A Tactical Emergency Response Management System (Terms) Framework

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Abstract

Effective accident management requires the organization of large amounts of information. This information consists of reference information which rarely changes during an accident and decision support information which changes very rapidly. Much of the rapidly changing information is a result of collaboration between accident response personnel. In Nigeria, the three major organizations involved in emergency response are the ***Nigerian Police Force, the Road Safety Commission and the Nigerian Fire Brigade****. These organizations each have their separate procedures for handling emergencies which can be problematic when inter-agency collaboration is needed. This paper discusses the design and implementation framework for a Tactical Emergency Response Management System (TERMS) which unifies all these different processes into a single process to be handled from a single point. TERMS also includes the use of mobile technology to enhance communication between emergency response personnel. The test results obtained revealed that if fully implemented, this technology can improve the speed of intervention between the use cases.*

Key words: Tactical emergency Response, mobile technology, intervention,

1.0 General Background

Emergencies are incidents that threaten public safety, health and welfare. If severe or prolonged, they pose a serious threat to lives and property. Such incidents range widely in size, location, cause, and effect, but nearly all have an environmental component. Response is an effort to mitigate the impact of an emergency on the public and the environment. Emergency response is a term for a series of appropriate actions and precautions in the event of an accident or disaster.

Emergency services are organizations which ensure public safety and health by addressing different emergencies [1]. Some agencies exist solely for addressing certain types of emergencies whilst others deal with ad hoc emergencies as part of their normal responsibilities.

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The main organizations involved in emergency response in Nigeria include the Nigerian police, the Federal Road Safety Commission and the fire brigade. For the purpose of handling crisis and emergency related incidents, the three different organizations receive reports from the general public and respond to them according to their own emergency response procedures. The fire department provides firefighters to deal with fire related rescue operations, the police force is responsible for providing community safety and acting to reduce crime against persons and property, and the Nigerian Road Safety Commission ensures the safety of road users by responding to road traffic crashes. Emergency response operations can benefit from the use of information systems that reduce decision making time and facilitate co-ordination between the participating units. When faced with crisis or an emergency situation, effective real time and reliable exchange of information plays a very critical role in responding to an incident. Information systems designed for emergency response operations can provide valuable help for better planning and coordination during an ongoing crisis. The time-critical nature in emergency situations necessitates fast decision making and reliable communication with emergency personnel and rescuers.

Nowadays, the use of mobile technologies is so broadening that people are depending on this technology in their day to day activities to effectively communicate and collaborate with each other whether handling their personal or business activities. Here in Nigeria, the number of mobile phone users has exploded over the past few years. It is now a common sight to see even the yongest of children with their own personal cell phones.

One of the features of mobile technologies that have come to be broadly used is Short Messaging Service (SMS) which enables the user to send and receive text messages using mobile phones. SMS technology is being broadly used from commercial applications to health applications. In Nigeria, SMS messaging is being widely used for socializing purpose where people exchange text message for birthday wishes, holiday wishes, and making appointments etc. Different SMS based applications are currently being developed globally by different organizations for different purposes in the business world, health, monitoring and supply chain management.

Problem Statement

Effective accident management requires the organization of large amounts of information. During an accident, decisions about resource allocations must be made quickly and correctly [3]. These decisions are made in response to the rapidly changing needs of current accidents and they require a large amount of collaboration between emergency response personnel which include police officers, firemen and road safety officers. Workers at the scene of the accident and resource allocators located at an emergency operations center must work together to identify the needs of each accident and ensure that the available resources are allocated efficiently. This cooperative decision making requires a large amount of communication and shared information. Unfortunately most emergency response agencies in Nigeria do not have the capability to meet this need effectively due to the fact that their emergency response

activities are still handled manually. This makes collaboration with other agencies very difficult and uncoordinated.

2.0 Related Work

Emergency Response Systems are used by organizations to assist in responding to an emergency situation. These systems support communications, data gathering and analysis, and decision-making. Emergency Response Systems are very much needed and must function well and without failure. Designing and building these systems requires designers to anticipate what will be needed, what resources will be available, and how conditions will differ from normal [10]

A standard model for an Emergency Response System is made of a database, data analysis capability, normative models, and an interface. This model is only somewhat useful as it fails to address issues such as how the Emergency Response System fits into the overall emergency response plan, Emergency Response System infrastructure, multiple organization spanning, knowledge from past emergencies, and integrating multiple systems. Emergencies are high stress situations that require organizations to respond in a manner that is different from their normal operating procedures. Emergency stressors, in addition to fatigue, include dealing with a complex, unpredictable and dynamic response, time pressure, and communications, dealing with the media, and operating within an integrated emergency management context ([2], [12]).

Emergencies are also a series of four phases: Situational Analysis (SA), Initial Response (IR), Emergency Response (ER), and Recovery Response (RR); and five decision/hands off points: the Initiating Event (IE), the control event (CE), the Restoration Event (RE), the Normalizing Event (NE), and a Terminating Event (TE). Figure 1 shows the phases and decision points and includes a general plot of the amount per unit time of immediate responses and decisions that need to be made as a timeline plot following some initiating event, IE.

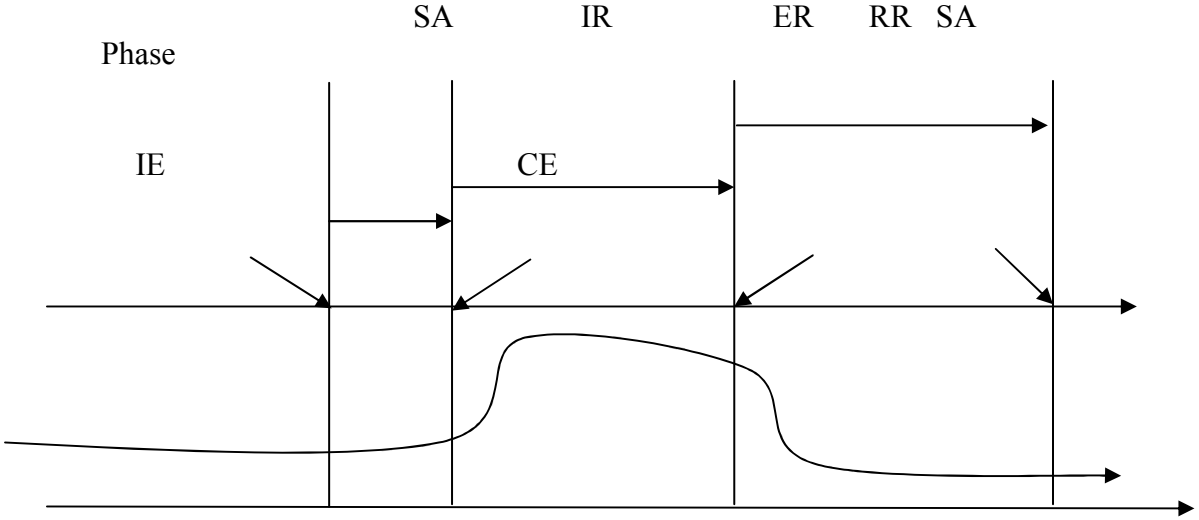

Figure 1: Phases and timeline of a typical emergency.
(Source: [11])

Organizations in the first emergency phase

Figure 1 shows that organizations are constantly in the first emergency phase, SA, which is a data gathering and assessment phase that has a base level of activity.

The application of new technologies to emergency mitigation, response and recovery and some issues associated with the technology used in an Emergency Response System were discussed. These issues include information overload, loss of information, retention of outdated information, the greater likelihood of the diffusion of inappropriate information, further diminution of non-verbal communication, and the inevitability of computer failures.[6]

Some additions to Emergency response systems to increase their effectiveness might include technologies such as CD/DVD based storage media, Web/Internet sites as a common infrastructure providing access for disaster response teams distributed across multiple locations or organizations, and e-mail for improving communications. Geographical Information System (GIS), Satellite capabilities to the Emergency/Crisis Response System, Intelligent agents were also advocated, but the major challenges are the difficulties in integrating them with other technologies ([8], [9], [11]).

