Implementation of a Wireless Bank Surveillance System with a Nomadic Monitoring Unit

Victor O. MATTHEWS, Felix O. OLOWONONI, Emmanuel ADETIBA

Abstract— Most countries of the world are experiencing a rising spate of crime and security challenges. Specifically, the banking sector is seriously imperilled by the menace of armed bandits as recent robbery incidents are targeted mainly at banks. Most security agencies are incapacitated due to the absence of efficient means for intelligence gathering. To this end, this paper reports the implementation of a Wireless Nomadic Bank Surveillance System which comprises of three intelligent sub-units namely the asset tracking unit, the panic button unit and the IP surveillance unit. The asset tracking unit is an assembly of an embedded system together with a programmed hybrid GPS/GSM module. The panic button system is also an embedded system that operates with a GSM module. The IP surveillance unit is used to remotely monitor the banking hall through covert IP cameras placed in the banking hall. All of the three sub-units are monitored and controlled by a nomadic system which is a mini computer system specially assembled for this purpose. The system is used to query the bag and money tracker for the present location. The Google earth software installed on the nomadic system is used to map the received longitude and latitude format to the actual position. To serve as a redundancy to the panic button system, a web application is developed using PHP, JavaScript and MySQL for managing the video feeds and forwarding SMS alert messages to security agencies saved in the database in case of a robbery.

Index Terms— AT commands, GPRS, GPS, GSM, IP Surveillance, Microcontroller, MySQL, PHP, SMS, Tracking.

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1 INTRODUCTION

SECURITY challenges in recent times is taking a new and frightening dimension as crime and criminal activities appear to gradually become permanent features of our modern society. Presently, the banking sector is seriously imperilled by the menace of robbers. Reports from security agencies and the mass media show that recent robbery incidents have been rather well-planned and executed and targeted mainly at banks.

The year 2011 will remain a remarkable one in the banking sector in Nigeria as a result of the prevalence of bank robberies during that year. Bank robbery rates increased from what it used to be in the past because of the deteriorating security situation that the country witnessed in the course of the year. According to reports, over 100 branches of different banks were robbed between January and December, 2011 [1].

Although there is no comprehensive report on bank robberies in 2012, reports from the media confirmed that the trend continued in the same manner. In the year 2013, a number of bank robberies have also been reported. An unfortunate incentive to crime escalation in Nigeria is the inability of the appropriate authorities to arrest and bring criminals to justice since they arrive late to the scenes of robbery and lack means for efficient intelligence gathering.

In order to deal with the highlighted problems, the authors have come up with the innovative solution of the Wireless

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Nomadic Bank Surveillance System.

This system is an integration of several modern embedded and communication technologies. The IP surveillance technology is used to remotely monitor the bank.

To provide location and time information anywhere on the earth, the Global Positioning System (GPS) is commonly used since it is a space-based global navigation satellite system. The location information provided by the GPS receiver can be visualized using the Google Earth. For wireless data transporting, Global System for Mobile Communication (GSM) and Short Message Service (SMS) technology is a common feature with all mobile network service providers.

Embedded systems that incorporate GPS and GSM modules have helped to guarantee intelligence and help man in solving most of his problems. These devices operate under the Machine-to-Machine (M2M) platform. M2M simply refers to the technology that enables the flow of data between machines and machines and ultimately machines and people [2]. Regardless of the type of machine or data, information usually flows in the same general way; from a machine over a network, and then through a gateway to a system where it can be reviewed and acted upon. These have been summarized into four basic stages namely Collection of data, Transmission of selected data through a communication network, Assessment of the data and Response to the available information.

Research works by various authors indicate the contributions and benefits of M2M technologies in diverse areas. Some of these include vehicle tracking [3-5], automatic accident alert and location [6-8], remote patient monitoring [9-10] and tracking kidnapped humans or employees [11-12].

The aim of this work therefore is to integrate the GPS, GSM and IP Surveillance technologies to design a nomadic system to aid security agencies in intelligence gathering and hence help in foiling bank robberies across the world.

2 OVERVIEW OF THE SYSTEM

The Wireless Nomadic Bank Surveillance System operates on the platform of three technologies namely the GPS, the GSM and the IP Surveillance. The system comprises of three units namely the asset tracking unit, the panic button unit and the IP surveillance unit.

