# A GSM-Based SMS Power Notification System for Network Operation Centers

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**Abstract**— In developing countries, electricity distribution to final consumers stands chances of failure due to epileptic power supply. Most times, failure can come from the electric power provider or problems with poor electrification of a building. Failure is detrimental to ICT Network Operation Centers as they require a 24/7 supply of electricity to effectively carry out their operations and provide the required network service to their clients. In times of power failure or restoration, it is necessary for ICT personnel to be notified of such a failure or restoration as a smart response to either bring a quick power restoration to the unit with the use of an alternative power source or in order to put off the alternate power source. For the effective operation of a Network Operation Center (NOC) in times of power outages or restorations, a Global System for Mobile Communication (GSM) based Short Message Service (SMS) notification system (ezzzyNotifier) which incorporates a shift timetable arrangement was developed. The system was tested and was found to work satisfactorily with an average user satisfaction of 87%. This paper, therefore, presents the design and implementation of a GSM-based SMS notification system for ICT Network Operation Centers.

**Index Terms**— GSM, SMS Notification Systems, Power Outage, Network Operation Center.

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## 1 INTRODUCTION

In contemporary society, it is impossible to live without electricity as most modern equipment requires a continuous supply of electric power. In periods of power outage [1], industries simply switch to other available sources of power supply so as to maximize profit and reduce downtimes. This is not only seen in industries but also in the household [2]. For network service providers, an uninterrupted power supply is needed for their proper operation.

In most critical applications [3], uninterrupted power supplies (UPS) are used. These devices cannot provide continuous operation in the event of a prolong period of power outage. In an ICT Network Operation Center, working shift arrangements is a regular scene for the purpose of proper monitoring and management of the day-to-day network challenges and in the event of power outage or restoration that might occur.

Many studies have found positive effects associated with the use of a GSM-based SMS notification systems [4, 5]. Hence, the need for an automated SMS based power failure notification system for Network operation centers. A power failure notification system can be installed for timely notification and monitoring of the electric power status. The idea of an SMS based warning system was proposed owing to the fact that mobile phones have become popular communication devices amongst people all over the world. While there are fewer than 7.2 billion people, the number of active mobile phone devices currently stands at 7.22 billion [6]. SMS is one of the most widely used means of communication around the world which is used by more than half of world's population [7].

In this paper, a GSM-based SMS notification system (ezzzyNotifier) is implemented on an Android device capable of sending SMS text messages and force vibrating the phone of the ICT personnel on duty based on an incorporated shift timetable arrangement. The smartphone device is connected permanently to the power source through a wall socket and any power outage or restoration is detected. The developed system (ezzzyNotifier) is easy to setup and use. The developed app is installed; admin logs in with email and password, adds a recipient name, phone number and activates notification by message and e-mail for the recipient and then plugs the phone to the power source that is to be monitored. To evaluate the performance of the developed system a questionnaire was distributed to 10 users to obtain the user satisfaction.

The rest of this paper is organized as follows. The related work done in this area of research is reviewed in Section 2. Section 3 presents the proposed method in detail. Section 4 presents and discusses the experimental results obtained and finally, conclusion is found in Section 5.

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## 2 RELATED WORK

Numerous studies have been conducted on power failure notification, management [4, 5, 8] and surveillance systems [3]. Most of the studies used the GSM technology for quick notification.

A system was designed and implemented to cater for household power management of at most 10 devices through the use of wireless technology was proposed in [5]. The developed system is able to manage power consumption of the connected devices and notify the users of the power status.

A GSM notification system to monitor a power generator placed at a remote area for a steel production process was presented in [8]. To minimizes downtime and maximize availability of power for production at the remote area, the GSM-based SMS alert system was set up to increase the efficiency of the process.

Also, a system containing a Cellular phone SIM (Subscriber's Identifying Module) card which uses wireless technology with a specific number for communication was presented in [9]. Here, the communication is made bi-directional where the user transmits and also receives instructions to and from the system in the form of SMS.

Similarly, [10] have presented the design and implementation of a SMS based control systems for monitoring. The system has three modules which include; a sensing unit for monitoring complex applications, a microcontroller-based processing unit and a communication module that uses GPRS modem or cell phone via serial port RS-232.