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3.0 Emergency Response systems As Cooperative Information Systems

During an accident, decisions about resource allocations must be made quickly and correctly. These decisions are made in response to the rapidly changing needs of current accidents and they require a large amount of collaboration between accident management personnel. Workers at the scene of the accident and resource allocators located at an Emergency Operations Center must work together to identify the needs of each accident and ensure that the available resources are allocated efficiently. This cooperative decision making requires a large amount of communication and shared information [3].

In a cooperative information system, multiple users view and modify a shared set of data. The users may access the data simultaneously or serially. This shared use of a common set of data by multiple users or systems is a defining feature of Cooperative information Systems. Furthermore, in some Cooperative Information Systems(CIS) applications, it is important that all users view the most recent data in the shared set at all times. The large amount of collaboration between emergency response system users, who view and modify a common set of rapidly changing data, distinguish it as a cooperative information system and make its design and implementation challenging. Several other factors specific to the domain of accident management further complicate the design problem.

It is the nature of accidents that the collaborative communication often occurs in bursts of activity. Large amounts of communication occur at the beginning of an accident and at other crucial points during its management. Once resource needs have been identified and the situation of the accident has stabilized, communication slows as workers concentrate on performing

their tasks rather than planning them. The mobility required by accident management personnel requires emergency response systems to employ state-of-the art wireless communication technology. This combination of communication characteristics and sometimes unreliable communication medium makes the design and implementation of a effective emergency response management system an extremely challenging shared information problem at many different levels.

The primary purpose of emergency response systems is to provide users concurrent access to a set of shared information. In this way, it is similar to ordinary information systems. One requirement that separates emergency response systems from traditional information systems is that concurrent users must see changes to the data as quickly as possible. This requirement is further complicated by the fact that information about active accidents changes very rapidly.

A final consideration is that the data utilized by emergency response systems can often be owned by geographically distributed organizations, each maintaining its own databases on site. The first two requirements, rapid change in the data and user awareness of the change, necessitate an understanding of the types of data which emergency response system must manage. Towards this end, the data has been classified according to two criteria: whether it is critical that all users view the most recent changes at all times and whether the data will change rapidly. The Figure below shows this classification.

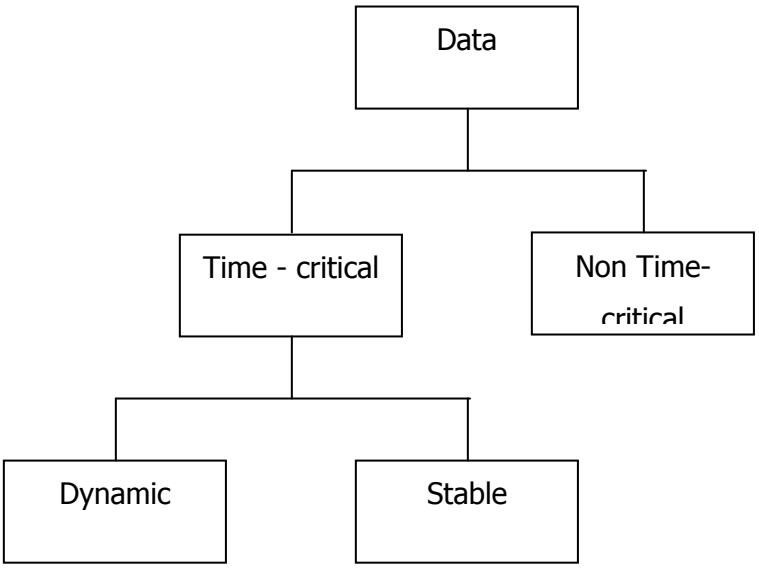

Figure 2: Classification of data in an emergency response system. (Source: [3])

3.0 Mobile Technology and Its Applications in Emergency Response Systems

Much work has been done exploring the use of cellular phones for emergency communication, especially related to large scale targeted warnings [7]. The cellular network provides a unique capability to infer the position of people in an affected area and to provide them with specific and relevant instructions.

There is an increasing awareness of the advantages associated with the use of cell phones and Personal Data Assistants (PDAs) in the management of disasters [5].

5.0 Methodology

System Analysis

Unified Modeling Language (UML) is a notation that resulted from the unification of Object Modeling Technique (OMT) and Object-Oriented Software Engineering (OOSE). UML has also been influenced by other object-oriented notations. The goal of UML is to provide a standard notation that can be used by all object-oriented methods and to select and integrate the best elements of precursor notations. For example, UML includes the use case diagrams introduced by OOSE and uses many features of the OMT class diagrams. UML also includes new concepts that were not present in other major methods at the time, such as extension mechanisms and a constraint language. UML has been designed for a broad range of applications. Hence, it provides constructs for a broad range of systems and activities such as distributed systems, analysis, system design, and deployment[4].

Current systems

1. Federal Road Safety Commission:

The Nigerian Road Safety commission Bauchi command is responsible for responding to Road Traffic Crashes (RTC) in and around the Bauchi metropolitan area. There are five unit command offices in Bauchi. These include RST 12.1 (Bauchi), RST 12.11 (Azare), RST 12.12 (Darazo), RST 12.13 (Alkaleri) and RST 12.14 (Toro). Their activities include rescue operations during Road Traffic Crashes (RTCs). They are responsible for the administration of first aid and conveying of victims to hospital. They work in close collaboration with the police force, as they are required to report all road accidents to the police.

The primary mode of receiving emergency reports is via telephone calls by civilians or officers on patrol. An average of 3 to 4 calls might be received daily. The information required when an incident is being reported include the location of the accident i.e. the specific route the accident has taken place and the location of the accident. The nature of the accident is also required. Calls are received from the public via telephone calls placed to the Rescue Officer who is responsible for deploying team members to the scene of the accident.

A typical rescue team consists of four members, a driver, rescue team leader as well as two other team members. The officers communicate with each other via the use of standard issued cell phones operating on the Glo network. These cell phones make use of a **closed user group**, which means that calls placed to team members are not charged. The team leader is the point of contact between his team members and the unit command. He is in charge of keeping the unit command updated on the status of each incident.

After successfully managing an incident, the team leader is responsible for the filing of Road Traffic Crash reports via SMS to the Abuja Headquarters. The contents of the

text message includes the command code, time of accident, route, location, number of people involved, number of injured which includes number of females, males and children involved. The number of people killed which includes the numbers of females, males and children. The cause of the Road traffic crash and the names of the drivers involved. He is also expected to submit a hard copy road traffic crash report form.

The use case and class diagrams are shown in figures 3 and 4 below:

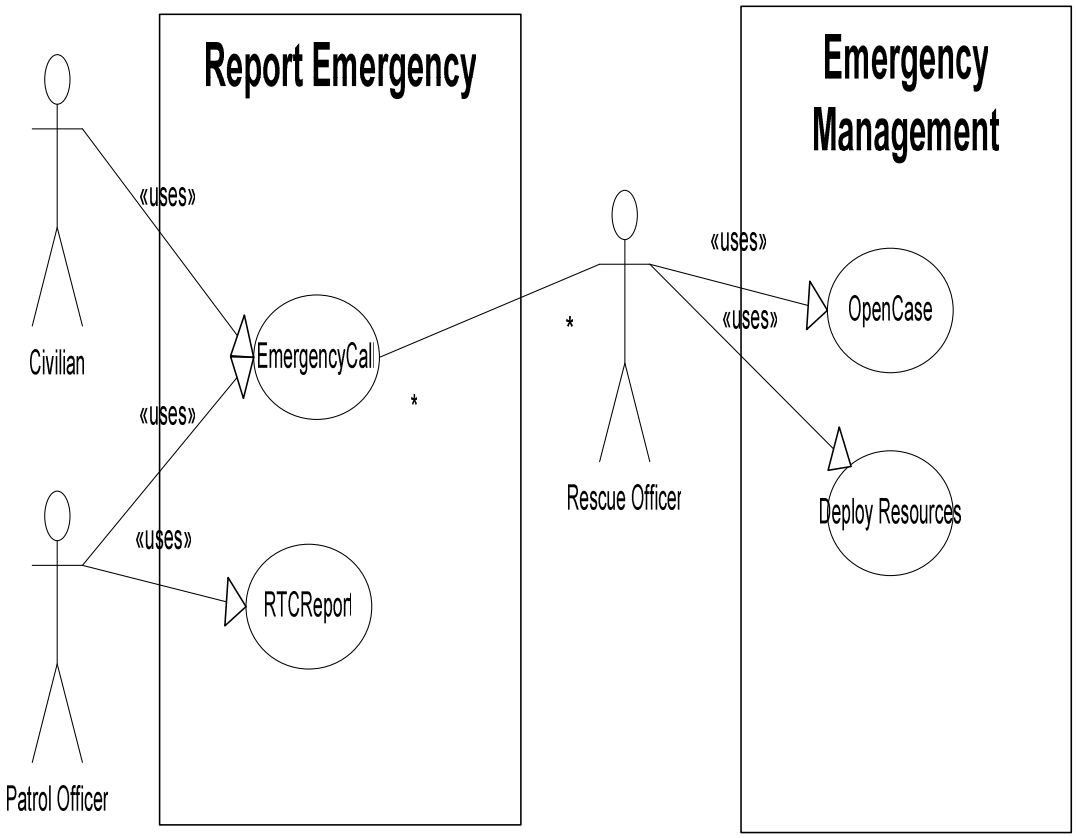

Fig 3: Use case diagrams for emergency operations of the Road Safety Commission

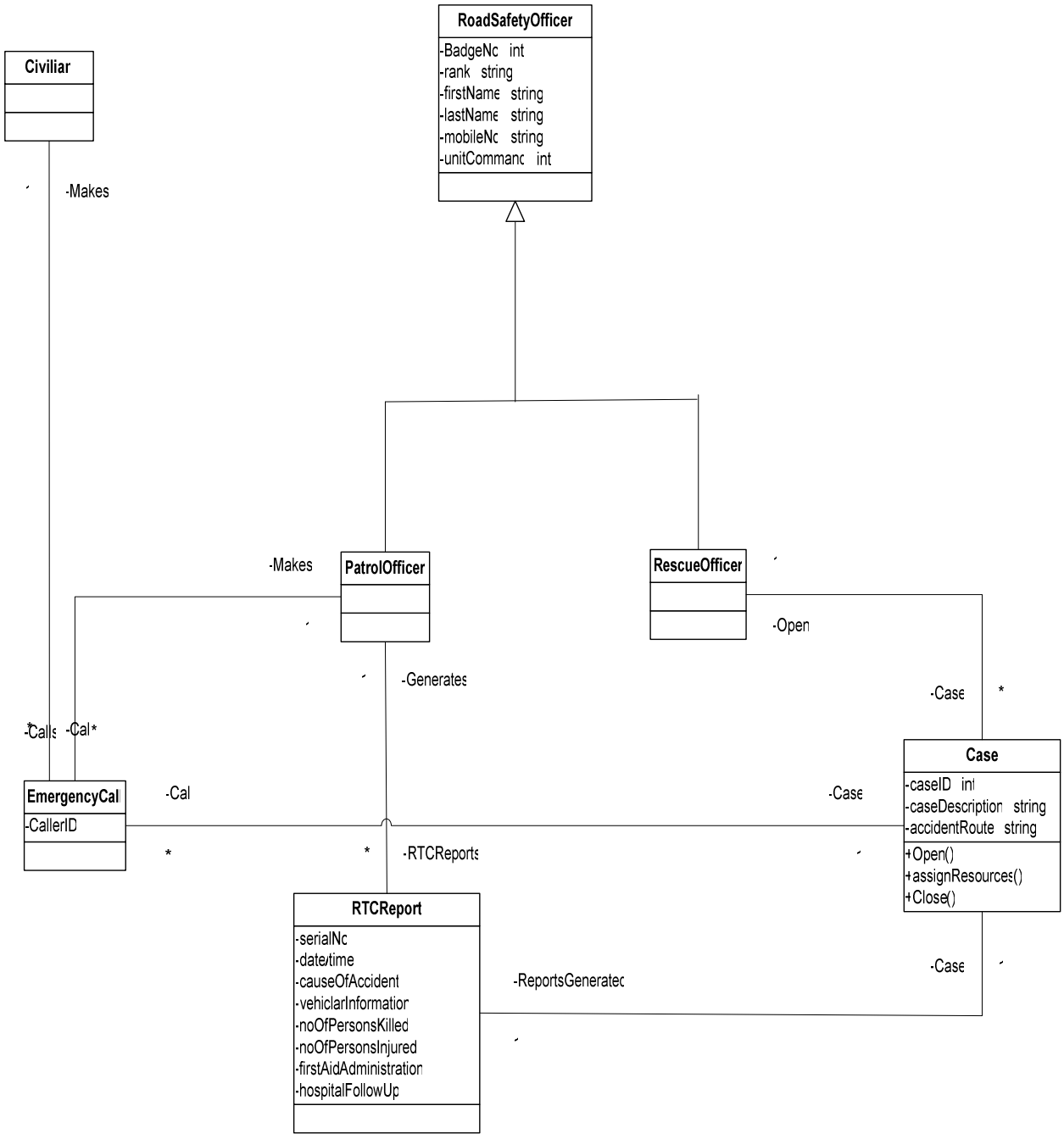

Figure 4: Class diagrams for emergency operations of the Road Safety Commission

The Nigerian Fire Brigade Bauchi command is responsible for responding to fire related incidents in around the Bauchi metropolitan area. There are two fire brigade stations in Bauchi state; they include the Headquarters which is in Bauchi city and the Azare station. Their activities include rescue activities in fire related incidents. In the absence of the police, they are responsible for administration of first aid to victims as well as the conveying of the victims to hospitals.

The primary method of receiving reports is via telephone calls from civilians. The calls are received in the control room by the station writer. An average of five incidents is reported daily. The information required during the reporting of an incident includes the name of the reporter and the location of the incident. The location might include the area, street, house number. In other cases it might be necessary for the reporter to lead them to the scene. There are sometimes cases of false reports and the fire service has no method of validating the authenticity of a report.

A typical rescue team consists of five officers per fire truck. The officers communicate with each other via cell phone operating on the Starcomms network. One among the five officers is the team leader and is responsible for keeping the control room updated with the status of an incident. The team leader is also responsible for the placing of assistance messages to the control room incase more resources are needed to tackle the incident.

After an incident has been successfully resolved, the team leader is responsible for the filing of a fire report form. After every six months a summary report is compiled and sent to the Abuja headquarters for analysis. The summary report includes information about the amount of total fire incidents in the area and total number of casualties