The panic button system, placed beneath the cashiers counters is a Machine-to-Machine (M2M) application that uses the GSM technology as the communication network for data transmission. The circuitry of the panic button consists basically of a GSM module and a microcontroller. To control the operation of the GSM module in the panic button system, another GSM module system incorporated into the nomadic system via the serial port is used. This is done by the use of instructions known as AT commands in a HyperTerminal window. The microcontroller is therefore programmed to control messaging to and from the GSM module. These panic buttons are placed such that the cashier or banker can access them easily. On the occurrence of a bank robbery, when the button is pressed, the microcontroller will detect the action and send a signal to the GSM module which will forward an SMS message from the Nomadic system to the nearest already assigned police station and other security agencies for necessary action. The IP surveillance unit is used to remotely monitor the banking hall through covert surveillance IP cameras placed in the banking hall. These cameras allow the banking hall and other priority locations to be monitored remotely from the nomadic monitoring unit. The dummy cameras also play a significant role in this unit. These dummy cameras look just like real surveillance cameras and are very difficult to differentiate by a criminal or intruder. Dummy cameras, however are more effectively used to complement real cameras by making an area look to have more surveillance than it actually does.

For this system, the placement of dummy cameras helps to achieve two major goals. First, the fear of these cameras placed in strategic locations deters intruders who don't want to risk being caught on tape. This level of criminals are people who want to make a fast break to enrich themselves and most often target a limited amount of money especially from the cashiers. Secondly, in the case of more sophisticated robbers who usually attempt to have a higher target of money by breaking into the vault of the bank, their first action on gaining entrance into the banking hall is to disable all cameras. The deployment of dummy cameras therefore trick or fool these robbers into believing that they have disabled all the cameras whilst surveillance by covert cameras is still on-going with the nomadic monitoring unit. To serve as a redundancy to the panic button system in terms of broadcasting alert messages to concerned personnel and security agencies, a web application is developed using PHP, JavaScript and MySQL for managing the video feeds and forwarding SMS alert messages to specially assigned security agencies saved in the database in the case of a robbery.
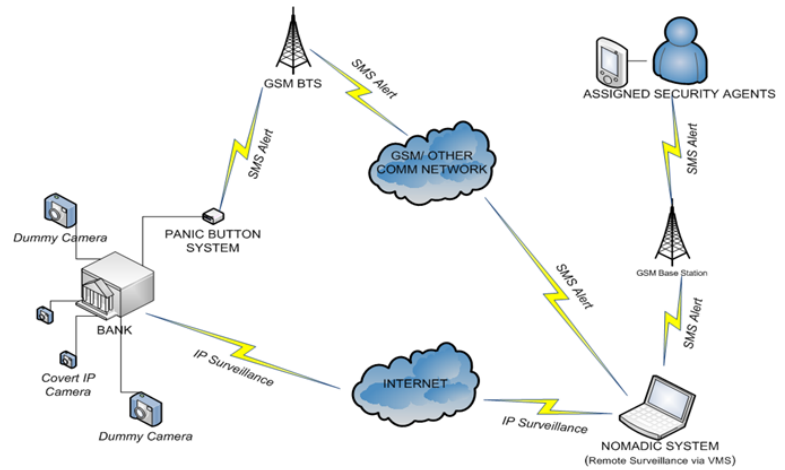

Fig. 1: Architectural diagram showing the operation of the Panic Button System and the IP Surveillance System

Furthermore, the asset tracking unit is an embedded system that is placed in certain packs of currency (money tracker) and bags (bag tracker). This minute unit with rechargeable low-power batteries is used for locating the whereabouts of the robbers after a robbery. The GPS receiver module interacts with the satellite in space and receives data i.e. location information in form of radio waves.
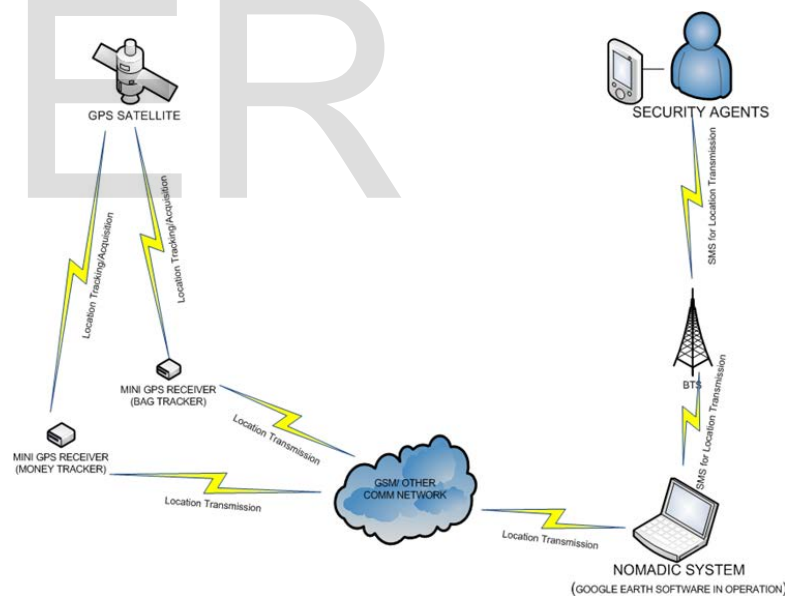
Figure 2: Architectural diagram of the Money/Bag Tracker

