Client Identification Model for GPS-based On-demand Real-Time Video Surveillance Security System

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Abstract
Due to continued increase in crime rate, the security of life, property and infrastructure has been an issue of national concern over the years and increasingly so all over the world. This paper presents a method of identifying clients that request for real-time surveillance security service activated by SMS or phone call in event of invasion or suspected robbery attack. Recognition of DTMF (Dual Tone Multi Frequency) tones produced by the buttons pushed on client's telephone keypads was done using Goertzel algorithm which is a digital processing technique that provides a means for efficient evaluation of individual terms of the Discrete Fourier Transform (DFT).The proposed GPS-based Real-time Security System (GRSS) is proposed to offer on-demand video capture using indoor cameras and outdoor surveillance cameras, transmit the data wirelessly to a remote data centre for monitoring via IP (Internet Protocol) technology. The Master control station should be able to receive a Save Our Soul (SOS) alert from a subscriber either by GSM (Global System for Mobile communications) call or SMS (Short Message Service), determine the sub control station in charge of the client's zone and transfer control to it. The station in charge should now pinpoint the client's location using Global Positioning System (GPS) based location data stored in the database, and trigger relevant components for surveillance action over the area. The system features a flexible and scalable remote automated client identification system for the proposed on-demand GPS based real-time security service system.

Keywords; real-time, surveillance security, on-demand, Goertzel algorithm, DTMF, GSM

1.0 Introduction

Criminal activities have tremendously increased especially at places of high national security all over the world. There is also increased threat from armed robbers and hoodlums who invade locations of both public and private interest even in broad daylight and at night. Security consciousness has consequently risen among all the nations especially since after the tragic incidence of September 11, 2001 attacks on the world trade centre in the New York City during which 2996 deaths were recorded[5], with about 6000 injured. And more so in such places as Nigeria where Boko Haram terrorism and kidnapping have been the talk of the decade. These incidents of crime often occur without anybody being able to trace who did it and how. This state of insecurity has led to individuals and corporate bodies apportioning huge sums of money in procurement of security apparatus. Consequently, there arose the need to identify who demands security service at any point in time for instant surveillance action.

2.0 System Description

The security system presented in this work is based on GSM, GPS and telecommunication infrastructure technologies. It utilizes an indoor mini dome digital camera model AS-IR1013D and an outdoor camera AS-IR2001-S420L with network DVR (Digital Video Recorder). Clients subscription database was designed and stored in the non-volatile RAM (NVR) of PIC microcontroller coupled with external storage typically MicroSD card device that easily interfaces with microcontroller unit via serial port interface (SPI). Microchip PIC microcontroller can interface seamlessly with microSD card. The read and write functions to the micro SD card through bit-bang method implemented in C language, coupled with the large memory in micro-scale structure makes the SD card a definite choice in large data management system involving 8bit chip processing. The system offers a form on-demand Video Surveillance as a Service (VSaaS) whereby subscribers to the system are offered real-time surveillance video coverage according to their request Each subscriber's geo-referenced location data was obtained with the aid of GPS and stored in the system database. However, the focus of this paper is to

instantly identify and authenticate WHO needs the surveillance security service.

2.1 Method

The clients send request for service either by phone call or by SMS. Requests by phone call are identified and authenticated using a DTMF detection technique, typically Goertzel algorithm, and AT-commands as the case may be, while request by SMS are handled using pure AT-commands.

Request by Phone call is made using valid registered phone number (known) or by using any other phone number (unknown) with client's identity number as suffix. If a request is made without specifying the duration or class of service, the default duration of 30minutes is rendered.

2.2 Phone call using valid registered phone number (known)

If a subscriber calls from any location at all using valid registered phone number (known), the controller detects the caller by the phone number using Goertzel algorithm (while comparing   the calling number with the database storage), and the request for service duration using AT commands. If the number is found in the database, surveillance service is activated, otherwise it waits for about 15 seconds for special client's identity number to be entered on the keypad, after which the system cuts off the call if no identity number is received from the caller. At any point in time, the system lies in wait to receive either phone call or SMS from clients

2.2.1 AT Commands basics

AT commands are instructions used to control a modem. AT is the abbreviation of ATtention. Every command line starts with "AT" or "at". Modem commands are therefore called AT commands. There are two types of AT commands:

1. Basic commands are AT commands that do not start with a "+". For example, D (Dial), A (Answer), H (Hook control), and O (Return to online data state) are the basic commands.
2. Extended commands are AT commands that start with a "+". All GSM AT commands are extended commands. For example, +CMGS (Send SMS message), +CMGL (List SMS messages), and +CMGR (Read SMS messages) are extended commands.

