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DESIGN OF A GPS/GSM BASED TRACKER FOR THE LOCATION OF STOLEN ITEMS AND KIDNAPPED OR MISSING PERSONS IN NIGERIA

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ABSTRACT

The high rate of kidnapping in Nigeria is fueled by the inability of security agencies to quickly identify the location of the kidnapped persons. This system combines the position location capabilities of the GPS (Global Positioning System) to identify the current location of the kidnapped person or stolen items. These coordinates are time stamped, accessed by the microcontroller and sent to predetermined mobile phones via the GSM network. The GPS readings are accessed at short regular intervals but only the latest five readings are stored per time and these five readings are transmitted on demand by the GSM modem under the control of the Microcontroller upon the receipt of a location request SMS. The system monitors the GSM signal strength as the tracked object or person moves and when the GSM received signal strength falls below a predetermined threshold value, an alert together with the last five location data is sent to the monitoring mobile phones and the control center notifying them that the tracked object is approaching an area without GSM coverage. The system is designed to be permanently on and it is run on batteries that can last for very long periods before requiring a recharge. The unit is designed to be attached to the clothing or strapped on the tracked person in such a way that it can not be easily identified or removed. It also has a panic button which can be activated during an emergency to send the location data to the predetermined numbers.

Keywords: GPS, GSM, kidnapping, microcontroller, SMS.

1. INTRODUCTION

The high rate of kidnapping of persons and theft of vehicles coupled with the low rate of recovery of both the kidnapped persons and the stolen vehicles is such that there is now a need for the use of technology based location finders with high precision and very high response time in the recovery of the stolen vehicles and/or the kidnapped persons. This will reduce the occurrence of kidnapping by discouraging kidnappers and car snatchers.

The tracking system currently deployed in the country utilizes the GSM system to locate the tracked object. The limitation of this system is that the GSM technology can only identify the BTS and the sector antenna under whose coverage the tracked object is located and this operation requires the services of the mobile operator whose network is used to carry the tracking information for the information to be accessed [1, 2, 3]. This system has a low response time and the location coordinates are not specific. This method may not be very effective in cases of kidnap where time is of the essence.

The system proposed in this work, utilizes the GPS module for determination of the exact location of either kidnapped persons or stolen vehicles. The location data is transmitted through the GSM network either on demand or at specified intervals. The system also incorporates a signal strength monitoring algorithm which monitors the signal strength of the BTS as the device moves within the geographical area. When the signal gets below a given threshold, the microcontroller sends the last five locations coordinates and an alert message to the control center informing the control center manager that the tracker is going out of coverage area.

The control center can be implemented with a GSM modem and a computer system configuration or a mobile phone. The use of the mobile phone enables the control center manager to communicate with the tracker at will and allows the manager to monitor the tracker from any remote location.

2. PROPOSED SYSTEM ARCHITECTURE

The block diagram of the proposed system is shown in Figure-1. From this diagram, the system comprises of four major components. The GPS module is used for determining the location data while the memory is used to store a preloaded data comprising of the GPS locations of the city and the actual names of the different locations. The microcontroller is the brain of the system. It accesses the memory location data from the GPS module and compares them with data stored in the memory. It then sends the names of the five consecutive locations to a predefined phone number and to the control center. In the event that the tracked object is out of the range of the GPS locations stored in the memory, the microcontroller will send the GPS coordinates alone. The GSM modem enables the transmission of the location data through the GSM network to both the authorized phone number of the control center manager and the database of the control center. The control center has an extensive database of the GPS coordinates and a higher resolution of the GPS data. The computer system at the control center also has location identification software that enables the determination of the actual location of the tracked object.

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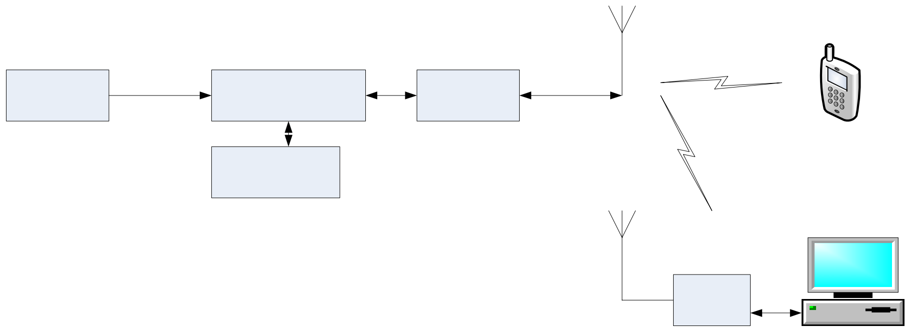

Figure-1. Block diagram of the proposed system.