All of the three units are monitored by the Nomadic monitoring unit which is a mini computer system specially assembled for this purpose. The system is used to query the bag and money tracker for the present location. The Google earth software installed on the nomadic system is used to map the received National Marine Electronics Association (NMEA) format to the actual position. It also serve as a redundancy to the panic button system, a web application is developed using PHP, JavaScript and MySQL for managing the video feeds and forwarding SMS alert messages to specially assigned security agencies saved in the database in the case of a robbery.

3 HARDWARE SYSTEM DESIGN

The design of the hardware part of the system is presented in this section. The choice of components, the justification for such choice and the circuit design is also presented therein.

3.1 Power Source

Due to the desired minute form factor and the mobile nature of the system, a direct current voltage supply source is utilized. A Lithium Ion rechargeable battery of 3.3 – 5.0V is used in this circuit design due to its energy conserving power and efficiency. A charging circuit is built into the circuit so as to charge the battery when needed. To conserve the battery, the device is programmed to lie in a sleep mode until it is 'triggered' by a sent SMS.

3.2 Microcontroller

The microcontroller is the heart of the device. It is a single chip containing a microprocessor, memory (RAM and ROM), A/D converter, input/output ports, timers and serial ports. It is designed for embedded control applications and its prime function is to control a machine or system using a fixed program stored in the ROM of the system. The program does not change over the lifetime of the system.

PIC18F2520 is chosen because it is ideal for applications requiring cost-effective, low-power solutions with a robust peripheral set in a small package. It is an 8-bit Microcontroller that has 32 Kilobytes of Flash Program Memory (ROM), a RAM size of 1.5kB, 4 timers and 25 I/O lines. Its maximum CPU speed is 40 MHz with an operating voltage range of 2V to 5.5V [13].

Furthermore, the microcontroller which is at the core of the circuit and serves as the driver of the circuit needed to be programmed so that it can perform the function of controlling the behavior and actions of the GPS and GSM receivers. In-Circuit Serial Programming (ICSP), a method of directly programming PIC microcontrollers is used to program the microcontroller through a programmer. The program is written in assembly language. Figure 3 below represents the operational flow process of the programmed microcontroller.

The hardware interfaces for GPS units are designed to meet NMEA requirements. The NMEA protocol which is commonly used is NMEA0183 protocol. GPS sentences begin with the following specifications: $GPGGA, $GPGSA, $GPGSV, $GPRMC, $GPVTG, $GPMSS and $GPZDA. The choice for this work (and most commonly used) is the $GPRMC (acronym for Recommended Minimum Specific GPS/Transit data).

