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Web Enabled Campus Emergency Communication System

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Abstract

Emergency communication service is the dissemination of information on fire, arm robbery, medical need for ambulance and other emergency related incidences to an organization that provides the related services. Information should get to the emergency service providers in reasonable length of time. During the last three decades, several countries of the world including Nigeria have witnessed how inadequate communication capability has adversely affected emergency responders and recovery efforts of accident victims. This research therefore, addressed the problems faced by victims and responders of emergency incidences in an institution due to inefficiency in the dissemination of rescue information to the right channels. A web enabled interoperability system for exchange of information between people at crime scene (eye witnesses), the campus security agencies and external emergency management bodies is proposed. The system enables an eye witness to use voice calls and messages for alerting relevant agencies who in turn use designated component of the system to make necessary contact for rescue efforts. The system also has ability to alert or warn people of imminent danger and the need to apply necessary caution. Results from the evaluation of the system exhibited its adequacy and suitability.

Keywords

Emergency incident; Communication; Web services; Campus security; Rescue efforts

Introduction

In its simplest format, communication is 'acting on information' [1]. Theodorson and Theodorson [2] view communication as 'the transmission of information, ideas, attitudes, or emotion from one person or group to another (or others) primarily through symbols. Scholars have categorized communication in a number of ways. One of which involves a 'traditional bifurcation of communication', whereby the subject is subdivided into 'mass (public) communication and human (speech) communication' [3]. While many theorists regard 'mass communication' as an intrinsic form of 'human communication', the subdivision is considered useful for the purpose of analysis. Mass communication occurs when a small number of people, in particular the mass media, send messages to a large, anonymous, and usually heterogeneous, audience through the use of specialized communication media. Human communication, on the other hand, is described as a special form of communication that occurs between and among people.

Human communication can be actional, interactional, transactional, intra-personal, inter-personal and group [1,4-6]. In actional communication, humans communicate either intentionally or unintentionally using a one-way process, and react to one another without a reciprocal effect while interactional communication allows participants to react to the other's actions in sequence. In transactional communication, participants involved in communication react to each other simultaneously just as intra-personal communication involves individuals who engage in the process of thinking, reflection or 'day-dreaming'. Interpersonal communication is the communication where two or more people transactionally influence one another, or have a mutual and simultaneous effect on one another. Group communication involves a set of persons with close long-term ties of association and communication. Theorists have identified many uses for communication. For example, communication is used where it is transmitted in order to achieve or obtain something, control or manipulation of cognitions in order to attain advantage and modification of behaviour in changing, reinforcing existing responses or in shaping new responses [6,7].

Emergency communication service is the dissemination of emergency information. An emergency is any unplanned event that can cause death or significant injuries to employees, customers or the public. An emergency can also result in shutting down of business, distruption of operations, physical or environmental damage or threaten the financial standing or public image. Emergencies include fire outbreak, hazardous materials incident, flood, hurricane, tornado, winter storm, earthquake and communications failure. Others are radiological accident, civil disturbance, loss of key supplier or customer and explosion [8,9].

Emergency services are activities engaged in by private, states and local government agencies to prepare for, prevent, minimize and respond to or recover from an emergency. They include but not limited to coordination, preparedness planning, training, interagency liaison, fire-fighting and oil or hazardous material cleanup. Emergency services also involve communication on incidences such as fire outbreak, arm robbery attack, medical need and so on with an organization that renders the needed emergency services. In emergency communication, it is expected that information get to the emergency services provider within a reasonable length of time. In recent years, nations across the world have witnessed how inadequate emergency communication capability has adversely affected response to emergency and recovery efforts. In most of the third world countries today, the problem of information dispersal is still a serious problem. Emergencies have encountered inadequate communication solution leading to loss of lives, destruction of homes and buildings and ruin of critical infrastructure. The reasons for the inefficiency in the dissemination of emergency information include ignorance on the part of the victims or their rescuers, use of obsolete communication equipment and poor interoperability between the emergency agencies. Emergency communication is mostly grouped into oral and print communication. Oral communication is fluid

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and dynamic, and is shaped by both the speaker and the audience. It is enhanced by nonverbal communication such as body language and tone of voice. Typical oral communication are individual briefings, phone conversations, public speeches, on-air interviews and public service announcements via radio and television. Print Communication is a form of written communication via fax, e-mail, public notice, fact sheet or flier, press release and feature article [10-13].

