Mauritius Research Council

INNOVATION FOR TECHNOLOGY

A MASS MEDIA COMMUNICATION SYSTEM USING MOBILE VOICE TECHNOLOGY FOR INFORMATION DISSEMINATION DURING DISASTER SITUATION IN MAURITIUS

Final Report

July 2018

Mauritius Research Council

Address:

Level 6, Ebene Heights
34, Cybercity
Ebene

Telephone: (230) 465 1235
Fax: (230) 465 1239
e-mail: mrc@intnet.mu
Website: www.mrc.org.mu

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A Mass Media Communication System Using Mobile Voice Technology for Information Dissemination during Disaster situation in Mauritius

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Principal Investigator: Mr. Raj Moloo

Investigator: Prof. T.V. Prabhakar

Assoc Prof. Dr Kavi Kumar Khedo

Mr. Aatish Chiniah

Department of Digital Technologies
Faculty of Information and Communication Digital Technologies
University of Mauritius

PI Name and Address

Raj Kishen Moloo,
Rm 2.18, Phase 2 Building, FoCDT, UoM, Reduit, Mauritius

MAURITIUS RESEARCH COUNCIL FINAL REPORT

PART I- PROJECT IDENTIFICATION INFORMATION
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Mauritius Research Council

PART II - SUMMARY OF COMPLETED PROJECT (for public use)

The Mass Media Communication system has been developed in collaboration with the NDRMMC and provides a simple and effective technology solution to prepare and warn vulnerable population group well in advance in case of disasters, hence minimizing casualties. Within minutes it can be deployed and mass call a particular vulnerable group. Besides, valuable reports/ statistics can be retrieved showing the percentage of people who received the calls, hence showing the effectiveness of the response.

Very conclusive results have been obtained, especially in the acceptance of such new technology medium by the targeted population. It demonstrates that voice calling is an active and immediate factor to warn vulnerable groups as compared to SMS message which is passive. Surveyed population unanimously agreed of the importance of such system and provided valuable inputs in enhancing the system

The research contribution for this project are as follows:

1. Development of a Mass Media Communication software system to quickly disseminate audio warning messages via phone calls
2. Provides useful recommendations on how such system is to be deployed by the authorities during disaster/crisis situations.
3. Survey results on a targeted group of 212 participants with 733 voice messages being sent.
4. Gives an insight of the user behavior over such system.
5. Publications are to follow.

PART III - TECHNICAL INFORMATION (for program management use)

List references to publications resulting from this award and describe in full primary data, samples, physical collections, inventions, software, etc., created or gathered in the course of the research and, if appropriate, how they are being made available to the research community. This section should be limited to 30 pages.

- *Refer to the Final Report for the Technical Information in the Design and Implementation Section*
- *A Mass Media Communication software system has been implemented*
- *Publications are to follow*

I certify to the best of my knowledge (1) the statement herein (excluding scientific hypotheses and scientific opinion) are true and complete, and (2) the text and graphics in this report as well as any accompanying publications or other documents, unless otherwise indicated, are the original work of the signatories or of individuals working under their supervision. I understand that willfully making a false statement or concealing a material fact in this report or any other communication submitted to MRC is a criminal offense.

Principal Investigator Signature:	Date: 20July 2018

TABLE OF CONTENTS

TABLE OF FIGURES

Acknowledgment

This material is based on work supported by the Mauritius Research Council under award number MRC/RUN/1515

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1 Introduction

Disasters whether natural or man-made are very much part and parcel of any country. Developing countries like Mauritius affected by accelerated changes in demographic, infrastructural and climatic changes are much more at risks in terms of the increased frequency and negative impact of such happening. Any responsible government has the duty to prepare and protect its population, hence minimizing casualties against such disasters. No doubt human misery and economic losses resulting from calamities can be reduced to a greater extent through advanced planning and preparedness.

Currently, early warning is conducted manually from the National Disaster Risk Reduction Management Centre (NDRRMC) to warn identified people in the Community Disaster Response Team (CDRT) in each vulnerable regions, who afterward relay the information to the whole community. However, this is a tedious and time-consuming tasks, bearing in mind that every second count during a disaster. Also, for ad-hoc situations, e.g flashfloods, where the population is unprepared, then it involves massive deployment of government agents to warn the population. Hence, in such critical events, early, accurate and timely warning to the vulnerable population is vital for better preparedness to mitigate the hazardous consequences and to avoid a state of panic.

Several research and crisis management applications have been developed and deployed over mobile technologies in times of crisis. However, most of these applications are based on internet and leverages the power of social media and crowdsourcing. These technologies have been developed for a technology-savvy audience over smartphones which further accentuates the "digital divide" (Stauffacher et al, 2014). Successful adoption of these applications depends on the usefulness, acceptance and ease of use of these ICT tools. Technology should ensure that all actors, regardless of their background and experience with IT usage, consistently access accurate information. Current systems force users to convert verbal communications into structured information to fit into the schema of underlying databases. An ideally integrated ICT environment should enable unstructured communication to flow easily into the structured domain of information systems and vice versa. The current ICTs do not facilitate seamless information flow between the Communication Technology (CT) and Information Technology (IT) domains; this task is left to the human actor (Paul et al., 2008).

Our proposed research project entitled the "*Mass media communication system using mobile voice technology for information dissemination during a crisis situation in Mauritius*" aims at providing early warning voice alert messages to the mass effortlessly over the simple dumb phone technology on the mobile infrastructure at a low cost. It uses the existing telephony network infrastructure, which provides 100% coverage over the island as compared to internet connectivity, to automatically call targeted vulnerable groups in the wake of crisis over their mobile phones. The advantages are numerous: 1) it can reach out everyone through their mobile phones without connectivity issues as faced by internet 2) there is quasi-no learning curve in using the system, since everyone knows how to receive a call 3) it eliminates the language barriers since alert messages are in native (creole) language 4) it eliminates the literacy barriers

(textual or technology) since one need not be literate or techno-savvy as smart application requires, to use the system. 5) from an administration point of view, the system can be deployed within minutes – audio alert messages can be uploaded on the system and assigned to a list of phone numbers – at a button click, the system will automatically do the mass calling and provide useful analytics.

This research project has been successfully developed and tested in collaboration with the NDRRMC. Numerous live testing had been performed on several targeted groups with 733 alert messages being delivered. 212 users were surveyed and the results proved conclusive in our approach to the design and implementation of the system. The system has been widely accepted by the majority of users who also provided various feedback which we have considered to improve the system. The system is interactive, accessible anywhere and anytime and provides for various levels of information granularity. Besides our research analyses people's behavior during such kind of sensitization campaigns and come up with best practices in information dissemination over our proposed medium. From an administration point of view, the system is very user-friendly and can be easily deployed within no time, which is vital in disaster management, unless there is a major network outage. The system performed as expected without any downtime or failures.

The successful implementation and deployment of our system denote that it is viable and feasible to be used in disaster management for better preparedness. The system can be scaled in other sectors as well such as education, agriculture etc. whereby targeted groups can be easily attained. In addition, such system can be interactive allowing targeted groups to interact with the system with more detailed information which can be either in the form of an automated response or simply interaction with an expert.

1.1 Project Justification

Recently there has been increasing interest towards mobile mass communication especially in the domains of emergency response and disaster situations. A crisis can occur anywhere at any time, and the people whose job is to respond might be geographically dispersed. Flexible and robust mobile communication is paramount for helping to ensure that the crisis is handled in the most efficient and effective manner possible. Effective and prompt communication with the population is vital to avoid a state of panic which can spin out of control. Besides, accurate and real-time information provide reassurance and preparedness to the population to mitigate the adverse effects of a crisis.

The 2004 tsunami was a wakeup call for the whole world on the importance of timely emergency communications for disaster management. Effective communication whether before or post a crisis enables citizens to better respond to hazards and hence mitigate the risk of death, injury, and property loss and damage, besides providing reassurance and comfort to avoid a state of panic.

Mauritius has its own disaster management committee under the aegis of the Prime Minister's Office and uses traditional means of communication. Recently, a smart application has been released to send notifications to users in case of disasters. Communities around the world have

adopted mobile technologies for disaster relief coordination. The Bangladeshi government announced that tens of thousands of mobile users in flood and cyclone-prone areas would receive advanced warning of impending natural disasters via mobile alerts (Reuters, 2009). Google created a crisis response team to deliver tools to help those affected by disaster with recent uses in the year 2013 such as Boston bombings, Oklahoma tornadoes, Jakarta and Alberta floodings (Google 2013). Moreover, mobile devices have become increasingly important in the developing world, facilitating communication between locals, government officials, and first responders. Many applications provide important information in areas of health, agriculture, disaster relief, and crime. In Eastern Africa, livestock herders use mobile phones to send early drought warnings, in an attempt to skirt disastrous agricultural calamities such as the drought that struck the Horn of Africa in 2011(Spence, 2013). However, these applications are heavily dependent on internet connectivity which unfortunately does not cover every region and does not reach out the mass.

There is no doubt that we have reached the era of unlimited, real-time information sharing and mobile communications play a prominent underlying role in opening vast avenues and applications for mass communication. The advent of Voice over IP, cheaper internet and new Open source framework positions mobile devices as a cheaper reliable alternative technology solution in the wake of the crisis. The usage and success of mobile applications depend on the simplicity of the technology, which several new applications fail to adhere to. They rely on a technology savvy audience which accentuates the digital divide. Mobile voice technology has been here for decades and has been accepted by all. It forms part of everyday usage, hence trusted by all parties and easy to operate. Therefore, leveraging its ease of use and technology acceptance by one and all, our research proposal becomes of prime importance. The need to probe further on how to implement a more resilient, flexible personalized, scalable and low-cost mass communication on mobile voice channel is a necessity and can definitely help the authorities, especially the Government of Mauritius.

1.2 Project Description

1.2.1 Objectives of Proposed Work

Major crisis can spin out of control and create havoc and confusion among the citizens if prompt information is not diffused at the right time. The objective of this project is to develop a "*mass media communication system using mobile voice technology for information dissemination during a crisis situation in Mauritius*" and to resolve research issues pertaining to mass content dissemination over the simple dumb phone technology on the mobile infrastructure at a low cost. Hence the main objectives of the proposed research are as follows:

(i) Investigate on the research question on how critical mass of information can be disseminated over dumb/simple phone technology, therefore reducing the digital divide.
(ii) Build up a critical audio/voice information database system which can be easily accessible anywhere and at any time by any citizen, but also allows authorities to broadcast critical information to targeted groups in the wake of a crisis.
(iii) Investigate on low-cost strategies and voice technologies to implement such kind of system.

(iv) Research on ways people interact with their mobile phone for calling (Human Mobile Interaction) and to leverage such practice to access voice information over the mobile infrastructure.
(v) Live deployment of such system with an analysis of the impact of such form of mass communication medium on its audience together with an analysis of the usage behavior of such system and come up with recommendations.

1.2.2 Project Scope

The scope of this project is to provide a mass media communication system using mobile voice technology for information dissemination during a crisis situation to the Mauritian population. Research issues pertaining to mass content dissemination over the mobile infrastructure are investigated. In the first instance, a situational analysis is done on how informative campaigns are carried out during a crisis situation in Mauritius. From there onwards, a voice information system is designed and implemented over the existing mobile infrastructure. Human mobile interaction is investigated to find the best strategy in accessing voice information over the mobile network. Information granularity is implemented whereby at the user's request more detailed information can be accessed, hence making the system interactive. Besides, information can be broadcasted to selected groups of users and the effectiveness of an information campaign can be monitored and evaluated. In addition, after the deployment of our system, the usage behaviour of such system and recommendation for a series of best practices are given.

1.2.3 Proposed Methodology

In order to achieve the overall aim of this project which is to design and implement a mass media communication system using mobile voice technology that can be used in a crisis situation in Mauritius, the following methodology is proposed:

1. Situational analysis of crisis management procedures in Mauritius and means for information dissemination during a different crisis situation. Eg Dengue Fever pandemic, flooding, cyclone.
2. An investigation of the usage, scalability and cost of existing mobile communication frameworks. An analysis of different voice technologies that can be used over dumb/simple phones will be carried out.
3. Strategies for user interactions through the use of simple mobile phone (Human Mobile Interaction) to access voice information system over a mobile infrastructure will be designed.
4. Design of a voice information system over mobile infrastructure. The voice information system would allow the handling of voice messages to be accessed at any time.
5. Design of a mass content dissemination framework over the mobile voice infrastructure incorporating the selected user interactions and information system.
6. Development of a mass content dissemination system as a proof of concept.
7. Deployment and overall testing of the system developed.
8. Assessing usage behavior and effectiveness of informative campaigns.
9. Conclusion and recommendations

1.2.4 Relevance to National Objectives

Based on the latest statistics (Statistics Mauritius 2018), Mauritius ICT infrastructure readiness with nearly 100 percent mobile coverage whereby each citizen owns at least one mobile phone, Mauritius can be a showcase to the world on the use of mobile voice technology for mass dissemination of information during times of crisis but at the same time reduce the digital divide.

This project is of national interest. It can be used by the Mauritius Disaster Management Committee under the aegis of the Prime Minister's Office for the dissemination of vital information during a crisis situation to a targeted group of citizens. Besides, the system can track the effectiveness of such campaigns. In addition, other government bodies such as the Ministry of Health, the Mauritius Meteorological Service, and the Mauritius Police Force to mention a few can use the proposed system to disseminate vital information and also to assess the effectiveness of their communication campaigns in the wake of a crisis situation. This may help the population to better face the crisis situation (such as the Dengue fever, cyclone, tsunami etc). To another extent, the proposed research can be ported to other domains such as education, whereby learning can happen over dumb phone technology.

1.3 Current state of knowledge in the field

Mass communication is the imparting or exchanging of information on a large scale to a wide range of people. The various technologies through which this exchange takes place vary from radio and television to Internet media and mobile mass communication. Mobile mass communication systems provide easy accessibility and outreach, as information can easily be broadcasted to many different regions simultaneously and cost-efficiently at any time and anywhere.

Recently there has been booming interest towards mobile mass communication especially in the domains of emergency response and disaster situations. Given that a crisis can occur anywhere at any time, and the experts might be geographically dispersed, flexible and robust mobile communication is paramount for ensuring that the crisis is handled in the most efficient and effective manner possible.

A typical crisis notification system normally has four steps. First is the detection of the crisis through a report or alarm mechanism. That is, an emergency call or sensors detecting alarming levels of water for example. Second, the information is processed at some kind of command-and-control center. Then messages are pushed out to first responders and members of the public (Magnuson, 2014).

Along with communication, another essential component of a response is the ability to coordinate actions among emergency team members, including rescuers, dispatchers, and resource coordinators, especially in risky, uncertain environments. This combination of communication and coordination is the key to an effective response (Gonzalez, 2008). Another recent area of investigation is how to integrate new ICT services for supporting crisis response coordination within the ICT infrastructure in daily use by emergency responders. A lot of systems are being deployed by the public and private sectors for crisis management (Neuhaus

et al., 2012), however, given the nature of the response required a centralized coordination is vital. As such, there is a need to converge those systems under one roof (Meun et al., 2013).

The remaining section describes the recent advances in the domain of mobile mass communication:

Hong Kong and Australia turned to mobile technology to mitigate rumors during periods of crisis. During the SARS pandemic, the government of Hong Kong sent SMS messages to 6 million mobile phones dissipate fears surrounding supposed government action (Clark, 2013). In Australia, Queensland police created a "Mythbusters" hashtag to manage misconceptions and diffuse rumors during the flooding. Using such emerging communication model, users also acts as collaborator helping to more accurately target and spread the message to others most in need of receiving it (McKuskerr, 2011).

Streefkerk *et al.* (2008) implemented a location-based notification system (LBNS) to increase Dutch police officer awareness of incident locations. The proposed mobile service notifies police officers proactively to warrants, agreements and police focal points in their current vicinity. The LBNS is able to support three police procedures that require awareness of incident locations. The system notifies police officers proactively to location-specific police focal points and warrants when they are in the vicinity of such a location. The system was implemented as a geographical map application on a PDA using GPS location tracking. The application employs auditory signals and pop-up screens to notify police officers and facilitates access to operational information on the handheld device. This is expected to help police officers in three ways. First, they are able to handle incidents faster and more effectively. In addition, because they have information available within the user context, officers have to rely less on communication with the emergency room. Finally, their awareness of incident locations will increase when they are notified of relevant information on location. These three effects are expected to have a positive influence on operational results, such as a higher chance of apprehending criminals or reducing nuisance. To assess the accuracy, efficiency, effectiveness and user experience of this service, a longitudinal field evaluation was conducted with thirty police officers over four months. The results show that using the LBNS, police officers were better informed of relevant information in their environment and this led to positive operational results. Users considered the interface clear and easy to use. However, users indicated that the system presented too many or non-relevant notifications and that the system is overly complex.

In the last decade, several mobile commercial application has emerged providing fully integrated, multi-layered and robust systems. As in the case of Japan, following several disasters which took place, several mobile applications have emerged. Yukuru Call is an iOS application which collaborates with Japan Meteorological Agency early warning system to sends automated alerts before an earthquake happens. It helps its citizen to prepare themselves before the earthquake hits. Evacuation Location App is another application which helps Japanese to find the nearest shelters, medical facilities and water supply on the map using GPS. Safe Area Checker is the most popular Android application allowing Japanese to check their

distance from Fukushima nuclear power plants together with the direction of the wind and radiation level (Emergency Journalism, 2012).

However, despite the availability of those solutions, the penetration rate of smartphones in Africa is about 12% (Sahota, 2014). As such only a portion of the population would be targeted. In order to outreach a maximum number of affected people during a crisis period, the medium that would most probably be functional is Voice Communication. Another factor for opting Voice-Enabled system is the fact that even novice phone users (those who cannot type/read SMS) are still able to use the system.

Voice-Enabled Systems are becoming more and more popular. “From phones, tablets and TVs to cars and, yes, kitchen appliances, voice-controlled computing is weaving its way into our lives. And while some of the use cases may feel a little absurd at first, talking is a very natural way for us to request things and influence our surroundings… ” (Titlow, 2013). Therefore the use of a voice medium for mass communication systems is an interesting avenue to explore.

1.4 Project Outputs

The expected outputs of the proposed research are as follows:

- The design and implementation of a Mass Media Communication System Using Mobile Voice Technology for Information Dissemination during Crisis Situation in Mauritius.
- The design and implementation of a voice information system over the mobile infrastructure.
- An analysis of usage behavior and response to such kind of system for mass communication.
- Recommendations on the suitability of mobile voice medium for mass communication.

1.5 Conception and Organisation

As mentioned in section 1.2.4, our research is in line with the National Objectives on disaster management. Hence, collaboration from the Disaster Management Committee under the aegis of the Prime Minister’s Office will be sought for early inputs in conceptualizing the project. Besides, the system is expected to be deployed at the National Disaster Risk Reduction and Management Center (NDRRMC) which will have the responsibility to manage the proposed mass media communication system.

The conception and organisation of the project involved the following procedures:

- Collaboration with NDRRMC will be sought for acceptance and deployment of the Mass Media Communication System.
- Main Server will be hosted at the NDRRMC. (installation & setup)
- Training of the NDRRMC staff for operating the system.
- Survey on vulnerable areas will be conducted.
- Identification of targeted population in the vulnerable areas.
- Registration and training of targeted population.
- Real life test/simulation will be conducted.

- Setting of a protocol for management of the system during a disaster. *(To be agreed by all stakeholders concerned).*

2 Background Study

The occurrence of disasters in Mauritius has drastically increased in the recent years. One of the striking disasters that caused an upheaval in Mauritius was the Flash flood that took away lives of 11 people and causing serious damages. The major problem identified was the lack of coordination between organizations. There should be a continuous flow of information between the organizations to achieve better decision making. Technology should be utilized to the maximum to improve flexibility in face of disaster risk. If the current system is not reviewed to cater for disaster management, the frequency in loss of lives and damages will eventually increase in future.

2.1 Disasters in Mauritius

Mauritius is a tropical island situated in the Indian Ocean with latitude 20° 17' S and longitude 57° 33' E. Being a tropical island, Mauritius is often hit by natural disasters like flood, cyclone, landslide, fogs, and wildfire. Unnatural disaster like accidents also affects Mauritians.

Mauritius is mainly affected by flood and cyclones. In Mauritius, during the year 2010, a Natural Disaster and Operations Coordination Centre were set up under the command of the Commissioner of the police for the support of the Central Cyclone and other natural disaster committees so as to make sure of timely disaster management response. In the rise of a disaster the center is started and initiates all required actions to deal with the state. During the committee meetings, list of refugee centers are finalized, instructions in respect to preparedness, relief, rehabilitation and reconstruction works are issued.