An overview of the technology supporting the different modules is presented in the following subsections.

2.1 GPS system

The GPS system is based on 24 satellites located in six orbital planes at a height of 20,200 km and they circle the earth every 12 hours. Each plane is inclined at 55° to the earth's equator and contains 4 satellites each. The GPS system was developed and is operated by the United States government. With an unobstructed and clear view of the sky, GPS works anywhere in the world, 24 hours a day, and seven days a week. [4, 5, 6, 7]. Each satellite transmits two signals: L1 (1575.42 MHz) and L2 (1227.60 MHz). The L1 signal is modulated with two pseudo-random noise signals - the protected (P) code, and the course/acquisition (C/A) code. The L2 signal only carries the P code while civilian navigation receivers only use the C/A code on the L1 frequency. Each signal from each satellite contains a repeating message, indicating the position and orbital parameters of itself and the other satellites (almanac), a bill of health for the satellites (health bit), and the precise atomic time.

The receiver measures the time required for the signal to travel from the satellite to the receiver, by knowing the time that the signal left the satellite, and observing the time it receives the signal, based on its internal clock. If the receiver had a perfect clock, exactly in sync with those on the satellites, three measurements, from three satellites, would be sufficient to determine position in three dimensions via triangulation. However, that is not the case, so a fourth satellite is needed to resolve the receiver clock error. With four satellites, a GPS receiver can provide very accurate clock (time, date) and position information (latitude, longitude, altitude, speed, travel direction/heading) [8].

GPS signals work in the microwave radio band. They can pass through glass, but are absorbed by water molecules (wood, heavy foliage) and reflect off concrete, steel, and rock. This means that GPS units have trouble operating in rain forests, urban jungles, deep canyons, inside automobiles and boats, and in heavy snowfall - among other things. These environmental obstacles degrade positional accuracy or make it impossible to get a fix on the GPS location [8].

The location data generated by the GPS modules are presented as a string of ASCII characters each preceded by a header. The most common format is the NMEA0183 (National Marine Electronics Association) format [9] developed for data communications between marine instruments. The data is transmitted as a 4800bps string of 8-bit ASCII character thus; any microcontroller with a serial port can extract data from a GPS module. However some receivers also have proprietary data formats and such proprietary formats are not covered by the NMEA standard.

A typical NMEA GPS data format and an example are listed as follows.

GLL - Latitude and Longitude, with Time of Position Fix and Status

Latitude and longitude of current position, time, and status.

Format:

$GPGLL, <1>, <2>, <3>, <4>, <5>, <6>, <7>*<8><CR><LF>

Example:

$GPGLL, 2447.2073, N, 12100.5022, E, 104548.04, A, A*65<CR><LF>

The description of the data content of each field is shown in Table-1.

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Table-1. GPS data format and field descriptions [8].

Field	Example	Description
1	2447.2073	Latitude in ddmm.mmm format. Leading Zeros transmitted
2	N	Latitude Hemisphere indicator, 'N' = North. 'S'= South
3	12100.5022	Longitude in ddmm.mmm format. Leading Zeros transmitted
4	E	Longitude hemisphere indicator, 'E' = East, 'W'=West
5	104548.04	UTC time in hhmmss.ss format. 000000.00~ 235959.99
6	A	Status, 'A' = valid position, 'V'= navigation receiver warning
7	A	Mode indicator 'N'= Data Invalid 'A'= Autonomous 'D'= Differential 'E'= Estimated
8	65	Checksum

Programs are then written to extract the desired information such as time, date, latitude, longitude, speed, and altitude from the data strings [10]. The GPS locations can be graphically displayed by entering the decimal coordinates in the "Search" field of the Google maps package (in map, satellite, or hybrid view) [11].

The GPS visualizer is a free online utility that can be used to graphically display a track or series of waypoints, and create maps and profiles from GPS data. GPS Visualizer can read data files from many different sources, including raw NMEA strings or tab-delimited or comma-separated text of relevant GPS data [12].

The GPS module used in this design is the Parallax GPS module. It provides current time, date, latitude, longitude, altitude, speed, and travel direction/heading, among other data, and can be used in a wide variety of commercial applications, including navigation, tracking systems, mapping, fleet management, auto-pilot, and robotics. [8]

Module highlights

- Fully-integrated, low-cost GPS receiver module with on-board, passive patch antenna
- Single-wire, 4800 baud Serial TTL interface to BASIC Stamp®, SX, Propeller, and other processors
- Provides either raw NMEA0183 strings or specific data requested via the command interface
- Requires single +5VDC supply @ 115mA (typical)
- 0.100" pin spacing for easy prototyping and integration.