In [11], the authors identified that distribution transformers have a long service life if they are operated under good and rated conditions. However, their life is significantly reduced if they are overloaded, resulting in unexpected failures and loss of supply to a large number of customers thus affecting system reliability. This system provided a flexible and accurate control of load parameters and also provided an effective means for rectification of faults if any abnormality occurs in the power lines through SMS notification.

Furthermore, [12] proposed a system that can send commands in the form of SMS messages to read remote electrical power parameters. The system can automatically send the real time details of electrical power parameters periodically (based on time settings) in the form of SMS alerts whenever the Circuit Breaker trips or whenever the Voltage or Current exceeds the predefined limits.

This paper presents the implemetation of a GSM-based SMS notification system (ezzzyNotifier) which is capable of force vibrating the phone of the ICT personnel on duty based on an incorporated shift timetable arrangement.

## 3 METHODOLOGY

The System Comprises primarily of an android mobile device on which the Graphic user interface (GUI) of the developed ezzzyNotifier app runs on. The block diagram of the system is shown in Figure 1. The android mobile device is permanently connected to a power supply and the ezzzyNotifier system waits for a change of state in power supply using an android broadcast receiver. At any time when there is a change of state in power supply, the broadcast receiver triggers the sending of SMS to the recipient(s) on duty at that particular moment. It checks the present recipient(s) on duty by connecting to a SQLite database and by checking the current date and time of the device. Immediately the SMS is sent to the selected recipient(s) who would have had the software called 'ezzzyNClient' installed on their android mobile device(s), ezzzyNClient listens for the SMS from the ezzzyNotifier and checks if the recipient's mobile device is on silent mode so as to force the phone to vibrate and hence notify the recipient of power state. The system flow chart is shown in Figure 2.

### 3.1 System Design

The processes and their relationships are represented in the block diagram in Figure 1. The ezzzyNotifier app is broken down into the client side (ezzzyNClient) and server side with each corresponding side with its function. The Phone Number of the server is updated on the client application and saved into a SQLite database. The basic function of the client side is to continuously listen for any message from the server.

The Server side performs the major function of scheduling, SMS and E-mail notifications. Scheduling involves the allocation of resources over time to accomplish specific task. It covers basically the operation scheduling which is a type of scheduling in which jobs are assigned to workstations or employees are assigned to jobs for a specified period of time. SMS is sent using either the standard GSM-based SMS or the Gateway SMS.
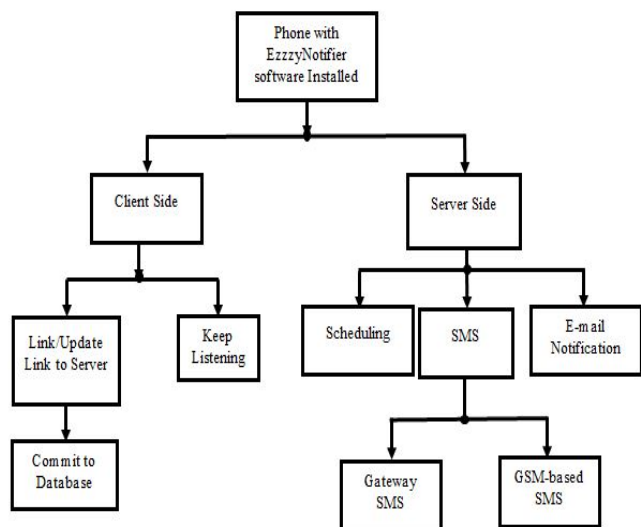
**Figure 1:** Block Diagram of the ezzzyNotifier application