In the year 2013, the National Disaster Risk Reduction and Management Centre (NDRRMC) was set up under the PMO with the Core Team. Whenever a cyclone approaches Mauritius, Rodrigues and the outer islands, the PIOR/National Disaster Risk Reduction and Management Centre (NDRRMC) is notified by the Director of the Meteorological Services. On receipt of cyclone warnings, the PIOR/NDRRMC will transmit them to:

● The President's Office	● The Prime Minister and Other Ministers
● The Commissioner of Police	● The Commanding Officer, Special Mobile Force
● All Divisional Commanders	● Other Government Agencies concerned
● Divisional Commanders will inform the Chief Executives Municipal and District Councils found in their Division)	

Elements Coordinated through NDRRMC are as follows:

● Policy and Governance	● Risk Assessment
● Risk Mapping	● Mitigation
● Preparedness	● Public Awareness and Education
● Response	● Relief
● Recovery and Rehabilitation	● Post Impact Evaluation

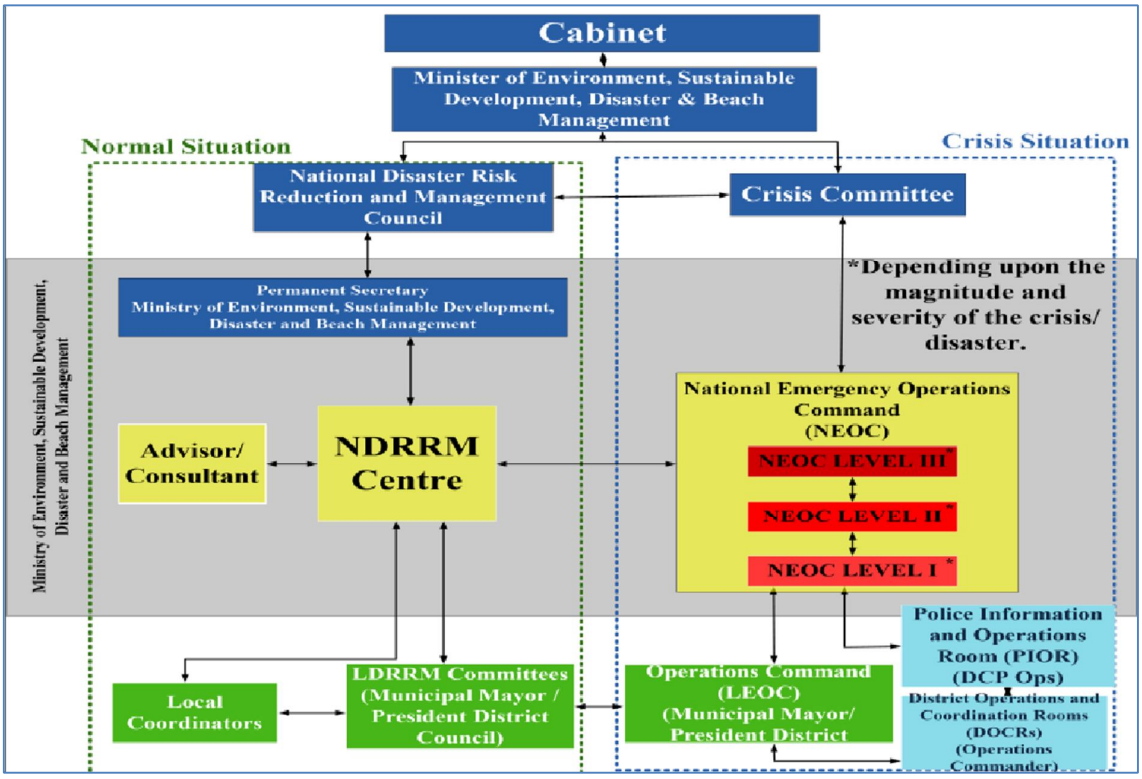


Figure 1 *Disaster Management Structure for Mauritius (Ellayah, 2015)*

Figure 1 shows the Disaster Management Structure for Mauritius. The National Disasters Scheme (NDS) Edition 2015 is a functional document to support agencies and stakeholders in understanding and carrying out their responsibilities and actions in emergencies, was launched by NDRRMC in October 2015.

The NDS defines the composition, roles and responsibilities of the various national and local Disaster Committees, Ministries and Departments, as well as other institutions involved in risk reduction, preparedness, and management before, during and in the aftermath of a natural disaster, such as cyclone, torrential rain, and tsunami. The document comprises the following: Cyclone Emergency Scheme; Heavy Rainfall, Torrential Rain and Flooding Emergency Scheme; Tsunami Emergency Scheme; High Waves Emergency Scheme; Water Crisis Emergency Scheme; Earthquake Emergency Scheme Landslide Emergency Scheme; and Port Louis Flood Response Plan.

2.2 Roles of stakeholders involved during a disaster

Involvement of stakeholders such as policemen, fire brigades, meteorological services and Mauritius broadcasting corporation services are important during natural disaster. Roles of each identified stakeholders are explicitly explained in this section.

2.2.1 Role of Mauritius Meteorological Services (MMS)

The MMS receives weather Numerical weather prediction (NWP) products by World Meteorological centers through Meteorological Data Distribution (MDD) and through internet link with Regional Specialized Meteorological Center (RSMC) situated at La Reunion. Tropical cyclones are forecasted by a tropical cyclone workstation. After receiving advisories and forecast from Regional Specialized Meteorological Center (RSMC) an analysis is done and a decision is taken to declare the cyclone as official.

When a cyclone is expected to cause damage, a cyclone warning center is established to issue a warning to the public and replying to their queries. Furthermore, the main method of broadcasting cyclone warnings is by radio and television.

As for flood, rainfall is measured in about 250 stations in Mauritius. This information is faxed to the Meteorological center. If ever amount of rainfall produced in Mauritius is 100mm in less than 12 hours and is persistent then the MMS will issue warnings.

2.2.2 Role of Mauritius Police Force during Cyclone

Upon receiving cyclone warning, area superintendent transmits the warning to all Stations and Posts in the area by the quickest mean. Officers in charge of police stations will transmit cyclone warning to the nearby Hospitals, Infirmaries, Convents and Public Assistance Officers. Special police force provides armored cars to the meteorological center (Vacoas), M.B.C/T.V Studios (Moka), Airport and Police headquarters. Each car is managed by 3 persons. In case there is a breakdown in the radio communications, the cars will be used as alternatives to carry messages to various locations. After the cyclone, Police gather information throughout the island.

2.2.3 Role of Mauritius Police Force during flood

Before the rainy season, the Police Information and Operation room (PIOR) will communicate with the Meteorological center daily to obtain weather bulletin forecasting mainly rainfalls and geographic areas of the island that are mostly affected and that are prone to flood. PIOR will then notify the Area superintendents of the upcoming danger and will make sure that the affected areas are monitored by the police.

Area superintendents organize vehicular patrols to determine which part is prone to flood and will constantly inform the PIOR about

● Locality and extent of the area affected	● Nature and level of flooding
● Traffic diversion plan	● State of road communication
● Danger to life and property	● Damage to infrastructures such as CWA pipes, roads, and bridges.

2.2.4 Roles of Mauritius Fire Brigade services

The fire services achieve their tasks in 2 ways namely proactive and preventive. In proactive method on receipt of an emergency call, the main control unit allocates the nearest available resources to it. Information such as name of caller, type of emergency (fire accident, trapped/injured special service request), nature of disaster (building, injured in industry, trapped in a place), name of location are gathered from the caller. If ever the special mobile force gets information about any disaster they inform the fire services and provide them with the necessary assistance. Through the information gathered the emergencies are prioritized by the main control unit, the most urgent emergency is catered first. Fire services nearby the disaster scene are contacted to provide quick service. In fire prevention method they aim at providing fire safety awareness through talks and demonstrations to the mass.

2.2.5 Role of Mauritius Medical services

On receipt of flood and/or cyclone warning from the Mauritius Police Force, Hospitals, deploy some medical teams depending on the level of the disaster on the site of the disaster. The SAMU team receives emergency calls, from the public, whereby each call is classified as non-emergency, emergencies and acute emergency. SAMU ambulances are equipped with emergency drugs to cater for an acute emergency. During an accident or a disaster, SAMU works in collaboration with the police and the firefighters.

2.3 Disaster Management System

The impact of the damage can be lessened through a disaster management system. Basically, a disaster management system is a system that helps to manage a disaster by evacuating potential victims of the disaster, providing alerts to the potential targeted area and monitoring the disaster until it is gone. It also enables to administer the consequences and to overcome from the damaged sustained. In such a situation, groups of individuals whether governmental or non-governmental (NGO) try to cut back the impact of the disaster occurring. In this section, we highlight the systems put in place in Mauritius.

2.3.1 Implementation of an Early-Warning System for incoming storm surge and tide in the Republic of Mauritius

The Republic of Mauritius is the first Small Island Developing State (SIDS) in the Indian Ocean with its own tide and storm surge Early-Warning System for improving preparedness and resilience to events like cyclones.

The EWS as shown in figure 2 was implemented in the context of the Climate Change Adaptation Programme in the coastal zone of Mauritius to increase the climate resilience of the coastal communities and funded by the Global Environment Fund jointly with the United Nations Development Program (UNDP).

The storm surge model was developed together by Deltares and the Ministry of Environment, Sustainable Development, Disaster and Beach Management. It predicts where and when a storm surge is to be expected. The prediction is produced every six hours and covers a period

of three days. This gives authorities enough time to evacuate the area. The storm surge prediction model covers the islands of Mauritius, Rodrigues and Agalega.

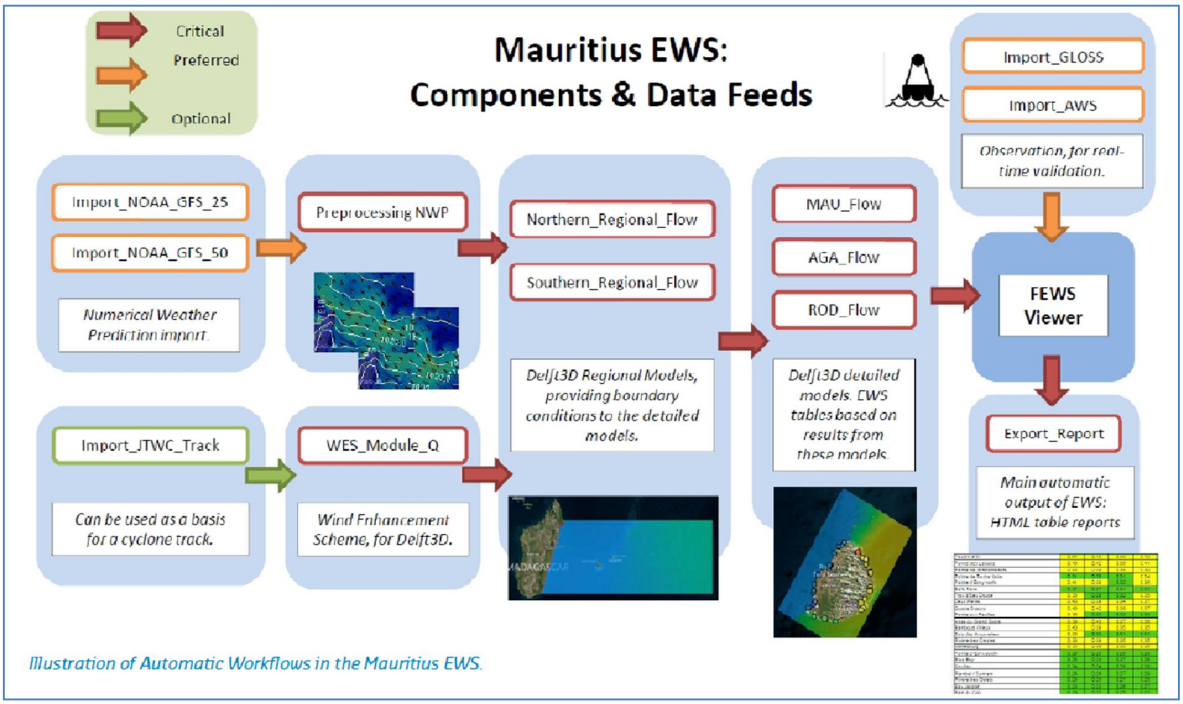


Figure 2: Automatic Workflows in the Mauritius Early Warning System (Deltares, 2015)

2.3.2 Tsunami Warning System in Mauritius

There is a Tsunami Warning System established by the Mauritius Meteorological Services. The Tsunami Warning System in Mauritius has taken into consideration the degree of risk as well as the time factor. In virtue of its geographical location, Mauritius and Rodrigues have a lead-time of 5-7 hours before tsunami waves are likely to reach their coasts from either the Sumatra or the Makran source. The warning system consists of the following stages:

1. **Tsunami Watch**
   This bulletin implies that a strong earthquake, generally of the magnitude greater than or equal to 7.0 on the Richter Scale, has occurred in a region adjacent to the Indian Ocean and the likelihood of a tsunami being generated is evoked. The bulletin is issued as a means of providing an advance alert to areas that could be impacted by destructive tsunami waves. At this stage, the public, sea-goers and fishermen, in particular, will be advised not to venture out at sea or on the beach, boats to be secured ashore and vessels to proceed off the lagoon.

2. **Tsunami Warning**
   This bulletin confirms that a destructive tsunami will affect Mauritius / Rodrigues within the next 5-7 hours. In case the incident point is closer to Mauritius / Rodrigues, the lead-time will be correspondingly lesser. Plan for the evacuation of vulnerable coastal areas will be implemented.

3. **Termination**
   This bulletin will be issued after information from the Police, Fisheries post, Environment Officials, observations from tide gauges at Port Louis and Port Mathurin and general sea state observation confirm that significant tsunami waves are no longer being noted.

2.4 Investigation of Existing Framework used in Disaster Management

In this section existing frameworks and technologies developed for disaster management are discussed. Any crisis notification system operates by following the procedures (Magnuson, 2014):

1. A report or alarm mechanism that allows the detection of the crisis.
2. A command-and-control center then processes the information.
3. First authorities concerned are notified (Police, Coast Guard, Hospital, …)
4. The public in general.

Several approaches have been successful so far, for example, radio and television, or even the use of Social Media. Mobile mass communication systems provide greater accessibility and outreach, as specific announcements can be forwarded to specific regions simultaneously in real time.

2.4.1 SMS

The first technology used for mass dissemination of information during crisis situation was SMS. As mentioned in Disaster Response whitepaper (GSMA, 2018), SMS was initially not designed for mass communication. However after disasters in 2004, Tsunami in Indian Ocean and Katrina is US, the need to change Public Warning System into Early Warning System, the 3GPP project was initiated in 2006, to come up with standards for fluid dissemination of messages through the mobile network. Two standards were developed, namely, 3GPP TS 23.041 - Technical Realisation of Cell Broadcast Service (CBS) and 3GPP TS 44.012 - Short Message Service Cell Broadcast (SMSCB). These two standards are the backbone for allowing bulk SMS services.

A lot of countries around the whole are using SMS as the preferred medium of mass communication. For example in India (NDMICS 2011), SMS is used for Flood and Cyclone warning systems. In Bangladesh also, (Mahmud et al., 2012), their Disaster Management System is based on SMS and they had positive feedback on the effectiveness of the system.

However, the as research has shown (Fraunhofer 2013), “the one message fits all” is not effective for all categories of the population. Illiterate persons having difficulties to read SMS is a huge downside of such systems.

2.4.2 Mobile Devices

Following an earthquake with a magnitude of 8.0 which struck the north-western part of Sichuan province, China in May 2008, a quick detection and response system was essential for preventing outbreaks of infectious diseases (Yang et al. 2009). However, the existing public health communication system in Sichuan province, China, was severely damaged by the earthquake. The Chinese Center for Disease Control and Prevention set up a mobile phone emergency reporting system for infectious disease surveillance. In total, 495 light-powered mobile phones were delivered to local health-care agencies in earthquake-affected areas. All phones were loaded with software designed for inputting and transmitting cases of infectious disease directly to a national database for further analysis. The authors argued that mobile phone is a useful communication tool for infectious disease surveillance in areas hit by natural disasters. Nevertheless, plans must be made ahead of time and be included in emergency preparedness programs.

2.4.3 Mobile Apps

Just after the Japanese tsunami, the conceptualization of mobile disaster applications has boomed and was being downloaded not just in Japan but in different places in the world. Many of these applications were built using various Japanese early warning applications – including Yurekura Call and Japan AED Map – as models (Emergency Journalism 2012). Apple featured a new section in its App Store called "Stay in Touch," providing a number of disaster relief applications such as: The American Heart Associations' Pocket First Aid & CPR; QuakeWatch, which tracks earthquakes and sends warnings using U.S. Geological Survey data; Disaster Alert, which provides information on instant global "active hazards;" the American Red Cross's Shelter View, which helps users locate a nearby shelter; and Emergency Radio (Saltzman 2011).

A number of government agencies, such as the U.S. Department of Health and Human Services (HHS) and global internet users have compiled lists of helpful disaster relief tools. David Burns of Campus Safety Magazine broke down a number of disaster applications into useful categories: reference, materials such as applications like First Aid; WISER, or Wireless Information System for Emergency Responders; FEMA's mobile app and Emergency Survival Handbook; personal preparedness, such as Survive Now; ICE, In Case of Emergency; BuddyGuard; tsunami; and IMPrepared; and situational awareness, which includes the USGS's mobile app; Floodwatch; and the American Red Cross's Shelter View. (Burns 2011)

Apps are more user-friendly and interactive than SMS but depend on the availability of smartphones and mobile data/Wi-Fi to function. Added to those, literacy and disabilities of the population makes them less appealing as an outreach tool.

2.4.4 Social Media

Social media is another alternative to outreach millions of its users worldwide, through a simple click. Facebook with its billions of users, can act as a huge database when information needs

to be communicated on a global scale (Walker 2011). Facebook recently created a Safe Check Application, to verify whether your friends/families are safe within disaster/crisis regions. Tweeter (Skinner 2013) and other social media could help up to some extent in crisis management, however how efficient and timely will it be done?

2.4.5 Voice

Voice communication has not been deployed yet for crisis/disaster management yet. Other fields of deployment include Emergency Evacuation Systems (Moore 2010) as well as commercial purposes such as sending reminders to staff or let customers know when there is sales, specials and events, or just to say thanks (www.onecallnow.com).

In the next section, we discuss about some existing tools and implementations that could be used for our implementation. Call Blast or Voice Broadcasting is the process of sending the same voice message to different recipients simultaneously. There are different providers offering call blast services:

1. CallFire (www.callfire.com)

CallFire provides Interactive Voice Response, Bulk Text Messaging, Cloud Call Center, Call Tracking as well as Call Broadcast. Voice Broadcast can be used to send important alerts, promotions, updates, and notifications to customers, employees, voters, and more. It's an easy and cost-effective way to reach more people in less time. Voice broadcast has numerous applications spanning across industries. It's simple to setup and adds a personal touch to communications.

CallFire also has its API that can be integrated with own applications. The CallFire Cloud API is a full REST API and performs the following:

- SMS API - Send and reply to SMS.
- CallFire XML Campaign - Create and Modify CallFire XML Campaigns
- Sending Calls - How to send out calls for any campaign.
- CallBacks - Signup for our CallBack API to get results posted to own server.
- Phone Numbers - Finding and ordering toll free and local phone numbers.
- Reports - Pull reports for calls and campaigns.
- Recordings and Files - Get reports on sound files and recordings.
- Validation - Area Code Validation Service

However, the services of CallFire is not free and is limited to only US customers.

2. ICTDIALER (www.ictdialer.org)

ICTDialer is free and open source Unified Communications marketing Software. ICTDialer is multi-tenant with Voice, Fax and SMS broadcasting capabilities developed over re-known open source Content Management System Drupal and Freeswitch based powerful ICTCore Communication Framework. It can be scaled to blast hundreds of simultaneous calls using either VoIP, FoIP or PSTN. ICTDialer capable to fit in many broadcasting and telemarketing

scenarios. It empowers the user with capabilities of Drupal CMS and ICTCore Communication Framework.

ICTCore (www.ictcore.org) is an open source communications library with a purpose to provide unified communications on a single platform. It is built with a focus on providing high-level APIs that will not only allow to create telephony applications easily but will also allow communication gateways to communicate with one another at the application level. This is the real edge that ICTCore has over its competitors. Existing software claiming as unified communications software are not really unified communications because these software are not able to communicate with multiple gateways at the same time and cannot share data/application with different gateways. ICTCore is developed using object-oriented principles of PHP and is built to provide reliable communication with different gateways such as FreeSWITCH, Kannel and Sendmail. It provides easy to use API for developers to build complex voice, fax, SMS and email applications.

3. Onecallnow (www.onecallnow.com)

One Call is a service provider that offers the following:

i. Create your contact list manually or import your contact list from a spreadsheet by using our Import Wizard Tool or automatically synchronize your own database with your contact list using a variety of integration tools.
ii. Choose the medium: voice, text, email, mobile app, or social media. Request responses to your messages. Set up subgroups and filtering within your contact list to send messages to specific contacts. Deliver messages to your contacts in a predetermined order. Send messages immediately or store them for future use. Translate up to 19 languages for voice messages and up to 52 languages for typed messages.
iii. Reports confirm message delivery and explain unsuccessful attempts. Reports show whether messages were delivered to a person or voicemail. Report summaries come to you by email after your messages are delivered. Reports can be filtered by contact names for quick and easy snapshots of messaging activity and history.

2.5 Example of Existing Systems

Similar systems developed around the world are surveyed and the readiness of Mauritius to implement and deploy such a system is examined.

A. Malaysia Flood Disaster Management System

The use of SMS and Voice in disaster and warning systems has become very popular nowadays. Several countries have been adopting this technology since it has proved to be very effective in crisis situation. In Malaysia, a country which very often is prone to floods has adopted a Flood Disaster Management System (FDMS) using SMS to warn the population and coordinate crisis activities. SMS is used in three stages of the FDMS namely: (i) Flood Forecasting and Warning System whereby SMS is used to alert the public in general and refugee centres. Besides, the current level of rivers/reservoirs is provided as information. (ii) During flooding, SMS are sent to persons in specific regions for indicating the closest refuge center, coordination

and evacuation purpose. (iii) Post-Disaster SMS is received by the organisation to estimate and coordinate the amount of aid required. During the period November 2010 to April 2011 a total of 90,071 victims (Total aid amount = 45,076,000 RM) used the System (Khalid & Shafiai, 2013). Language and literacy have been identified as factors that affected the proliferation of the system.

B. Bangladesh Disaster Management System.

Bangladesh adopted a Disaster Management System using both SMS and Mobile Calls. First the population in general receives SMS as alerts for potential or going disasters. Secondly, the authorities use the technology of mobile phones and SMS for tracking and extraction purposes. The usability of the system has been evaluated through both qualitative and quantitative surveys, and the result of the survey shows a global acceptance rate of 81% (Mahmud et al., 2012).

C. NHS, UK M-Health System

A system which uses Voice and mobile phones as dissemination medium is m-health. It was introduced in the UK, by the NHS. Since, it has been widely adopted by the majority of the population for treatment compliance, appointment reminders, health promotion, health monitoring, health emergencies and health surveys. Given the popularity and effectiveness of the system, the World Health Organisation is investigating the adoption of the system for worldwide deployment. However, the major cost factor of such system is the use of Call centres which employ hundreds of employees 24hrs a day to provide all corresponding logistics (World Health Organization, 2011).

