Emergency Data Exchange with Interactive Voice Response in Sri Lanka

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1. Synopsis

The January 2011 Floods in the Eastern Province of Sri Lanka accounted for one million victims (DMCSL, 2011). The local community-based organization: Sarvodaya, responded with humanitarian aid. Telephones calls were their main mode for communicating between the field and the central hub. The action research: Feasibility study to enable Freedom Fone with voice-based emergency data exchange (FF4EDXL) investigated the use of voice and text technologies for streamlining Sarvodaya's disaster information communication needs. Interoperable content standards for alerting and situational reporting were adopted. Freedom Fone (FF) interactive voice interlinked the field with the central hub. The voice messages converted to categorical text data were managed in the Sahana Disaster Management System (Sahana). Transforming the local languages between text and speech, with software, is a challenge. The human substitution, for software, significantly degraded the efficiencies. The FF4EDXL research conducted controlled exercise in four districts with Sarvodaya emergency coordinators to evaluate the interoperability shortcomings. The voice quality was below expectation with a Mean Opinion Score (MOS) of 3.52, Difficulty Score (DS) of 29.44%, and Comparison Categorical Score (CCR) of -1.55. Operational efficiencies and information quality must be improved before FF Interactive Voice Response (IVR) system can be deployed in a wider-scale.

Keywords: disaster, interoperability, emergency, information, communication, Sri Lanka

2. Introduction

Ted Turner, United Nations Foundation Chair, in his forward contributed to the Relief 2.0 report (UN-OCHA, 2011) emphasizes that “powered by cloud-, crowd-, and SMS-based technologies, individuals can now engage in disaster response at an unprecedented level”. This was evident during Haiti 2009 earthquake when affected members of the community used social media to plea for help. Sahana Software Foundation was a key technology player in aiding the race to fill the information gap by collaborating with Ushahidi and Google Crisis Response (Prustalis and De Silva, 2010). NetHope Emergency Response Director: Gisli Olafsson (2011), indicates how digital age technologies, like social media, are revolutionizing the way humanitarian response will be conducted in the future. He emphasizes how crowd sourcing, mass collaboration, volunteer & technical community self-organization, and "information to the edge" will push totally new approaches into the disaster space. Given that social media statistics (Sverdlof, 2012) show that main users are from USA and Europe, the acceptance of these unlocalized text reliant technologies are questionable when applied to non-native-English speakers in a grass-roots community-based disaster management setting in Sri Lanka.

A six country study, in Asia, on the use of technology choice by Zainudeen and Ratnadiwakara (2010) conclude that simple telephone calls, by a large margin, precedes all other text and Internet based communications. FF4EDXL project survey conducted with Sarvodaya emergency coordinators revealed that telephone calls were their predominant choice (~99%) for exchanging daily, weekly, and monthly response resource reports (Wilfred and Waidyanatha, 2011). With over 86% mobile and 17% fixed subscriptions, people in Sri Lanka have easy access to telephones. The nine mobile and fixed telcos cover more than 95% of the Island (TRCSL, 2011). In this regard, voice based technology interfaces are a viable tool for exchanging crisis information. Simple telephone calls remove literacy and language barriers. Hence, the FF interactive voice interface presents itself as an effective tool that can be leveraged for emergency communication. A challenge lies with integrating the system and transforming the voice data to standardized categorical text-based information that can be analyzed for rapid decision support and resource allocation.

Information standards enabled interoperability; namely, technical interoperability, semantic interoperability, and business process interoperability. Technical interoperability is for moving data between the FF system to the Sahana system. Technical Interoperability is concerned with the conveyance of payload. It neutralizes the effect of distance, is domain independent (Open System Interconnection Mode's levels 1-6), and is fundamentally based on Information Theory.

Semantics interoperability requires the FF system and Sahana system to understand the data in the same way. For example, the hazard event “hurricane”, in alphanumeric form, is interpreted in the same way when voiced through the FF system in an audible form. Semantic interoperability communicates meaning unambiguously. It is domain-specific (Open System Interconnection Model's Level 7) and is needed to understand, properly to interpret and use data. To elaborate, the word “hurricane” in a tavern would refer to an alcoholic drink but is a type of cyclone in the disaster space. "Proper interpretation" means that the transmitted information will be used appropriately by a receiving computer system because the logical implications derivable from transmitted information will be the same as those that the sending system would derive.