Fig. 3. Operational Flow Process of the Programmed Microcontroller

3.3 GPS/GSM Module

The hub of data communication in this system is carried out by wireless communication control terminals that use GSM modules for reliable data transfer with the support of instructions known as AT commands. The GPS receiver module interacts with the satellite in space and receives data i.e. location information in form of radio waves. The hardware inte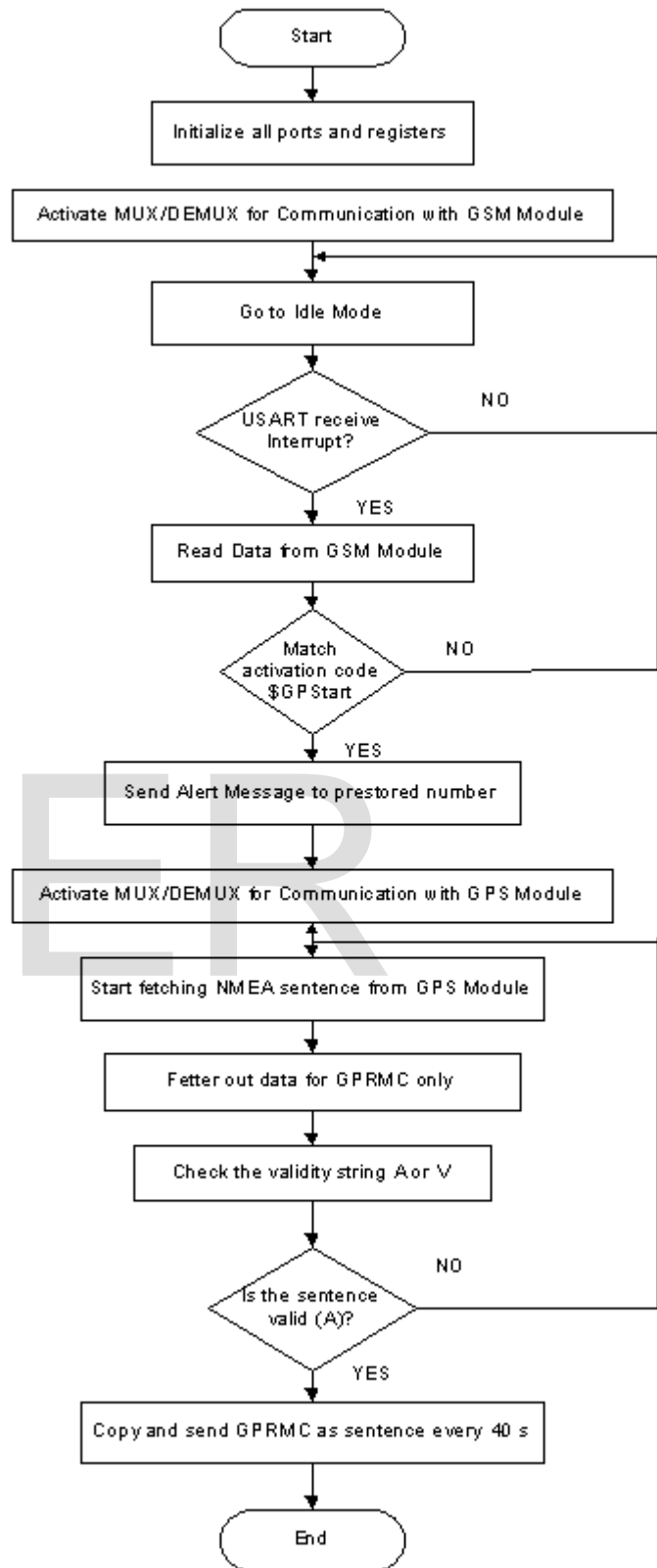rfaces for GPS units are designed to meet NMEA requirements. The NMEA protocol which is mostly used is NMEA 0183 protocol. This data is communicated to the GSM modem by the microcontroller. The GSM modem enables the transmission of the location data through the GSM network to pre-assigned authorized phone numbers and the nomadic system. Like the mobile phones, a GSM modem requires a SIM card from a wireless operator to enable it transfer data through the operator's network.

For this system, the SIM 908 is chosen because it is a hybrid of the GSM/GPRS/GPS modules. It also has a small package size of 30x30x3.2mm. This helps to reduce cost and saves extra PCB cost of the system. Also, with advanced, innovative design, it can reduce sleep mode power consumption, providing a power saving of up to 40% compared to current industry averages. SIM908 is integrated with high performance GSM/GPRS engine and an internal GPS engine. The GSM/GPRS engine is a quad-band GSM/GPRS module that works on GSM 850MHz, EGSM 900MHz, DCS 1800MHz and PCS 1900MHz frequencies [14].

3.4 THE 74HC138 De-Multiplexer

This device serves as an intermediary between the microcontroller, the GPS module and the GSM module. Considering the pin layout of the microcontroller, it has one transmit (TX) pin and one receive (RX) pin. TX is the port through which data is sent out to other devices while RX is the port or line through it receives data from other devices Nevertheless, there is need for the transmit (TX) pin to communicate with both the receive (RX) pins of the GPS and GSM modules. This device is therefore used to de-multiplex the serial output data into a multi-lined data transmitted from the USART pins of the Microcontroller Unit. The 74HC138 devices are designed to be used in high-performance memory-decoding or data-routing applications requiring very short propagation delay times. It is a 3-line to 8-Line Decoder/Multiplexer.