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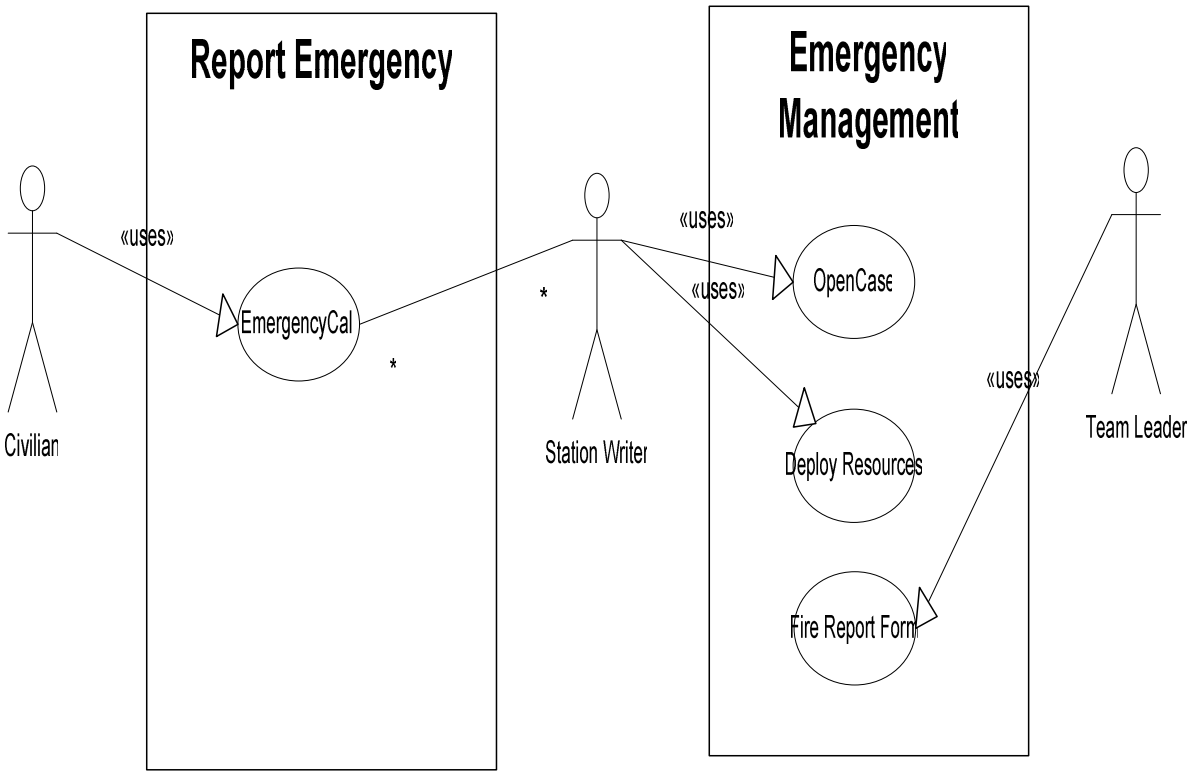

Figure 5: Use case diagram for Emergency Operations of the Nigerian Fire Service.

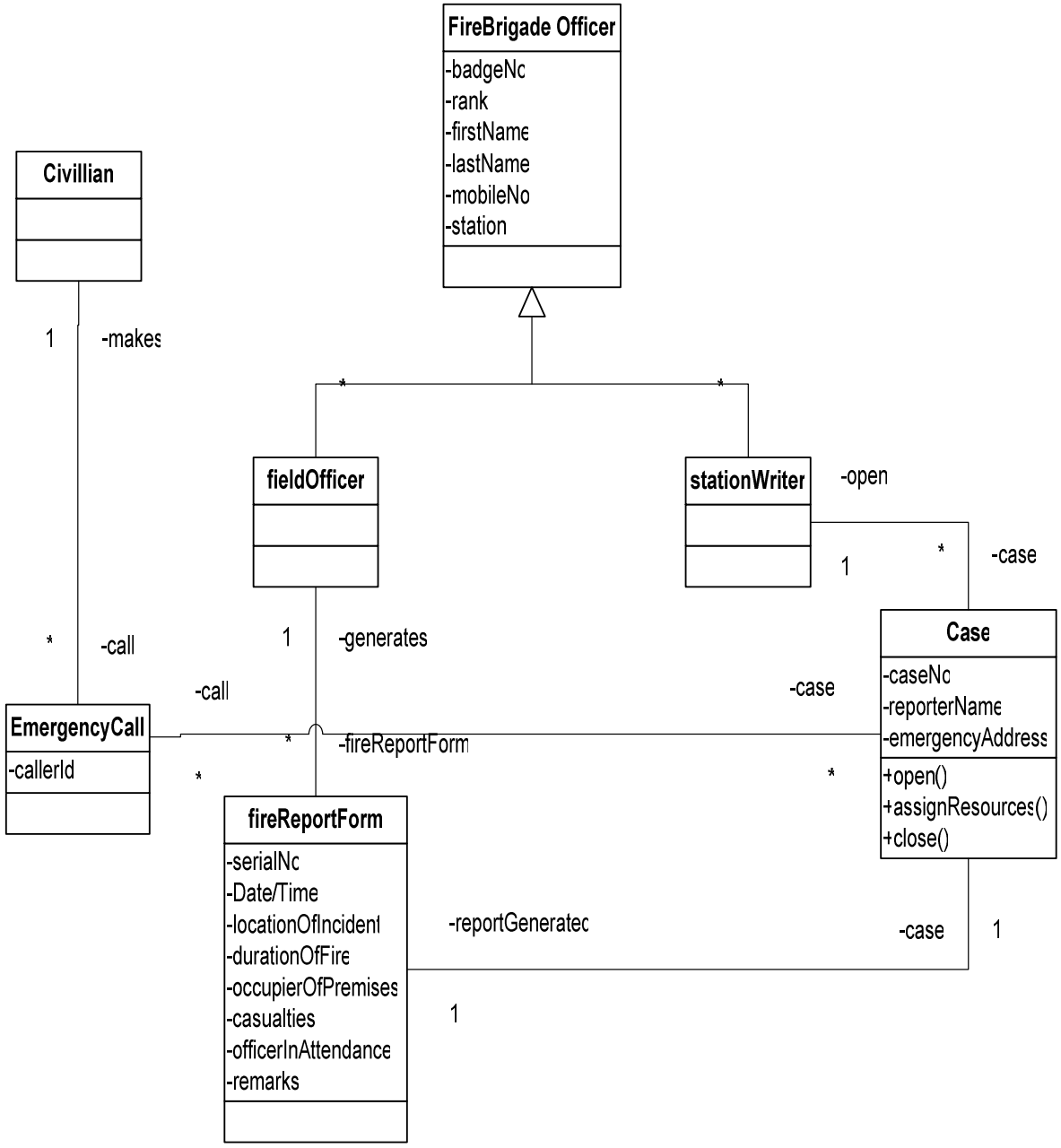

Figure 6: Class Diagram for emergency operations of the Nigerian Fire Service

Proposed System and Modeling

The Tactical Emergency Response Management System (TERMS) is to be built to handle all communication required during the handling of an emergency situation. As mentioned earlier, the effective handling of an emergency situation requires interaction between the various emergency response agencies. The main objective of TERMS will be the unification of all emergency

response procedures of the various agencies into a single architecture to be handled from a single point. TERMS will also make use of SMS technology to report emergency situations as well as enhance the communication between officers involved in emergency response.

System Modules

1. Report Emergency Module

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This module is responsible for all the handling of emergency reports submitted either by field officers of civilians via SMS or phone calls. The use case diagram is shown below:

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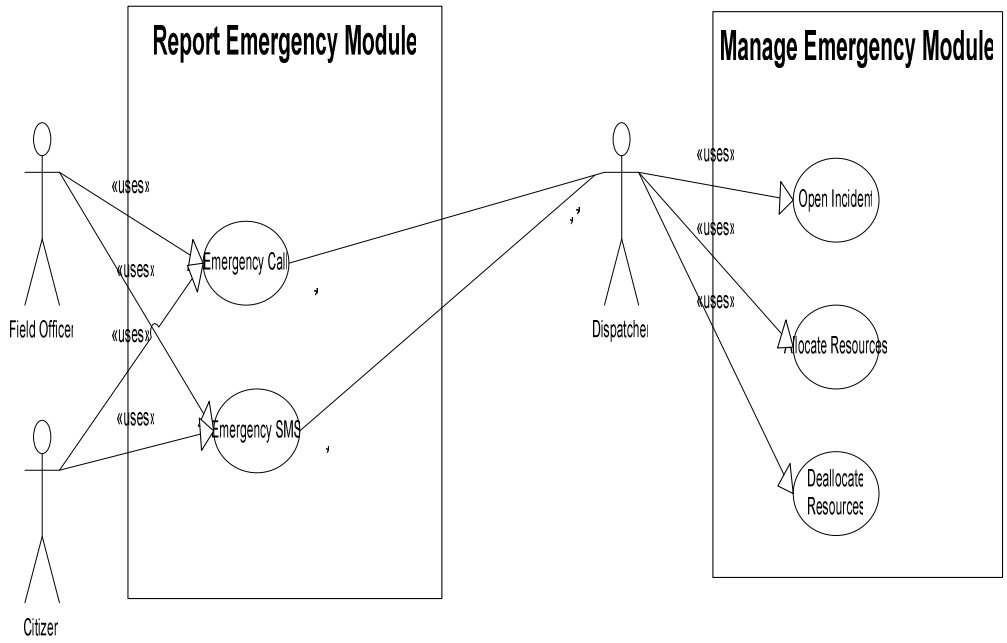