D. DSSRIDE, China

In recent years, there have been outbreaks of several emerging infectious diseases in China. The epidemics of infectious diseases and natural disasters seriously threatened human health and safety, highlighting the importance of establishing tools for timely data collection and analysis of epidemiological information for rapid decision making and response to infectious-disease emergencies and natural disasters in the field. Li *et al* (2013) proposed a decision support system for the response to infectious-disease emergencies based on WebGIS and mobile services (DSSRIDE). The DSSRIDE provides functions including data collection, communication and analyses in real time, epidemiological detection, the provision of customized epidemiological questionnaires and guides for handling infectious disease emergencies, and the querying of professional knowledge in the field. The DSSRIDE system provides a geographic information platform based on the Google Maps application programming interface to display information of infectious disease emergencies, and transfers information between workers in the field and decision-makers through wireless transmission based on personal computers, mobile phones and personal digital assistants. The authors reported that, after a 2-year practice and application in infectious disease emergencies, the DSSRIDE is becoming a popular platform and is a useful tool for investigations in the field carried out by response sections and individuals.

E. Crowdsourcing Disaster Support Platform (CDSP)

Crowdsourcing platforms for disaster management have drawn a lot of attention in recent years due to their efficiency in disaster relief tasks, especially for disaster data collection and analysis. Although the on-site rescue staff can largely benefit from these crowd-sourcing data, due to the rapidly evolving situation at the disaster site, they usually encounter various difficulties and have requests which need to be resolved in a short time. Yang *et al.* (2014) developed CDSP, a Crowdsourcing Disaster Support Platform which is designed specifically to provide real-time assistance to on-site users by efficiently leveraging the crowdsourcing power of off-site users. CDSP integrates a user selection feature to identify the most relevant off-site volunteers for a specific request according to user expertise, obtained from various sources such as manual input, extracting from one's social networks, learning from one's historical usage records, etc. Moreover, the authors adopted the “divide-and-conquer" approach for the requests that need the collaboration of off-site volunteers, and provide an instant message communication service to them for discussion. The system was validated by the authors through experiments with the three rounds of user trials and these experiments have shown the effectiveness and efficiency of CDSP.

2.5.1 Infrastructure Readiness to adopt Mobile-based system for Disaster Management

The ICT Sector in Mauritius has experienced tremendous growth over the past years. There has been a significant increase in ICT access since 2005 averaging a yearly average growth of 12.5%. The population is connected mainly by fixed telephony lines, mobile and internet. According to the (ICT Indicator, 2014), total number of subscribers to fixed telephone attained 372,000 while mobile phone subscribers stood at nearly 1.652 million, in 2014, resulting to an approximate teledensity and mobidensity of 29 % and 127 % respectively. Nowadays Mauritius has attained 99% population coverage by mobile cellular telephony.

Till the end of the year 2014, a total number of internet subscribers reached 735k, a significant 10% increase compared to the previous year. This is attributed to the decline in broadband tariff. In terms of global indices as an indicator of our competitiveness, Mauritius has a network readiness index of 4.5, positioning itself as the first country in Africa with the lowest risk in terms of network reliability and 45th worldwide.

The above positive indices in relation to ICT infrastructure readiness, phone penetration and coverage make our system technically feasible. The teledensity and mobidensity figures imply that almost all the Mauritian Population can be reached by phone calls in case of a disaster.

2.6 Telephony Infrastructure to support Voice

This section provides an overview of different telephony system which supports voice communication namely the Public Switched Telephone Network (PSTN), Global System for Mobile Communication (GSM), Voice over IP (VoIP) and gateways used to link these heterogeneous networks. Traditional Private Branch Exchange (PBX) systems, VoIP servers (also called IP PBX) and VoIP clients are also discussed.

2.6.1 Public Switched Telephone Network (PSTN)

PSTN is a wired phone system that relies on circuit switching to operate and over which telephone calls are made. Before 1960, voice was transmitted as analog signals across a dedicated copper wire. Calls were connected by routing them through multiple switches working at different levels – namely local, national, regional and international – until a connection was set up between a pair of telephones. This connection was referred to as a circuit and is set up for the duration of a call preventing other network traffic to use it (Roos, 2015).

The analog system was later replaced by a more efficient digital system where voice was digitized and manual switching gave way to automatic electronic switching. Besides, the digitized voice does not require a dedicated wire, it can be transmitted along with other digital signals along the same wire. The use of fire-optic has made it possible to handle thousands of calls along the same wire. Despite the shift to digital systems and availability of higher bandwidth, the underlying nature of the PSTN has not changed, a connection – or circuit – still needs to be set up and sustained over the duration of the call.

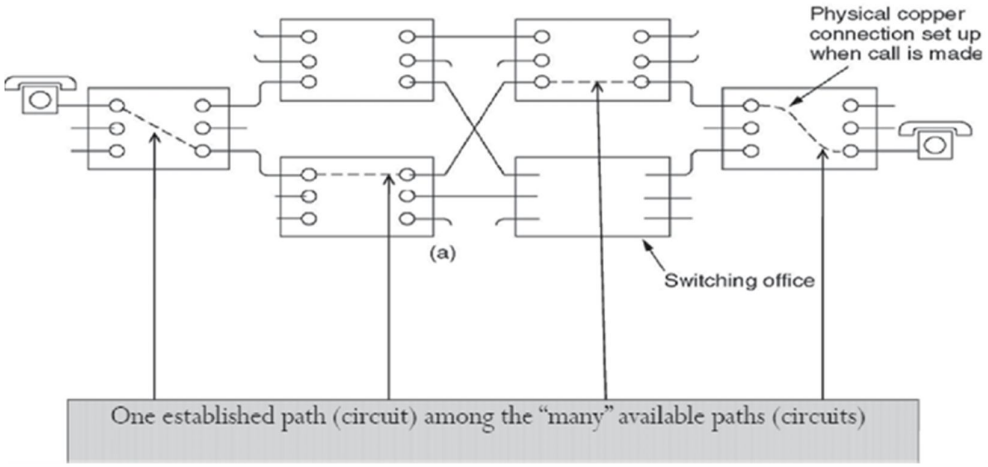


Figure 3 – PSTN Architecture (Internet Society, 2015)

Of the thousands of lines in the circuit, only one is dedicated and used during a call (see figure 3). When the call ends, the line is released and becomes available to set up other calls (Internet Society, 2015).

2.6.2 Global System for Mobile Communication (GSM)

First launched in 1991 in Finland, GSM was developed in Europe, it is now used in about 213 countries, embodies 82.4% of all global mobile connections with its estimated 2 billion users (Rouse, 2007). GSM uses a variant of Time Division Multiple Access (TDMA) wireless network technology which compresses and converts data in digital format before transmitting it together with two other streams of user data in separate time slots. Using this technology, GSM networks can transmit mobile voice, data services and SMS at a speed of up to 9.6 kbps. GSM uses both terrestrial facilities (base stations, antennas and other equipment) as well as satellites to ensure maximum coverage. GSM operators ensure availability of service to their subscribers from other operators and even for subscribers traveling abroad by signing agreements with GSM operators of foreign countries.

To access a GSM network, a GSM user should:

- use a GSM-compliant mobile phone which operates at the same frequency as the operator,
- pay subscribe for paid either prepaid or post-paid services with a GSM operator,
- Equip the phone with a Subscriber Identity Module activated by the GSM operator.

2.6.3 Voice Telephony Infrastructure in Mauritius

In this section, we discuss about mobile network operators within Mauritius. Till date, there are 4 telecom operators (among which 3 are mobile operators) in Mauritius as shown in the table below:

TABLE 1 – List of Telecom Operator in Mauritius - (Africa & Middle East Telecom, 2018)

Telecom Operator	Primary Activity	Website
Emtel Ltd.	Mobile	www.emtel-ltd.com
Mahanagar Telephone (Mokoze)	Mobile	www.mtmltd.net/mtml/
Mauritius Telecom Ltd.	Fixed	www.mauritiustelecom.com
My.T	Mobile	www.mauritiustelecom.com

There are three GSM networks – Orange (Mauritius Telecom in partnership with France Telecom/Orange), Emtel (operated by Millicom International) and Mahanagar, a subsidiary of India's MTNL which is also the island's second fixed-line operator using CDMA2000 technology. The market share amongst them is as follows: Orange - 53%, Emtel – 37%, MTML -10% (Budde 2015).

The graphs below provide an insight about the mobile network evolution in Mauritius:

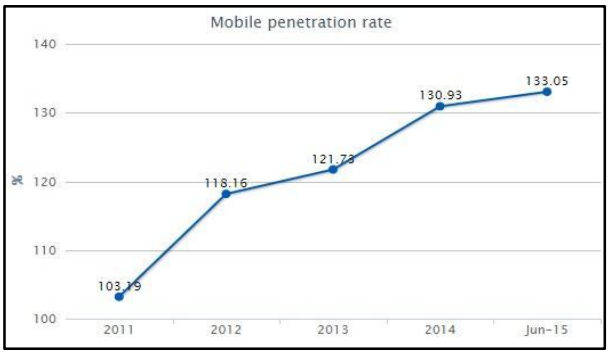


Figure 4 – Mobile Penetration Rate for Mauritius (ICTA 2015)

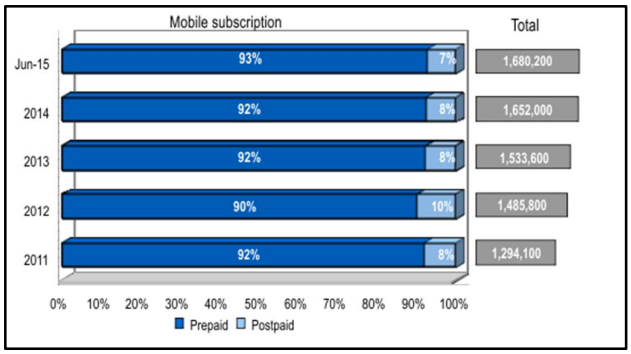


Figure 5 – Mobile Subscription for Mauritius (ICTA 2015)

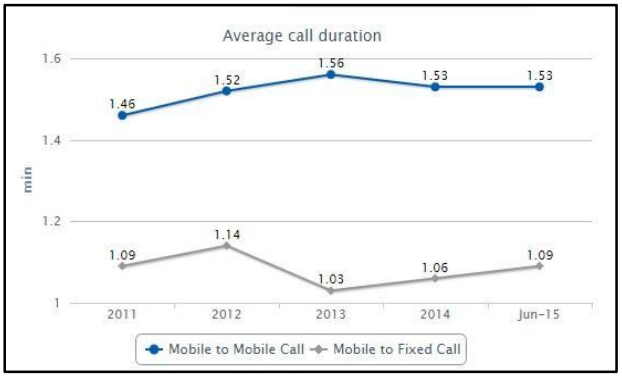


Figure 6 – Average call duration - (ICTA 2015)

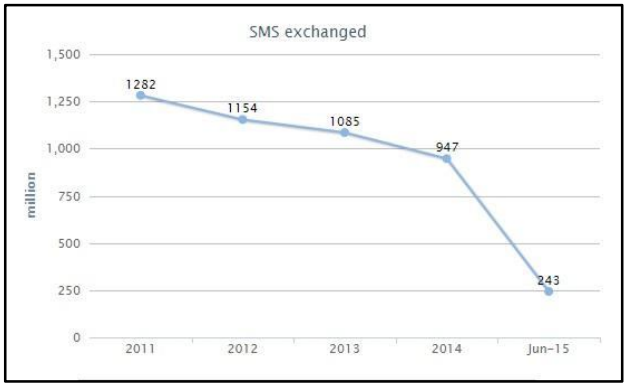


Figure 7– SMS exchanged (ICTA 2015)

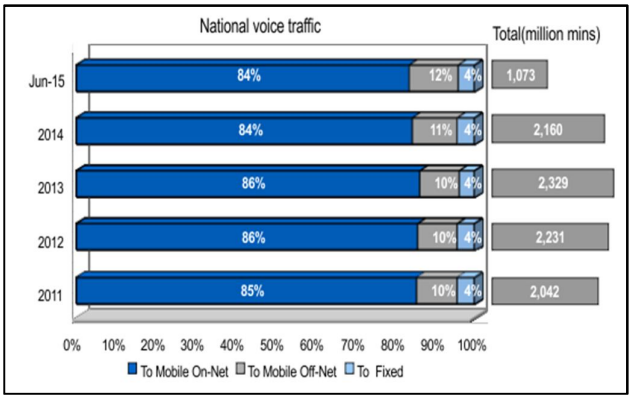


Figure 8 – Voice Traffic (ICTA 2015)

From the graphs, several deductions can be made: Firstly, given such a high penetration rate and the number of subscribers (almost 1.5 the population of the country), we can say that almost everyone has a mobile phone, and can be contacted in cases of disaster/crisis. Secondly, the graph of the SMS sent clearly shows the declining interest to use SMS as a technology for mass communication. And finally, the voice traffic graph shows that our network is capable of handling traffic peaks up to the certain level in times of crisis, which is always the case, as denoted any various research.

2.7 Voice over Internet Protocol (VoIP)

The terms IP telephony, Internet telephony, broadband telephony, and broadband phone service are used interchangeably to refer to VoIP. Voice over IP is a combination of technologies used to transmit voice, fax, SMS, voice messaging and multimedia data over IP networks like the Internet rather than via PSTN. Transmission of the digital information occurs as IP packets over a packet- switched network rather than over a circuit-switched network (Wikipedia. 2018). VoIP is regarded as the new trend for communication with which calls can be made over the Internet for free. However, implementing a VoIP system entails hidden costs namely: infrastructure (switches, routers, and bandwidth), training costs, complex security, additional IT support staff etc (TMCnet,2015).

2.7.1 VoIP Servers (IP PBX)

They are the communication servers that route calls to VoIP phones (hard phones or softphones) using TCP/IP protocol. Devices connected to the VoIP server request for real-time audio communication. VoIP servers work in a similar way the proxy server does i.e. handling data processing and answering incoming requests from clients. When making a call through VoIP, the call is routed through the internet whereas calls from regular phones are routed via the PSTN (telephone system). VoIP servers can be hosted and accessed over the cloud instead of setting up and administering an on-premise server. With a VoIP server, extensions can be configured to make phone calls and access low-cost services like video calls, conference calls, call forwarding and much more (see Figure 9).

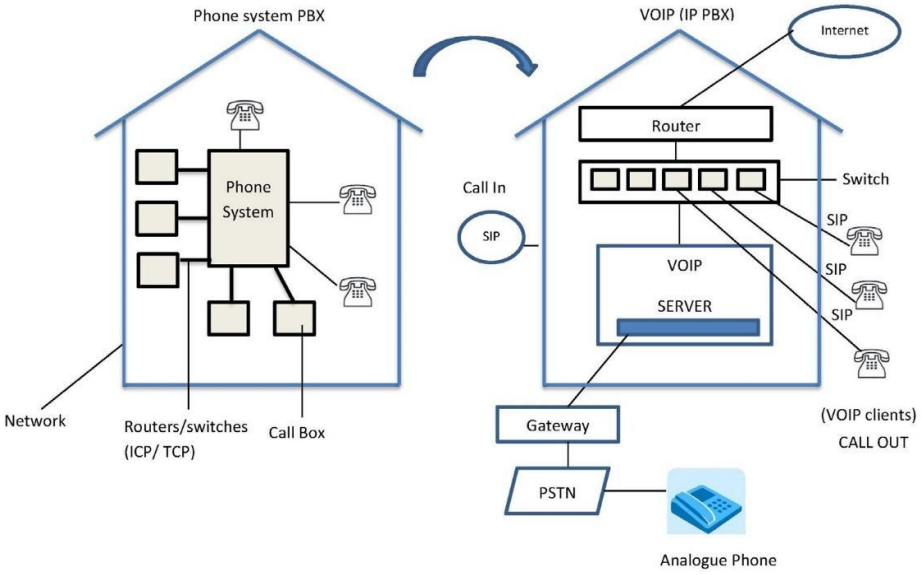


Figure 9 - VoIP Server (Eli, 2011)

2.7.2 Internet Protocol Private Branch (IP PBX)

An IP PBX is a digital telephone switching system that supports VoIP. It provides services similar to PBX services, but over data networks like a LAN or WAN rather than through circuit-switched networks. IP PBX systems switch calls between VoIP and local lines or between VoIP and regular telephone users in the same way a PBX does (Webopedia, 2018.). Asterisk and FreeSWITCH are two popular IP PBX systems.

2.7.3 FreeSWITCH VoIP Server

FreeSWITCH is a free and open source VoIP communication platform that helps in the creation of voice and messaging applications. The platform supports various communication technologies such as Skype, SIP, H.323 and Google Talk, making it easy to interface with other open sources PBX systems such as sipXecs, Call Weaver, Bayonne, YATE or Asterisk. It builds natively and runs standalone on several operating systems including Windows, Max OS X, Linux, BSD and Solaris on both 32 and 64-bit platform (Minessale, A, 2015).

FreeSWITCH is "in its base a library, not an application." Therefore a program is needed to load the library which will operate as a Softswitch. It is capable of acting like a softphone (software that emulates a telephone), a PBX (often an office telephone system), a softswitch (software that operates like legacy hardware based on telephone company switches), or anything in between. The FreeSWITCH platform handles audio, video, text or any other form of media by using a wide range of tools.

2.7.4 VoIP Clients

The clients are connected to the VoIP servers to receive the services. VoIP clients can either be headphones or softphones.

2.7.4.1 Headphones

They look like a telephone which include a traditional phone keypad, they are connected to the IP network through RJ-45 cables for the transmission of real-time audio services. Headphones can be used for more than just voice communication, they can also provide web access.

2.7.4.2 Softphones

A softphone is a computing device (PC, Android phone, iPhone) with specific software installed that enables it to emulate the behaviour of a real phone i.e. real-time audio communication through VoIP systems.

2.7.5 VoIP Gateways

In order to connect the PSTN to a VoIP system, a bridge between the IP network and the PSTN is needed. A VoIP gateway connects different types of communication networks e.g. VoIP and PSTN allowing VoIP callers to reach any user connected to the GSM or PSTN network. Depending on where the voice traffic originates from, the gateway will convert the voice traffic so that it can be received at the destination (IP or PSTN/GSM), i.e.:

- analog voice traffic originating from the PSTN/GSM digitized, compressed, packetized and transferred across the IP network.

- digital voice traffic is originating from an IP network is decompressed and converted into an analog signal so it can be sent across the PSTN/GSM.

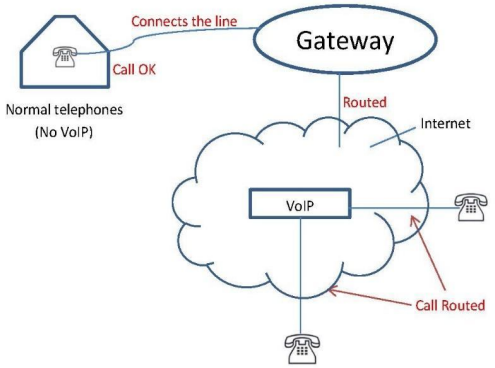


Figure 10 – Analogue to Digital voice traffic (Eli, 2015)

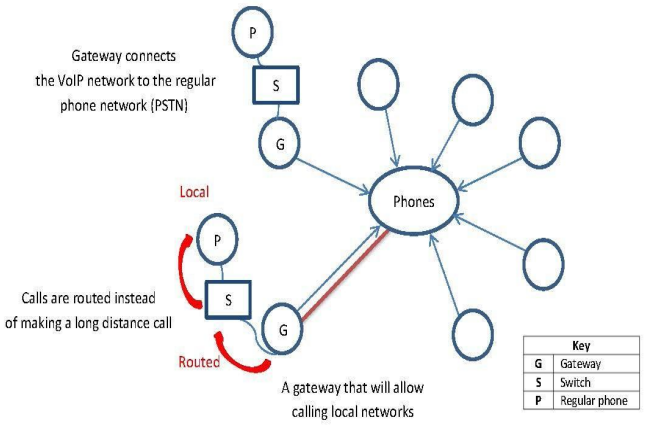


Figure 11– Digital to Digital voice traffic (Eli, 2015)

2.7.5.1 GSM Gateway

VoIP GSM Gateways act as connectors to enable transmission between the IP and GSM networks. This hardware can be used to significantly reduce the money spent on calls between IP and GSM networks. Some specific makes of GSM modems can accommodate several SIM cards with different providers and route calls using the most efficient routes to benefit from reduced communication costs, this feature is known as Least Cost Routing (LCR) (Batikova. 2015).

2.7.5.2 GSM Dongles

A GSM dongle is a relatively cheap modem which accepts a SIM card, and operates over a prepaid or post-paid subscription to a GSM operator, just like a mobile phone. From the GSM operator perspective, a GSM modem is treated as a mobile phone. Connecting a GSM dongle to a computer allows it to make use of the GSM dongle as a modem to communicate with the GSM network. While these GSM dongles are most frequently used to provide mobile internet connectivity, some specific makes (certain models of Huawei dongles) can also be used for sending and receiving SMS and MMS.

2.7.5.3 GSM VoIP Gateway (GoIP)

GoIP gateways were developed by DBL Technology and are yet another type of hardware that provides a seamless connection between the GSM and VoIP networks. GoIP operates using mobile phone SIM cards and can be registered with VoIP Softswitch systems. In addition, the GoIP supports the transparent transmission of the caller number from PSTN to VoIP. The cost of implementing GoIP with a VoIP system ranges between Rs 3,535.75 ($100) and Rs 60,107.75 ($1,700).

GoIP gateways provide between 4 and 32 SIM card ports allowing them to provide different channel numbers. GoIP is used by call centers, system integrators, traffic operators, and Softswitch manufacturers.

2.7.6 VoIP Protocols

VoIP Communication uses protocols. The standard protocol is abbreviated to SIP (Session Initiation Protocol). SIP resides above the TCP/IP network protocol which is an application layer and allows for interoperability. Open source VoIP server and big players like Cisco are all using the SIP protocol.

2.7.6.1 Session Initiation Protocol (IP PBX)

SIP is the protocol for VoIP and other text and multimedia sessions, like instant messaging, video, online games and other services. SIP is very much like Web protocol (HTTP or SMTP). Messages consist of headers and a message body. SIP message bodies for phone calls are defined in SDP – the session description protocol.