To terminate a command line enter <CR>. Commands are usually followed by a response that includes."<CR><LF><response><CR><LF>" . Sometimes, only the responses are presented, <CR><LF> are omitted intentionally.

2.5 SMS blank using registered known phone number

A blank SMS from a registered client's line is identified by the sender's phone number. The blank SMS is interpreted using

In application, controlling device controls the GSM engine by sending AT Command via its serial

interface. The controlling device at the other end of the serial line is referred to as following term:

TE (Terminal Equipment);

DTE (Data Terminal Equipment) or plainly "the application" which is running on an embedded system.

There are two modes in which a GSM/GPRS modem or mobile phone can operate. They are called SMS text mode and SMS PDU mode. (PDU stands for Protocol Data Unit.) The mode that a GSM/GPRS modem or mobile phone is operating in determines the syntax of some SMS AT commands and the format of the responses returned after execution.

For the purpose of this project, SMS in text mode was used because of its simplicity which enables one to   represent SMS messages as readable text   instead of PDU (protocol description unit) mode where SMS messages are represented as binary strings encoded in hexadecimal characters

2.3 Phone call with another phone number (unknown)

When a client/subscriber calls with another phone number (unknown), he does so along with the client id number such as *xxx* as suffix, followed by service request class which determines the duration of coverage, where xxx represents a three –digit number which corresponds to clients subscription number in the database.   For example, if the number, *100*101A08064515115 is received at the control station, it is interpreted as follows; *100* represents the caller id number, 101A stands for the request class, while the rest of the digits points to the phone number used by the caller. The subscribers location data is obtained from the database as directed by the first three digits bordered by the asterisks as they serve as location pointers. The microcontroller detects the DTMF signals of the pressed keys from the caller using Goertzel algorithm, and the id number, with class of service (if any) using AT commands. If the client id is recognised and accepted, it gives a feed back tone to the caller indicating activation of the caller.

2.4 SMS containing client id number and duration of recording.

All SMS sending and receiving was   done in SMS text mode. SMS received from subscribers are identified by the id number which points to the phone number and hence the location. The id number enables the subscriber to be identified even if he uses an unregistered line. The AT command set is typically applied   to handle this service. The duration of service indication is used to know for how long the surveillance video recording should be made.

AT commands and a default duration of 30 minutes is used to render the service.

The client's location is equipped with servomotor, 18f4520 microcontroller, GSM module, indoor and outdoor cameras,

DVR, VSAT (Very Small Aperture Terminal) facilities including modem and router. The block diagram of client end connections is as shown in fig.1.
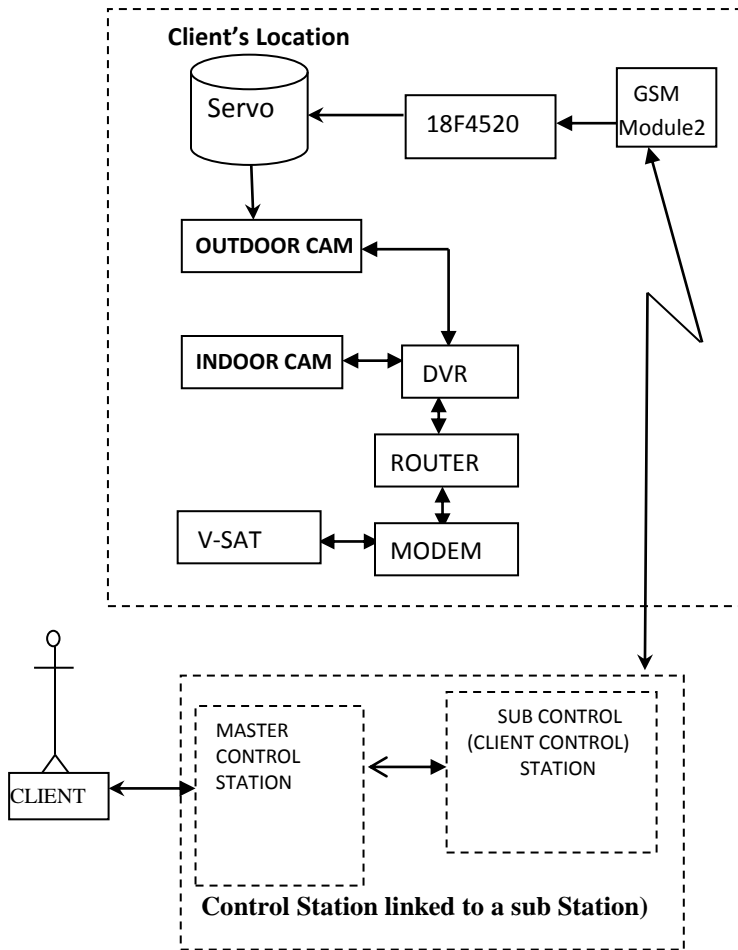