Figure 7: Use case diagram for Report Emergency and Manage Emergency Module

2. Authentication Module

This module manages all user information which includes usernames, passwords and well as user roles. The use case diagram is given below

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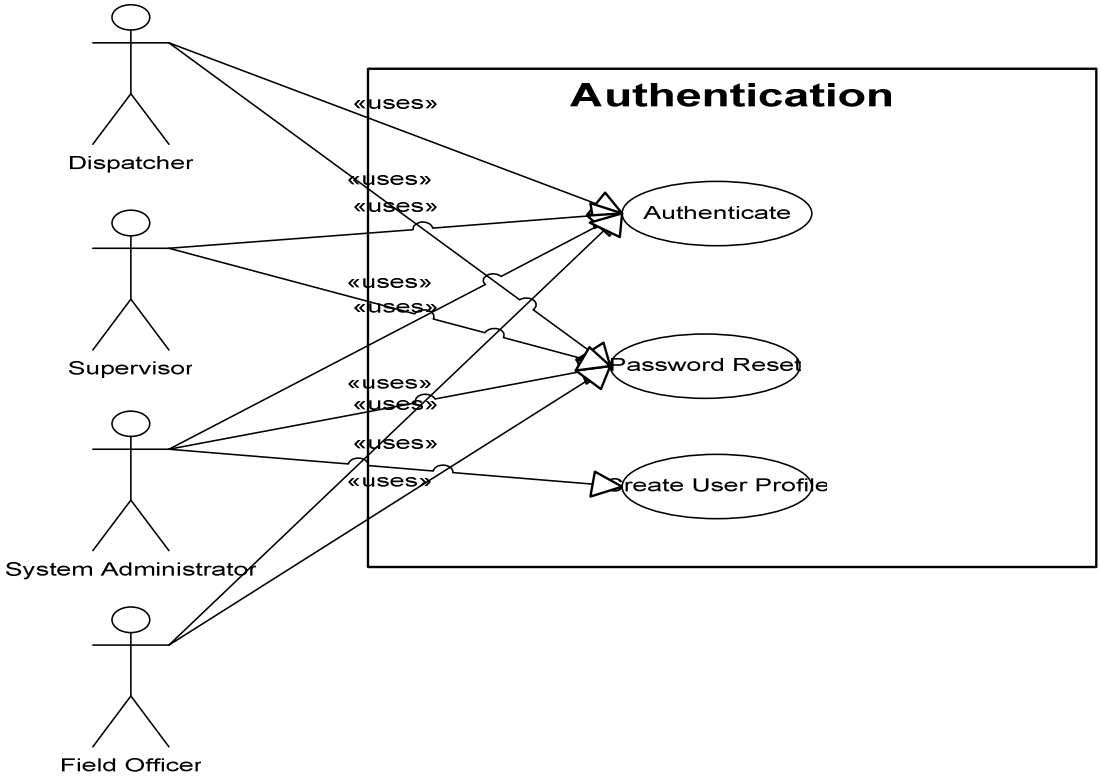

Figure 8: Use case diagram for authentication module

3. Resource Management Module

This module handles the management of all resources used in the management of resources. The use case diagram is given in figure 9.

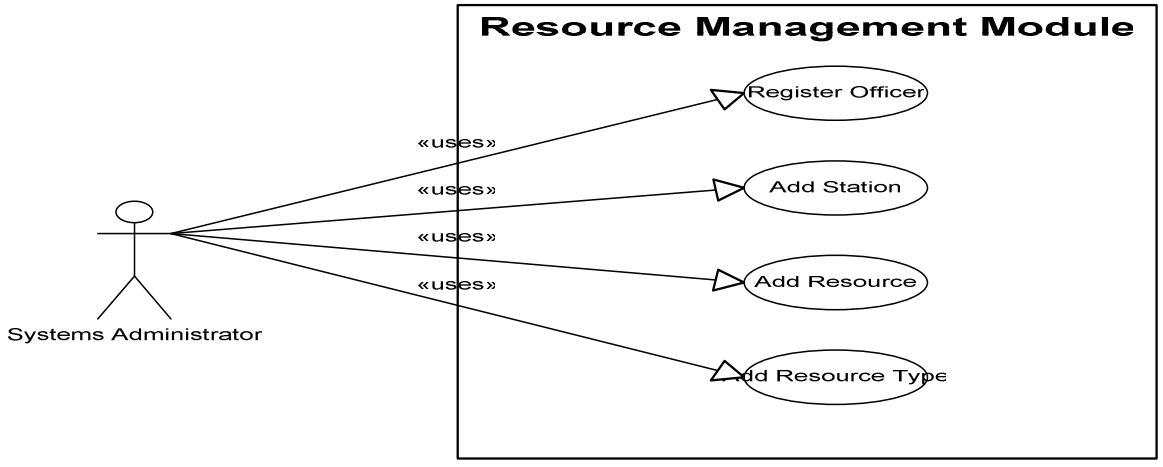

Figure 9: Use case diagram for resource management module

Design Goals

The new system is considered to be successful if it meets the following sets of criteria:

1. **User Interface**: The user interface of the system should be easy to use by each user of the system with little training.
2. **Documentation**: System administrators and other users are provided with proper documentation about the software's features.
3. **Performance**: The system should be able to serve a number of users which are expected to access it concurrently.
4. **Error Handling and Extreme conditions**: The system should be robust enough to handle error conditions and continue with normal operations.
5. **Availability**: The system availability should be available most of the time since it is handling emergency situations.
6. **Security**: The system should prevent the sensitive data from unauthorized access.
7. **Modifiable**: The system should be designed in Object Oriented language so that modification to some part of the system could not affect other parts.

System Model

This represents the system decomposition and other implementation designs necessary to achieve both the design goals and the functional requirements. The following architecture is considered.

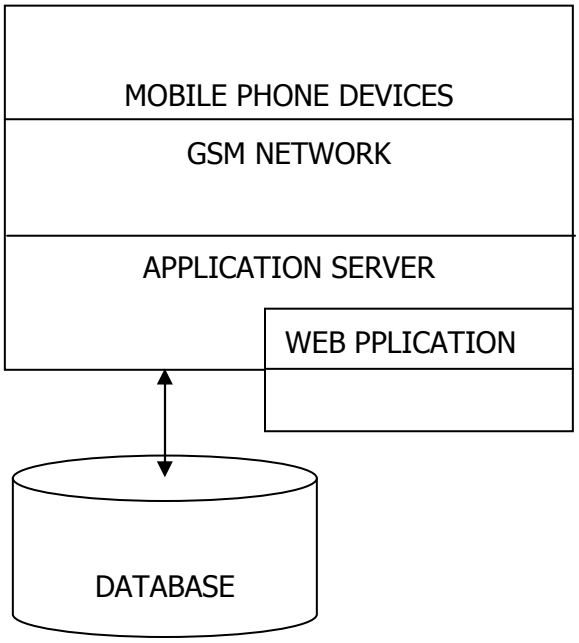

Figure 10: General Architecture of the System

At the top of the architecture we have the Mobile Phone Devices. This layer defines any mobile device with SMS functionality that will enable users to make calls and send SMS messages.

At the next layer, we have the Global System for Mobile Communication (GSM) network which is provided by the GSM network service provider. Cell phone calls and SMS messages are sent or received via a GSM network. This serves as a communication link between the application server and the mobile devices.

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The next layer, the Application Server, accepts the phone call or SMS message from the GSM network either via a wireless GSM modem or a GSM mobile device with a serial port cable connected to the application server. The application server automatically receives the calls or messages and stores it to the database taking necessary action.