Emergency Management

Emergency management refers to various activities such as immediate response, recovery efforts, disaster mitigation, and preparedness efforts for reducing the impact of current or possible future disasters. The timely access to desired information by intended person or rescuing organization is vital for successful emergency management operations. Depending on the intensity and coverage area of a disaster, it might be a multi-organizational operation involving government and public authorities, volunteer organizations and the media. These entities work together as a virtual team to save lives and other community resources. The conceptual view of emergency management life cycle is presented in Figure 1 [14-16]. The Pre-crisis stage is the first stage of the major emergency management life cycle involving all the essential functions which are paramount and must be considered and acted on prior to the occurrence of a serious damaging event. In particular, it involves the mitigation and readiness phases. The mitigation phase involves all long-term efforts to anticipate, assess and prevent the possibility of the occurrence of a hazard. It also involves the reduction of the effects of a subsequent major emergency in cases of failure of preventive measures. Mitigation efforts include putting in place structural measures such as building floodgates and seismic retrofitting buildings. It also include all non structural measures such as effective land planning and enhancing community awareness on potential hazards. The Readiness stage takes care of the event that mitigation efforts fail, and a major emergency is imminent. It involves readiness and preparedness of major emergency plans, equipment, personnel and procedures in order to effectively respond to a disastrous event to prevent injury, loss of life and damage to the environment. Key elements in this stage include major emergency planning and preparedness at both individual and societal levels.

When all mitigation and prevention measures fail to thwart a major emergency from occurring, responders begin to focus on the crisis stage of the emergency life cycle. There can be a sudden

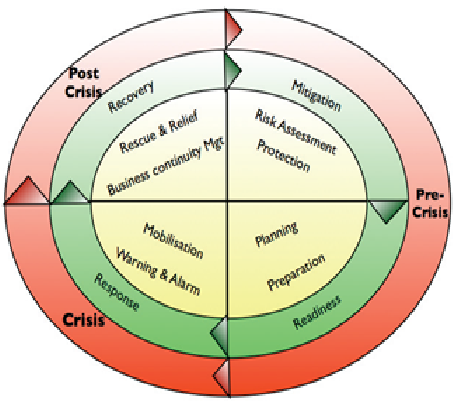

Figure 1: Emergency management life cycle.

occurrence of this stage, which may result in lost of several lives. Once a major emergency actualizes, the priority for all concerned is to ensure basic safety and survival, to contain the event, and to protect critical infrastructure. Efforts are then directed to warning and alarming the public as well as mobilizing necessary resources in order to deal with the situation. The post-crisis stage is involved with the rescue, recovery and relief management. It hammers on the process of restoring and rebuilding the community in the aftermath of the emergency. It also involves critical functions such as business continuity management

In most educational institutions across the globe, emergency management is accorded high priority towards fostering stable and safe environment for learning. The priorities for managing any emergency situation on campus include safeguarding human life, security of critical infrastructure and facilities and minimizing disruption to educational programs and business continuity of the institution [17-19].

There are guidelines for employees and students of various institutions to address emergency situations. One of the guidelines is the Emergency Management Plan (EMP) that is used for addressing major disasters or emergencies that may disrupt programmes and operations or threaten the safety of the people in the campus. Some of the emergencies that may occur in an educational institution are students riots, fire (such as structural, forest fire in the nature preserve or surrounding cedar groves, vehicle fire), severe weather (such as tornado, extreme hail, flooding, winter storm) and isolated catastrophic structural failure (such as roof collapse, falling glass from skylights). Others are explosion (such as terrorist incident, bomb threat, mechanical or natural gas failure), criminal activity (such as bank robbery, hostage situation, shooting, homicide and rape), loss of utilities (such as electricity, natural gas, sanitary sewer, water, telecommunications), hazardous chemical spill, water contamination and food shortage. Different agencies are in charge of the management of these emergencies. For instance, students' riot, explosion and criminal activities are all handled by the police while the fire fighters handle fire incidents.