Process Interoperability enables shared human understanding that is needed to coordinate work processes and enable business systems to interoperate. Thus, the information exchanged between the Community Emergency Response Team (CERT) members in the Districts and the HIHO at the Sarvodaya hub should support each others’ intended actions. It is essential if, interoperability is to provide any benefits in managing disasters.

There can be gains in efficiencies at the Sarvodaya Hazard Information Hub (HIH) if, text-To-Speech (TTS) and Speech-To-Text (STT) software can be implemented to mediate the information between FF and Sahana. The FF4EDXL researchers surveyed literature and consulted with Sri Lanka academia, working on natural language processing, to study the feasibility. Weerasinghe et al (2007) developed the first Sinhala TTS converter diphone database and implemented the natural language processing modules. Later, Bandara et al (2010) were successful in building a new prosodic phrasing model for Sinhala. Both are based on the Festival speech synthesis engine. The overall “modified rhyme test” intelligibility of the Festival Sinhala TTS system was found to be 71.5% in their lab. Nallathamby et al (2011) improved Festival-Sinhala speech syntheses models towards developing a Sinhala IVR. The speech recognition (more or less the STT) accuracies are diverse, ranging from 31% to 92% under various circumstances.

This work continues from LIRNEasia's research on early warning systems and emergency exchange platforms. An early action research: the HazInfo (Samarajiva and Waidyanatha, 2009) field tested wireless technologies and the use of Emergency Data Exchange Language (EDXL) Common Alerting Protocol (CAP) for alerting last-mile communities. The Sahana Alerting and Messaging module was an output of the research. Thereafter, the mHealth Biosurveillance research (Careem et al, 2010) enhanced the Sahana Alerting and Messaging module to produce the Sahana Alerting Broker (SABRO). Sahana had an Incident Reporting module but had not Incorporated the EDXL Situational Reporting (SITREP) content standard. FF4EDXL introduced SITREP to Sahana. These developments are discussed in the Technologies section below. The integration of FF and Sahana through EDXL evaluated for its complexity, usability, and utility. This paper specifically discusses the automation challenges resulting from unreliable data and standards adaptation.

3. Technologies

3.1. Freedom Fone

Freedom fone is a voice based, interactive, two way information system. The users of this system only need a fixed or mobile phone to interact with the system. Since it does not need Internet access or computer skills, people from any part of the country including rural areas, where there is coverage, can easily interact with this system using their own phones (Otieno , 2011).

This user friendly information system consists of interactive voice menus, voice messages, SMS and polls. The FF software provides simple web browser interface for system administrators; they can create menus and menu options that can be easily updated, and received messages can be tagged and commented (Panth, 2011).

A user can call to this IVR, and listen to the information recorded on the system or can leave a voice message as their response to the system. A typical FF voice menu will be like this:

Welcome to the Sarvodaya Disaster Management Center, press 1 to listen to Alerts, press 2 to record a Field Observation report (record a voice message), press 3 to submit answers to a Survey. The voice menus can be made available in any language.

Administrators can use SMS facility to make available sending and receiving SMS through the system, and SMS polls can be conducted for specific requirements. The SMS polling was implemented to receive and monitor CERT acknowledgements to issued alerts. This guarantees that the disseminated alerts were, indeed, received by the targeted audience.

3.2. Sahana Disaster Management System

"Sahana is a project which provides various services to handle the post disaster situations efficiently so the casualties from a certain incident can be minimized through making a coordination between governments, aid organizations, civil society and the victims themselves" (Prustalis and De Silva, 2010).

a) Sahana Alerting Broker

An alert is an indicator for making one known of a certain situation. An alert is usually a message in the form of language text, audible alert, audio message, blinking light, a graphical message that is intended to provide information regarding a certain event. A public warning is one type of an alert. While an alert can be disseminated by anyone, warnings are only for Governments to issue. An alert can be restricted to a closed group of people such as emergency first-responders. The alert may indicate that their is possibility of flash floods in affect due to the heavy rains. The recipients of the message would choose to respond accordingly.