SIP is a flexible protocol that makes the addition of more features possible while preserving downward interoperability (SIP, 2018). It is an application-layer control protocol; a signaling protocol for internet telephony. SIP can establish sessions for features such as audio/video conferencing, interactive gaming, and call forwarding to be deployed over IP networks, thus enabling service providers to integrate basic IP telephony services with the web, e-mail and chat services. In addition to user authentication, redirection and registration services, SIP servers support traditional telephony features such as personal mobility, time-of-day routing and call forwarding based on the geographical location of the person being called.

SIP offers all features of the common internet telephony:

- call or media transfer;
- call conference;
- call hold.

2.7.6.2 VoIP Codecs

Codecs are used to encode and encapsulate voice traffic into a signal which is then split into small packets and sent down to the network. The codecs used determines the sound quality of the conversation. The type of codec (open source or proprietary) used will affect the bandwidth requirements. Proprietary codecs make optimum use bandwidth and provide a high audio definition for better communication. On the other hand, open source codecs will provide high voice quality at the expense of bandwidth.

3 Requirement Analysis

In this chapter, all the requirements for a mass media communication system using mobile voice technology for information dissemination during a crisis situation in Mauritius are identified and defined. The use-case scenario analysis is performed in order to describe the different operations that should be performed by the system. Then the functional and non-functional and non-functional requirements for the system are derived. These requirements are used in the next chapter to provide a detailed design for each component of the proposed system.

3.1 Identified List of Actors

Based on the background study carried out, the following List of Actors for the proposed system has been identified.

List of Actors

1. Citizens
2. Disaster Management Centre Personnel
    a. POLICE/Traffic
    b. SMF
    c. Meteo
    d. Health
    e. Ministries
3. Telephony Operators
4. System Administrator

3.2 Use case scenario

In this section, the following use case scenarios for respective actors are identified and described.

UC 1.

Use Case Name	**Retrieve Information**
Actor	Citizen
Description	Citizen accessing the system to retrieve information about the Crisis Situation happening
Freq. of use	Often
Access Medium	IVR Phone Calls

UC 2.

Use Case Name	**Disseminate Information**
Actor	Disaster Management Committee (DMC)
Description	DMC broadcasting information to the population – can be to the whole population or can be targeted/ localized
Freq. of use	Often
Access Medium	Website

UC 3.

Use Case Name	User Registration
Actor	Citizen
Description	Citizen registering to the system by providing their name, phone numbers and address
Freq. of use	Often
Access Medium	Website

UC 4.

Use Case Name	DMC members registration
Actor	DMC Members
Description	DMC members register to their respective groups on the system with their details (name, phone number etc.)
Freq. of use	Often
Access Medium	Website

UC 5.

Use Case Name	Groups Creation
Actor	System Admin
Description	System admin creates different groups – targeted group/ DMC Members group/ Stakeholders
Freq. of use	Rarely. Upon Configuration
Access Medium	Website

UC 6.

Use Case Name	Crisis Creation
Actor	System Admin
Description	System Admin creates different types of the crisis on the system
Freq. of use	Rarely. Upon Configuration
Access Medium	Website

UC 7.

Use Case Name	send localized mobile numbers
Actor	Telephony Operators
Scenario	Telephony operators to send a list of localized phones numbers from cellular network in the affected region to the system for further processing
Freq. of use	During Crisis/Disaster
Access Medium	Via web interface/ excel file

UC 8.

Use Case Name	Creating Audio and Text Message
Actor	DMC Members
Description	DMC members to create audio and text message on Crisis Situation
Freq. of use	Often
Access Medium	Website

UC 9.

Use Case Name	Schedule Message Delivery
Actor	DMC Members
Description	DMC Members to schedule message delivery to citizens
Freq. of use	Often
Access Medium	Website

UC 10.

Use Case Name	Generate Statistics
Actor	DMC Members, System Admin
Description	A system to generate calls and message statistics on broadcast messages
Freq. of use	Often
Access Medium	Website

UC 11.

Use Case Name	Authenticate Users
Actor	DMC Members, System Admin, Citizen
Description	A system to authenticate users and provide appropriate access rights
Freq. of use	Often
Access Medium	Website

3.3 Functional Requirements

The proposed system shall have the following requirements:

3.3.1 Crisis Situation

REQ 1. The proposed system shall cater to the following crisis situations that Mauritius is frequently exposed to:

a. Cyclone
b. Flash flood
c. Tsunami
d. Disease Outbreak

REQ 2. The proposed system shall identify the target groups for the dissemination of information based on the respective crisis situations.

REQ 3. Expected Target groups and types of Information Dissemination

Cyclone	Types of Message Alerts
Whole population (pull message)	● Cyclone Warnings ● Specific “Refugee” Shelters ● General Precautions to take ● Emergency Numbers

Targeted	● Context-Aware
Whole population (pull message)	● Torrential rain alerts ● Meteo Data
Targeted (Highly Localised)	● Context-Aware (Where flash occurring - + people in that region) ● General Precautions ● Real-Time Alerts (Traffic/ Police/ Bus Transportation ..)
Whole population (pull message)	● Tsunami Alerts ● General Information/ precaution
Targeted	● Context-Aware (Where tsunami occurring - + people in that region) ● General Precautions ▪ Assembly points ▪ Refuge centers ● Real-Time Alerts (Traffic/ Police/ Bus Transportation ..)
Whole population (pull message)	● Outbreak Alerts ● General Information/ precaution
Targeted	● Context-Aware (Where outbreak occurring - + people in that region) ● General Precautions ● Real-Time Alerts (Ministry of Health - plan of work to mitigate outbreak)
Targeted	● Informing of disasters based on location (push message)

3.3.2 Communication

REQ 4. The system shall support both pull and push type of messages (Voice and SMS)

REQ 5. The system shall allow registration of users for targeted groups (people at risk + stakeholders)

REQ 6. The system shall allow communications with all users in specific locations + targeted groups

REQ 7. The system shall provide communication endpoints to different telephony operators for call forwarding

REQ 8. The system shall provide an interface to interact with telephony operators to capture localized mobile numbers

REQ 9. The system shall resend voice and SMS messages in case of previous failure delivery

3.3.3 Message Management

REQ 10. The system shall provide an interface for the recording of voice messages

REQ 11. The system shall provide a service of Text To Speech (TTS)

REQ 12. The system shall allow classification of messages w.r.t. to Crisis Situation

REQ 13. The system shall provide a scheduler for message delivery

3.3.4 Statistics and Logs

REQ 14. The system shall provide call statistics as follows:

- Callee details, Call duration, Start time, end time, Call Pickup, Miscalls,
- SMS sent, delivered and received.

REQ 15. The system shall provide historical data analysis and statistics

3.3.5 Stakeholder Access Rights

REQ 16. The system shall cater to different access rights for different stakeholders

REQ 17. All users of the proposed system shall be authenticated through a login mechanism

REQ 18. The system shall be only accessible from Intranet of the Disaster Management Committee

3.3.6 HCI

REQ 19. The system shall allow message dissemination in the following languages: English, French and Creole

REQ 20. Navigation through the system options shall be via DTMF (dialed keys) for voice interaction

REQ 21. Information retrieval for SMS shall be via keywords sent to a particular number

3.4 NON-FUNCTIONAL REQUIREMENTS

A non-functional requirement specifies the criteria that can be used to evaluate the operation of the system. The most important non-functional requirements for the proposed system are given in this section.

3.4.1 Ease of use

NFR 1. The system interface shall be menu-driven.

NFR 2. The system shall display appropriate error messages in the event of an error.

NFR 3. The system shall display appropriate messages whenever an action is completed.

NFR 4. Training time for the system shall not exceed one week.

3.4.2 Size

NFR 1. The system shall work on a server having a minimum of 2GB RAM.

NFR 2. The system shall work on a server having a minimum of 30GB hard disk space.

3.4.3 Design

NFR 3. The system shall be portable to all platforms.
NFR 4. The user interface shall be web-based.
NFR 5. The system shall allow users to access the website from any browser.
NFR 6. The system shall be developed using a content management system.

3.4.4 Security

NFR 7. The system shall restrict access to call blasting to administrators.
NFR 8. The system shall restrict access to bulk SMS campaigns to administrators.
NFR 9. Access to the database shall be password protected.

3.5 Use Case Diagram

Figure 12 shows the use case diagram for our Mass Media Communication system. The System Admin can create groups, users and audio alert warnings. Same for the Disaster Management members who can create alert messages, associate them to target groups and then have the alert warning message broadcast to the groups. A user can login the system to retrieve useful messages from the system.

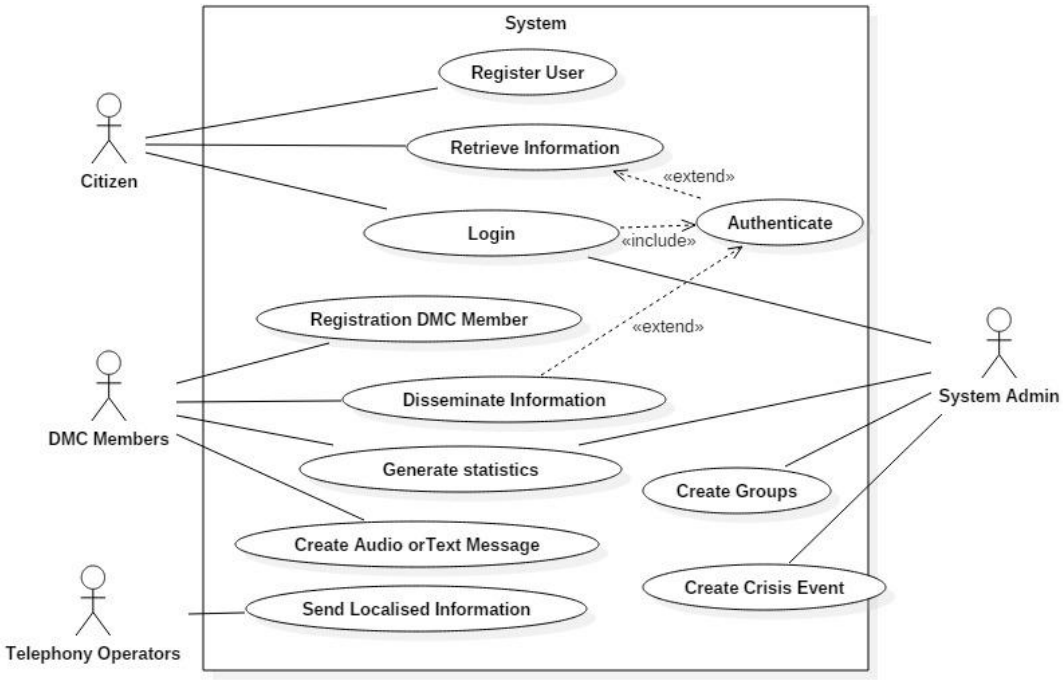


Figure 12– Use Case Diagram for Disaster Management System

DESIGN

4 Design

This chapter gives an overview of the building blocks and the overall architecture of the system. The design issues, system architecture, unified modeling language, and database design discussed hereafter aim to provide a conceptual model of the system's structure, behavior and view.

The second part of this chapter will give an overview of the implementation issues; discuss the different tools used as well as the environment in which the system has been developed.

4.1 Design Issues

4.1.1 Performance

The system should be reliable even with large volumes of VoIP, GSM/PSTN calls and SMS. The number of concurrent calls that can be made will largely depend on the available bandwidth for VoIP calls. On the other hand, concurrent outbound calls to the GSM and PSTN networks require one channel for each concurrent call. The system's performance will also rely on the CPU speed to allow processing of many simultaneous calls for e.g. audio conversion before transmission using codecs.

4.1.2 Usability

The usability of the system refers to how easy it is to learn and use. The system will, therefore, be designed with that objective in mind. The system will be intuitive by providing a consistent look and feel across different parts of the system, easy navigation and provide helpful messages to indicate successful completion of tasks as well as error messages when errors occur.

4.1.3 Responsiveness

While processing of calls and SMS are done in the background by the VoIP server, the system will allow the administrator to perform other tasks.

4.1.4 Flexibility

While administrators will be restricted to the Debian Linux operating system, normal users will be able to access the system through the web on any operating system and different devices.

4.1.5 Quality of Service

The quality of service refers to the quality of the communication i.e. audio quality during calls which will depend on the codecs used by FreeSWITCH and the bandwidth available.

4.1.6 Security

The system will ensure that access rights to different parts of the system are allocated so that users access the only information they are entitled to and operations they perform.

4.2 Detailed Description of Core functionalities

The completed system will be a hosted on an Azure Virtual Machine (VM) running Debian x64. The system will consist of two main parts:

1. A Drupal 8 website
2. FreeSWITCH

The Drupal 8 website will consist of two main custom modules. The first one is Mass Media module (mass_media), which will allow moderators to create mass media events such as (call campaigns, SMS campaigns and IVRS). The second custom modules install on the Drupal 8 is FreeSWITCH Configuration (fs_config), which will allow users to send control commands and performs operations on FreeSWITCH.

FreeSWITCH will be installed as a service on the VM. Using this method, it will be easier to perform custom configuration later.

The complete detailed design of the different components is given below:

4.2.1 Mass Media

4.2.1.1 Registration

By default, there will be one administrator account. The administrator can manage (create/edit/delete) moderators, as well as regular users. Once a new user is created, the user's XML file will be automatically generated and added to the FreeSWITCH user directory and the new configurations will be saved and operational. A batch upload option will also be provided so that users can be created in batch using a CSV file. Upon registration, users will be able to select their group and region, which will be required later.

4.2.1.2 Campaigns

Moderators will be able to create campaigns and associate Mass Calling, SMS and IVR Menus to them. The moderator will have to provide a name and a description for each campaign. In this situation, a campaign can be seen as a disaster (Cyclone, Flood, etc.). An additional option is available for moderators to check the progress of Calls/SMS campaigns in progress.

4.2.1.3 Mass Calling

This section is where moderators will be able to create and manage call campaigns event. A form will be available for the moderator to fill in the details to communicate. The moderator will be able to specify the time period that a specific call campaign will be active and also choose the target group and region. A test functionality is implemented to test the created call campaign before it is finalized.

Once a user confirms a call campaign, using the parameters given, a script will generate a list of users that will be concerned with this call campaign and will generate record entry in the database. On regular interval of time, a CRON job will check this specific table and perform call blasts.

The same features will be used for Mass SMS, where moderators will be able to create SMS campaigns.

4.2.1.4 Interactive Voice Response Menus (IVR)

A form to generate Interactive Voice Response (IVR) menus will be provided so that moderators can create IVR menus. The moderator will first have to fill on the basic information required for any IVR, then the moderator will be able to map numeric keys to actions. After an IVR is saved, the system will automatically generate the IVR entry using the provided parameters and redirect the moderator to the Dial-Plan page. There, the moderator will be expected to copy and paste the generated entry in the IVR section of the dialplan. Once the configuration has been saved, they will be automatically loaded and operational.

4.2.2 FreeSWITCH

4.2.2.1 Server Details

Before being able to control FreeSWITCH via the web (HTTP API), the server details on which FreeSWITCH is running should be provided. A form will be available in the FreeSwitch module so that the moderator can insert the IP address, username, password and default directory path for FreeSWITCH. These details will be saved in the database and will be used in various parts of the FreeSwitch module.

4.2.2.2 Server Control

Once the server details have been saved, the moderator will be able to control FreeSWITCH from the website. A link will be available for the user to see the different available commands. This will be done using CURL function in Php which will send the commands as URL and retrieve the output.

4.2.2.3 GSM Operators

This section will allow the moderator to link and configure SIM Banks for FreeSWITCH.

4.3 Architectural Design

We present the structural and architectural diagram of the Mass Media Comm. The system in Fig. 13 and 14.

4.3.1 Structural Diagram

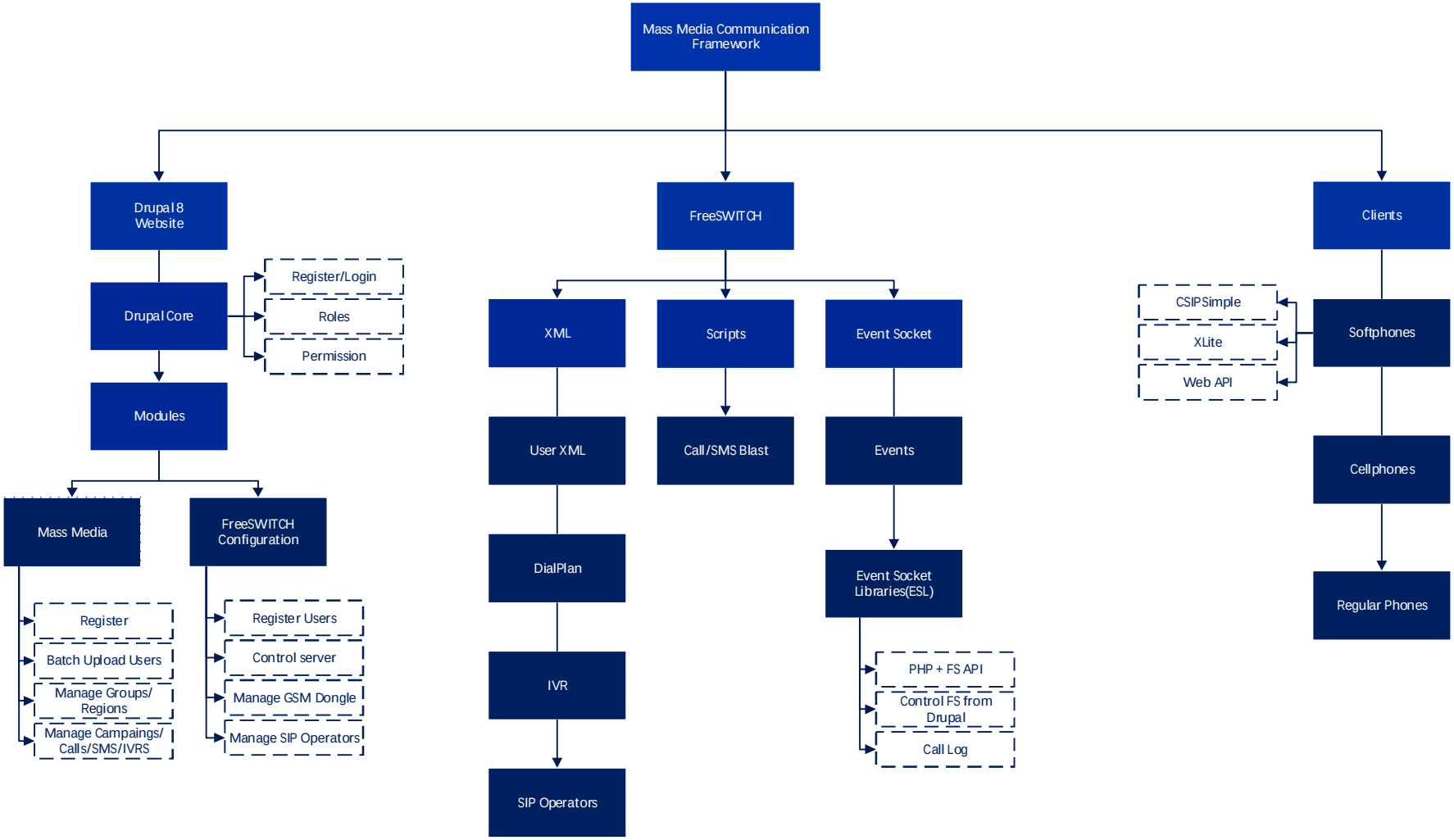


Figure 13- Structural Diagram

4.3.2 Overall High-Level Design

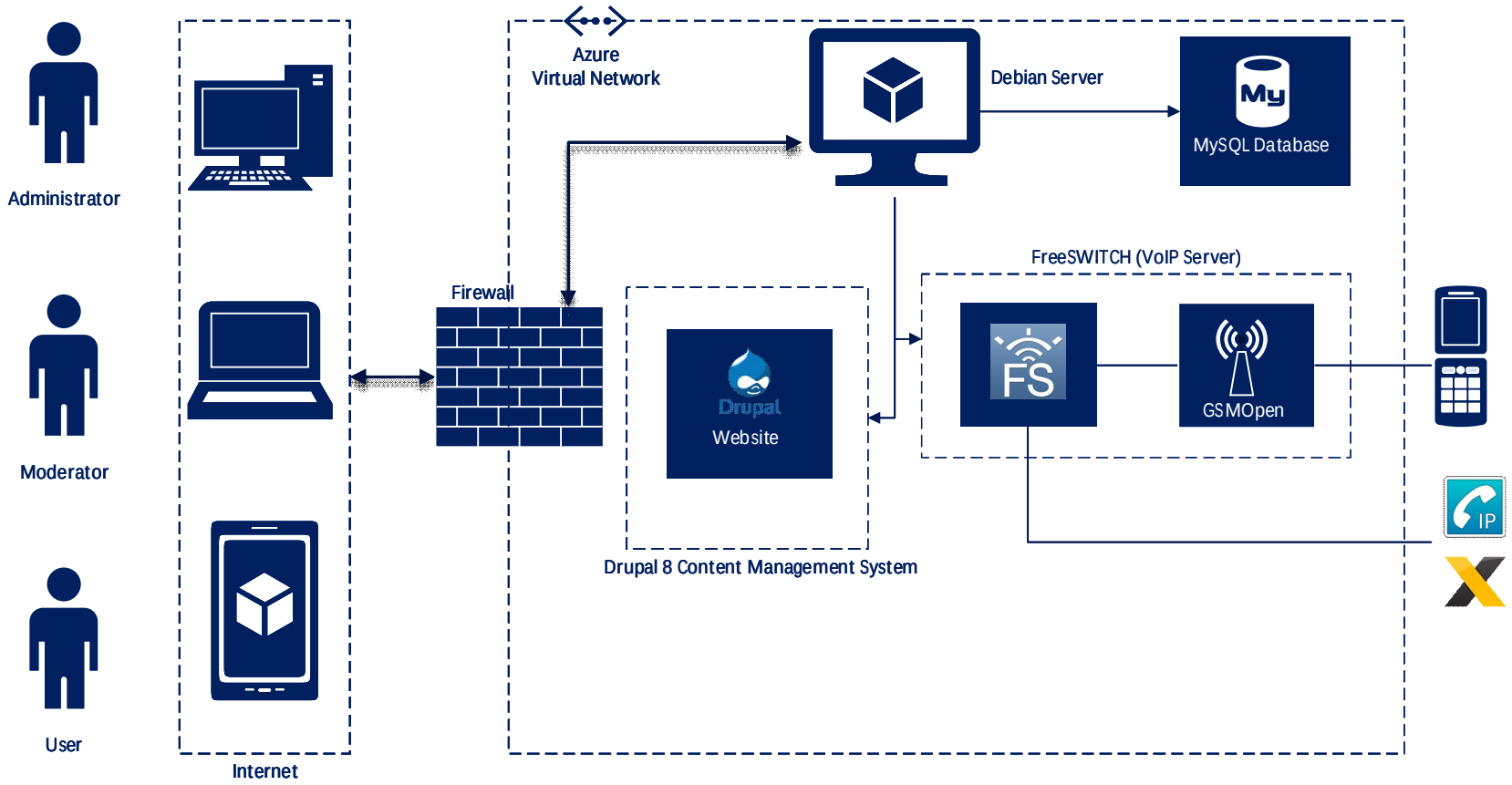


Figure 14- Architectural Diagram

4.4 Unified Modelling Language

In this section, we will focus more on the behavioral aspect of the system. It will consist of the flowing parts:

- Use Case Diagram
- Sequence Diagram

4.4.1 Use Case Diagram

Use case diagrams are used for gaining a system overview from the user's perspective. A use case is a set of scenarios describing the different interaction between a user and a system. A use case diagram displays the relationship between actors and the use cases. Figure 15 shows the use case the system:

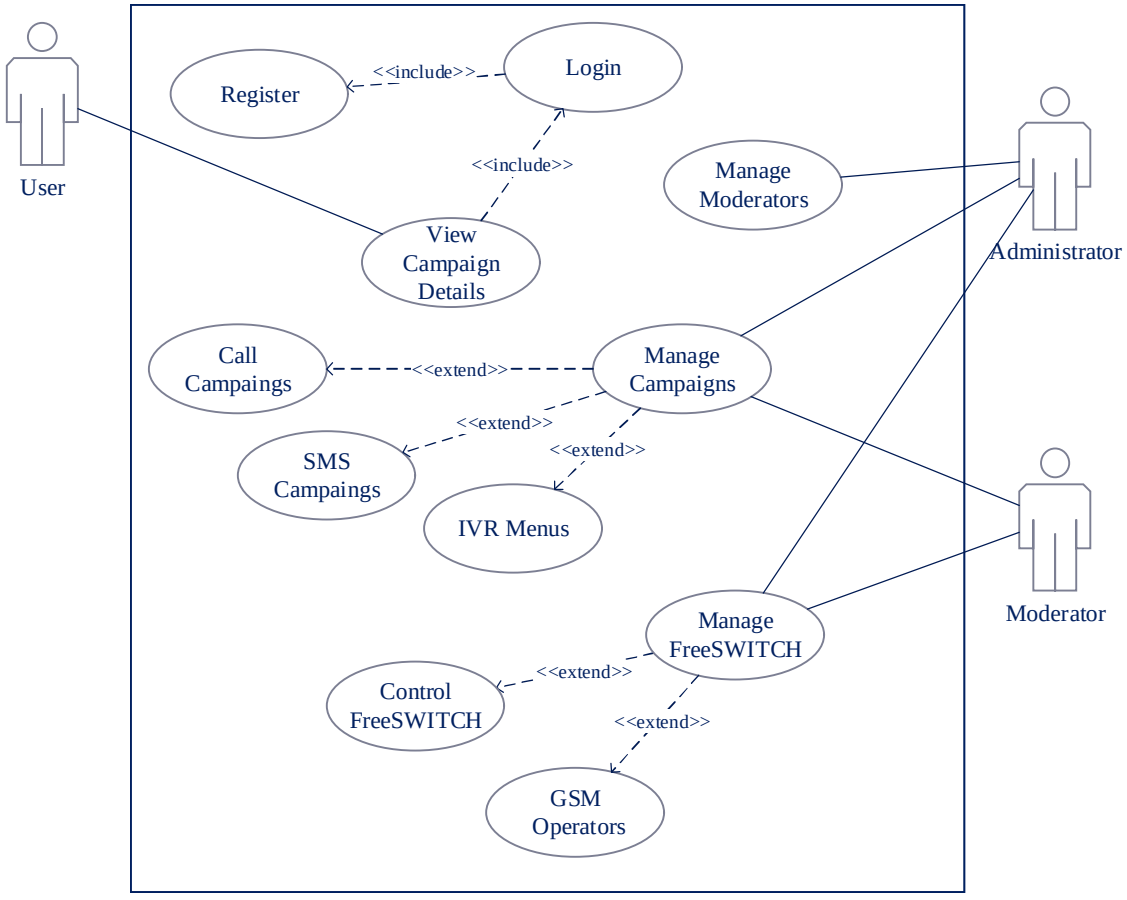


Figure 15- Use Diagram for Mass Media Comm System

4.4.2 Sequence Diagram

Sequence Diagrams are used to model the interactions of the different objects of the system based on a time sequence. The figures below represent the sequence diagrams for each of the different stages of using the system.

4.4.2.1 User Registration

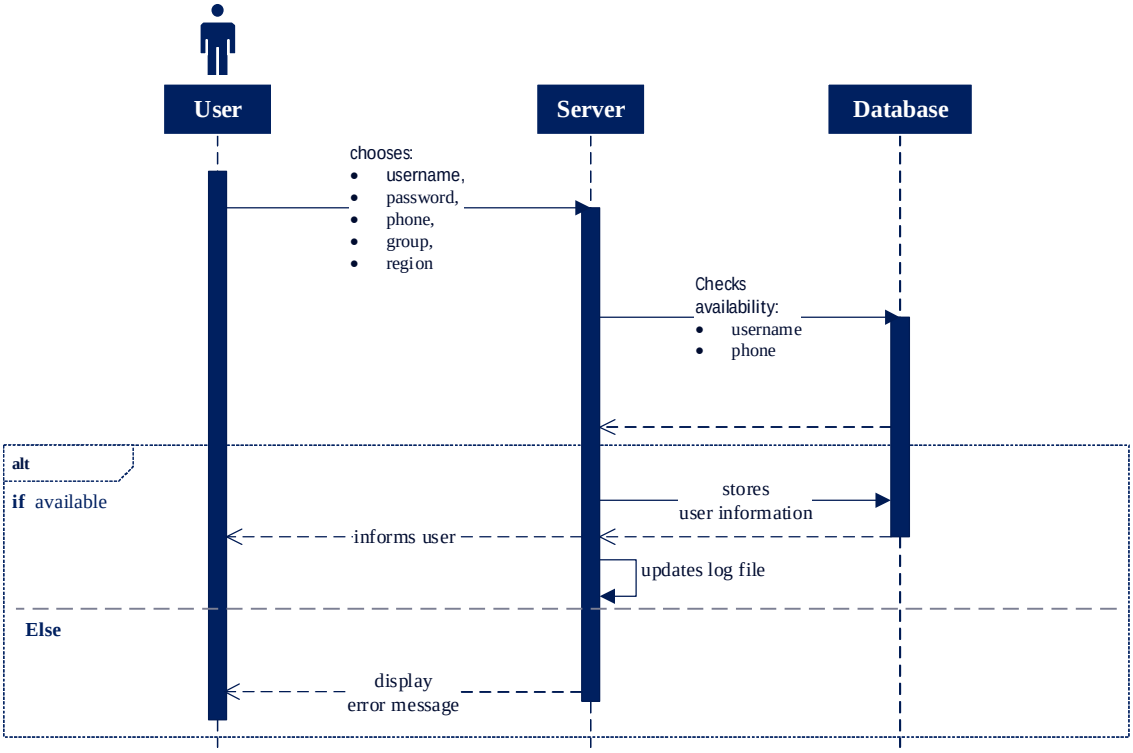


Figure 16- Sequence Diagram for User Registration

4.4.2.2 Create Call Campaign

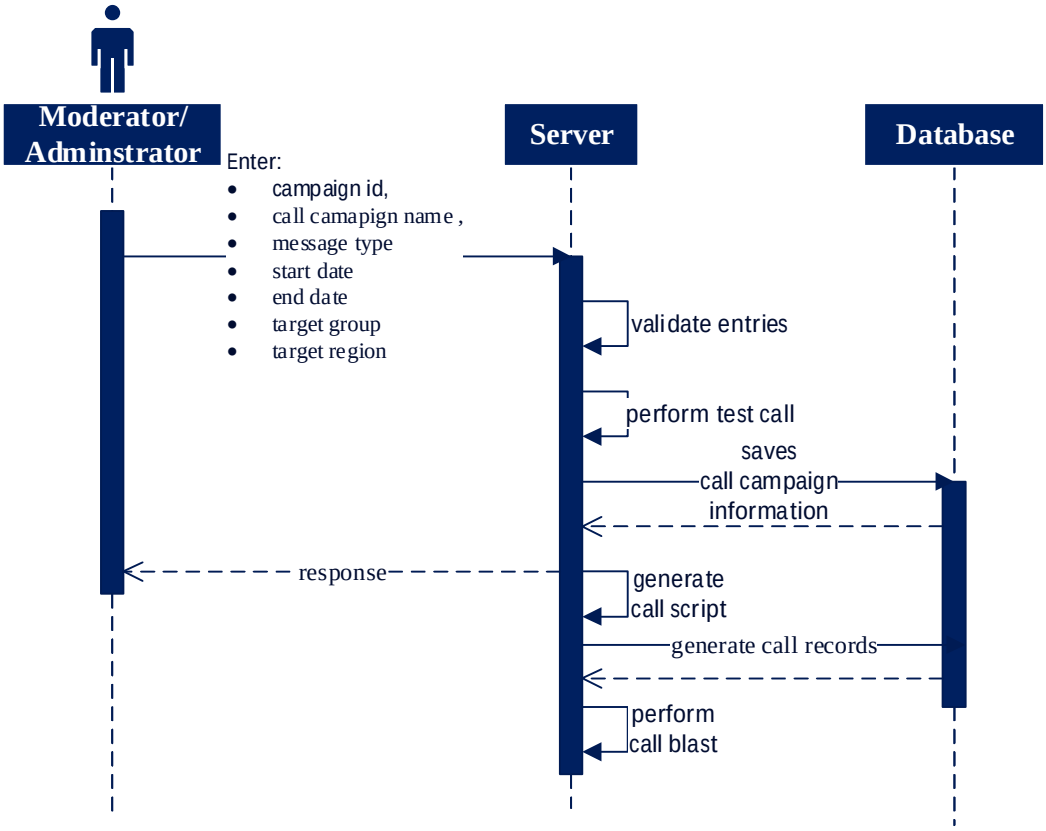


Figure 17- Sequence Diagram for creating a call campaign

4.4.2.3 Create IVR Menu

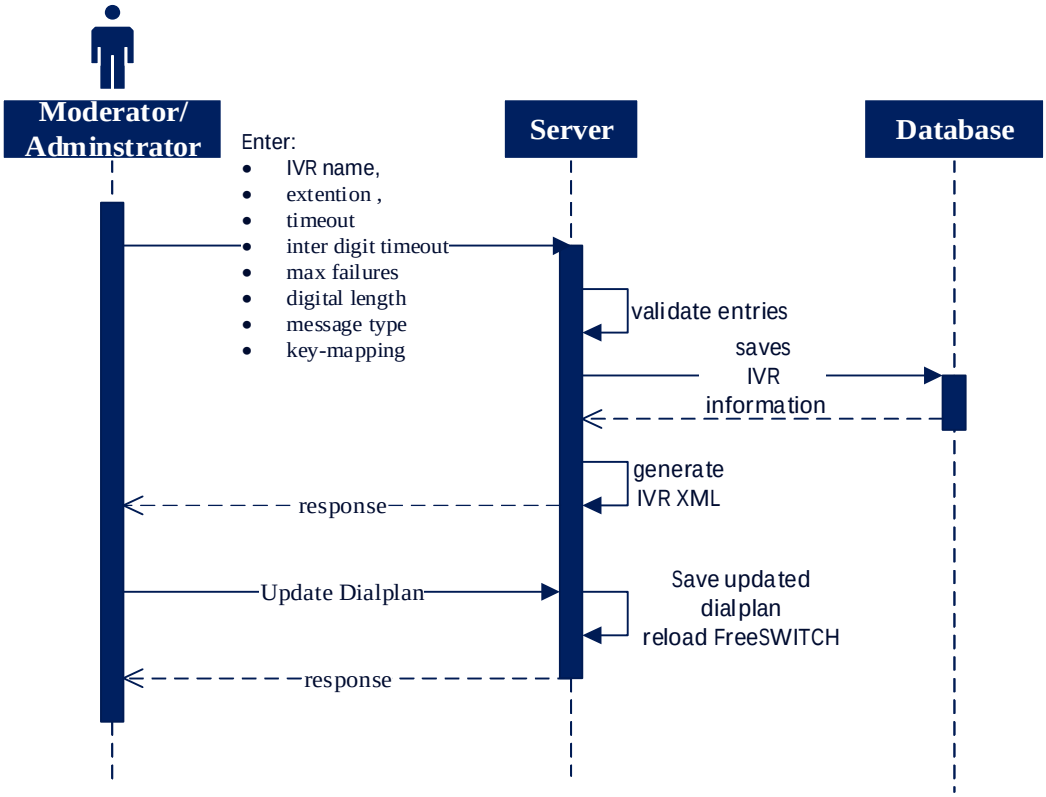


Figure 18 - Sequence Diagram for creating an IVR Menu

4.4.2.4 FreeSWITCH Server Control

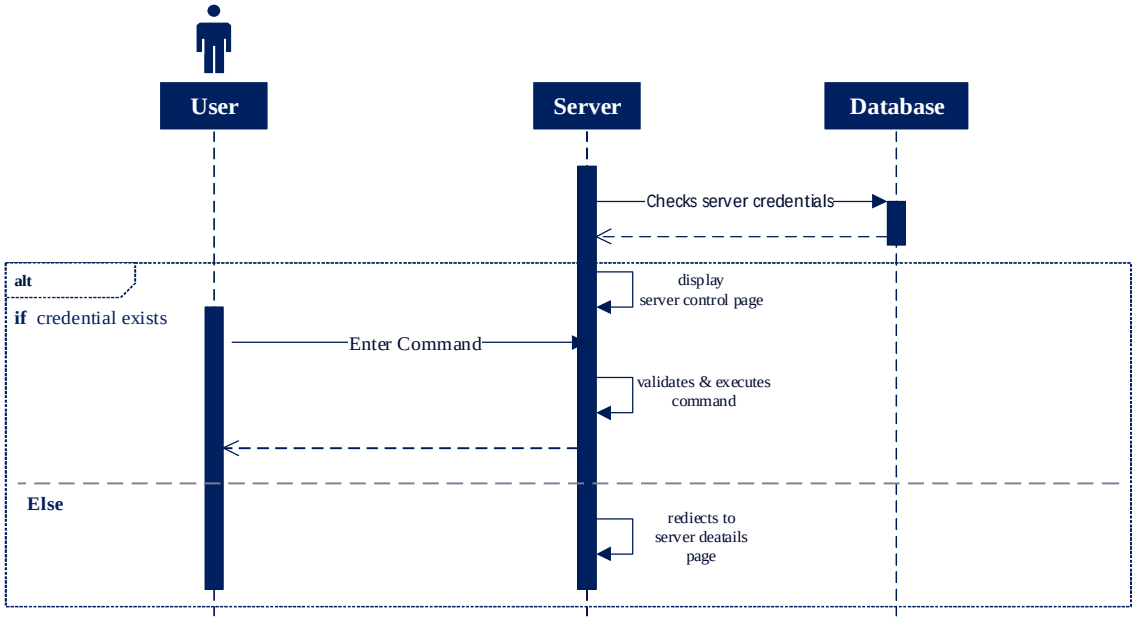


Figure 19- Sequence Diagram for controlling the FS Server

4.5 IVR interface Design Guidelines

This section provides guidelines for the IVR interface design based on IVR best design practice guidelines. (IVRa & IVRb , 2018)

4.5.1 Menu options design

- **Few menu items:** Menu Items should be restricted to 7+-2, i.e, between 5-9 menu choices based on Miller's Magic 7 theory. This is because people's working memory capacity is limited to about 7 items, and beyond that, they tend to forget.
- **Popular options first:** Put the most frequently used menu items at the beginning of the list.
- **Pause between menu items and menus:** When asking callers to press buttons as responses, make sure there is an appropriate pause between menu items since people using a cellphone must constantly move the phone away from their ear in order to press the correct key. Usually as a rule - *Short pauses between menu items, slightly longer pauses between menus*
- **Numbers after descriptions:** To reduce callers' dependence on short-term memory, describe the key action first followed by the key to press, i.e, the key press should follow the text description of the item itself. E.g, "To hear cyclone warnings, press or say 1," rather than "Press 1 to hear cyclone warnings."
- **Keep the main menu options to 30 seconds**. Simplifying the main menu options strengthens the customer experience while making the IVR experience more efficient.

4.5.2 Navigation

- **Voice options:** Allow users to select items by either pressing a number on their keypad or using voice commands.
- **Instructions up front:** When customers call, they should immediately be given instructions on how to navigate the system and which keys are reserved for special functions.
- **Option selection:** Allow users to select an option at any time. Don't force callers to listen to an entire menu before they can make a selection.
- **Default options:** Provide some basic default options that are used consistently throughout the application, such as a way to repeat a menu option, return to the main menu and speak with a customer service representative.
- **Always confirm selections:** Verbally confirm caller choices so they can be confident that the system correctly understood their selection.
- **Consistency:** Make keypad presses consistent throughout the entire IVR.

4.5.3 Language

- **Be friendly:** Present voice prompts in the user's language and in a friendly tone.
- **No jargon:** Avoid the use of technical terms and unfamiliar acronyms.
- **Be short:** Use short, concise phrases for menu items and other prompts.
- **Explain errors:** If an error occurs, tell the caller what the error was, and explain in more detail what type of correct input is expected.

- **Silence:** Use silence to convey structure to callers, but be careful not to use too much, as users may think the system is no longer operating.

4.6 Database Design

4.6.1 Table Design

The data for the system will be distributed across several tables, namely: *user_extension*, *user_groups* and *user_regions*, which will hold additional details on registered users. *campaign*, *call_campaigns*, *sms_campaigns*, *calls*, *IVR* and *ivr_key*, which will hold information specific to the Mass Media module and finally, *fs_server* and *fs_gsm* which will hold information specific to the FreeSwitch module.

4.6.1.1 User Extensions

The user_extension table will store additional information about all the Drupal registered users.

user_extension					
Field name	**Datatype**	**Constraint**	**Length**	**Default**	**Description**
uid	int	PRIMARY KEY, Not Null	-	-	The unique identifier for a user.
number	varchar	Not Null	15	-	number of the user
gid	int	Not Null	-	-	The group id of the user.
rid	int	Not Null	-	-	The region id of the user.
uid	int	PRIMARY KEY, Not Null	-	-	The unique identifier for a user.

4.6.1.2 User Groups

The user_groups table will store the different types of group of users who will use the system. If a user does not form part of any of the groups, the group field will be marked as “undefined”.

user_groups					
Field name	**Datatype**	**Constraint**	**Length**	**Default**	**Description**
gid	autoincrement	PRIMARY KEY, Not Null	-	-	The unique identifier for a group.
group_name	varchar	Not Null	255	-	The name of the group.

4.6.1.3 User Regions

The user_regions table will store the different regions in which the users who will use the system are.

user_regions					
Field name	**Datatype**	**Constraint**	**Length**	**Default**	**Description**
rid	autoincrement	PRIMARY KEY, Not Null	-	-	The unique identifier for a region.
region	varchar	Not Null	255	-	The name of the region.

4.6.1.4 Campaigns

The campaigns table will be the parent table for all calls/SMS campaigns and IVRs and will allow them to be linked to a specific event.

Campaigns					
Field name	**Datatype**	**Constraint**	**Length**	**Default**	**Description**
campaignid	autoincrement	PRIMARY KEY, Not Null	-	-	The unique identifier for a campaign.
name	varchar	Not Null	255	-	The name of the campaign.
description	varchar	Not Null	250	-	The description of the call campaign.

4.6.1.5 Call Campaigns

The call_campaigns table will contain all the information on call campaign.

call_campaigns					
Field name	**Datatype**	**Constraint**	**Length**	**Default**	**Description**
cid	autoincrement	PRIMARY KEY, Not Null	-	-	The unique identifier for a call campaign.
campaignid	int	FOREIGN KEY (campaigns), Unsigned, Not Null	-	0	The unique identifier for a campaign.
name	varchar	Not Null	255	-	The name of the call campaign.
file	int	Not Null	tiny	0	0 = tts, 1 = voice message
filepath	varchar	Not Null	255	-	The path for the voice message.
tts	varchar	Not Null	500	-	The text to speech message.
start	varchar	date, Not Null	-	-	The start date of call campaign.

end	varchar	date, Not Null	-	-	The end date of call campaign.
gid	int	Not Null	-	-	The group id of the user.
rid	int	Not Null	-	-	The region id of the user.

4.6.1.6 SMS Campaigns

The sms_campaigns table will contain all the information on SMS campaign.

sms_campaigns					
Field name	**Datatype**	**Constraint**	**Length**	**Default**	**Description**
sid	autoincrement	PRIMARY KEY, Not Null	-	-	The unique identifier for a SMS campaign.
campaignid	int	FOREIGN KEY (campaigns), Not Null	-	0	The unique identifier for a campaign.
name	varchar	Not Null	255	-	The name of the SMS campaign.
sms	varchar	Not Null	500	-	The SMS to speech message.
start	varchar	date, Not Null	-	-	The start date of SMS campaign.
end	varchar	date, Not Null	-	-	The end date of SMS campaign.
gid	int	Not Null	-	-	The group id of the user.
rid	int	Not Null	-	-	The region id of the user.

4.6.1.7 Calls

Once a call campaigns has been saved a script will generate the records of the users concerned with that specific call campaign and will store them in this table as well as additional information concerning the progress of the call campaign.