Related Work

Recently, Web-based services have received focus of attention to emergency management due to offered advantages of instant information and exchanges that are practically impossible in real-life scenarios. Response to emergency incidences now requires a major shift toward more scalable, workflow-efficient, and cost-effective products for managing the sudden situations. During a period of emergency, decisions are made in human perceptual timeframes under pressure to respond to dynamic and uncertain conditions. For its effectiveness, an emergency management system must present real time emergency information and data in understandable and easy form [20]. A Web-based system in a smart space for joint response actions to fire incidences is proposed in [21]. The system comprises of a smart framework for integrating concepts of smart space, Web-services and Web-based communities. The proposed Web-services represent the resources of the smart space as well as members of the Web-based community. A service-oriented architecture was designed for the coordination of the system's interactions. The limitation of the system include failure to take into account cases of insufficient or disabled acting resources and lack of passing cars for evacuation of people from the fire incidence.

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Gao et al. [22] presents a medical information tag which is a cost effective, self-organizing and scalable wireless sensor platform that automatically tracks patients from disaster scenes to ambulances and then to the hospitals. The tag platform supports a variety of sensor add-ons including Global Positioning System (GPS), pulse oximetry, blood pressure, temperature, Electro Cardiogram (ECG) and relays data over a self-organizing wireless mesh network. Although the system provides a promising and new approach to the collection and dissemination of patient data during emergencies, its practicality in a wide ranges of places such as airports, Shock Trauma Center (STC) and schools is not established. The emerging computing model of Dynamic Data-Driven Application (DDDA) fits well during emergencies. The value of a DDDA is explored in a system proposed in [20] in support of emergency medical treatment decisions. The system is a complex multi-layered dynamic platform for simultaneously feeding and responding to ever-changing streams of real-time data for the coordination between ambulance teams, local site management and a distributed collection of hospitals. The system improves on the efficacy of decision-making during medical crisis. Its limitations include inability to balance data flows across potentially overloaded network links, intermittent or disconnected operation in the presence of extremely high-bandwidth data streams and lack of support for in-network data processing such as aggregation, filtering, triggering and so on.

Nada Hashmi et al. [23] proposed a scalable emergency medical response system that couples the efficient data collection of sensor networks with the flexibility and interoperability of a web services architecture. The system has several major components including web services architecture to process and present information, a local command site for field coordination, a central command site for global resource management and a cellular/satellite wireless links for real time communication between local and remote sites. Other components are a wireless infrastructure for real-time data transport between motes and local Personal Digital Assistants (PDAs) and tablet PCs, patient sensors (a pulse oximetry sensor integrated with a GPS receiver, micro-processor, data storage and transmitter) for patient vital sign and location monitoring. Others are wireless PDAs and tablet PCs for use by Emergency Management System (EMS) [24] field personnel. The system achieved accuracy in term of patients loading into the ambulance and GPS as well as vital sign relay (pulse oximetry and heart rate) via the ambulance base station to a central command center. It however experiences notable time delays in relaying the GPS information. A Petri-net representation of a web-service-based emergency management system is proposed in Karmakar and Dasgupta [25]. The system has features for monitoring situation of railways as well as dispatching necessary resources during emergency. Although the proposed system suitably represents various complex systems, it does not ensure a deadlock free situation.

In Chen et al. [26], a geospatial information system for initial condition reporting and update to guide search and rescue operations and deployment of equipment with safety considerations for the rescuers in large scale disaster response scenarios is proposed. The system is a web service center that takes information such as victim locations, damage conditions and resource on demands from civilians in disaster areas. The web service is able to provide guide in disaster responses through a distributed decision making approach, it however becomes inefficient in cases of overloading and great number of demands. Marchese et al. [27] used agent technologies to adopt a specific executable protocol system for the specification of simulated interactions among distributed processes. The system was tested in flood emergency response domain activities to support coalition formation and process coordination in open environments. The work shows good ability in response to emergency scenarios because of its strong approach to fault tolerance via dynamic peer-to-peer architecture. Its limitations include poor interaction model design, use of inappropriate workflow technology and non-dynamic interactions.

System Architecture

The proposed institution-based emergency communication system uses an internet-based communication system for solving communication-based problems of poor interoperability, obsolete technology and ignorance. It proposed three different roles for communication during an emergency incident in any campus; namely calling, communication and alerting. The overall architecture of the proposed system is presented in Figure 2. The following are its major components:

- *A web system* that hosts the relevant web services;
- *Voice call services* which provides voice communication;
- *SMS services* that creates and disseminates text messages;
- *Hand held devices* for cross communication among stakeholders during cases of real or perceived emergency;
- *Routing services* for generating a set of feasible plans for handling request from eyewitnesses;
- *Decision making service* for selecting the nearest and available emergency agents; and
- *City Wide Mobile Service* for communication with emergency service provider located off campus.