SABRO was designed with CAP as the underlying data standard , specified for alerting and situational awareness. It is one that is recommended by the ITU-T (2008). The recommendation is documented by ITU-T as X.1303. CAP Document Type Definition (DTD) XML data structure consist of a main element <Alert> and sub elements <Info>, <Area>, and <Resources>. Each of the sub elements are composed of several other elements. The ITU-T X.1303 document defines each of these elements with respect to semantic interoperability.

The original design of SABRO was capable of relaying CAP messages using SMS, Email, and Web technologies. The FF4EDXL project enhanced the software to support dissemination of CAP messages through IVR systems. A typical CAP message, comprising data associated with the CAP elements, is transformed in to proper human readable sentences using XML Style Language (XSL). This transformation produces a paragraph that can be fed in to a TTS engine for generating an audio file or be used by a person to record the audio file. Those audio files are then hosted in the FF IVR for intended recipients to access by dialing in to the FF and selecting the option to listen to that voice-alert.

b) Sahana Eden Situational Reporting

Situation reports mainly focus on reporting the facts that can be observed and any immediate implications of the event. Situation reports are used to give most up to date details for decision makers for an incident. It provides a quick and easy way to report and disseminate the information to relevant authorities for rescue and relief operations. This kind of reporting is typically used during incidents like natural disasters, sudden breakdowns, accidents, military clashes, so on and so forth.

Eden-SitRep was developed by the FF4EDXL project. The software developments were guided by the SITREP data standard. It comprises <Root>, <FieldObservation>, <CasualtyIllness>, <SituationInfo>, <ResponseResource>, and <ManagementSumm> main elements with each of them further structured with a set of sub elements for documenting the information. EDXL SITREP is still in a state of production and is due to be released in the near future. The FF4EDXL development team used the beta version in developing the Eden-SitRep.

A typical Eden-SitRep work flow begins with a CERT member calling the FF system to record an incident report; specifically, a <FieldObservation> or <CasualtyIllness> report. To simplify the research <CasualtyIllness> reports were not considered in this project. The voice recording of the <FieldObservation> report would initiate a new Eden-SitRep alphanumeric record. The most efficient method would be for a STT engine to transform the voice message to text, then another software process to parse that information in to the relevant SITREP elements. However, the project had HIHOs transfer the <FieldObservation> information from FF to Eden-SitRep.

Each Eden-SitRep record has a <Root> elements with the qualifying data. The <FieldObservation> data elements describe the nature and location of the incident as well as describe the immediate needs. The received message is augmented with <SituationInfo> that would tag the location on a map, categorize the incident, set the dates and time it is for, and other pertinent indexing values or descriptions. Thereafter, incident managers at the hub would analyze those field reports to derive the <ResponseResource> details.

3.3. Emergency Data Exchange Language

EDXL is a group of content standards that support semantic and process interoperability. It enables coherent work flows between various emergency management systems and organizations. EDXL standards were integrated in to the project because they are open source XML-based protocols with clearly defined elements, capable of supporting data interchange across multiple channels, and an EDXL-enabled system will more easily integrate with other national or international systems.

The Organization for the Advancement of Standardization of Incidence Systems (OASIS) developed and maintains the range of EDXL standards. They are based on XML because XML enables interoperability. Typically, each EDXL standard carries the references to a document definition Uniform Resource Locater (URL); i.e. the unique schema that defines the data structure, data dictionaries, and their definitions (i.e. how should the data be represented and what the data elements are meant for).

The FF4EDXL action research investigated the interoperability issues of integrating the voice-based FF system and Internet based Sahana system, specifically for disaster management. An action was to implement the globally recognized Emergency Data Exchange Language (EDXL) content standard that would act as the structured payload container for exchanging information between the two disparate systems. Thereby, studying additional implications with these domain specific restrictions. The project investigated the EDXL CAP for issuing messages for activating first-responders and the EDXL SITREP for communicating incident reports.