Calls					
Field name	**Datatype**	**Constraint**	**Length**	**Default**	**Description**
cid	int	PRIMARY KEY, Not Null	-	-	The unique identifier for a call campaign.
uid	int	FOREIGN KEY (user_extension), Not Null	-	-	The unique identifier for a user.
attempts	int	Not Null	-	0	The number of call attempts
status	varchar	Not Null	255	N/A	The status of the call.
last_try	varchar	datetime, Not Null	-	-	The timestamp of last call.

4.6.1.8 IVR

The ivr table will store the essential information of custom ivr menus created by moderators.

Ivr					
Field name	**Datatype**	**Constraint**	**Length**	**Default**	**Description**
ivrid	autoincrement	PRIMARY KEY, Not Null	-	-	The base table for IVR menus.
campaignid	int	FOREIGN KEY (campaigns), Not Null	-	0	The unique identifier for an IVR.
name	varchar	Not Null	255	-	The unique identifier for a campaign.
number	varchar	Not Null	15	-	The name of the ivr.
file	int	tiny, Not Null	-	0	number of the ivr.
filepath	varchar	Not Null	255	-	0 = tts, 1 = voice message
tts	varchar	Not Null	500	-	The path for the voice message
timeout	int	Not Null	-	-	The text to speech message
inter_digit_timeout	int	Not Null	-	-	-

max_failures	int	Not Null	-	-	-
digit_length	int	Not Null	-	-	-

4.6.1.9 IVR Key

The ivr_key table is an extension of the ivr table which will store the key-action mapping of IVR Menus.

ivr_key					
Field name	**Datatype**	**Constraint**	**Length**	**Default**	**Description**
ivrid	int	FOREIGN KEY(ivr), Not Null	-	-	The base table for IVR menus.
num_key	int	PRIMARY KEY, Not Null		-	The unique identifier for a num_key.
action	varchar	Not Null	255	-	-
parameter	varchar	Not Null	255	-	-
ivrid	int	FOREIGN KEY(ivr), Not Null	-	-	The base table for IVR menus.

4.6.1.10 Server Details

The fs_server table will contain the credentials required to control FreeSWITCH over the HTTP API.

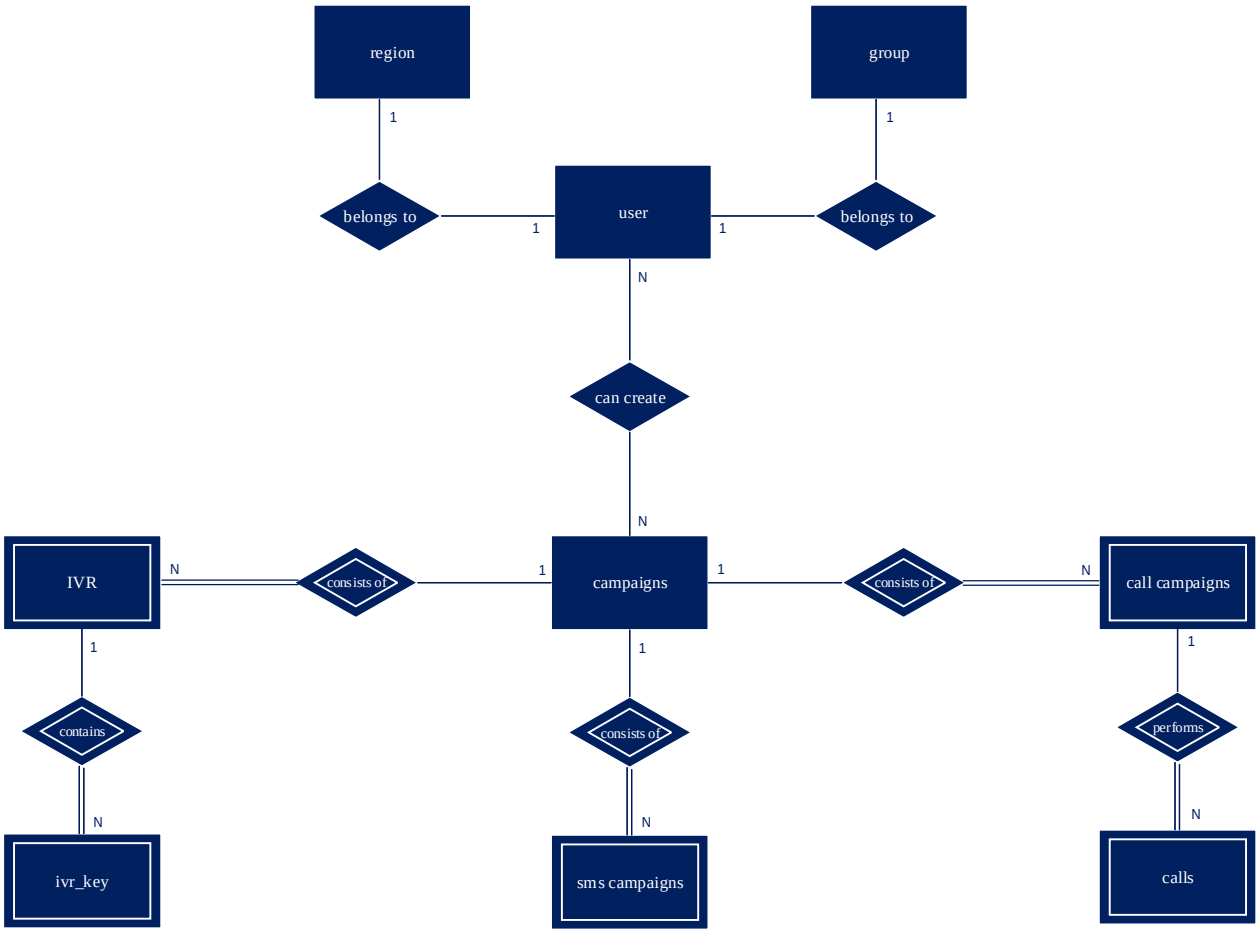
fs_server					
Field name	**Datatype**	**Constraint**	**Length**	**Default**	**Description**
sid	autoincrement	PRIMARY KEY, Not Null	-	-	The unique identifier for a record.
ip	varchar	Not Null, UNIQUE	255	-	The IP address for FreeSWITCH server.
user	varchar	Not Null	255	-	The user name for FreeSWITCH.
pass	varchar	Not Null	255	-	The password for FreeSWITCH server.
path	varchar	Not Null	255		The default directory for FreeSWITCH

4.6.1.11 GSM Operators

The fs_gsm table will contain information regarding the SIM cards use for SIM banks connected to FreeSWITCH

fs_gsm					
Field name	**Datatype**	**Constraint**	**Length**	**Default**	**Description**
did	autoincrement	PRIMARY KEY, Unsigned, Not Null	-	-	The unique identifier for a chip.
name	varchar	Not Null	255	-	The name of GSM chip.
control_device_name	varchar	Not Null	255	-	The control device name of GSM chip.
control_device_audio_name	varchar	Not Null	255	-	The control device audio name of GSM chip.
imei	varchar	Not Null	20	-	The imei number of GSM chip.
imsi	varchar	Not Null	20	-	The imsi number of GSM chip.
destination_extension	varchar	Not Null	20	-	The destination extension number of GSM chip.

4.6.1.12 Entity Relation Diagram (ERD)



Implementation Of a Mobile Mass Content Dissemination System

5 Implementation

This chapter focuses on the implementation of the system providing the various implementation issues considered, Development tools and platforms, screenshots of the system and a small explanation of the various screens and how the system performs.

5.1 Implementation Issues

5.1.1 5.1.1 Operating System

Initially, it was planned to use Ubuntu Server 16.04 64-bit because of its popularity and community. But unfortunately, during the implementation phase, it was found that FreeSWITCH no longer supports this operating system. The next operating system choose was Debian Server 1.8 64-bit.

5.1.2 File Access

Debian Server uses Unix's permission pattern whereby each file and directory has specific access rights for the owner of the file/directory, groups and other. Rights to read, write to and execute a can be given. The *chmod* comment allows modifying the access rights of file and directories. Since the system needs to write new, edit existing and delete files, the access rights of the required directories have been changed to permit those operations.

5.2 Development Tools and Environment

5.2.1 Linux-Apache-MySQL-PHP (LAMP) Server

The LAMP server in Debian Server includes Apache 2, MySQL 5 and PHP 7.0. Apache is the webserver used to host the system. MySQL holds the database used by Drupal and PHP is used by Drupal and in custom modules created.

5.2.2 Drupal 8

Drupal 8 is a Content Management System (CMS) which comes with multiple built-in functionalities in its core and a vast number of additional modules developed by the Drupal Community to extend its core. Contributed modules can be downloaded from drupal.org and copied on the modules folder of Drupal. These modules can then be activated in the extend configuration of the CMS.

Drupal 8 is the latest release version of the CMS. The structure of how the system handles modules has changed as compared previous versions.

5.2.3 Custom Modules

To develop custom modules in Drupal 8 there are four important files that should be included. The *info.yml* file which will hold details on the module, *the module.install* which will contain the instructions to be performed when the new module is installed, this file is used to create and install the tables to be used by the new module. The *libraries.yml* will have all link and description of the additional libraries that the module required to work properly. Finally, the *routing.yml* will have a list of the pages in the modules and their matching URL path.

5.2.4 FreeSWITCH

The FreeSWITCH system has a modular design with modules built around the switching core to provide a stable and scalable telephony platform on which developers can build communication applications. FreeSWITCH can be used for conferencing, Interactive Voice Response (IVR), voice over IP protocols including Session Initiation Protocol (SIP), Messaging. FreeSWITCH is versatile and allows control of calls using scripting languages like Python, Perl, Lua, JavaScript and others. Applications to control FreeSWITCH externally can make use of the Event Socket or the mod_httapi module

The system is able to make two types of calls namely VoIP calls from FreeSWITCH to softphones and GSM calls from FreeSWITCH and through a gateway – a SIM Bank – to cell phones and landlines.

5.2.5 Softphones

To be able to make and receive VoIP calls, smartphones, tablets and computers must have softphone software, be registered to the FreeSWITCH server and connected to the same Local Area Network.

Softphone Software	
Platform	**Software**
Android	CSipSimple
Windows	XLite
IOS	Acrobats

5.2.6 User Directory

To register with the FreeSWITCH server, users should have a user account with the following information: a username, an authorization username (usually same as the username), a password and a domain (IP address of the FreeSWITCH server). FreeSWITCH stores user accounts as an XML file at /etc/freeswitch/directory/default/. Any application that creates users in FreeSWITCH should access that folder and place an XML file there. For the user account to be active, the extension number should match the regular expression used to check valid extension numbers in the Local_Extension Dialplan entry found at /etc/freeswitch/dialplan/default.xml

5.2.7 Dialplan

The dialplan is an XML file that allows routing of calls i.e. connecting calls. A dialplan is a list of instructions on how to connect and control calls. The Dialplan contain extensions which contain conditions validated using regular expressions and actions that are executed only if conditions evaluate to true. Actions execute dialplan applications or scripts.

5.2.8 Event Socket Library (ESL)

The Event Socket is a TCP socket used to send and receive events in other applications. ESL is a library that allows developers to interact with FreeSWITCH using programming languages

like PHP, Perl, Ruby, .NET and others. ESL PHP is not part of the default FreeSWITCH installation and has been installed separately. Since FreeSWITCH was installed as a search, an apt-get is sufficient to install this library.

5.2.9 Operating System

Debian Server 64-bit operating system has been preferred mainly because of it fully supports FreeSWITCH. Most online help for FreeSWITCH that are available are for Linux distributions. Moreover, Drupal is much faster on Linux than Windows, tasks like module installation which take a long time in Windows is much quicker Linux.

5.2.10 Text Editors

5.2.10.1 Sublime Text

Sublime Text is a text editor used for writing PHP codes for Drupal and editing of FreeSWITCH. XML files. Sublime Text can be customized according to Drupal Coding Standards and provide auto-completion, quick access to the online Drupal APIs to ease Drupal development. Sublime text allows easy navigation through the code and use of customizable colour combinations and syntax highlighting for improved visual comfort.

5.3 Infrastructure Used

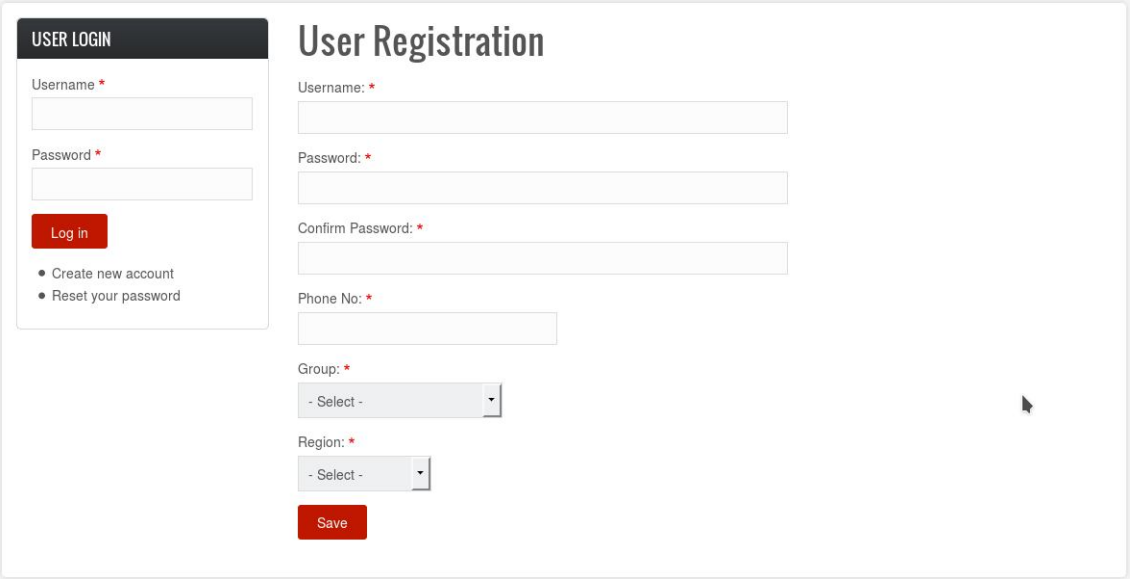
The system was hosted on cloud using Microsoft Azure. A Linux Virtual Machine (VM) running Debian was -setup and the above-mentioned software was install. For security reasons, only the ports used by system has been allowed to pass through the VM. Secure Shell (SSH) was used to access the remote server from local machine to perform the required modifications.

5.4 Implementation of Interface

5.4.1 User Management

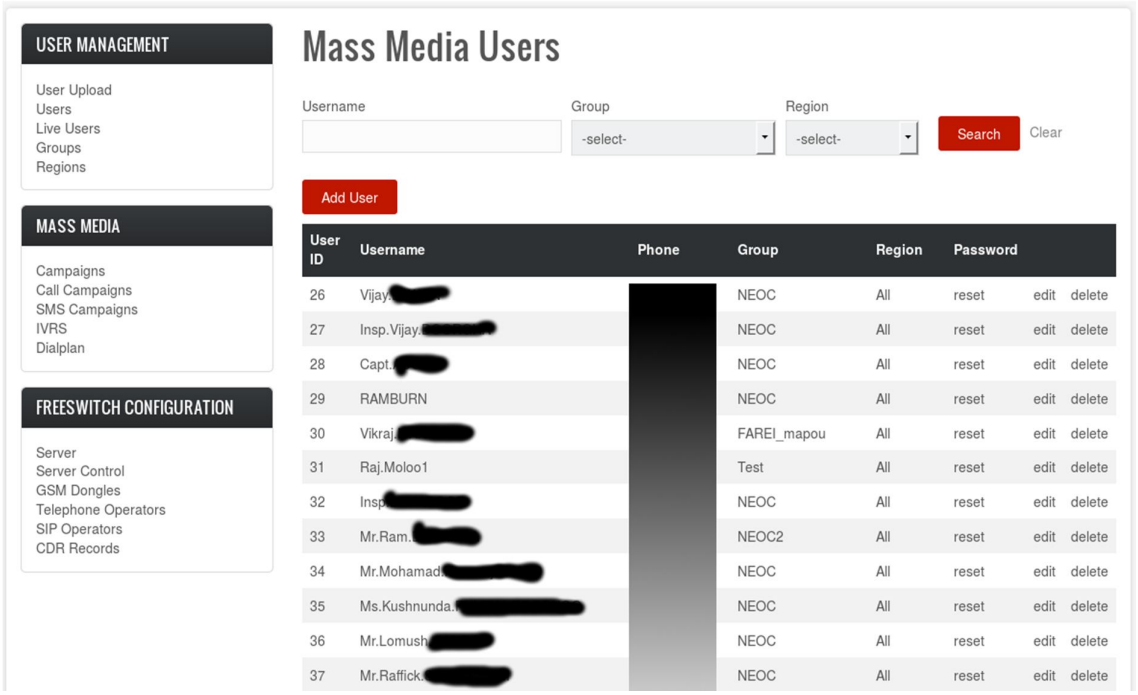
5.4.1.1 Registration Form

The registration form for the system which is accessible to anyone.



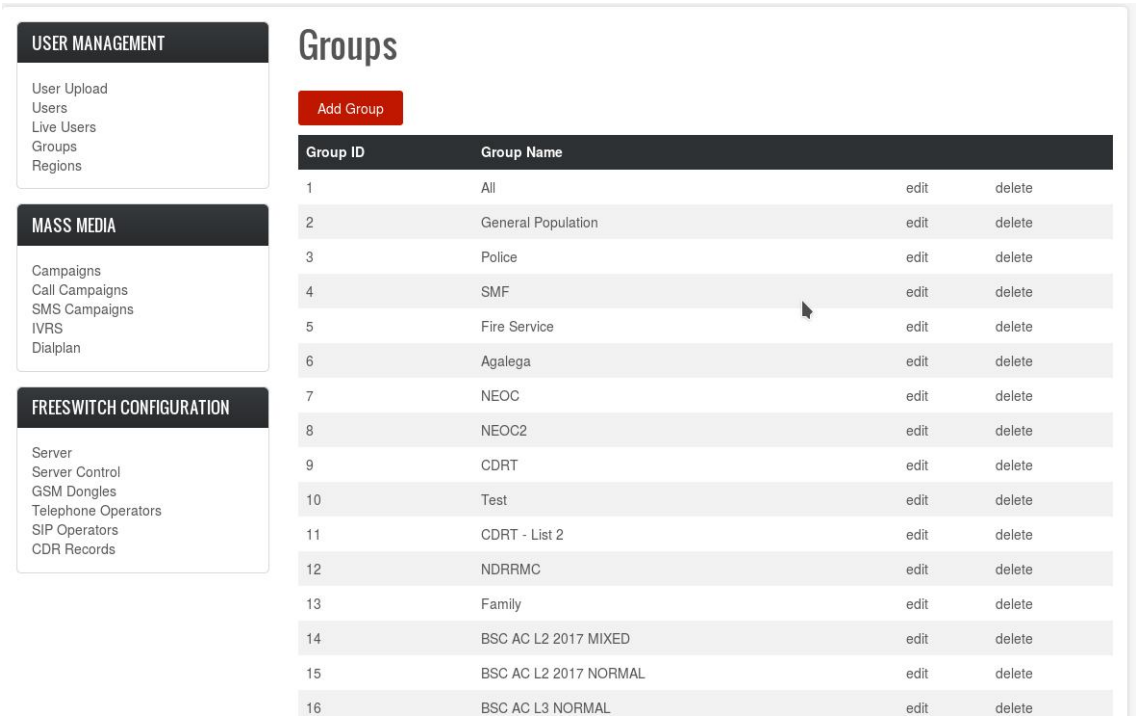
5.4.1.2 Users

List of Users registered to the system, where moderators and administrators can perform modifications if required.



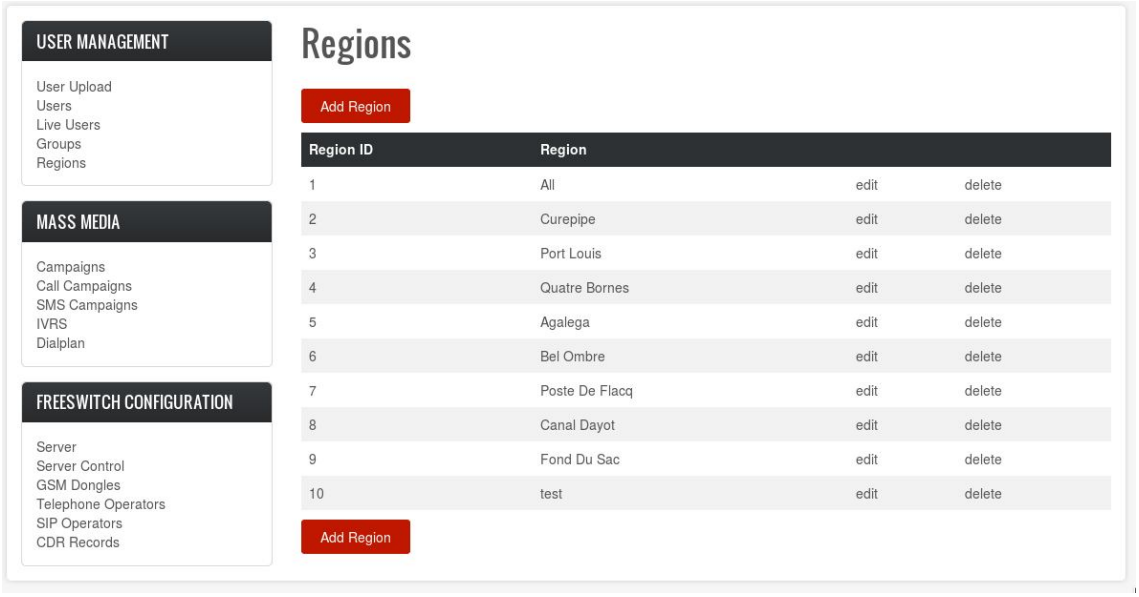
5.4.1.3 Groups

List of groups, where moderators and administrators can perform modifications if required.