Program Architecture

The program architecture of the proposed system is given in figure11 below

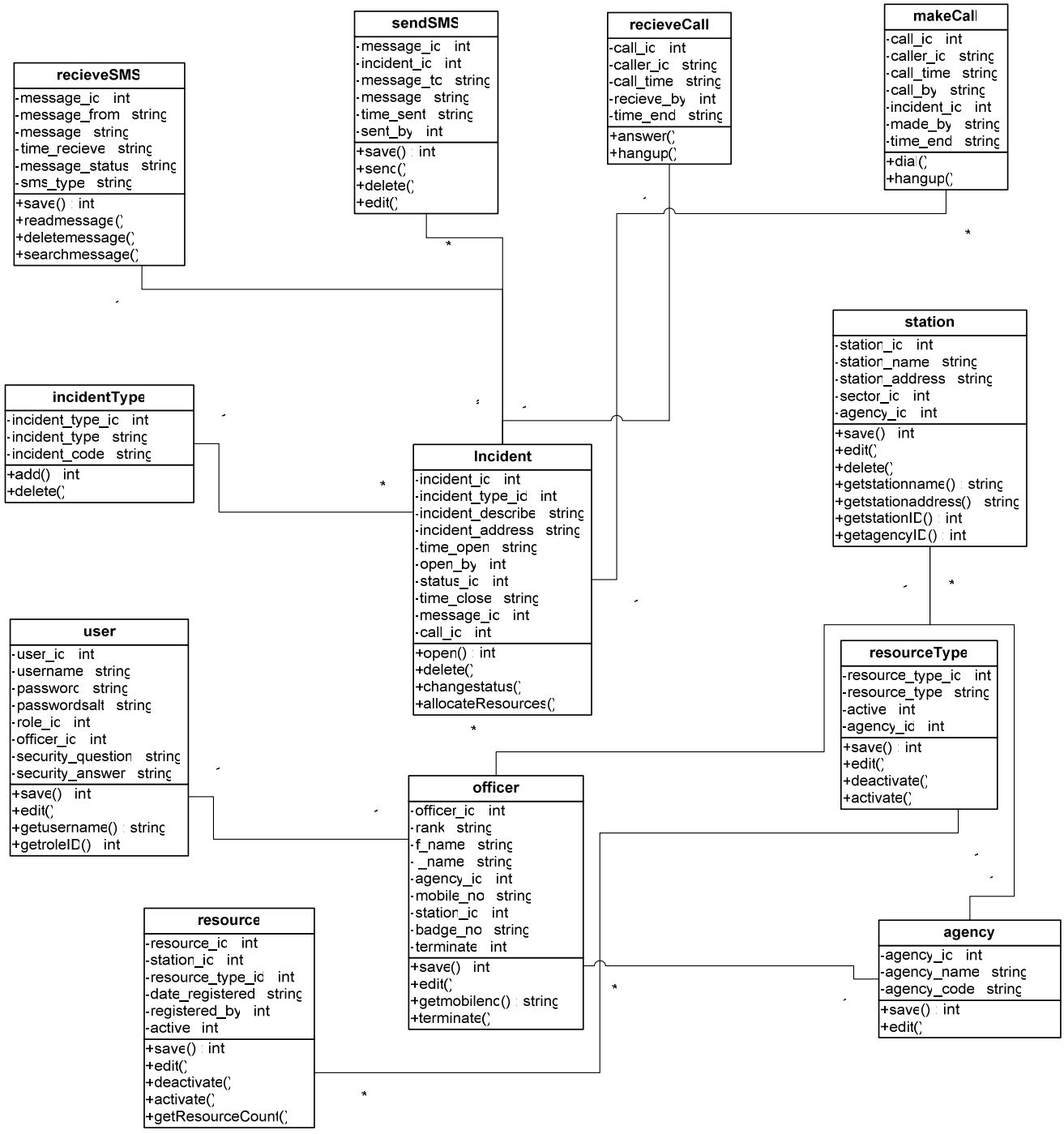

Figure 11: TERMS Class Diagram

The system will use a relational database to keep its persistent data.

The relational database designed is as shown in figure 12.

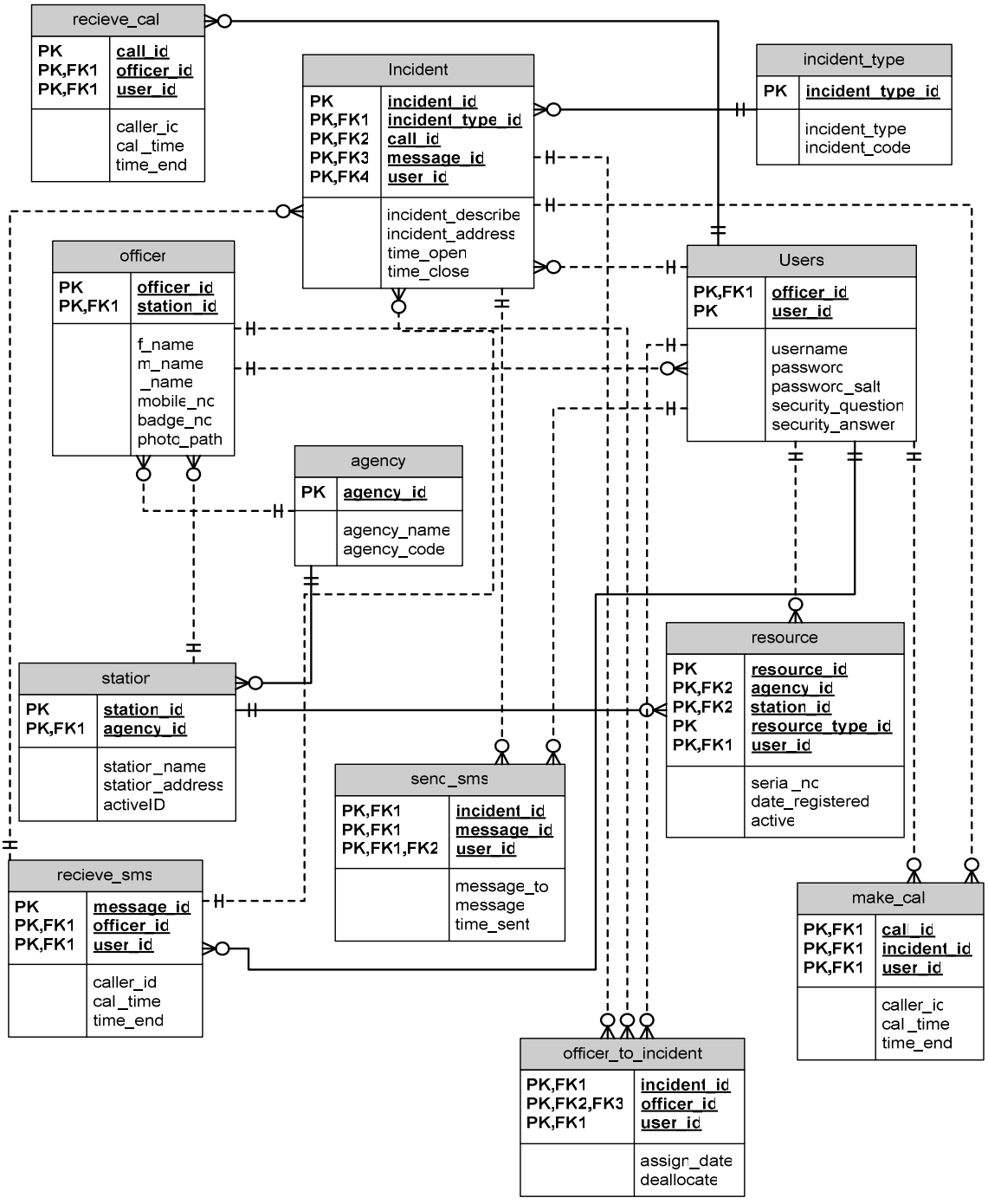

Figure 12: TERMS Database Model

Deployment Diagram

The system is web-based therefore client nodes should have browser components, whereas the web-server machine will have IIS. The same web-server or an independent machine, will host MSSQL server DBMS component. Figure 14 shows the deployment diagram which includes the application server where all the business logic functionalities are deployed and the database server. The system will be using client/server architecture