4. Research Design

4.1. Actors and their responsibilities

Sarvodaya has a 'Hazard Information Hub' (HIH) at its Community Disaster Management Center in Moratuwa. Volunteers – referred to as HIH Operators (HIHO) by the project team - would monitor hazard information through various websites and subscriptions (e.g. email bulletins) for 'events of interest' that might be cause for concern (e.g., an earthquake off the coast of Indonesia). From here, information bulletins would be issued to selected individuals, typically Sarvodaya village leaders, in the communities. These individuals - referred to as CERT members – are responsible for activating local community emergency response plans (e.g. disseminating a local alerts to evacuate the community to a safer place or a wake up call that would activate CERT members to assess an incident).

Another function of the HIH is to coordinate relief operations. The hub would receive various field reports from CERT members requesting for resources to respond to those incidents. The most common Sarvodaya service is facilitating the internally displaced persons with food, shelter, and health. The HIHO at the Sarvodaya hub: HIH were trained to administer the FF and Sahana systems. The HIHO had an aptitude to issue a CAP message and process inbound SITREP messages.

Four Sarvodaya Districts: Colombo, Matara, Nuwara-eliya, and Ratnapura were chosen to participate in evaluating the pilot system. Between ten to thirteen CERT members from each District were trained to operate the FF technology. They learned to receive an SMS alert, then dial the FF system to listen a localized descriptive version of that message. Thereafter, leave messages pertaining to various situational reports, mainly, requesting resources to respond to incidents.

5. Methodology

Kajackas et al (2011) discuss the speech quality impairing factors limiting the Quality of Service (QoS). These degradation factors are time variant caused by to changing communication conditions such as the weaker quality of service immediately following a disaster that may bring down the physical cellular infrastructure. They logically proved that mobile cellular network quality of service is predominantly on packet loss.

5.1. Mean Opinion Score

ITU-T P.800 recommends the MOS as a method to test transmission quality in one's own laboratory (ITU-T, 1996). MOS determines how satisfactorily telephone connections and FF may be expected to perform. Drawing from the ITU-T MOS recommendation, each researcher listened to the individual messages to rate them on a Likert scale: 1=Bad, 2=Poor, 3=Fair, 4=Good, 5=Excellent.

The researchers took in to consideration any circuit noise (mechanical noises), environmental noise (background noise), sidetone (feedback loop caused by the mouth piece), talker echo, and harmful effects of voice-operated devices that would deteriorate the audible quality. The MOS evaluation in this project varied from that of Nallathamby et al (2011). As they conducted their research purely with a computer in the lab, FF4EDXL evaluations took place in a real setting with actual voice calls over mobile telecomm networks.

5.2. Difficulty score

For the same sample of audio messages used in the MOS exercise, the researchers evaluated each audio recording on the ability to listen, parse, and transform that information to categorical text-based information. If the response was free of any intolerable noise then it was labeled *clear*, else noted as *unclear*. An intermediate label *partial* was used if, sections of the information was clear. The number of unresponsive answers were distinctly labeled *null*. Other observed difficulty remarks were also recorded by the evaluators.

The reason to include the null and partial elements as responses, besides the clear and unclear elements was because missing information or incomplete information can lead to false predictions that may subsequently lead to inappropriate response action. Difficulty score is an extension of the ITU-T P.800 (1996) *percent difficult* evaluation method.

5.3. *Comparison Category Rating*

While each CERT member was speaking to the phone to leave a message on FF, the researchers, simultaneously captured that sample on to a high quality digital audio recorder. Evaluators were presented with the pair of speech samples. First was the reference (or unprocessed) speech sample that was captured on-site with the digital audio recorder. Second was the speech sample transmitted through the telephones and captured by the FF system (or processed). The researchers rated the processed speech sample relative to the unprocessed one. The rating used a likert integer scale: 3=much better, 2=better, 1=slightly better, 0=absolutely the same, -1=slightly worse, -2=worse, -3=much worse.