The workflow of the planning and decision stage is presented in Figure 3.

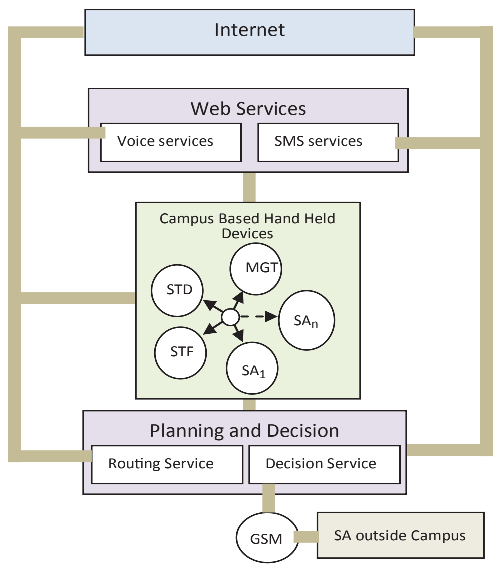

Figure 2: Architecture of the proposed system. MGT=Management, STD=student, STF=Staff, SA=Security Agent.

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The system is designed to run on all mobile internet-based platforms including tablets as well as smart and non-smart phones. The development technology is presented in Figure 4 showing the business layer, which handles all forms of communications between two parties, sitting on top of the Microsoft.Net platform with C# (pronounced "C-Sharp") as the frontend. The presentation layer is based on HTML for platform independent while the data layer is MySQL [28], which interfaces the database. The user experience will be a mobile web-based client that cut across all platforms so as to be viewed by all browser supported devices. The business and data layers are located on the server. The following are the supporting platforms:

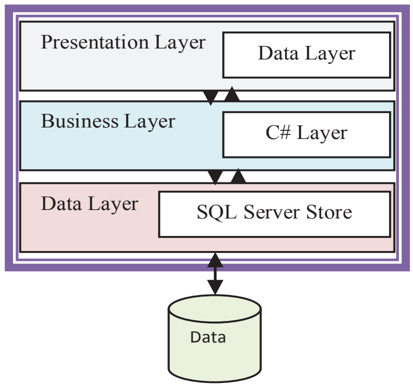

Figure 4: Interaction between development technologies.

Net framework

C# programs run on the .Net Framework which is an integral component of Windows that includes a virtual execution system called the Common Language Runtime (CLR) and a unified set of class libraries. Source code written in C# is compiled into an Intermediate Language (IL) that conforms to the Common Language Infrastructure (CLI) specification. The IL code and resources, such as bitmaps and strings, are stored on disk in an executable file called an assembly, typically with .exe or .dll extension. An assembly contains a manifest that provides information about its types, version, culture, and security requirements [29]. Figure 5 illustrates the compile-time and run-time relationships of C# source code files, the .Net Framework class libraries, assemblies, and the CLR. In addition to the run time services, the .Net Framework also includes an extensive library of over 4000 classes organized into namespaces. This library provides a wide variety of useful functionality for everything from file input and output, string manipulation, XML parsing and Windows Forms controls. The typical C# application uses the .Net Framework class library extensively to handle common "plumbing" chores [29].

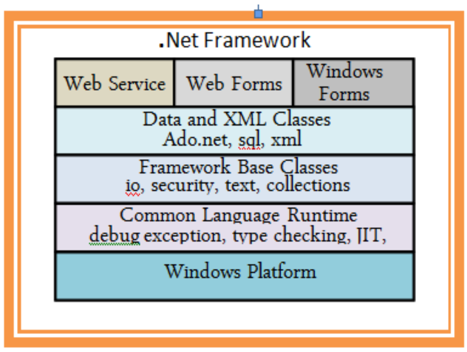

Figure 5: .Net Framework Architecture.