The GPS Receiver Module can be integrated into any design using a minimum of three connections. The circuit in Figure-2 is used for connecting the GPS Receiver Module to the BASIC Stamp microcontroller: The Parallax GPS module is shown in Figure-2.

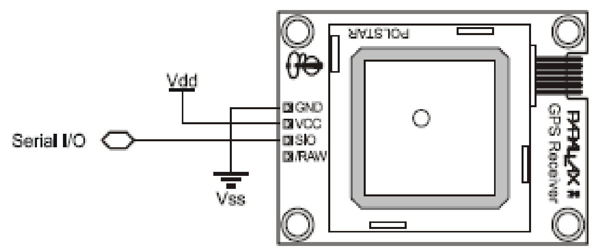

Figure-2. Parallax GPS module [8].

The GPS Module is configured as a data pusher in that it sends the position data of the tracked object through a GSM Network. This transmission is facilitated by the use of a GSM Modem and a microcontroller as shown in Figure-1. The module stores the location data and sends it at predetermined intervals. It can also send the data on receipt of an interrupt signal or the activation of the panic button.

2.2 Microcontroller

The Microcontroller is a single chip containing a microprocessor, memory (RAM and ROM), input /output ports, timers and serial ports and it is designed for embedded control applications. The prime use of a microcontroller is the control of a machine or system using a fixed program stored in the ROM and this program does not change over the life time of the system.

The chip used in this design belongs to the Intel 8051 micro controller family. The core of the 8051's slot CPU is made up of 8 bit Registers, 4 Kilobytes of ROM, 128 bytes of RAM, 2 Timers 32 I/O Pins, 1 Serial Port. The Intel 8051 Microcontroller can also access external memory and this is particularly useful because the GPS coordinates will be stored in the memory on the tracker. The 8051 family of microcontrollers can address 64K of external data memory and 64K of external program memory. These may be separate blocks of memory, so that

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up to 128K of memory can be attached to the microcontroller. The 8051 has two separate read signals, RD# (P3.7) and PSEN#. The first is activated when a byte is to be read from external data memory, the other, from external program memory. Both of these signals are so-called active low signals. That is, they are cleared to logic level 0 when activated. All external code is fetched from external program memory [13]. The Program that controls the overall system is loaded onto the external memory chip.

2.3 GSM modem

A GSM Modem is a wireless modem that works with a GSM wireless network to transfer data. It can be an external device or a PC card. External GSM Modems are connected to the PC through a serial cable or a USB cable. Like the GSM Phones, a GSM modem requires a SIM card from a wireless operator to enable it transfer data through the operators' network. GSM modems are controlled by a special set of commands known as AT commands [14]. With these commands the GSM Modem can be used to:
Read, write and delete SMS messages.

Send SMS messages.
Monitor signal strength.
Reading, writing and searching phone book entries.

A GSM modem has a limitation of accessing 6 to 10 SMS per minute. To increase this capacity, a GPRS modem is required. The GPRS modem supports GPRS technology for data transmission and it has a higher data rate than the GSM with a capacity of handling up to 30 SMS per minute. The GPRS modem also has the capability of handling MMS messages [15].

The system diagram in Figure-1 shows the memory linked to the microcontroller. The GPS coordinates are mapped to the different locations and stored in the memory chip. The flow chart of the microcontroller program is listed in Figure-4.

2.4 Interrupts

The interrupt mechanism provides a way of having the microcontroller respond to events as they occur. The interrupt calls the attention of the microcontroller to an event that requires an action or device that needs servicing. After responding to or ignoring the interrupt, the CPU resumes processing where it left off. The system is designed to respond to two interrupts. The interrupts are:

2.4.1 Location request interrupt

The Location Request SMS is an SMS originated by the authorized mobile phone requesting the tracker to send its latest set of location data. The content of the SMS is location request. The interrupt is activated by the receipt of a location Request SMS by the tracker system from an authorized number. This SMS causes the microcontroller to transfer the site names of the 5 GPS locations as stored in the memory. This will enable the determination of the possible trajectory of the tracked object/ person and the current location. The flow chart for the location request interrupt is shown in Figure-5.