## 3.2    Flowchart of the System

The flowchart in Figure 2 shows the visual representation of the sequence of steps and decisions needed to perform the ezzzyNotifier and ezzzyNClient function.
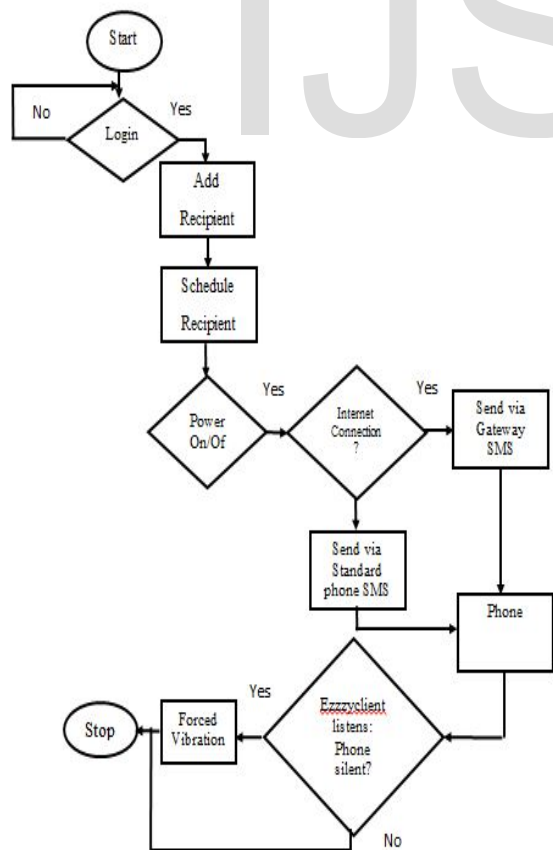


**Figure 2:** Flowchart of ezzzyNotifier application

The first step is to open the ezzzyNotifier app and login as an administrator. Afterwards, recipient(s) are added and scheduling is done for the recipient(s) added. The application continuously checks if there is a power outage or restoration to the unit. If either of the two processes does not take place, no action is taken. However, if there is power outage or restoration, the next step the application takes is to check if there is a network connection or not. If there is internet connection, SMS is sent via the Gateway SMS else it uses standard phone SMS available on the android smartphone.

On the client side, a different process occurs, ezzzyNClient is installed on every recipient(s) phone that is added. Once a message is received on a recipient's phone, ezzzyNClient verifies if the message is coming from the ezzzyNotifier server. If the message is from the server, it checks if the phone is on silent or not. If the recipient's phone is on silent, there is a forced vibration to notify the recipient of a power outage or restoration so that appropriate action can be taken by the scheduled recipient.

## 3.3    User Interface Design

The first step towards the ezzzyNotifier and ezzzyNClient implementation was to create an application that would be able to access some features on any smartphone. It would therefore be logical to start from choosing a platform that will be useable. This brought about the need to settle between the use of Android, IOS, Blackberry OS and windows mobile platforms. ezzzyNClient is a client based app that listens to message(s) from ezzzyNotifier. The client side is imperative because the ezzzyNotifier has to provide notification for the ICT personnel irrespective of if the phone is on silent or in vibration or off. In this condition, the alarm is fired and this forces the phone to vibrate. However, if the client's phone is dead, nothing is done by ezzzyNclient. The ezzzyNClient continuously listens for message(s) from the ezzzyNotifier, only messages from ezzzyNotifier would fire an alarm on the person's phone. This is made possible via the updated phone number on the server added through the settings in ezzzyNClient. The ezzzyNClient only listens to messages from that phone number sent to scheduled recipients. ezzzyNClient must be installed on all the NOC ICT personnel's (recipients) phone in order to enjoy the full functionalities.

The Android platform was chosen for implementation of the ezzzyNotifier and ezzzyNClient app. The Android platform allowed the use of smartphones without proprietary inhibitions. The Android platform was designed to protect the privacy and security of Android users, as well as the operating system. This was made possible because of the rich security architecture, application certificates, and application permissions that Android offers. The purpose of introducing the Android security architecture was to prevent applications from being able to automatically perform operations that could jeo-

pardize the security of other applications, the operating system or the user. Appropriate certificates were enforced to identify the authors of particular applications and to prevent users from installing fraudulent software on their devices. This was made possible since Android will not install an application that has not been signed with a certificate. Therefore, the origin of all published applications was traceable. Android security permissions were handled by the *AndroidManifest.xml* file that was activated within all application files. The *AndroidManifest.xml* was also used to take care of both software and hardware permissions. The *AndroidManifest.xml* permission allows the client side include contact read, read message, mobile network while the only permission for ezzzyNClient needed is the read message. ezzzyNotifier was programmed in the native java programming language for java.