5.4.1.4 Regions

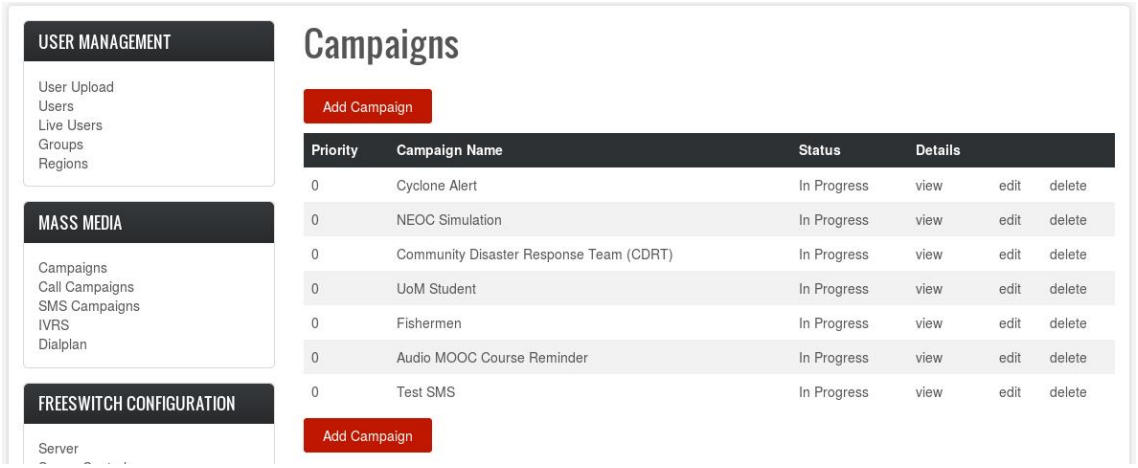
List of regions, where moderators and administrators can perform modifications if required.



5.4.2 Mass Media

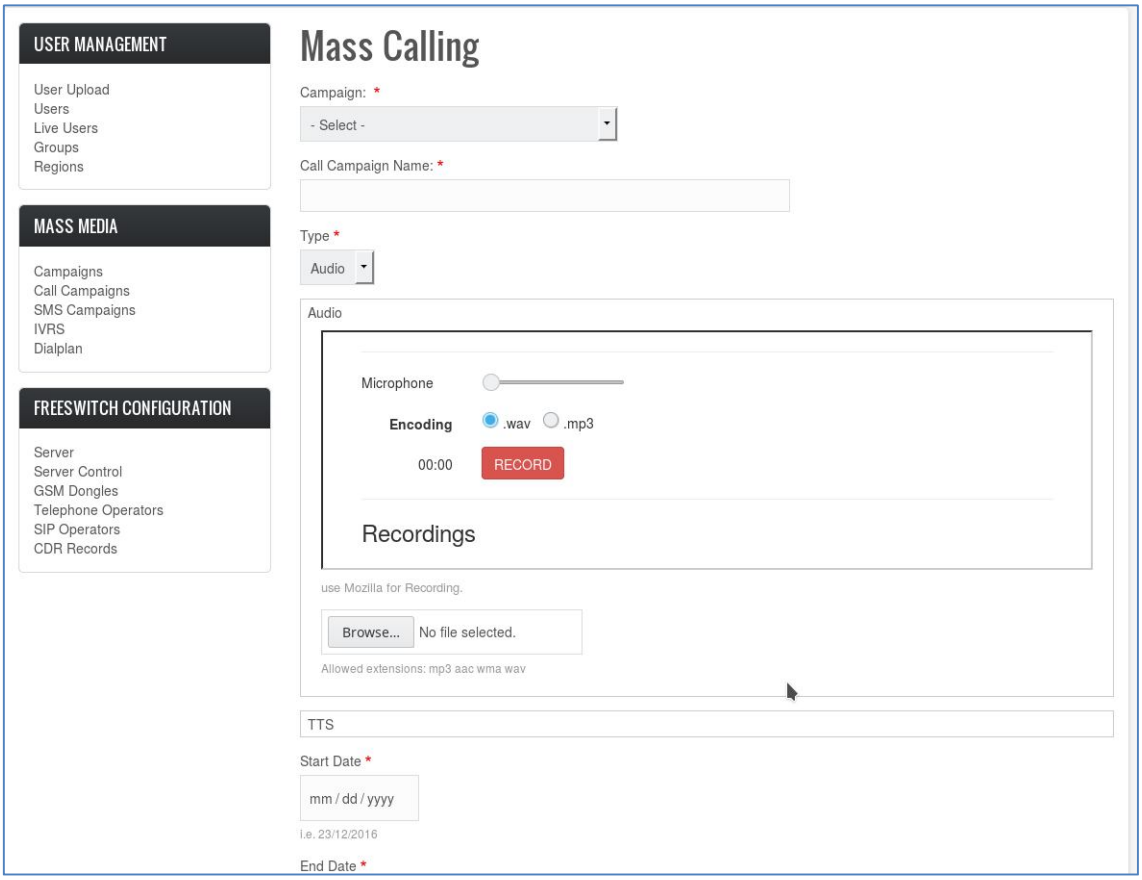
5.4.2.1 Campaigns

List of campaigns, together with a detailed list of associated call/SMS campaigns and IVR menus as created by moderators and administrators. Users will only be able to see the campaigns but not modify them.



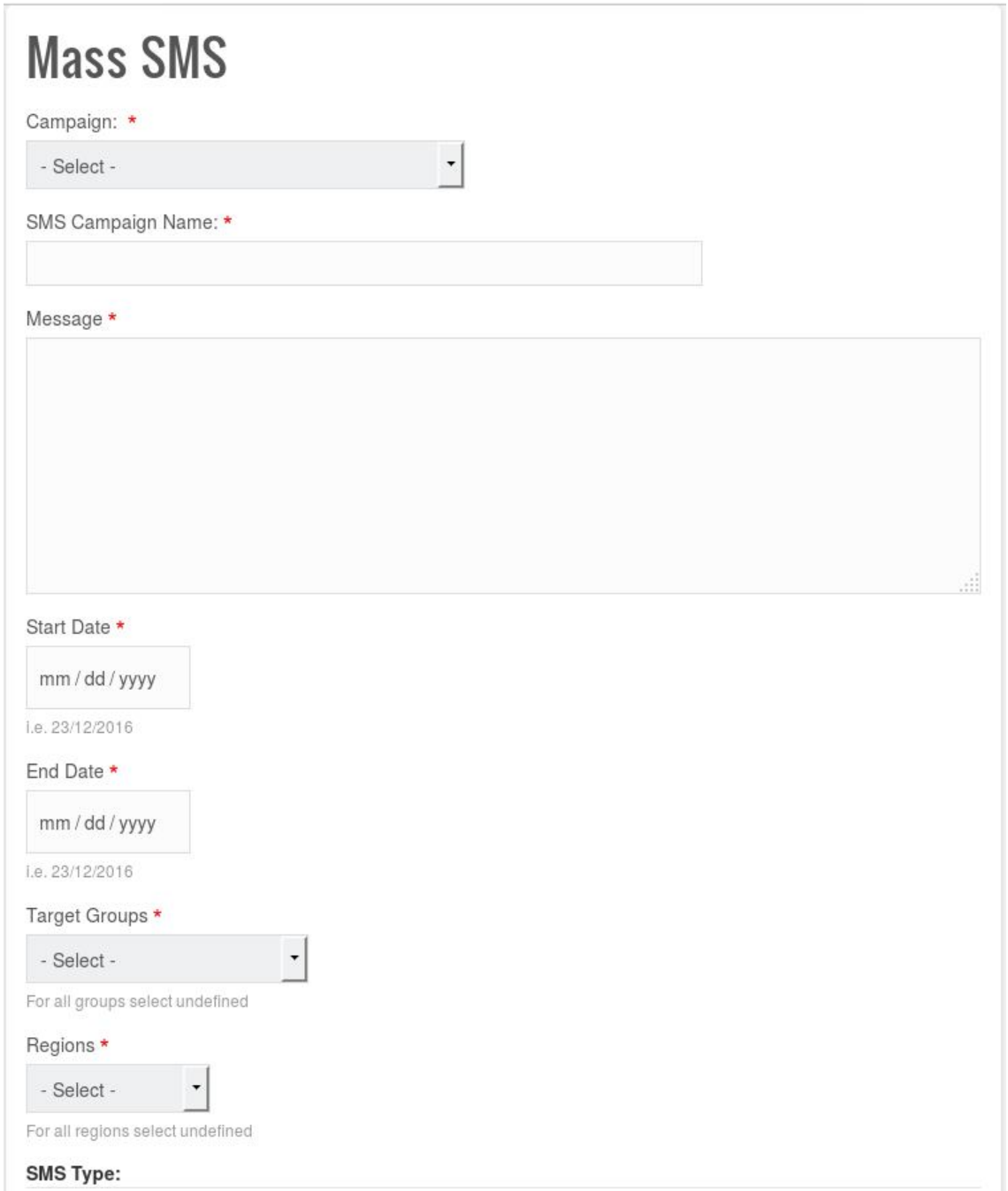
5.4.2.2 Call Campaign

This form allows moderators and administrators to create and test call campaigns.


USER MANAGEMENT
User Upload
Users
Live Users
Groups
Regions
MASS MEDIA
Campaigns
Call Campaigns
SMS Campaigns
IVRS
Dialplan
FREESWITCH CONFIGURATION
Server
Server Control
GSM Dongles
Telephone Operators
SIP Operators
CDR Records
Mass Calling
Campaign: *
- Select -
Call Campaign Name: *
Type *
Audio
Audio
Microphone
Encoding
.wav
.mp3
00:00
RECORD
Recordings
use Mozilla for Recording.
Browse...
No file selected.
Allowed extensions: mp3 aac wma wav
TTS
Start Date *
mm / dd / yyyy
i.e. 23/12/2016
End Date *

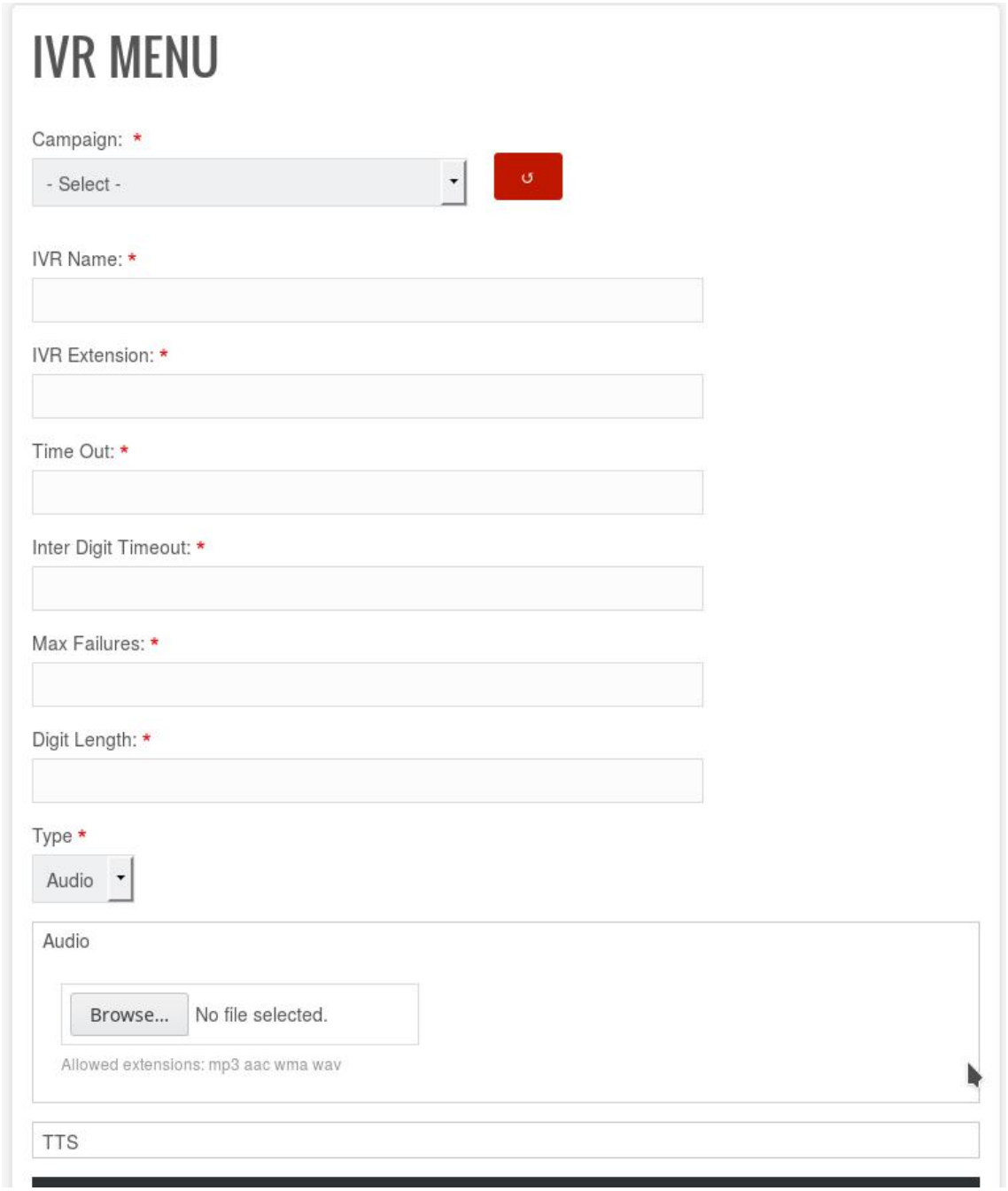
5.4.2.3 SMS Campaign

This form allows moderators and administrators to create and test SMS campaigns.



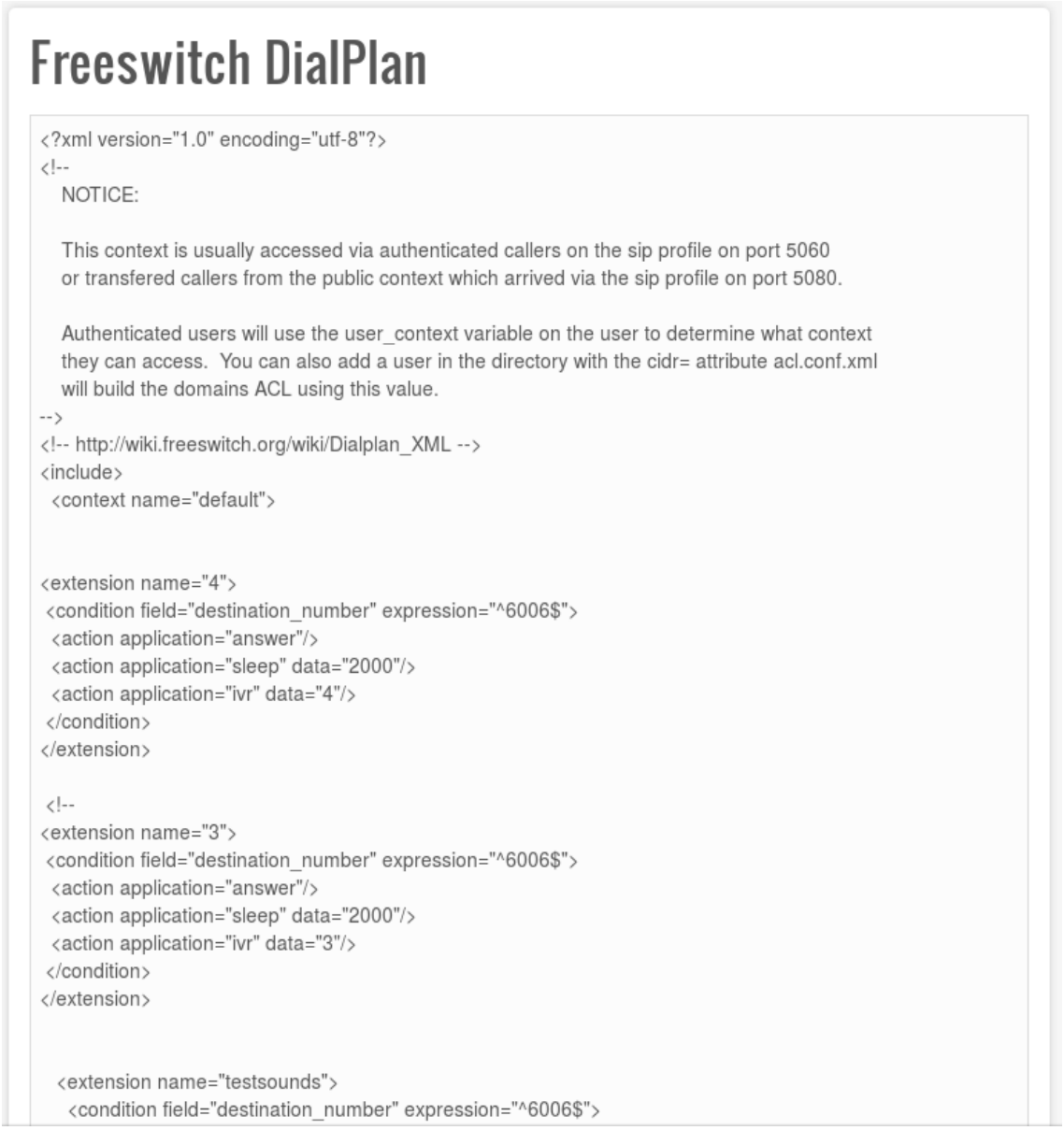
5.4.2.4 IVR Menu

This form allows moderator and administrators to create IVR menus including the key-action mapping.



5.4.2.5 Dialplan Form

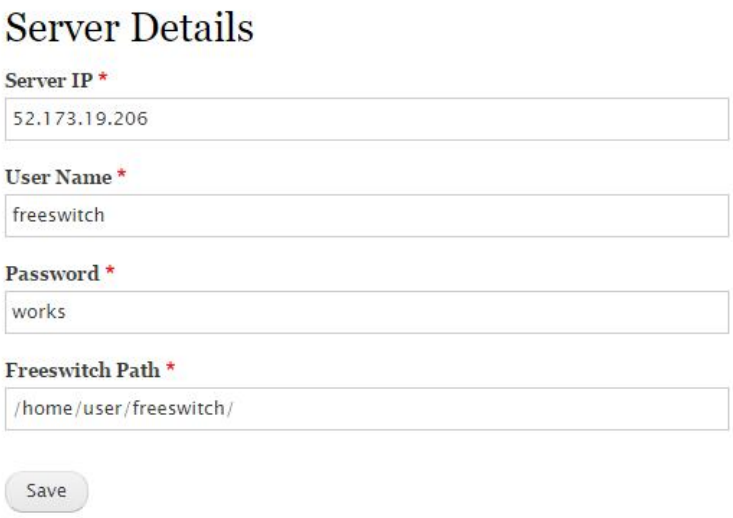
Once an IVR menu has been saved, the system will gather the required information and automatically generate the dialplan entry for this particular IVR and display it. The current dialplan will be loaded from the FreeSWITCH server and displayed as well. The moderator/administrator will have to manually copy and paste the generated IVR entry in the required place.



5.4.3 FreeSWITCH

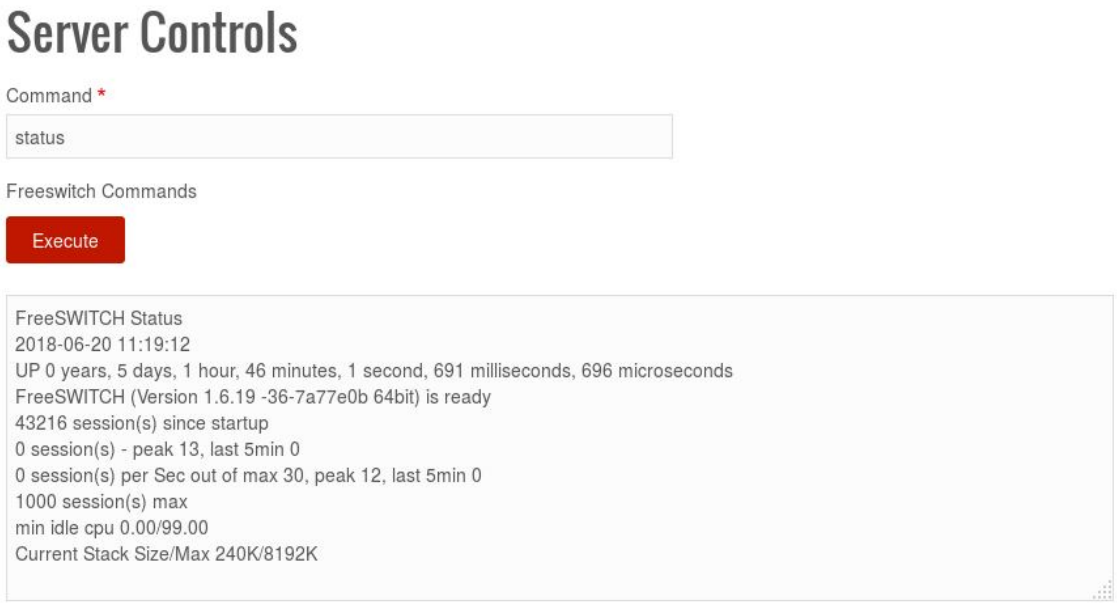
5.4.3.1 Server Detail

As mentioned above, this form will allow moderators and administrator to insert the credentials of FreeSWITCH in order to use the HTTP API and the default directory path for FreeSWITCH.