Fig. 1: block diagram view of the client location with respect to the control stations in the system.

The signal sent by the client gets to the master control station which has the database of all the clients (subscribers) and
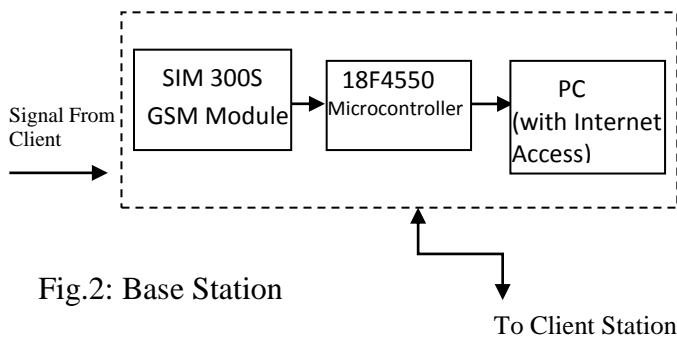
determines the sub control station in charge of the subscriber's zone. The sub control station takes over the charge to initiate surveillance action over the client's location. This paper however, focuses on the model for identification of clients with a view to proffer response to surveillance service request by subscribers in real-time. The research work is ongoing and is being implemented using two SIM300S GSM modules, one at the client's location, and the other at the base station i.e a base station wirelessly linked directly to a client station.

3.0   GSM Modules

A GSM modem is a wireless modem that works with a GSM wireless network. GSM stands for Global System for Mobile communications, this architecture is used for mobile communication in most of the countries in the world.

A wireless modem acts basically like the traditional dial-up modem, the main difference is that a dial-up modem sends and receives data through a fixed telephone line while a wireless modem sends and receives data through radio waves. Besides the dial-up connection, GSM modem can also be used for sending and receiving SMS which is also one of the key features of GSM modem. Some modems are GSM/GPRS modems, these modems additionally support the GPRS technology for data transmission. GPRS stands for General Packet Radio Service. It is a packet-switched technology that is an extension of GSM. A key advantage of GPRS over GSM is that GPRS has a higher data transmission speed. The operation of a GSM modem requires a SIM (Subscriber Identity Module) card just like mobile phones to identify a subscriber to the cellular network and to store the subscriber information. Also they have IMEI (International Mobile Equipment Identity) number similar to mobile phones for their identification.

GSM module such as SIM 300S (fig. 3) can accept any GSM network operator SIMM (Single Inline Memory Module) card and act just like a mobile phone with its own unique phone number. The advantage of this module is that its RS232 port can be used to communicate and develop embedded applications such as SMS control, data transfer, remote control and logging.