The application tagged "ezzzyNotifier" was developed to make operations in a NOC easier by providing notification to certain numbers based on the recipient added by the administrator. This is done by sending SMS using the standard phone SMS system or gateway SMS system. The gateway SMS is implemented using Hypertext Transfer Protocol (HTTP) and Short Message Peer-to-Peer (SMPP). SMPP is used in the telecommunication industry for exchange of SMS messages that allows for fast delivery of the messages. Also e-mail notifications are also sent using the simple mail transfer protocol (SMTP). All the services run in the background.

The system has a splash/demo screen that contains information about the software. In order to gain access to the application, the action button or action bar is pressed to display three options which are the settings, help topics and ezzzyNotifier interface as shown in Figure 3.
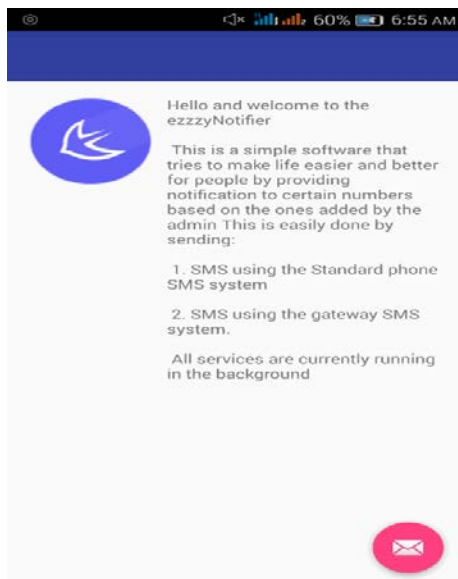
to enter the email and password of the administrator and a sign in button. After login by the admin, the options provided include create a recipient, add recipient from phonebook, view recipients, Edit recipient, change password and ezzzy schedule as shown in Figure 4.
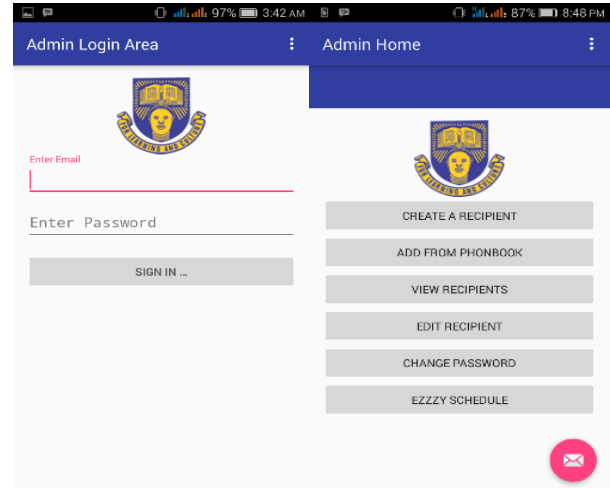


**Figure 4:** Admin Login Interface

To create a recipient, the name, email and phone number of the recipient is added with an add button and can also be added from the phonebook. The recipient added can be viewed and edited as shown in Figure 5. Also personnel scheduled for a particular date cannot be re-scheduled for another time that day unless the previous schedule is deleted as depicted in Figure 5.
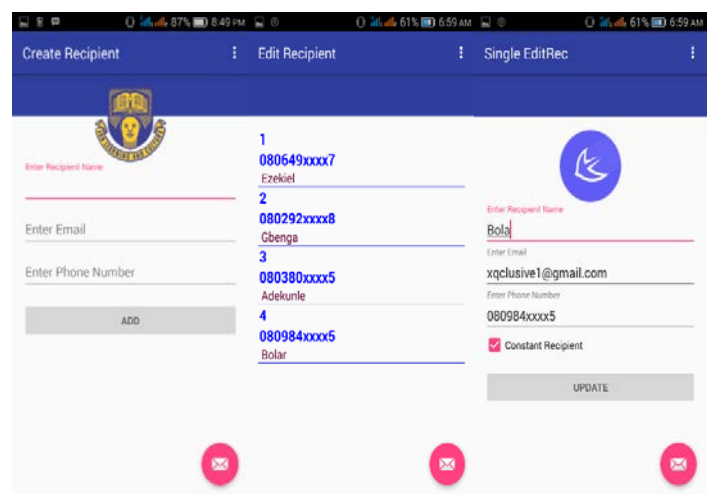