5.4. *Exercises*

CERT members in the four pilot districts were subject two exercises: survey-exercise and controlled-exercise. Recordings from the first and second exercises were used as speech material that consist of simple, meaningful, short sentences.

a) Survey-exercises

The exercise involved Sarvodaya CERT members responding to a baseline survey with information on their past disaster communication experience. They were asked ten questions on the ways and means in which they had communicated disaster information in the past. The questions were combined with a choice of answers to select from. They recorded the applicable answer through the FF IVR.

The multiple choice questionnaire in the survey-exercise resembled a speaker-dependent system - the evaluators had a sense of the answers and could predict the answer, in spite of any distortion in the voice recording. Therefore, the voice quality DS evaluation process, in this exercise, emulates measuring the reliability of a trained interference engine that is expected to recognize the voiced terms.

b) Controlled-exercises

Figure 1 shows the controlled-exercise work flow. It began with the HIHO receiving information on an event of interest (Get HazInfo). The event information is transcribed in to a CAP message that is created with SABRO. That alert message is issued to activate the Sarvodaya first-responders: off duty HIHO and village CERT members, by means of a SMS short-text and posting a voice-alert in FF. CERT members listen to the voice-alert and acknowledge with a SMS text. Acknowledgements are received in to the FF polling function that are reviewed by the HIHO. CERT members assess the situation and record a Field Observation Report (FOR) in FF. Those voice reports are processed by the HIHO to enter them in to the Eden-SitRep module. The completed situation reports are analyzed by Sarvodaya Emergency Managers (EM) to derive the required Response Resource Report (3R). The HIHO and CERT members were presented with hypothetical hazard events and were asked to execute the standard operating procedures.

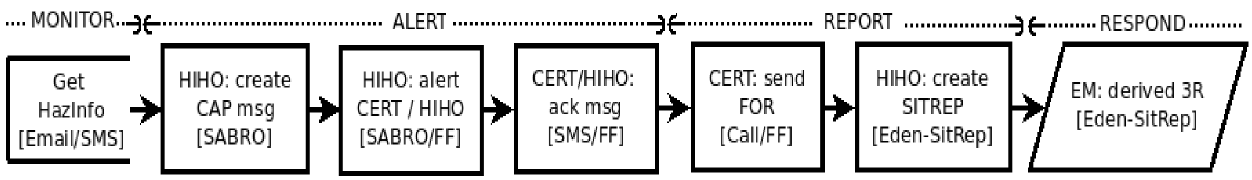

Figure 1: work flow from activating first-responders to formulating response resources

Unlike the survey-exercise, the controlled-exercises did not restrict the CERT members to a selected set of answers. They were given a reference guide to follow a sequence of questions that would result in providing the required FOR details. They spoke naturally to record the information with vocabulary and sentences of their own choice. The evaluators analyzing this information, besides knowing the nature of the scenario, were unaware of the answers. This process emulates a speaker-independent system with no prior training to recognize the patterns of the received information. Similar to the survey-exercise, the DS methodology was applied to evaluate the reliability of the voiced information.

6. Results

Authors wish to emphasis that this research was mainly a feasibility study to realize the design requirements and challenges for integrating FF with Sahana for information exchange; i.e. learn by doing. Therefore, the evaluation was not rigorous such as obtaining a statistically agreeable sample size and trials to attain the desired confidence levels. Instead, the intent was to apply the defined statistical methods and execute the exercises to understand the workable and unworkable components of the system.

Figure 2 and Figure 3 show the district-wise MOS outcomes from the survey and controlled-exercises, respectively. Figure 4 and Figure 5 show the district-wise DS outcomes from the survey and controlled-exercises, respectively. The survey exercise resulted in n=51 voice samples that were evaluated by m=3 people. The controlled-exercises produced n=41 voice samples that were evaluated by m=7 people.