Fig.2: Base Station

Fig. 3:   SIM 300S GSM Module

3.1   GSM Interfacing with PIC microcontroller

When a client calls the control station, the call is received by the GSM module at the control station which is interfaced to PIC18F4550. GSM modems' serial interface makes it very easy to interface a GSM Modem to a PIC Microcontroller. The USART (Universal Synchronous/Asynchronous Receiver/Transmitter) serial input pin R_X and T_X of the microcontroller are connected to the T_XD and R_XD pins of the GSM Modem as shown in fig.4.
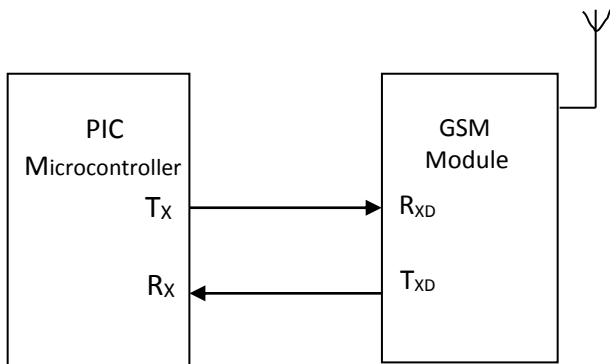

Fig. 4: PIC microcontroller connection to GSM module

The modem can optionally be connected directly to PC serial port. It can be used to   send and receive SMS or make/receive voice calls. It can also be used in GPRS mode to connect to the internet and do many applications for data logging and control. In GPRS mode, you can also connect to any remote FTP server and upload files for data logging.   The modem is a highly flexible   plug and play quad band GSM modem for direct and easy integration to RS232 applications.

DTMF signal encoding and then decoding techniques were applied. DTMF tones can be decoded and converted to digital signals which can then be used by a microprocessor to determine if an appropriate series of digits was entered by the user. If the correct code is entered, the microprocessor activates one of the subsystems. Multiple codes or one code with an options menu can be used to activate the appropriate

subsystem. The Goertzel algorithm was typically applied in the DTMF decoding.

3.2   Simple GSM Module Connectivity Test Using Hyper Terminal

- First of all, proper understanding of the AT Command set required to communicate with the SIMM300 modem was made..
- The modem was connected to the computer according to the setup guide specified in the manual provided with the GSM modem.
- A valid SIM card was inserted into the GSM/GPRS modem.
- GSM/GPRS modem was connected to a computer, and the corresponding wireless modem driver setup was made.
- MS HyperTerminal was run.
- In the Connection Description dialog box, a name and an icon was chosen for the connection, then OK button clicked.
- COM1 port that   GSM/GPRS modem is connecting to in the *Connect using* combo box , and the correct port settings was selected with OK button clicked.
- On typing   "AT" in the main window. A response "OK" was   returned from the   GSM/GPRS modem indicating that the GSM/GPRS modem was connected successfully.

4.0   DTMF SIGNALLING

A DTMF tone consists of two superimposed sinusoidal signals selected from two frequency groups. The frequency groups represent rows and columns on a touch tone keypad as shown in Figure 5. Each DTMF tone must contain one sinusoid from the high-frequency group (1209, 1336, 1477 and 1633 Hz) and one sinusoid from the low frequency group (697, 770, 852 and 941 Hz). This allows a touch tone keypad to have up to 16 unique keys.

Fig.5: frequency groups of DTMF

4.1 Generation of   DTMF Signal

Dual tone generation can be done with 2 sine wave sources connected in parallel. However,

Different methods can be used for such implementation which include; Polynomial approximation, Look-up table and Recursive oscillator. DTMF signal must meet certain duration and spacing requirements such as; 10 Digits are sent per second, Sampling is done via a codec at 8KHz and each tone duration must be at least 40ms, and a spacing of 50ms minimum between two digits is required. Tone generation of a DTMF is generally based on two programmable, second order digital sinusoidal oscillators, one for the low frequency f_l the other one for the high frequency f_h tone. Two oscillators instead of eight reduce the code size. Coefficient and initial conditions are set for each particular oscillation

4.2   Recognition of DTMF Signals
Like DFT, the **Goertzel algorithm** analyses one selectable frequency component from a discrete signal. Unlike direct Discrete Fourier Transform (DFT) calculations, the Goertzel algorithm applies a single real-valued coefficient at each iteration , using real-valued input sequences. For covering a full spectrum, the algorithm has a higher order of complexity than Fast Fourier Transform (FFT) algorithms.   The simple structure of the Goertzel algorithm makes it well suited to small processors and embedded applications, though not limited to these. In reverse order, the algorithm can also be used as a sinusoid synthesis function, which requires only a single multiplication and a single subtraction per generated sample.