3.5 The 74HC151 Multiplexer

This device also serves as an intermediary between the microcontroller, the GPS module and the GSM module. The TX data line of both the GSM and GPS modules need to communicate with the RX data line of the microcontroller hence the need for a multiplexer.

4 HARDWARE IMPLEMENTATION

In our system, PROTEUS ISIS is used to create the circuit design and simulate it. Furthermore, PROTEUS ARES is used to create the PCB layout. The circuit design of the money tracker is shown in Fig 4, Fig. 5 shows the implemented money track-

er and Fig. 6 shows the Nomadic Monitoring Unit.
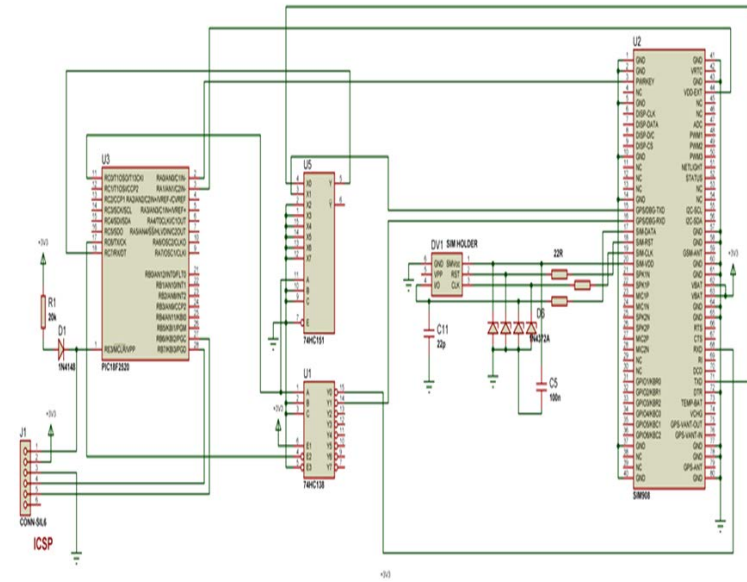
Fig. 4. Circuit diagram of the money tracker

Furthermore, the actual implementation of the money tracker was also achieved. The electronic components with functionalities already discussed in the section above are used to achieve this.

Fig. 5. Actual implementation of money circuit

Fig. 6. Assembling of Nomadic Monitoring Unit

5 SOFTWARE DESIGN AND IMPLEMENTATION

The software designed in this system has the sole purpose of interfacing the bank with security agencies. The occurrences in the banking hall are monitored remotely from video feeds from surveillance cameras placed in the bank from the Nomadic system and in the occurrences of any emergency, a bank robbery in this case, alert messages are sent to the closest security agencies as already stored in the database of the nomadic system. The architecture of a database backed web application usually varies depending on the desired functionality of the built web application. The Web database application built herein has a database structure as shown in the Fig.7 below.
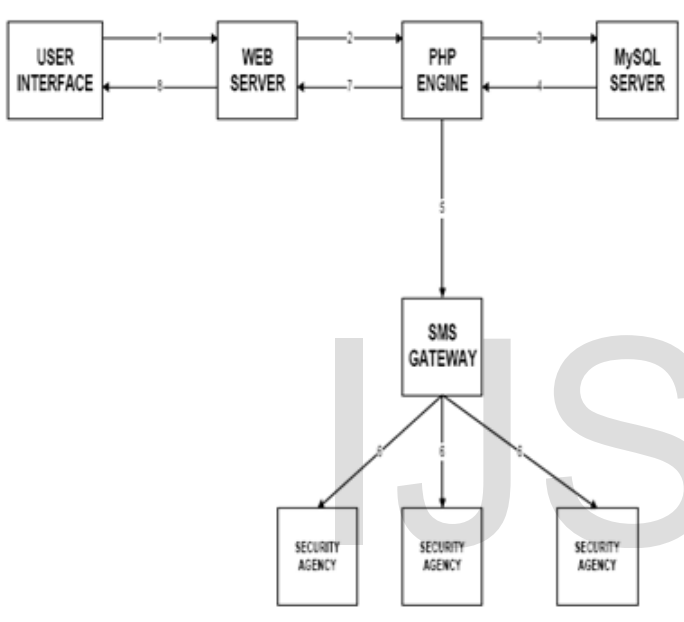
Fig. 7. The Web Application Architecture

The tools, applications and programming language used in designing this system include HTML, Cascade Style Sheet 3 (CSS3), Adobe Photoshop, Apache Web server, PHP5.2.5, MySQL 2.0 to house the backend database, SMS Gateway and Windows 7 operation system for development. The login is the first point of contact, where an existing user is granted access and any unrecognized user is denied access. After access has been granted to the user, there is an opportunity for users to add cameras, connect to cameras, manage mobile numbers, manage short messages and view the log of connected persons.