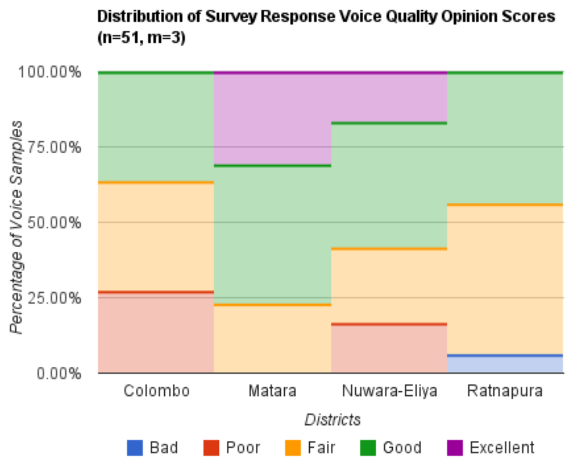

Figure 2: Survey-exercise MOS

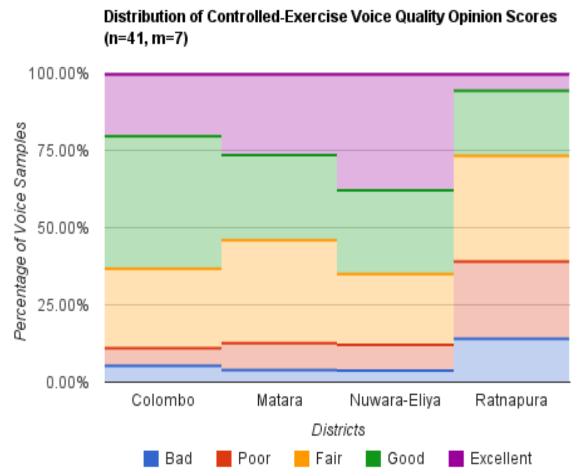

Figure 3: Controlled-exercise MOS

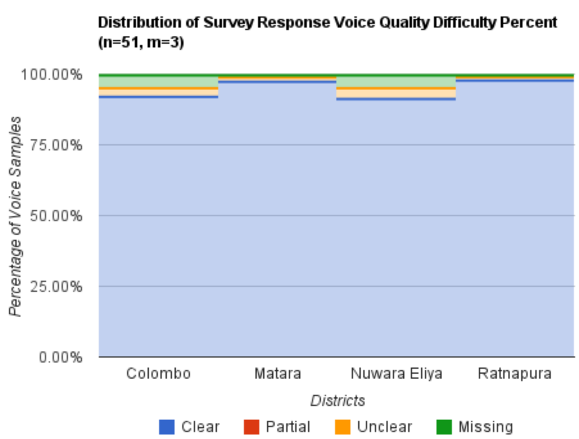

Figure 4: Survey-exercise percent difficult

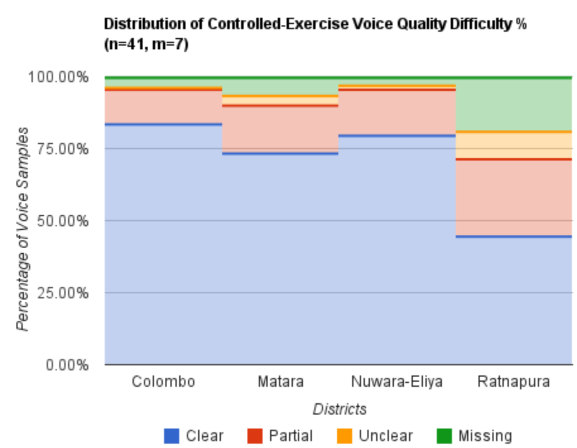

Figure 5: Controlled-excises percent difficult

Figure 6 shows the district-wise CCR. The researchers were able to obtain on-site recordings of the voice messages in two of the four districts (Matara and Colombo only). Recordings from Ratnapura and Nuwara-eliya districts are unavailable. The on-site recordings from the two districts were used as the reference to score the quality of the FF received matching recordings.