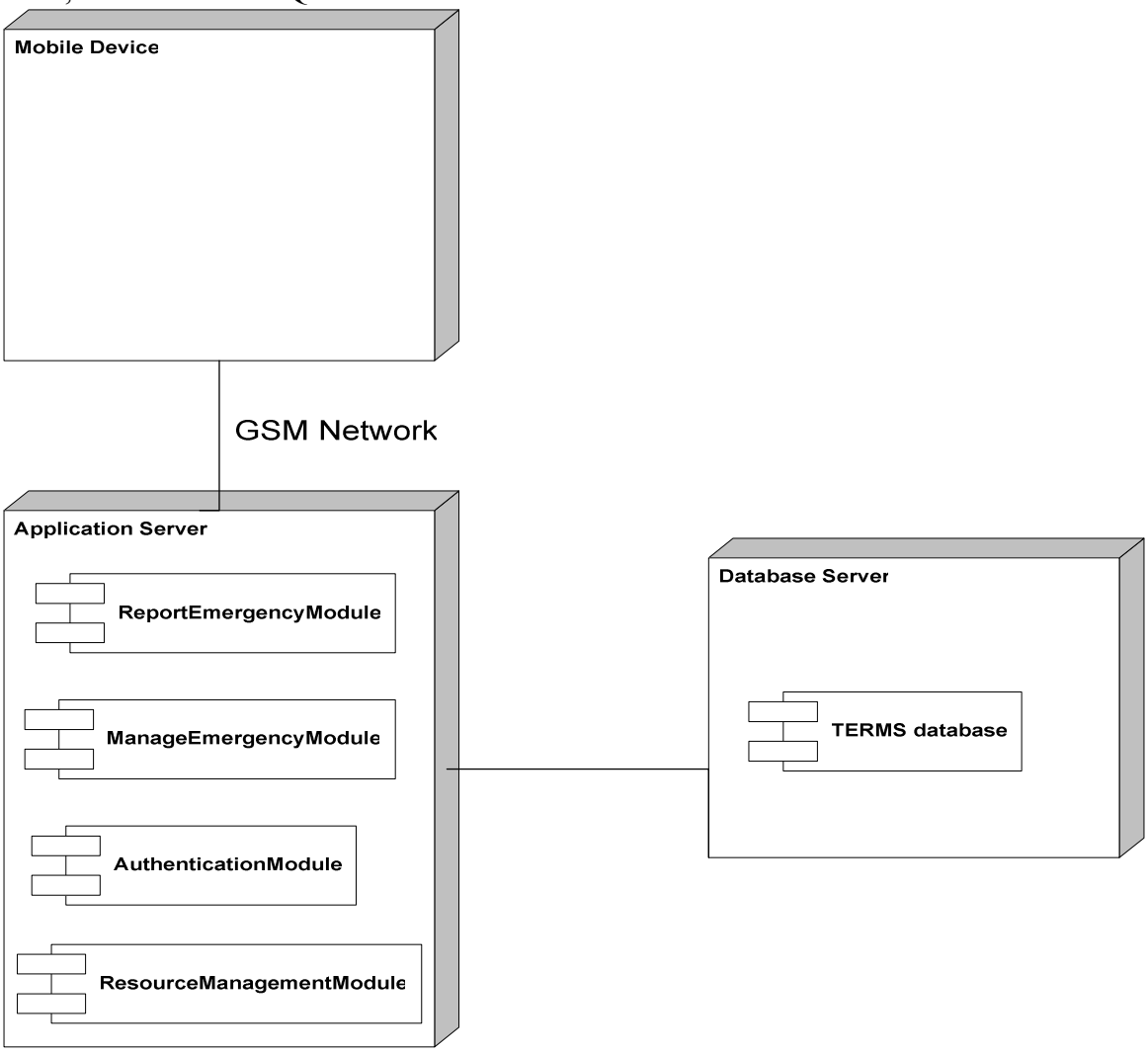

Figure 13: TERMS Deployment Diagram

Testing

The programming language used is Visual C#.Net, which was chosen because it provides suitable facilities for operating system services and also for its flexibility and simplicity as well as its ability to have easy access to low level hardware components, and its guarantee for speed or fast application

Results and Discussion

The System prototype is a web based application that communicates with a GSM modem or GSM mobile phone connected to the server, using the ATSMS library. The system uses the ATSMS library to enable it send and receive text messages as well as makes and receive phone calls via a mobile network (www.codeproject.com). Snapshots of some pages in the system and discussions are given below

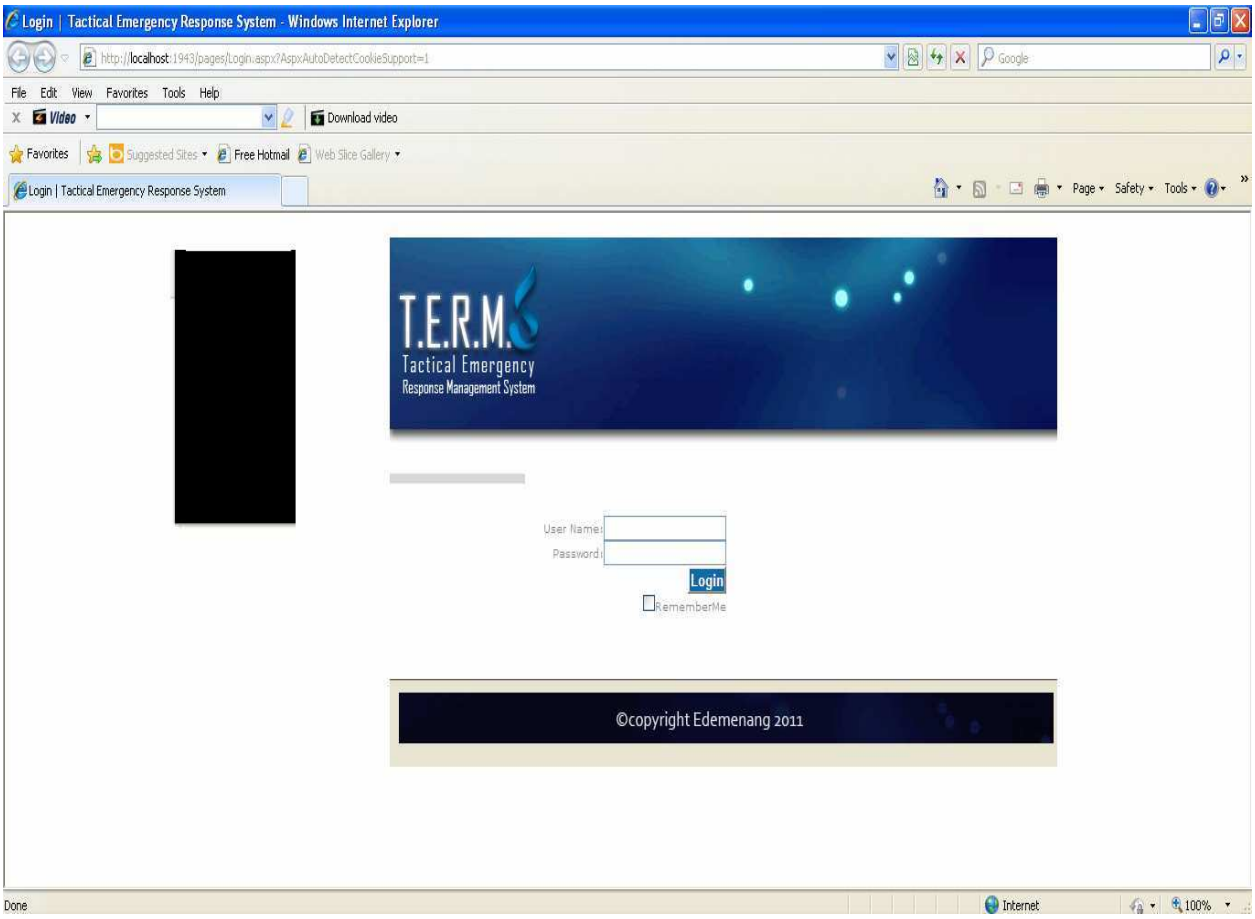

Figure 14: Login Interface for TERMS

The first page that the user sees when he or she accesses the system is the login interface shown in Figure 14 above, every user has a user name and an encrypted password which is stored in the TERMS database. After successful login to the system every user will be linked to the SMS Center.