Microsoft Structured Query Language (MSSQL)

MSSQL server is an application used to create computer databases for the Microsoft windows family of server operating systems. Its server provides an environment used to generate database that can be accessed from workstations, internet and so on. The server also uses relational database management system that offers a variety of administrative tools to ease the burdens of database development, maintenance and administrations [30,31].

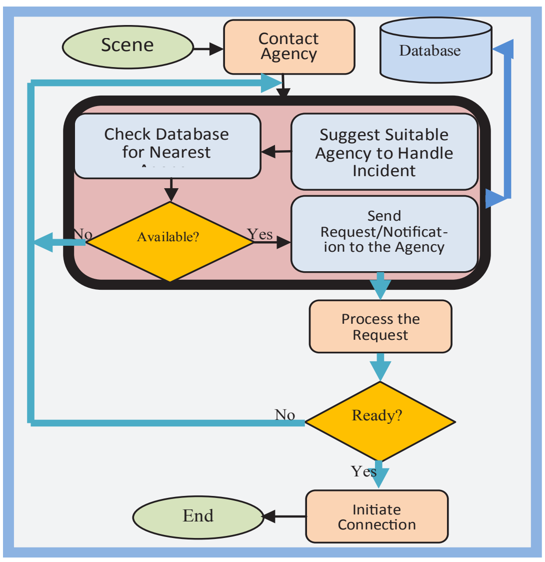

Figure 3: In Campus emergency management Planning and Decision Phase.

ASP.Net MVC (Model-View-Controller)

ASP.Net Model-View-Controller (MVC) as an open source web development framework combines the effectiveness and tidiness of MVC architecture. It also combines the most up-to-date ideas and techniques from agile development as well as the best parts of the existing ASP.Net platform. The MVC framework implement the MVC pattern in which the user take an action and in response, the application changes the data view and delivers an update view to the user. It is a powerful and elegant means of improving separation of concern such as separating the User Interface (UI) from the data access layer into three main parts; namely model, view and controller. The model is a set of classes that describe the data used in the web application as well as the business rules that describe how the data can be manipulated and changed. The view part defines how the application user interface is displayed while the controller consists of a set of classes that handle communications from the user and overall application flow and specific logic [32,33]. The interaction between the different parts is illustrated in Figure 6.

Implementation

This phase allows the translation of the design into software. All program codes were implemented using C# programming language which is an Object-Oriented language [34,35]. Other tools for the implementation include Microsoft Visual Studio 2012

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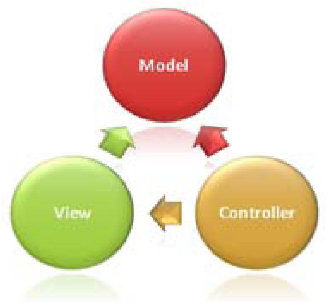

Figure 6: The relationship between the 3 user interfaces.

(MVS) and Microsoft SQL Server 2008 R2 (MSS). The minimum system requirements for running the application include a browser compatible hand held device, Wireless Access Point Router, computer running on a Pentium II Intel processor, a 32MB of RAM memory and Windows 7 Operating System. During the implementation, some tasks or transactions including login and logout were identified and steps detailing their accomplishments were given. All the interfaces also provide self-describing links for performing related operations. The supporting internet system is built using servers with homogeneous features. The servers are located at four different and strategic stations with an approximate inter-distance of 600m within the Federal University of Technology, Akure (FUTA) Nigeria. The places are the Senate, Centre for Research and Development (CERAD) and Centre for Continuing Education (CCE) buildings and the Female Hostel. The choice of these places is premised on their suitability for giving the entire campus good coverage of the service. The map of FUTA and the server stations are presented in Figure 7.

The servers were connected to Very Small Aperture Terminals (VSATs) that received internet signals from the same source. Each server has unique IP address for hosting or network interface identification and location addressing with support for file with size exceeding 2 GB on 32 bits operating system. Each server is maintained with bandwidth size of 256 Mb/s using Java and ASP.net client side scripting. The distributed server approach is adopted to provide campus-wide system availability and forestall failure inherent to centralized server systems. For continuous power supply, Un-interrupted Power Supply Systems (UPS) and Voltage Regulators (VR) were provided at each station. Even though the servers rely on the power supply from the national grid, an alternative power generator is available at each station to guide against system failure occasioned by power outage from the national grid. There is a cross boundary effect of the servers as each system configurations allow wireless signals coverage within radius of 500 m.