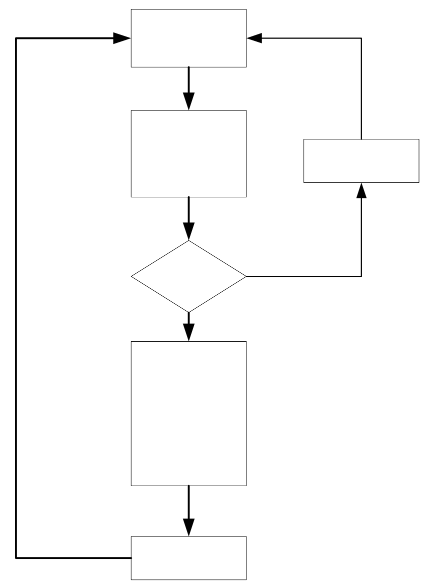

Figure-4. Flowchart for the microcontroller program.

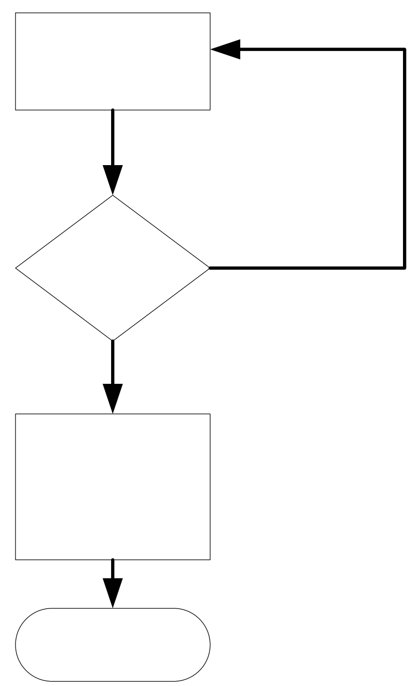

Figure-5. Flowchart for the location request interrupt.

2.4.2 Low signal strength interrupt

This interrupt is activated when the received signal strength gets below a preset threshold level (T). This causes the system to send the last five locations to the authorized GSM number and control center. This scheme is introduced to ensure that the last set of location data is transmitted before the system goes outside GSM coverage,

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the flow chart for the low signal strength interrupt is shown in Figure-6.

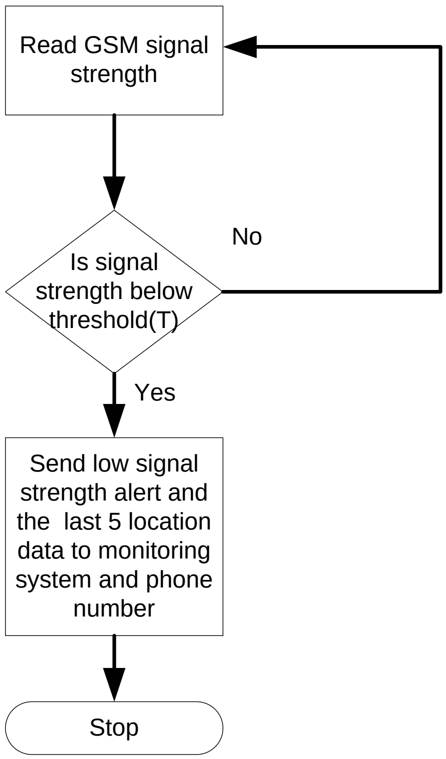

Figure-6. Flow chart for the signal strength interrupts.

3. EXPECTED RESULTS

The system is designed to keep a record of the trajectory of the tracked person or the device and to provide same regularly and on demand or when the tracked approaches the edge of coverage area. The result sent out to the monitor is in the form of an SMS message containing the name of the last 5 locations of the tracked object or person. These names are sent to enable a rapid response in the location of the tracked person and object. The tracker however will send the GPS coordinates to the data logging system of the control center if the location is outside that covered by the data in the tracker system memory. Each reading is taken with a 5 minutes delay. The system also incorporates a panic button which when activated by the tracked person will result in the sending of the location data to the monitor.

4. CONCLUSIONS

In this paper, a tracking device has been designed. This tracker is to be worn on the person to be tracked either as a wristwatch or on the clothing. It provides continuous monitoring of tracked person and upon the receipt of a location request, the last 5 locations of the tracked person or object is sent to the authorized number. The microcontroller accesses the location data every 5 minutes and stores at any given time the 5 most recent location data. This data is mapped to the location stored in the memory and this is sent to the authorized numbers regularly and upon the receipt of location request SMS sent by the monitor or the approach of a low signal strength area or activation of the panic button by the user.

This system utilizes the signal strength monitoring feature of the GSM modem. 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 data. The system will provide accurate data in a timely manner such that it will enable the security agencies to know the location of the tracked object and facilitate an early recovery of the tracked objects.

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