**Figure 3:** Splash Screen for ezzzyNotifier

Once you press the settings menu. Two text fields are shown



**Figure 5:** Adding, Viewing and Editing Recipients

The admin can change profile details which includes username and password and the scheduling of recipient(s) can be

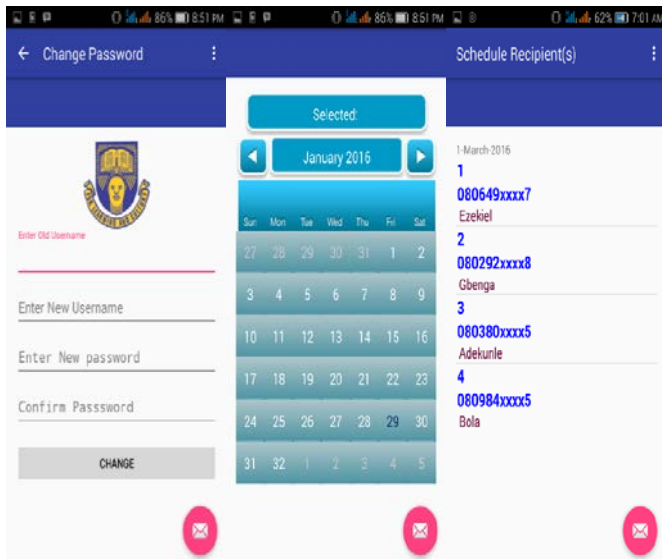done using "ezzzy Schedule" as shown in Figure 6 through the calendar.



**Figure 6:** Interface to change Admin profile and schedule recipient using Calendar

Also the interface of the ezzzyNClient shows the home screen. It listens for a message from ezzzyNotifier and the settings for a phone Numbers on the server as depicted in Figure 7.
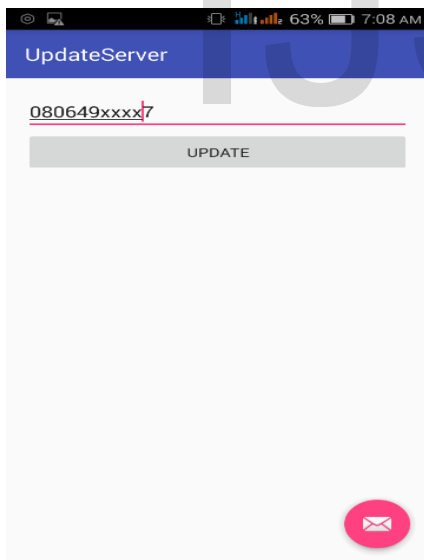


**Figure 7:** UI for home and Settings for ezzzyNClient

### 3.3 Database Design

The ezzzyNotifier app also makes use of a SQLite database to save recipient details that were added, scheduled recipients, Log ID and password for the administrator and other personnel given the permission. The ezzyNclient saves a phone number that serves as the client on the database as depicted in the entity-relationship diagram (ERD) in Figure 8.
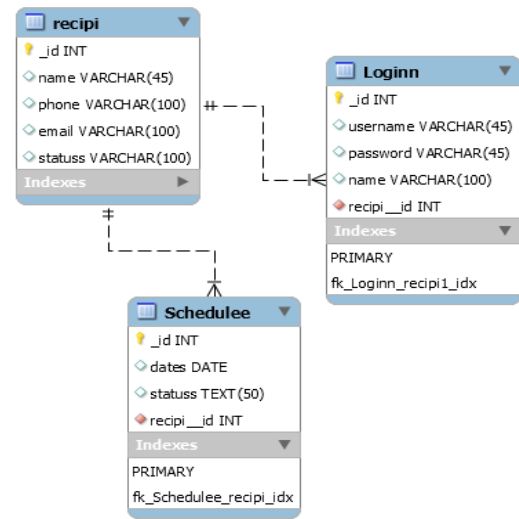


**Figure 8:** ERD Diagram for the ezzzyNotifier app

## 4    RESULTS AND DISCUSSION

The proposed system has been tested on various models of smartphones. The system detects the power outage and sends a text message to the scheduled recipient. The system is very light, simple and easy to use. It requires only an android phone, the ezzzyNotifier app and ezzzyNClient.