Before a user sends or receives voice and SMS information, he or she is firstly registered by the system's Administrator. The contact information obtained during the registration is stored in the system's database. Similarly, before a communication device (hand held or computer system) is able to receive or send voice or SMS information, the software developed must be installed in it. Voice and SMS Emergency communication then involves loading the application followed by the use of the right platform. For simplicity and convenience, the system is developed to provide self-learning capability on loading, login, communications and logout to the users.

Evaluation

The system was evaluated using cases of information exchange between the FUTA community and emergency service providers within and outside the campus during staged emergency scenarios. Security agents including the civil defence (campus police), the fire fighters, Road Safety Corps and health officers (Doctors and Nurses) ensure the safety of lives and properties in the campus and they are stationed in strategic places or stations where they can oversee human activities. Emergency rehearsals took place at different times and places. The female hostel, senate building, the campus main road, the chemistry laboratory and a bank located in the campus were selected for rape, fire outbreak, road accident, chemical spill and bank robbery rehearsals respectively. The location of these places, which were selected because they are strategic and with great likelihood of the occurrence of the incidences are shown in Figure 7. Five hundred and fifty (550) subjects including five hundred (500) students and staff and fifty (50) security officers were selected and pre-registered for the evaluation exercise. The registration involves the collection and entry

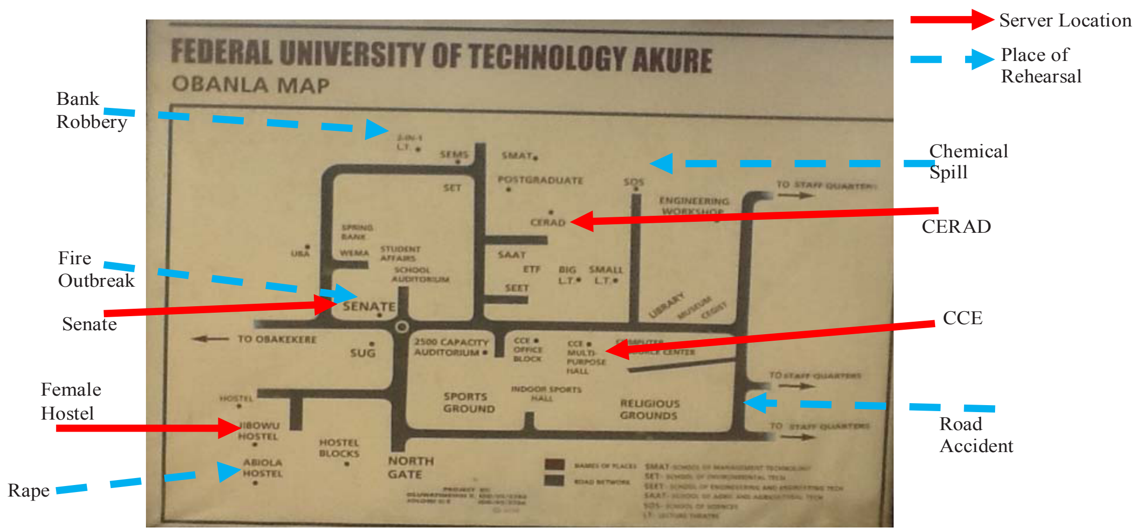

Figure 7: Map of FUTA and the Locations of Severs.

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into the system's database, such information as contact numbers and biological data (biodata). The distribution of the pre-registered security officers is presented in Table 1.

All pre-registered subjects had no prior knowledge of the exercise and time. However, in view of the expected false alarms, concerned University authorities were informed of the rehearsals but advised to keep sealed lips. The arrival time of the concerned officers to the scenes of the rehearsals were used for the evaluation of the proposed system during voice and SMS communications. The arrival time is the time interval between the end of the call and the Officers' arrival to the scene. The number of acknowledgements received from staff and students were also used for SMS communications. Upon the receipt of an SMS, an acknowledgement in the format 'Ok, message received' is sent back to the sender. The Security Officers (SO) who reported (as a team in one or two cars) upon the receipt of a presumed eyewitness's voice and SMS calls, the length of the journey (distance) and the arrival times at average vehicular speed of 80 km/h to the scenes as well as their SMS delivery time are presented in Table 2. The SMS delivery time is the time between sending and receipt of the SMS.