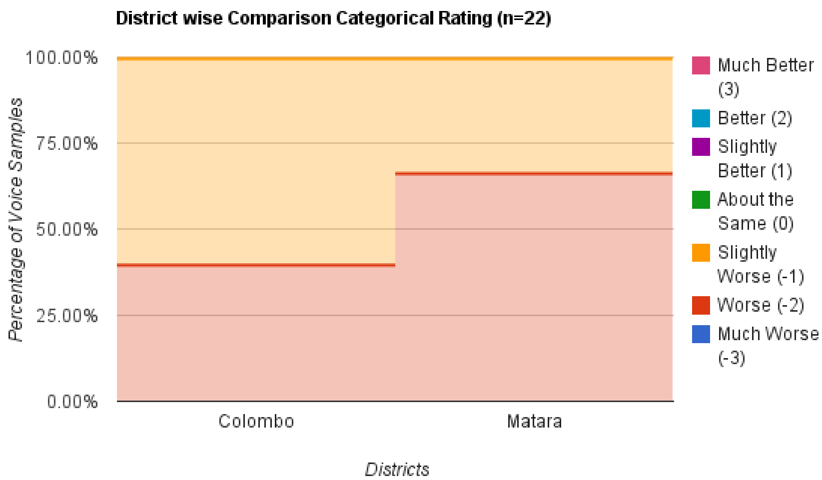

Figure 6: CCR of FF audio samples with reference samples

7. Discussion

7.1. Effects of audio quality

The differences between the survey-exercise (Figure 2) and controlled-exercise (Figure 3) MOS for each of the Districts show that Nuwara-eliya was unchanged. Colombo had improved, while Matara and Ratnapura had dropped. Relatively, Ratnapura District had the lowest quality rating. A weak signal strengths in the Ratnapura exercise location was apparent because users were struggling to get a clear signal.

The researchers used a CDMA phone during the survey and GSM mobile phones during the controlled-exercises. This may point to some patterns in the CDMA and GSM network coverage in the respective Districts. However, there is not evidence pointing to one network being better in voice quality than the other (i.e. MOS 3.39 on CDMA network and 3.52 on the GSM network).

The noticeable voice quality degrading factors were: circuit noise (mechanical noise overlaying the voice recordings) and environmental noise (background voices and sounds). The evaluators rated 53.84% (Figure 2) of the survey data and 51.84% (Figure 3) of the controlled-exercise data to be either “good” or “excellent” (i.e. MOS likert scale 4 and 5).

The overall MOS for the survey-exercise was 3.52 and controlled-exercises was 3.39. The two exercises depict a similar patterns of “fair” but less than “good” voice quality, even though the number of voice samples and evaluators differed. Nallathamby et al (2011) attained similar MOS results for the two Sinhala IVR models tested in the laboratory. However, the MOS is subjective and contextual. Therefore, we cannot draw on any correlations between the FF4EDXL field tested and Nallathamby et al laboratory tested MOS data.

Figure 4 and Figure 5, respectively, show that there is a significant distinction in the percent difficult (or DS) between the survey-exercise (5%) and controlled-exercise (29.44%) clear voice data samples. It was easier for the evaluators to predict the survey-exercise answers because they had a prior knowledge of the type answers the CERT members may provide (i.e. the speaker-dependent like STT system). Contrary to that is the speaker-independent system that is untrained and could not recognize the voice unless it was a perfect match.

The CCR for the FF system, in Figure 6, shows the voice quality, on average (-1.55), to between slightly worse (-1) and worse (-2). The lowered quality voice messages received over the telecommunication infrastructure is compressed by the 2N GSM Modem before presenting the processed audible MP3 files to the HIHO. During the compression in to MP3, the noise embedded in the data gets amplified causing the quality to drop below the unprocessed on site voice recoding. These degradation effects, described by Kajackas (2011) are unavoidable, at least, until such time over the air transmissions are improved.

7.2. Impact on efficiencies

Certain predicaments can be associated with the poor voice quality. An HIHO action was listening to the FOR FF message, then translate the localized message to English, and entering that information in to Eden-SitRep (process illustrated in Figure 1 – HIHO: create SITREP). Perera et al (2011) analyzed the MTTC to be 8.57 minutes, on average, for HIHO to complete this action. The average time of a FOR voice message was 1.38 minutes. The Observers' qualitative assessments documented that the HIHO were repeatedly replaying the audio recording in order to extract the information. Their, standard practice would be to pause the recording in between text entry but the replaying of the audio was directly a consequence of the poor voice quality. In some cases, the HIHO had to call the CERT member to confirm the partial, unclear, or missing information.