The performance evaluation of the system was done via a subjective test based on System Usability Scale (SUS). This is a simple 10-item scale that gives a view of the subjective assessments of usability as shown in Table 1. Usually, its score has a range of 0 to 100 [13]. The questionnaire was distributed to ten respondents. The application was installed on individual smartphone and tested.

**Table 1:** Questionnaire to test system usability

| S/N | Questionnaire | Strongly Agree (5) | Agreed (4) | Indifference (3) | Disagree (2) | Strongly Disagree (1) |
|---|---|---|---|---|---|---|
| 1 | I would use this system frequently | | | | | |
| 2 | I found the system unnecessarily complex | | | | | |
| 3 | The system was easy to use | | | | | |
| 4 | I would need the support of a technical person to be able to use the system | | | | | |
| 5 | I found the various functions in this system to be well integrated | | | | | |
| 6 | There was too much inconsistency in this system | | | | | |
| 7 | I would imagine that most people would learn to use this system very quickly | | | | | |
| 8 | I found the system very cumbersome to use | | | | | |
| 9 | I felt very confident using the system | | | | | |
| 10 | I needed to learn a lot of things before I could get going with this system | | | | | |

The scores for individual items are not usually meaningful on

their own. To calculate the SUS score, the sum of the score contributions from each item was summed. Each item's score contribution will range from 0 to 4. For items 1, 3, 5, 7, and 9 the score contribution is the scale position minus 1. For items 2,4,6,8 and 10, the contribution was 5 minus the scale position. The sum of the scores was then multiplied by 2.5 to obtain the overall value of System Usability. SUS scores have a range of 0 to 100.

Figure 9 shows the applications user satisfaction, with users 4, 7 and 10 having a score above 90.
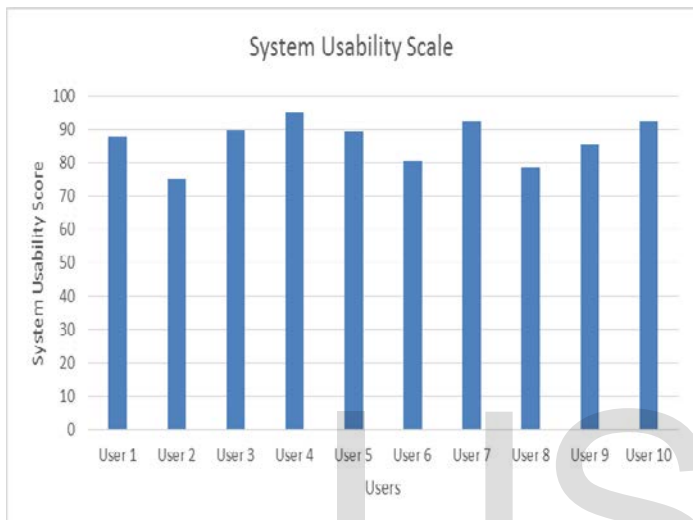


**Figure 9:** SUS scale for user satisfaction

The average user satisfaction is 87% as shown in Figure 9. This means the system performed its designed function. The user satisfaction was high because the system is easy and simple to use. People were confident using the system and were able to learn very quickly because they only had a few things to accustom themselves with. The use of the system did not require the support of any technical person. The various functions in the system were also well integrated.

The system was also subjected to unit testing based on each of the services via a local wireless network with an average speed of 625kbps down and 1.3mbps up, response time of 24ms, latency of 258ms, jitter of 236ms, maximum speed of 2.7mbps down and 9.6mbs up. The average of the transmission time and resource utilization for each of the services is shown in Table 2. The time taken by the system to deliver the SMS is dependent on the strength and connectivity of the wireless network. If the smartphone is in a strong coverage area, SMS is delivered within 30 seconds on the average. The system requires 4MB of RAM from the smartphone to perform. Therefore, it works on a phone memory as low as 256MB RAM and 512MB internal memory. It was tested and found to work on android versions 2.2 and above.