The arrival of these security officers after receiving voice or SMS call through the web-based system established its suitability for the mobilization for life saving efforts during an emergency. In the SMS based scenarios, distress messages were sent to the concerned security officers with information on the venue of the emergency and the need for them to come for the rescue. Higher arrival time recorded for the SMS indicate that voice communication is better for the alert and mobilization of security officers during emergencies. While the voice calls provided instantaneous delivery, SMS experienced some delay. Worst still, when the hand held device is not within the immediate reach of the responder, or the alert tone is not audible enough for instant notice of the receipt of SMS, the emergency response or arrival time is elongated. Table 3 presents the number of the acknowledgements from the 500 staff and students that received SMS notices. The recorded figures were obtained from the acknowledgements received between the time of sending the messages and the next 3 minutes. The very high percentages of acknowledgements buttressed the capability of the system to serve as a suitable platform for quick and reliable emergency information dissemination.

Presently, the existing emergency communication platform within FUTA is the Global System for Mobile Communication (GSM) and the arrival time for separate emergency rehearsals using the three leading services; namely Mobile Technology Nigeria (MTN), Global Communication Nigeria (GLO) and Air Telecommunication Nigeria (AirTel) are presented in Table 4. The 3 minutes SMS acknowledgement data from the 500 pre-registered staff and students for these services is also presented in Table 5. From Table 2, it is revealed that it took an average time of 5.53 minutes for the security officers to arrive at the scene of the rehearsal based on information received through voice communication. The average arrival time at an average vehicular speed of 80km/h after SMS communication is 6.74 minutes. According to the values in Table 4, the arrival time of the security officers to the scene of the rehearsals based on voice communication via MTN, GLO and AirTel services are 8.42, 8.43 and 8.05 minutes respectively.

Average arrival time of 11.35, 11.38 and 10.85 were also recorded for SMS communication using MTN, GLO and AirTel respectively. The average SMS delivery time for the proposed system, MTN, GLO

Table 1: Distribution of pre-registered Security Officers.

S/No.	Officer	Number
1	Police	15
2	Fire Fighter	13
3	Road Safety Corp	10
4	Health Officer	12

Table 2: Pre-registered Security Officers' Arrival and SMS Delivery Times.

Incident	Officer	Distance	Arrival time for Voice call (Min.)	Arrival time for SMS (Min.)	Ave. SMS Delivery time (Sec)
Rape	Police	700	5.13	6.56	3.75
Fire outbreak	Fire Fighter	800	6.25	8.15	4.05
Road accident	Road Safety Corp	400	4.54	6.25	3.98
Chemical Spill	Health Officer	850	6.58	6.89	4.15
Bank Robbery	Police	700	5.18	5.85	3.99

Table 3: Distribution of Acknowledgement from staff and students.

S/No.	Incident	Acknowledgement	%
1	Rape	497	99.40
2	Fire outbreak	493	98.60
3	Road accident	492	98.40
4	Chemical Spill	496	99.20
5	Bank Robbery	497	99.40

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Table 4: Pre-registered Security Officers' Arrival and SMS Delivery Times for GSM.

S/No.	Incident	Officer	Arrival time for Voice call (Min.)			Arrival time for SMS (Min.)			Ave. SMS Delivery time (Sec)		
			MTN	GLO	AirTel	MTN	GLO	AirTel	MTN	GLO	AirTel
1	Rape	Police	7.81	8.09	7.88	10.54	10.92	10.63	12.12	11.52	10.35
2	Fire outbreak	Fire Fighter	9.50	9.48	9.29	12.82	12.79	12.54	15.24	11.65	11.25
3	Road accident	Road Safety Corp	6.90	6.98	5.86	9.31	9.42	7.91	13.26	12.51	13.42
4	Chemical Spill	Health Officer	10.00	9.57	9.51	13.50	12.91	12.83	14.23	12.25	12.23
5	Bank Robbery	Police	7.87	8.05	7.69	10.62	10.86	10.38	14.23	15.24	14.11

Table 5: Distribution of Acknowledgement from staff and students for GSM.