4.3   The Goertzel Algorithm
Goertzel algorithm (first described by Gerald Goertzel in 1958) is a Digital Signal Processing (DSP) technique that provides a means for efficient evaluation of individual terms of the Discrete Fourier Transform (DFT). It is just a recursive way to evaluate a DFT at a single frequency. Like the DFT, the Goertzel algorithm analyses one   selectable frequency component from a discrete signal [7][8]. It is more efficient than the Fast Fourier Transform in computing an N-point DFT if less than $2\log_2 N$ DFT coefficients are required [4]. The major computation in Goertzel   algorithm has the form of a digital Infinite Impulse   Response (IIR) filter. Actual application of the algorithm demands that some preliminary calculations must be done which requires the following;
-    Decision on the sampling rate
-    Choice of the block size N
-    Pre-computation of one cosine term and one sine term
-    Pre-computation of one coefficient.

The sampling rate is chosen (applying Nyquist rules) such that it is at least twice the frequency of interest. The block size controls the frequency resolution (bin width) according to the relationship;

Resolution =   Sampling Rate/Block Size N.

In DTMF detection, we need only 8 of, for example, 205 DFT coefficients to detect the first harmonics of the 8 possible tones, and then apply decision logic to choose the strongest touch tone.

Since DTMF signals do not have second harmonics, we could compute another 8 DFT coefficients to compute the second harmonics to detect the presence of speech [2]. DFT's bin frequencies are arithmetically spaced while DTMF's frequencies are geometrically spaced. The number 205 was chosen to place the DTMF frequencies near the centers of DFT's bins at a sampling rate of 8KHz.

The pre-computed constants needed during the processing are given as follows;

$$k = (int)\left\{ 0.5 + \frac{N * \text{Target}_{\text{Frequency}}}{\text{Sample}_{\text{Rate}}} \right\} \qquad (1)$$

$$w = \frac{2\Pi k}{N} \qquad (2)$$

The following relationships also hold;
cosine = cosw
sine = sinw
coeff = 2cosw

Let us denote three variables needed for the per sample processing as Q_0, Q_1 and Q_2, where
Q_1 =previous value of Q_0,
Q_2= previous value of Q_1
Q_1 and Q_2 must be initialized to zero at the beginning of each block of samples, and for each sample, the following three equations are run;
Q_0 = coeff * Q_1 – Q_2 + sample
Q_2 = Q_1
Q_1 = Q_0
After running the per-sample equations N times, the presence of the tone is detected.

Real = (Q_1-Q_2 * cosine)
Imaginary = (Q_2 * sine)
Magnitude^2 = real^2 + imaginary^2
A simple threshold test of the magnitude reveals the presence or absence of the tone. The next block then starts all over again, resetting Q_2 and Q_1 to zero.

In order to receive DTMF signals with a Microcontroller without the use of costly special components, signals which are received need to be processed with an Analog-to-Digital Converter (ADC), and recognized with a digital filtering algorithm. Connection of microcontroller to analog systems is usually made easy because of the built-in ADC. The project uses PIC18F4520 microcontroller at the client station and PIC18F4550 at the base or control station and applies Goertzel algorithm to detect DTMF frequencies with source code written entirely in C language.

5.0   Client Subscription
Relevant data of possible subscribers were gathered in a database (table 2) stored in the base station microcontroller memory with microSD interface for additional memory space. Subscribers are intended to be billed according to the service

request class which will be dealt with in the proposed client service model.

Table 2: **Client Subscription Database**

Client_Nm	Phone_No	ID_No	Area_Code	Long.	Lat.	Cam_No
Mdona_Hsp	07056419866	001	001	7316695	6273112	CAM1
First_Ave	07034213222	002	001	7296970	6287485	CAM2
Shprite_En	08145667191	003	001	7297492	6275486	CAM3
Army_Bar	08023421780	004	001	7306470	6276981	CAM4
Nline_Com	08064515115	005	001	7326980	6274557	CAM5
NwokoloB	08033224496	006	001	7313778	6271824	CAM6

5.1 Application Areas

The application areas include but are not limited to the following;

- **Remote Controlling System:** A mobile phone can be used to send an SMS to switch ON/OFF remote devices. You could control your entire home devices, switching ON/OFF lights, fans, pool motor, garage motor and so on with just a simple SMS from a distance.