Fig. 8. Screenshots from Surveillance Software

6 RESULTS AND DISCUSSION

As already explained, the money tracker circuit is mostly in an idle mode in order to conserve the battery power. On the occurrence of an emergency, the money tracker is re-awakened by sending an SMS with '$GPStart' as the content to the Subscriber Identity Module (SIM) number of the GSM module. Thus, the GPS receiver on the money tracker begins to receive GPS co-ordinates of the present location from the GPS satellite. The GSM module on the same money tracker sends the co-ordinates to the GSM module on the nomadic system. In summary, while the microcontroller is the brain of the system and the GSM modem controlled by AT commands facilitates data transmission over GSM network while the GPS module provides the location date. The nomadic monitoring system consists basically of the GSM Modem, RS232 cable and the computer hardware. The GSM modem receives the message through GSM while the message is transferred to the computer through the serial port. The received GPS co-ordinates are presented in MS Hyper-Terminal as shown Fig. 9 below.

Fig. 9. GPS coordinates from HyperTerminal

Furthermore, the log of the received GPS coordinates is used to trace the path of travel of the money tracker circuit when in motion. This is done with the use of Franson GPSGate software; a web-based GPS tracking platform with functions such as GPS simulation and logging and connecting a GPS to Google Earth among others. This software installed on the nomadic monitoring system acquires the GPS coordinates reaching the GSM module interfaced with the receiver, logs it continually and connects dynamically with Google Earth to provide a trace of the path of the tracked item. During test, Figure 10 displays the path of travel on Google Earth.

Fig. 10. Illustration of path of travel of money tracker

7 CONCLUSION AND FUTURE WORKS

This research work has presented the utilization of an integration of cutting edge technologies to aid security agencies in gathering intelligence and hence afford them the opportunity to react swiftly to bank robberies. The nomadic nature of the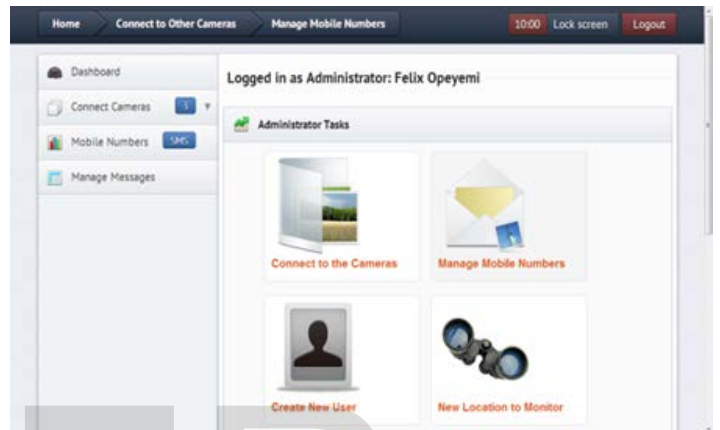 monitoring system inputs efficiency as it is independent of location hence giving it an edge over pre-existing systems. The system was deployed and tested in the local bank of Covenant University, Ota, Nigeria where this research work was carried out and the outcome was satisfactory. By testing the circuitry of the money tracker, it was discovered that the accurate location of the tracker and its path or line of travel could be monitored and relayed at any point in time to the Monitoring system.

Through the implementation of this system, the following milestones among others were achieved:

• The development of a money tracker, which can be embedded into a pack of currencies covertly for remote monitoring of the path of travel of the money and its present location in the occurrence of a theft.

• The development of a web-based software with the functionality of assigning the mobile phone numbers of concerned individuals and security personnel at strategic locations to certain banks; both already stored in the database for sending of notifications in case of an intrusion.

• The development of same Video Management Software with a capability of viewing an unlimited number of locations, irrespective of their locations and the manufacturer of the IP camera.

The directions for future work are wide, considering the comprehensive nature of the work. In this work, the nomadic monitoring system is used to monitor the location of the money tracker and such information is then transmitted to the security operatives. Efficiency can be guaranteed by ensuring that the security agencies can remotely login into the nomadic system and monitor real-time the location of the asset tracker.

ACKNOWLEDGMENT

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