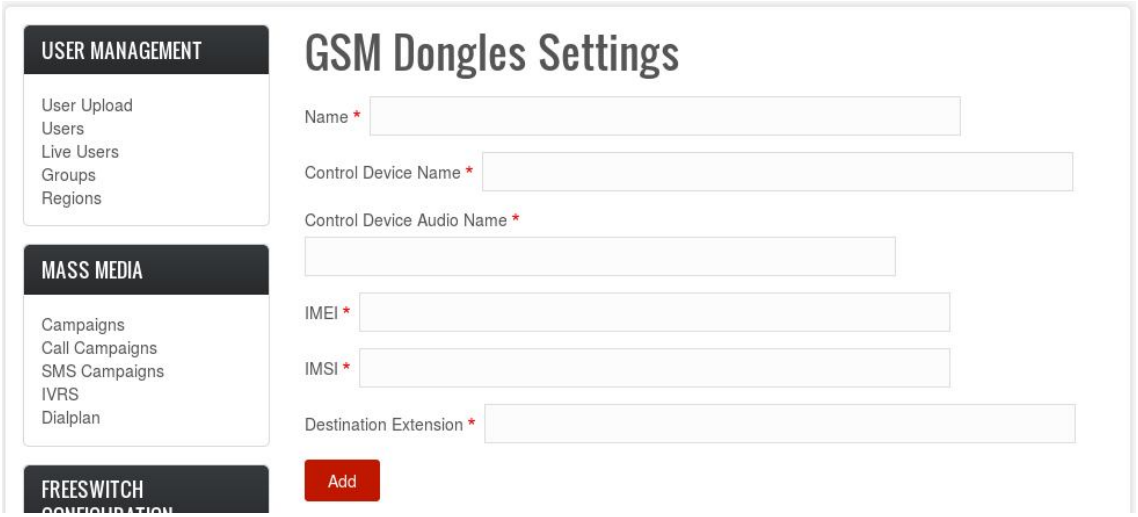
5.4.3.2 Server Control

This form allows moderators and administrators to send commands to FreeSWITCH. For example: status, restart. A link which contains the different available commands is also provided.



5.4.3.3 GSM Operators

This form allows moderators and administrators to add and configure SIM card connected to FreeSWITCH via a SIM Bank over the internet.


USER MANAGEMENT
User Upload
Users
Live Users
Groups
Regions
MASS MEDIA
Campaigns
Call Campaigns
SMS Campaigns
IVRS
Dialplan
FREESWITCH
GSM Dongles Settings
Name *
Control Device Name *
Control Device Audio Name *
IMEI *
IMSI *
Destination Extension *
Add

6 Testing

This chapter illustrates the live testing that we have performed in collaboration with the National Disaster Risk Reduction Management Centre (NDRRMC). Thorough testing of the different capabilities of the proposed system has been carried out by different target groups. Live testing scenarios were planned and conducted. Then feedback from the target groups was collected and analyzed.

6.1 National Disaster Risk Reduction Management Centre (NDRRMC).

The National Disaster Risk Reduction and Management Centre (NDRRMC), situated on the 6th floor at Citadelle Mall, Corner of Louis Pasteur, Sir Virgil Naz and Eugene Laurent Streets in Port Louis, is the body that acts as the main institution for the State of Mauritius for the planning, organizing, coordinating and monitoring of disaster risk reduction and management activities at all levels.

The NDRRMC coordinates with all stakeholders to ensure that risk reduction and preparedness planning is included at all levels of the country, from individuals and communities to Government policy and strategy.

http://ndrrmc.govmu.org/English/Pages/default.aspx

6.1.1 Prototype Evaluation

The prototype was presented to the NDRRMC for views. Members of the NDRRMC found the system to be useful and feasible to use during disasters. They asked for some modifications. Thereon, several meetings were conducted to fine-tune the system.

Once the system was stable, in consultation with the NDRRMC, we decided to have live testing on users. NDRRMC identified targeted groups of users on which the system could be tested. An alert message was scripted, recorded and uploaded on the system for mass phone calling.

6.1.2 How it works?

The early warning system works as follows on either registered or ad-hoc groups.

1. An administrator can create and register target groups from a csv file provided in a particular format. Once the csv file is uploaded, accounts for each user in the csv file are created and registered on the system. They can later login into the system and modify their personal details.
2. Otherwise, in case of emergency, ad-hoc users can be created in batch using csv file with a particular format. The difference is that these users are not registered on the system.
3. The audio alert message is then uploaded on the system and assigned to a specific target group either registered or ad-hoc.
4. The admin then makes a call blast to the target groups. The call blast module will loop through each mobile numbers in the group, call them and play the alert message. Once the

alert message reaches the end, it automatically disconnects the calls. It is to be noted that if a user does not pick up the call in the first attempt, the system will wait for some time and recall them. The system has been set to perform only three (3) call attempts.

5. The admin can then monitor the status of the call blast, viewing users who have responded to the audio alert message over the phones and those who have not.

Targeted Groups

Below is a list of targeted groups on which the system was tested. Specific alert scripts for each target groups were prepared by the NDRRMC team. We then created the audio alerts, uploaded them on the system and assigned them to respective groups. The system was then programmed to automatically call the group members on their mobile phones and play the alert messages.

Nb: For simulation purpose and to avoid panic, these groups were warned beforehand of the alert calls they will receive. Besides, the Alert message at start included a message that it was a test simulation and not to panic.

Target Groups	#
NDRRMC	
1. NDRRMC members	18
NEOC	
2. NEOC members	43
CDRT	
3. Bel-Ombre	10
4. Poste De Flacq	30
5. Canal Dayot	26
6. Fond Du Sac	11
UNIVERSITY OF MAURITIUS	
7. Year 2 and Year 3 Students	146
FiTEC	
8. Fishermen	46
FAREI PLANTERS	
9. Palma	40
10. St-Pierre	36
11. Mapou	40
12. Plaisance	17
13. Unity	16

7 Results

7.1 Survey Results

In this section, we present the result of the surveys conducted with the different stakeholders involved during the testing phase of this project. We will present 2 sets of results, one for the students and another one for the other groups (Target Groups), as the scale used for both surveys were different.

7.2 Low Literacy Groups

The target population of this study constituted of CDRT, planters as well as fishermen making up 34 %, 49 % and 16 % respectively. 72% of the people were male while the remaining 28% were female. Approximately 41% of the respondent studied up to school certificate level, 27% hold a certificate of primary education, 14% had higher education certificate, 6% hold diploma while few as 4% held degree or post-graduate certificate. The respective percentage is shown in figure 20 below.

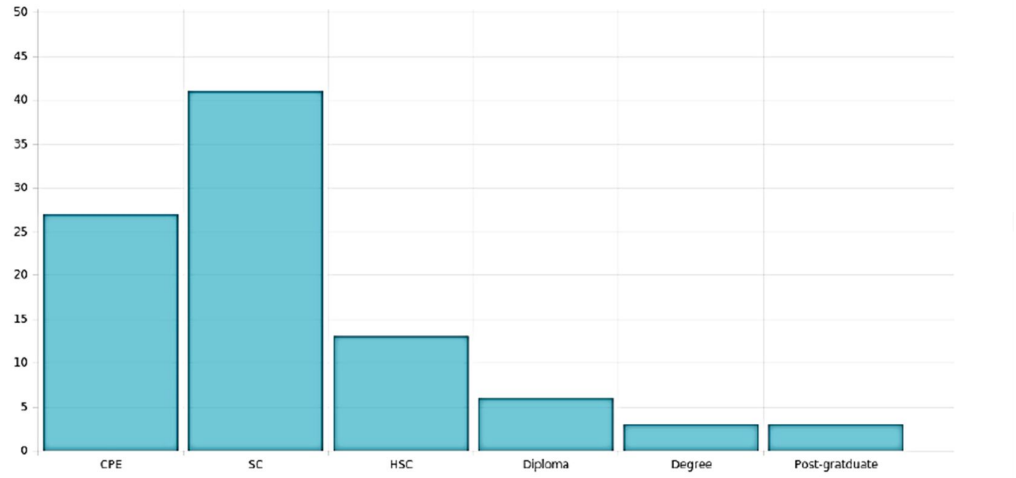


Figure 20: Qualification level of respondents

83% of the respondent holds average knowledge on mobile phone usage, 12% considered themselves as an expert while only 3% denoted themselves as a novice.

7.2.1 User behavior w.r.t the alert call voice message

The targeted population received phone call concerning weather forecast and current situation of disaster. 92% of the population found the message useful and 87% listened to the whole alert message. However, 10% of the population listened to part of the message only. 25% of the population agreed that the duration of the alert message is too long and recommended to shorten the alert message while 58% of the respondent found the message ideal which means neither too long nor too short. The sound quality of the alert message was perfect (88%

respondent agreed) hence, 95% of the population answered they would readily subscribe to such alert service in the future.

7.2.2 User suggestion on number of Call Attempts

The goal behind such audio alert message is to be able to quickly inform people of disasters and progress of crisis as well as precaution to take. 90% of the respondent would immediately call their contacts to inform and warn them of disaster progress if such situation was to happen.

Overall, 73% of respondent suggested at least 3 calls attempts must be made to inform a person, 20 % answered a single attempt is enough, 4% suggested the system can keep on calling until answered while only 3% responded that 5 attempts are also good.

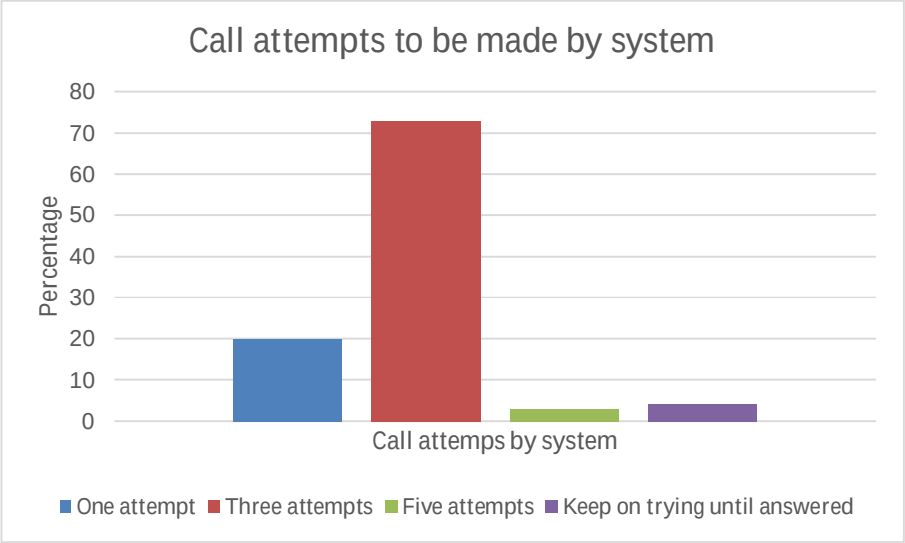


Figure 21: Call attempts to be made by call alert system

7.2.3 User suggestion on call interval time for next call in case of miscall attempt

When asked, 37% of respondents suggest the system should wait at least 5 minutes before attempting to call people again to warn them, 33% suggest a delay of 15 minutes in case someone is busy, 16% answered the system could call immediately while respondents such as fishermen (7%) suggested to call after 30 minutes or even an hour. Alongside an audio alert call, respondents would prefer to receive alert message also.

7.3 University Groups

Students from different academic year and course were selected. Second-year student studying a specific course constituted 27%, class with students from different course consisted of 17% while class with student from a specific course and mixed class, all from third academic year accounted for 39% and 17% respectively. This study comprised of 54% male and 46% female.

67% of the student held average mobile knowledge, 29% denoted themselves as expert and 4% as novice in mobile knowledge. 68% students answered they spend more than two hours using their mobile phones, 29% said they use mobile phone only one to two hours per day and only

3% answered they spend less than one hour on their phone. Main activities would include using the internet (90%), music (62%), SMS (57%), camera (41%) and 35% for games.

7.3.1 Students' behavior w.r.t the alert call voice message

The students received phone call concerning weather forecast and current situation of disaster. 85% students found the alert message useful, 42% listened to the whole message while 16% only listened to part of the audio alert message and hung up. 44% students had a neutral view on the duration of the audio message, 14% found the message as too long and 42% said the callblast alert message was ideal. 62% of the respondents found the sound quality of the alert message as good. 71% students would strongly recommend such audio alert service to others and 66% will subscribe to such service in the future. 75% of the respondents would call their contacts immediately and inform them about the situation after having received the audio call alert. Among the participants, 42% had a tendency to call back the system to inquire more on the crisis.

7.3.2 Students; suggestion on number of Call Attempts

Students were also asked about their opinion on the number of times the system should call back again, had it been the first attempt failed to reach the person. The respond is as shown in figure 22.

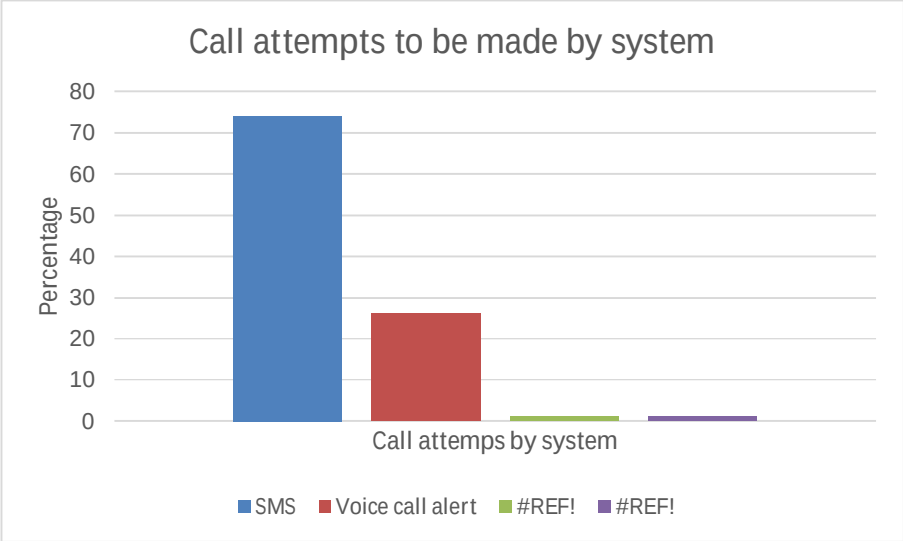


Figure 22: Callback attempts to be made by the system

7.3.3 Students' suggestion on call interval time for next call in case of miscall attempt

As it can be seen in figure 22, 58% suggested three time is enough, surprisingly nearly equal percentage participants (20-21%) agreed that the system can call until the person has been reached or a single call would be enough to inform about such a disaster. The system also needs

to take into consideration the lapse of time before the next call attempts. Students were asked about their opinion. 30% participants answered the system need to at least 15 minutes before trying to call the person again, 29% said five minutes is enough, 23% suggested to wait at least an hour in case, the person is busy. However, 14% said a call can be made immediately after the first call attempt has been a failure.

7.3.4 Students' suggestion on audio message duration

The idea is to forward important weather forecast news as quickly as possible as well as targeting a maximum number of individuals making up the population. The message, therefore, needs to be concise, short and informative. 51% participants preferred if the message was to be between 30 to 60 seconds, 47% suggested to have the alert message below 30 seconds while only 2% answered that the message should be at least one minute.

Even though, voice call alert ensures that the person receives the weather forecast news. However, it must also be taken into account that people are busy hence, an SMS would be preferable. The proportion of people favouring SMS over voice call alert amounted to 74% as shown in figure 23.

Figure 23: Preference of alert message

Some recommendations suggested by the students included having the systems spread the message in different language, extending the alert message over multiple platforms, adding options to call for emergency services.

7.4 Combined Statistics (Low Literacy Groups and Students)

In this section, we present the combined analytics of usage behavior for the system in terms of call duration and call attempts made. The sample population constituted of students at the

University of Mauritius, Faculty of Information, Communication and Digital Technologies, planters, fishermen and CDRT making 52.8 %, 7.5 %, 23.1 % and 16.5 % respectively.

7.4.1 Call Attempts

As it can be seen in Figure 24, a maximum of 3 call attempts was made by the system to warn the users. 733 calls were made. The majority of users (65%) took the call on the first attempt itself, 12 % on second attempt, 7% on third attempt while 16% did not answer the call.

Attempts

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Attempt 1	476	64.9	64.9	64.9
	Attempt 2	88	12.0	12.0	76.9
	Attempt 3	51	7.0	7.0	83.9
	No answer	118	16.1	16.1	100.0
	Total	733	100.0	100.0	

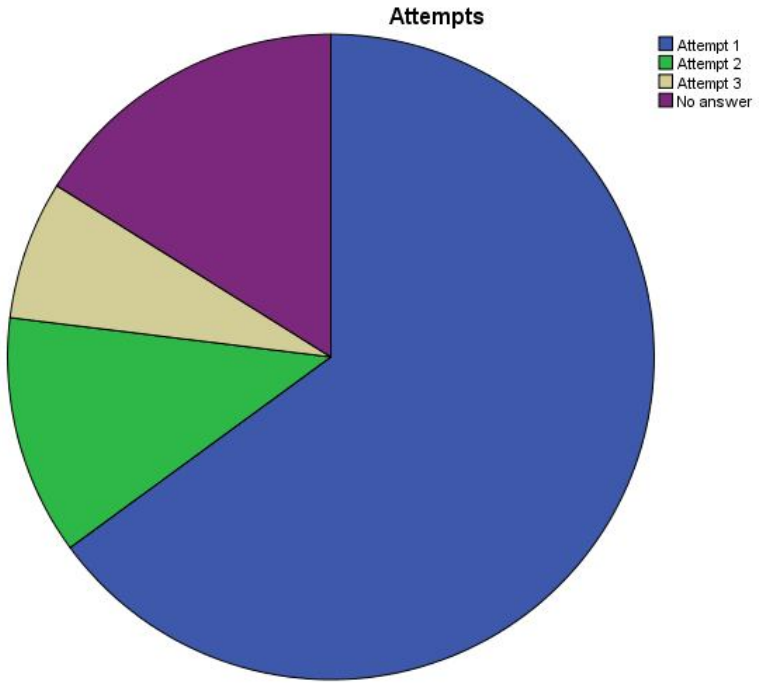


Figure 24 – Call Attempts

7.4.2 Call Duration

For those who answered the phone call, the majority (64%) listened to the whole message while the rest listened partly as shown in the table below:

Call Duration

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-10	59	8.0	8.0	8.0
	11-20	37	5.0	5.0	13.1
	21-30	40	5.5	5.5	18.6
	31-40	470	64.1	64.1	82.7
	No answer	127	17.3	17.3	100.0
	Total	733	100.0	100.0	

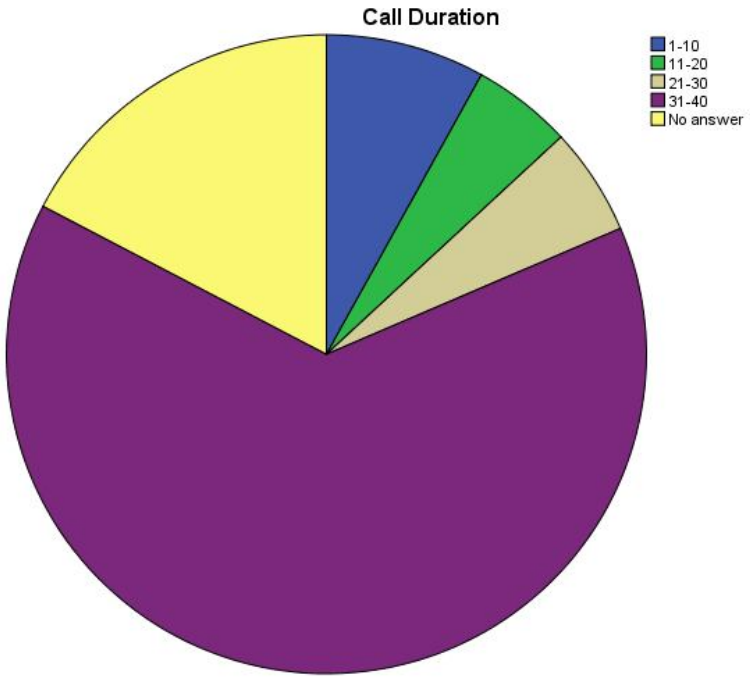


Figure 25 – Call Attempts

8 Conclusion & Recommendations

Disasters whether natural or man-made are very much part and parcel of any country. Developing countries like Mauritius affected by accelerated changes in demographic, infrastructural and climatic changes are much more at risks in terms of the increased frequency and negative impact of such happening. Any responsible government has the duty to prepare and protect its population, hence minimizing casualties against such disasters. No doubt human misery and economic losses resulting from calamities can be reduced to a greater extent through advanced planning and preparedness.

Currently, early warning is conducted manually from the NDRRMC to warn identified people in the Community Disaster Response Team (CDRT) in each vulnerable regions, who afterward relay the information to the whole community. However, this is a tedious and time-consuming tasks, bearing in mind that every second count during disaster. Also, for ad-hoc situations, e.g flashfloods, where the population is unprepared, then it involves massive deployment of government agents to warn population.

The Mass Media Communication system provides a simple and effective technology solution to prepare and warn vulnerable population group well in advance in case of disasters, hence minimizing casualties. Within minutes it can be deployed and mass call a particular vulnerable group. Besides, valuable reports/ statistics can be retrieved showing the percentage of people who received the calls, hence showing the effectiveness of the response.

The system has been successfully implemented in collaboration with the NDRMMC. Very conclusive results have been obtained, especially in the acceptance of such new technology medium by the targeted population. Surveyed population unanimously agreed of the importance of such system and provided valuable inputs in enhancing the system. Hence, based on the conclusive testing and results obtained the following recommendations are formulated:

1. Push-based alerts call provide a better option than SMS in an emergency situation with around 94% answering the alert call almost immediately, the majority listening to the alert message in full.
2. Alert calls should have ALERT label as caller identification.
3. It is recommended to have a pull-based service as well (i.e, a callback feature, whereby users can call back the same number which called them and listen to the Alert message) in case they could not answer the phone, as confirmed in the survey results.
4. Three (3) calls attempts is enough to warn users accompanied by the pull-based service.
5. A 5 min interval after the first miscall attempt and a 15-minute interval after the 2nd miscall attempt is advisable.
6. Alert messages played should be within 30s-60s to captivate the attention of users.
7. Feedback from surveyed users showed that they would like to have SMS as well in addition to the Alert call, just in case they missed the calls
8. For mass calling to warn very big target groups, it is recommended to integrate the system directly to VOIP gateways of existing telephony companies such as Orange, Emtel and MTML since they have the required resources to simultaneous calls.

9. So as not to congest/ flood the bandwidth, it is advisable that calls are made in phased mode, Eg. A batch of 100 at a time.
10. NDRMMC to have MoUs with major telephony companies to easily and quickly send a list of mobile phone users in a particular affected area so that these groups can be reached via their phones for the early warning message.

It is recommended that a MoU be signed between University of Mauritius and the NDRMMC and the system be deployed at the national level.

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10 APPENDIX