- **Remote System Monitoring:** In a remote system monitoring application, a microcontroller for example could be used to constantly monitor the status of a remote sensors, let say temperature or moisture sensors. If a certain condition is reached, the program will send an SMS to notify the situation, if these sensors are installed in a farm for example, the farmer could be notified of any situation happening in the farm about heat, moisture, drought, etc.

- **Home Alarm System:** When a motion sensor detects a movement of an intruder, an SMS will be sent to a predefined number which could be you or your security reaction company and a siren or any other sound device could be triggered in the process as well.

- **Security Access Control:** A security access can be implemented at apartments or housing complexes. A security guard could inform by intercom a resident if he/she has a visitor at the main gate. with a replied SMS, the resident could open remotely the gate for his/her visitor.

- **Vehicle tracking:** A GSM/GPRS module together with a GPS module can be used to create a real time vehicle tracking device. An SMS could also be sent to notify that the car has entered a restricted area, notify about the level of remaining fuel in the car etc. If the vehicle is stolen not only the system can indicate the location of the vehicle but an SMS could also be sent to switch OFF the engine.

- **Pre-paid Electricity:** The customer can recharge pre-paid electricity by sending an SMS with a recharge coupon to a pre-paid electricity recharge server.

5.2 Surveillance video security system in crime prevention, deterrence and   investigation

A number of factors must come together for a crime to occur. These include:

1. an individual or group must have the **desire** or motivation to participate in a banned or prohibited behavior,
2. at least some of the participants must have the **skills** and tools needed to commit the crime; and,
3. an **opportunity** must be acted upon.

Primary prevention addresses individual and family level factors correlated with later criminal participation. Individual level factors such as attachment to school and involvement in pro-social activities decrease the probability of criminal involvement. Family level factors such as consistent parenting skills similarly reduce individual level risk. Risk factors are additive in nature. The greater the number of risk factors present the greater the risk of criminal involvement. In addition there are initiatives which seek to alter rates of crime at the community or aggregate level. For example, Larry Sherman from the University of Maryland in Policing Domestic Violence (1993) demonstrated that changing the policy of police response to domestic violence calls altered the probability of subsequent violence. Policing hot spots, areas of known criminal activity, decreases the number of criminal events reported to the police in those areas. Other initiatives include community policing efforts to capture known criminals.

Secondary prevention uses techniques focusing on at risk situations such as youth who are dropping out of school or getting involved in gangs. It targets social programs and law enforcement at neighborhoods where crime rates are high.

Tertiary prevention is used after a crime has occurred in order to prevent successive incidents. Such measures can be seen in the implementation of new security policies following acts of terrorism such the September 11, 2001 attacks.

Situational crime prevention uses techniques focusing on reducing on the opportunity to commit a crime. Some of techniques include increasing the difficulty of crime, increasing the risk of crime, and reducing the rewards of crime [6].

6.0   Conclusion

Security concerns have been with man from creation and the problem of insecurity continues to change in forms and levels as long as technology influences social activities and environmental design. This calls for consequent evolution and change in techniques to tackle insecurity problems. The identification and authentication model as it applies to real-time surveillance video security system discussed in this paper is a state-of-the-art system designed to suit-on-the fly demands of subscribers to deter robbery from places of interest and inculcate sense of security in them. For crime event that has already occurred, video evidence provided by the system is of great use in forensic investigation. The scalable nature of the system design makes it possible to add or remove locations without difficulty as the need arises. The automated nature of the system also makes it possible to be used in other service

delivery scenarios.   The surveillance video security system has come to serve as "eyes on the street" in an automated fashion and on 24/7 basis since human eyes cannot be on the street in time of sleep and is a worthy aid in crime prevention, deterrence and investigation.

6.1   Recommendations

The cost of loss of lives and property including various levels of infrastructural damage due to criminal activities are not comparable to the cost of procurement and security apparatus. There is therefore   need to enforce centralized surveillance video security system in every state of every country such that every activity by individuals and/or groups is fully monitored, especially in places of high incidence of terrorist attacks. This will enable the governments to form a network of surveillance video monitoring system that could be linked globally to combat crime by serving as a means to prevent or deter crime and aid in crime investigation for forensic purposes. The project can equally be viewed as a universal process automation system in which surveillance security service hereby implemented can be seen as mere transducer in that it could be modified to render any other service for various purposes.

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