**Table 2:** Evaluation parameters

| Parameters | E-mail | Bulk SMS | SMS |
|---|---|---|---|
| Transmission time | 2 min | 1 min | 30s |
| Resource Utilization | 2MB | 1MB | 500KB |

The advantage attached to the use of the system is its cost effectiveness where the user selects the most preferable platform to use, namely; the SMS platform, email or both. These platforms are incorporated to allow for proposer decision making. Also, the system would not function if the wireless network and mobile network is experiencing downtimes. Therefore, in such situations SMS or email might not be delivered.

## 5 CONCLUSION

In this paper we have presented the design and implementation of a GSM-based SMS power outage notification system. The developed system was tested with the available mobile network and internet connection to ascertain its effectiveness. The scheduled recipient will get alerts anywhere from the system through the GSM technology thus making the system location independent and reliable. The SMS based power outage notification system is very easy, user friendly and has many software features. This type of system is useful when the ICT personnel are in or out of the NOC. The system has been tested in an ICT NOC to determine its functionality and efficiency.

## ACKNOWLEDGMENT

## REFERENCES

[1] Oluwole, A., Samuel, O., Festus, O. and Olatunji, O., "Electrical Power outage in Nigeria: History, causes and possible solutions", *Journal of Energy Technologies and Policy*, vol. 2, no. 6, pp. 18-23, 2012.

[2] Singh, S. N. and Singh, K., "Optimal Design of A Cost Effective Solar Home Power System - An Alternative Solution to Dg For Grid Deprived Rural India", *International Journal of Research and Reviews in Applied Sciences*, vol. 2, no. 1, pp. 60-66, 2010.

[3] Lin, C., Chu, E. T., Ku, L. and Liu, J. W. S., "Active Disaster Response System for a Smart Building", *Journal of Sensors*, vol. 14, no. 9, pp. 17451-17470, 2014.

[4]  Sarsamba, M., Yanamshetty, R., and Sangulagi, P., "The Load Monitoring and Protection on Electricity Power lines using GSM Network", *International Journal of Advanced Research in Computer Science and Software Engineering* (ijarcsse), vol. 3, no. 9, pp. 1131-1136, 2013.

[5]  Ganiyu R. A., Arulogun O. T., Adetunji A. B. and Okediran O. O., "Development of a GSM Based Household Power Management System", *British Journal of Science*, vol. 1, no. 2, pp. 1-14, 2011.

[6]  International Business Times, "Active Mobile Phones Outnumber Humans for the First Time". Available online: http://www.ibtimes.co.uk/there-are-more-gadgetsthere-are-people-world-1468947, (28.05.2015).

[7]  Azid, S., Sharma, B., Raghuwaiya, K., Chand, A., Prasad, S. and Jacquier, A., "SMS Based Flood Monitoring and Early Warning System", *ARPN Journal of Engineering and Applied Sciences*, vol. 10, no. 15, pp. 6387- 6391, 2015.

[8]  Boopathi, S., Jagadeeshraja, M., Manivannan, L., and Dhanasu, M., "GSM Based Generator Monitoring System for Steel Melting Shop (SMS)", *International Journal of u- and e- Service, Science and Technology (Ijunesst)*, vol. 8, no. 2, pp.313-320, 2015.

[9]  Palamar, A., "Control System for a Diesel Generator and UPS Based Micro-grid", *Scientific Journal of Riga Technical University Power and Electrical Engineering*, vol. 27, pp. 47-52, 2010.

[10] Ciubotaru-Petrescu, B., Chiciudean, D., Cioarga, R. and Stanescu, D., "Wireless Solutions for Telemetry in Civil Equipment and Infrastructure Monitoring", *3rd Romanian-Hungarian Joint Symposium on Applied Computational Intelligence (SACI),* pp. 25-26, 2006.

[11] Vimalraj, S. and Gausalya, R. B., "GSM Based Controlled Switching Circuit between Supply Mains and Captive Power Plant", *International Journal of Computational Engineering Research*, vol. 3, no. 4, pp. 204-208, 2013.

[12] Sachan, A., "Microcontroller based Substation Monitoring and Control System with GSM Modem", *IOSR Journal of Electrical and Electronics Engineering*, vol. 1, no. 6, pp.13-21, 2012.

[13] Bangor, A., Kortum, P., and Miller, J., "An Empirical Evaluation of the System Usability Scale,"*International Journal of Human-Computer Interaction,* vol. 24, no. 6, pp.574–594, 2008.