S/No	Incident	Acknowledgement			%		
		MTN	GLO	AirTel	MTN	GLO	AitTel
1	Rape	276	291	288	55.20	58.20	57.60
2	Fire outbreak	275	288	295	55.00	57.60	59.00
3	Road accident	281	286	289	56.20	57.20	57.8
4	Chemical Spill	268	275	294	53.60	55.50	58.80
5	Bank Robbery	285	279	287	57.00	55.80	57.40

and AirTel are 3.98, 13.94, 12.63 and 12.27 respectively (Tables 2 and 4) while the average SMS acknowledgement from pre-registered staff and students are 495, 277, 283.86 and 290.6 respectively (Tables 3 and 5). The exceedingly higher arrival times recorded for the GSM services and the higher acknowledgement figures for the proposed system revealed that voice and SMS communication via the proposed system enjoy faster and wider coverage. The under-performance of the GSM services is attributed to their poor states. During the period of the evaluation, making a successful call on MTN, GLO and AirTel required between 2 and 5 trials at an average time of about 30 seconds, depending on the network loads and time. The increasing number of subscribers without a commensurate network quality and strength has been the factors responsible for this. The column chart of the percentages of SMS acknowledgements for rehearsals on rape, fire outbreak, road accident, chemical spill and bank robbery presented in Tables 3 and 5 for the proposed system and the three GSM networks is presented in Figure 8. From the higher values recorded, it is evidenced that the proposed system is the best for emergency information dissemination.

The very low security officers' arrival time and high acknowledgement figure recorded for the system indicate that it provides deadlock free information dissemination necessary for dispatching of needed resources during emergencies. All pre-registered users were able to receive and acknowledge information without one hampering the other. This is a significant success over

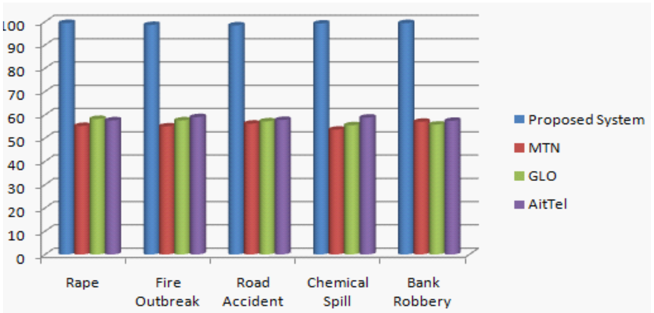

Figure 8: The column chart of the acknowledgement figures.

Federal emergency Management Agency- Effective Communication [24] and Chen et al. [26] where the major problems are communication deadlock and restriction on dynamic interactions with multiple users respectively. Due to the distributed servers approach, the system is able to provide balanced signal flow to the University community.

Occasional system failure due to poor internet services arising from low or no VSAT connection were encountered during emergency rehearsals. The measure being taken to address this is to diversify the signal sources by engaging multiple VSAT internet service providers. Rehearsals on chemical spill could not hold at the initially set time because all the health personnel were engaged on their primary duties at the University Health Centre (UHC). The ambulances were also committed to real life emergency services. One of the fire ambulances was also reported to be grounded due to engine problem while the other one was being serviced during the period of the rehearsal. These developments compelled delays and hindered free flow emergency rehearsals.

Conclusion

A detailed description of the characteristics, challenges and modalities of emergency communication had been presented in this report. Discussions on emergency management life cycle, pre-crisis, mitigation, readiness, crisis and post crisis stages were also presented. Finally, a web-based campus emergency communication system that provides an interoperability platform for communication between the eyewitnesses, the campus security units and the public security agencies has been developed. Using the system for communication between students and staff and emergency officers located within FUTA during emergency rehearsals revealed its capacity for good information disseminations. The ability of the system to deliver speedy emergency information to a large number of people was demonstrated. With obtained emergency officers' arrival times, SMS delivery times and acknowledgements results for emergency rehearsals showing a better performance of the system over existing GSM systems, the system is therefore a considerable platform for improving on the rate of responses to emergencies by rescue workers. The use of the system will also help to increase the number of people reached by emergency information within short interval of time.

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Major deficiency of the system in terms of server failure has been reported with measures being taken to forestall it. It is also noted that the efficiency of the proposed system will be optimal if the other resources, both material and human, are in good numbers and conditions. Future research aims at widening the scope of the system to accommodate video communication and make it operate in inter-campus and intra-city modes.

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