Given that the both exercises resulted in similar MOS scores (i.e. survey-exercise 3.39 and controlled-excise 3.52) but the DS results significantly differed, it can be argued that, in the presence of noise, a speaker-dependent STT system would increase the reliability. Therefore, investments in the training regime is an important implication; whereby, both CERT and HIHO are properly trained to use common structured language pertaining to disaster information communication. With such a policy, it is impossible to implement a crowd sourcing solution, as Ted Turner (UN-OCHA, 2011) and Gisli Olafsson (2011) mention in the respective reports, because one cannot expect untrained volunteers to be skilled in the domain specific communication. The ad-hoc unstructured crowd sourced messages would significantly affect the efficiencies and integrity of inferencing response resource for rapid response.

7.3. Positioning voice for emergency communications

Disasters can damage communications infrastructure. The Dialog Axiata (previously Dialog Telekom) experience from the 2004 Tsunami was that it took them 3 days to restore 66% and 4 days to restore 100% of the GSM infrastructure (CTO, 2006). Therefore, quality of the cellular networks are expected to be weak during the critical early rescue and response -hours following a disaster. Crippled infrastructure may further incapacitate the audio quality increasing the workload on the HIHO having to follow up with the CERT member to clarify the incomplete information. An advantage is that the initial recorded field observation message would alert the HIHO to respond to that message, unless otherwise, may go unheard.

Emergency communications policy planners should take into consideration the congestion problem prevalent during crises. Networks get congested (Samarajiva, 2005) as everyone wants to contact their loved ones or others. The congestion period typically lasts for several hours. During this period one may repeatedly get a busy tone refusing a connection. Such circumstances can affect the reliability of FF system to offer its services. Therefore, positioning an IVR system for alerting first-responders during this congested period is unwise. Countries that have the capacity to afford a priority channel could use an IVR, as they do in Canada (conversation with

Prof. Peter Anderson, Disaster Communications Expert, Simon Fraser University, 13 August 2011). Instead, implementations riding on regular cellular channels, can use it several hours after the disaster, when the networks are more accessible. Therefore, a policy is to utilize the FF interactive voice system for alerting that does not require critical life saving actions. It is more effective for CERT members to supply situational reports upstream.

7.4. Policy implications

Despite numerous technical barriers and inefficiencies that were encountered at various stages during the project, the series of exercises conducted over the course of the project have provided evidence to suggest that a voice-enabled interface for community-based initiative like this can improve disaster management capabilities for Sarvodaya. The ICT systems would streamline their processes and provide accountability that was previously inexistent.

In the face of wide variety of solutions available for emergency data communication, it can be argued that mobile phones reveal one very important relationship in terms of access: provide technology that has wide application value, keep it simple, and individuals are more likely to use it, maintain it, and even possibly experiment with it. This insight provides one piece of the puzzle to the sustainability challenge by suggesting that dedicated systems for emergency communication may be less desirable than general purpose ICTs that can serve a dual role in supporting everyday activities in addition to emergency communications.

Social, economical, and human investment in this case refers to economic, social, and human commitment sustaining the system is minimal. The main component is the datacenter that houses the modem, server with FF and Sahana software, and an Internet connection. Given that Sahana and FF are free and open source software that are supported by a global community, there is minimal need for high quality expensive skilled staff for administering and maintaining these systems.

8. Conclusion

FF is an easy to use and useful emergency communications tool, especially for CERT members. The aptitude of voice and language combined software technologies, at present, are unstable for interfacing the IVR with an expert system such as Sahana to maintain categorical information for crisis decision-support. Researchers and practitioners in the disaster communication field should consider investing in developments to bridge the integration shortcomings; specifically improved software libraries for voice and text data interchange. Thereby, system developers can integrate such mature components to offer locally adaptable simple and effective public goods for developing countries. Particularly, FF4EDXL research reveals certain patterns that may serve as important lessons for policy makers and planners involved in ICT intervention strategies.

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