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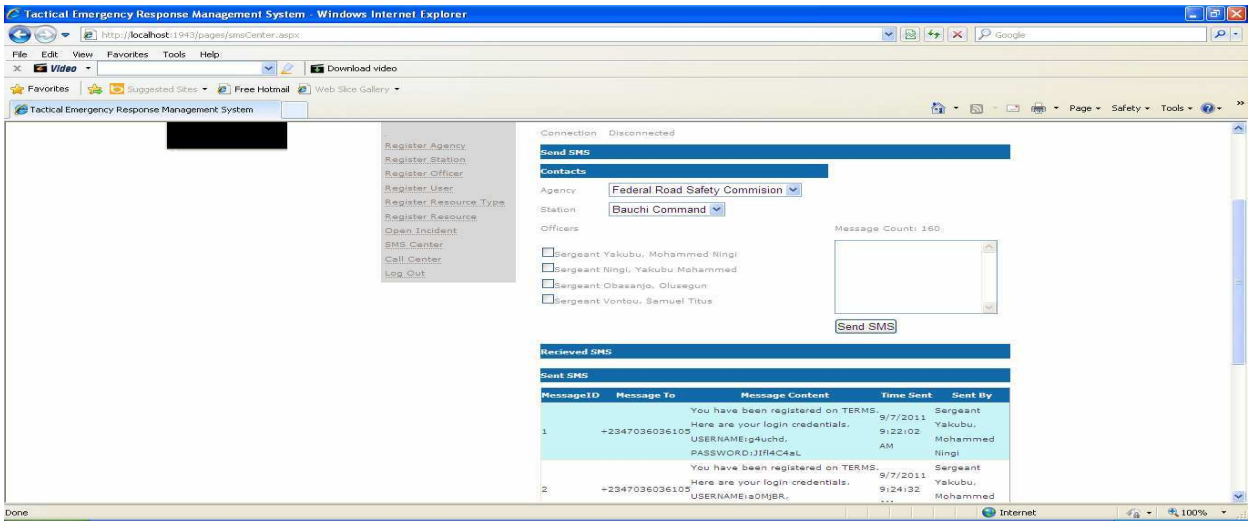

Figure 15: TERMS SMS Center

The sms center can be used at any point in time pass notification to field officers. Figure 16 shows the interface where the user selects the registered field officers by selecting his agency and his station. The user can then type in the contents of the text message in the given text box and send by clicking the send sms button. A log is also available for the user to view all his sent and received text messages.

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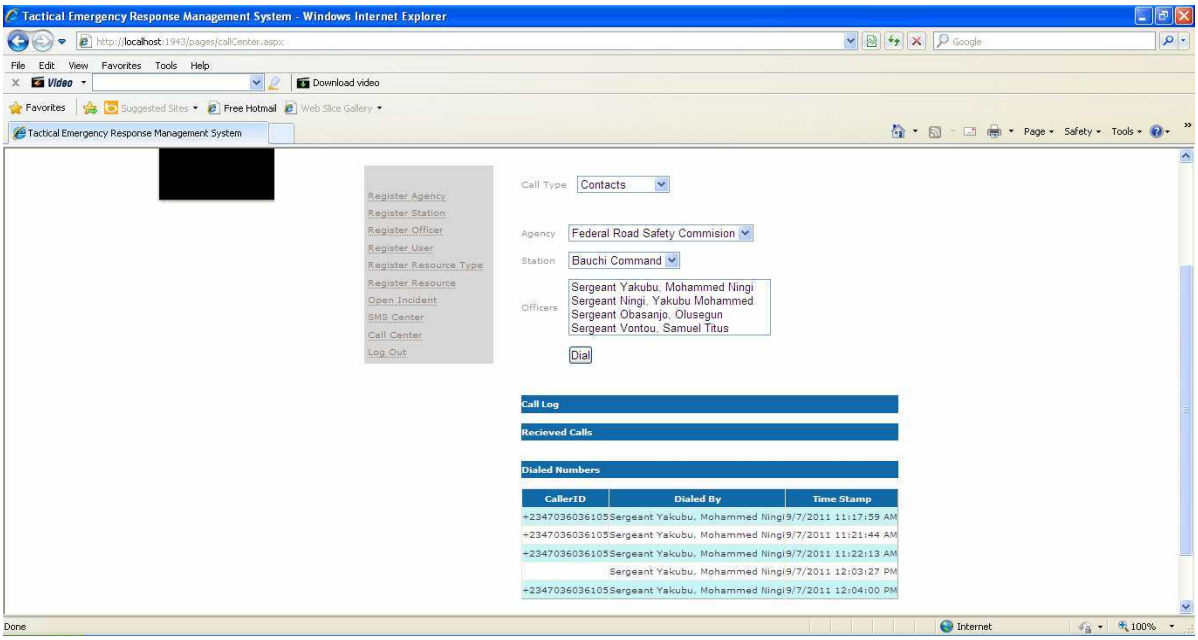

Figure 16: TERMS Call Center

The call center can be used to contact field officers by placing phone calls via a mobile network. Figure 16 shows the interface where the user selects the registered field officers by selecting his agency and his station. The user can then place calls by clicking on the dial button. A call log is also available showing all dialed and received calls.

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Figure 17: TERMS Incident Form

Figure 18 above shows the TERMS incident form. This is the form used by the dispatcher to open reported incidents. After filing all the necessary information, the dispatcher can assign officers to the incident by selecting the appropriate agency as well as their station. The dispatcher then selects a team leader as well as other officers. By clicking on the open incident button, a new incident is opened in the database and text messages are sent to all selected field officers

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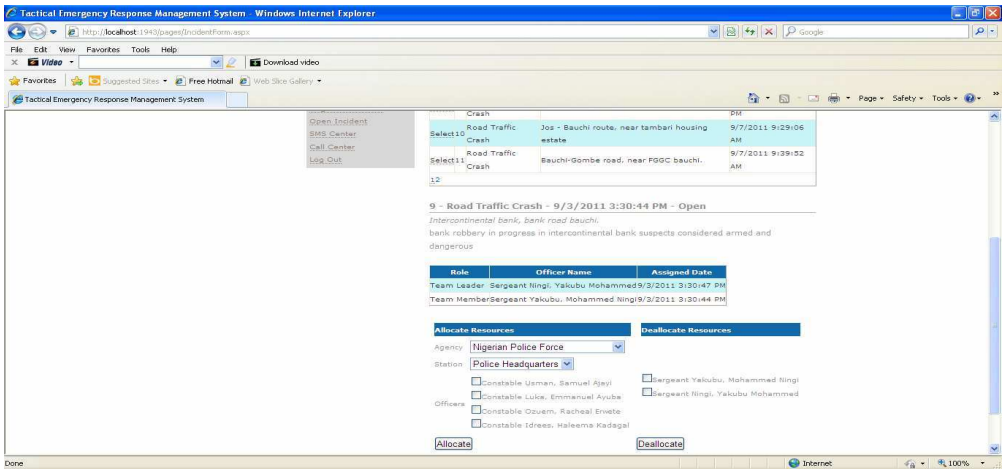

Figure 18: TERMS Incident Form

Conclusion

A framework towards creating an emergency response system fitted for the Nigerian environment was provided. The system was developed using .NET framework, mobile technologies which include mobile telephony as well as short messaging service. This provided a proof of concept to illustrate the capabilities of an emergency response system in the Nigerian environment, displaying how much such a system could improve emergency response activities of the various agencies. Implementing this work will greatly improve the activities of the various emergency response agencies in Nigeria, providing them with cheap and effective means of communication.

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