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Automatic vehicle over speed, accident alert and locator system for public transport (Buses)

A case study of Tanzania

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Abstract

Over speed limit violation done by public transport (buses) is a common problem in most of major roads in Tanzania. This has been reported to be one of the traffic accident causes in Tanzania. Moreover road accidents in Tanzania have been incessant and to bar the loss of life due to accidents is more crucial.

This research work proposed and implemented a prototype called Automatic Vehicle Over Speed Accident Alert and Locator System (AVOAALS). The system uses GPS and GSM network, especially GPRS function of the GSM network. The system monitors the speed and accident event of the bus. Once an event is detected, the system leads the current position of the bus using GPS. The event, bus registration number and position data are sent to the control database server as SMS via GPRS services of the GSM Network. The event, bus registration number and position data are then stored in the data base.

SMS application software was developed using Microsoft visual studio package. Microsoft SQL saver was used for storing data because of its high performance query engine, tremendously fast data insert capability and strong support for specialized web functions. Using this SMS application software, end user was able to receive SMS on any standard mobile phone about event, position of the targeted object, date and time of event. The administrator at the control data base server was able to extract reports about accident and over speed offenders. This system is very much useful for monitoring speed limit violations, reckless driving, and minifying the accident occurrence as well as optimizing rescue operations.

The system was implemented using Sunrom's GPS receiver with active antenna, GSM modem SIM900D, PIC18F4520 Microcontroller, mobile phone handset Nokia 110 and laptop computer. Prototype was tested and worked perfectly notifying nearby police station, hospital and fire station whenever appropriate event occurred. This work extends the utilization of mobile communication coverage on major roads in Tanzania to enhance road safety.

Key words:- NMEA, GSM, GPS, SMS, Microcontroller, CDS, AVOAALS, Geocoding

I. INTRODUCTION.

Road traffic represents 70 percent of freight and 90 percent of passenger transport market share in Tanzania. Road transport is essential to the socio economic development of Tanzania.

However, the current level of loss of life and property associated with road accidents in Tanzania is on the increase. Between 1977 and 2008 a total of 379,699 road traffic accidents occurred, where over 48,754 reported fatalities (deaths) were caused and over 347,657 reported injured persons. The number of fatalities (deaths) reported in the year 2004 was 2,366 while in the year 2006 the number of fatalities was 2,884 and in 2007 it was 2,594[1]. It is estimated that the number of fatalities and injury due to road accidents will double within the next ten years if nothing tangible is done to reverse the current trend.

There is clear evidence of the effect of speed on accident rates and accident severity. The energy to be dissipated in an accident is proportional to the square of the impact speed. For example an impact speed of more than 130km/hr involves more than twice the energy of one at 90km/hr [2]. However, by efficiently enforcing speed limit still accidents can occur, and a quicker response from emergency services could significantly decrease both the number of injured and dead passengers [3].

The design enables efficient enforcement of speed limit and provides quicker information to the concerned authorities in case of accident. Thus reduce accident occurrence and response time to accident victims.

II SYSTEM ARCHITECTURE

In this research work the AVOAALS system consists of three main units, which communicates with each other and makes sure that accident and over speed information are sent to the responsible authorities with minimum delay. Thus the system is divided into three units;

- On Board Processing Unit (OBPS)

- Control Database Server (CDS)

- Mobile Phone Handsets

The On board processing system (OBPS) installed in the vehicle senses the accident or over speed event and send the sensed event information to the control database server. The control database server finds out the physical name of the event location and report the event to the responsible

authorities with appropriate information. The architecture of this system is shown in figure 1 below.

Figure.1: System architecture diagram

On board processing system (OBPS)

According to the design, every bus must have its own on board processing system (OBPS) unit. The vehicle OBPS unit consists of four (4) impact sensors, microcontroller, GPS system and a GSM module. The impact sensors used in the vehicle OBPS continuously sense for any extreme impact on the bus from either side. The microcontroller will also continuously extract the bus speed from GPS. The microcontroller compares the extracted speed and the allowable speed, if the extracted speed is larger than the allowable speed it extracts the current position of the vehicle (latitude and longitude) from the GPS. Then send the Over speed event and location in form of short text message (SMS) to the Control Database Server via GSM modem. The GSM modem number of the Control Database Server (CDS) is already there in the OBPS unit as an emergency number.   The bus OBPS unit is shown in Fig. 2: below.
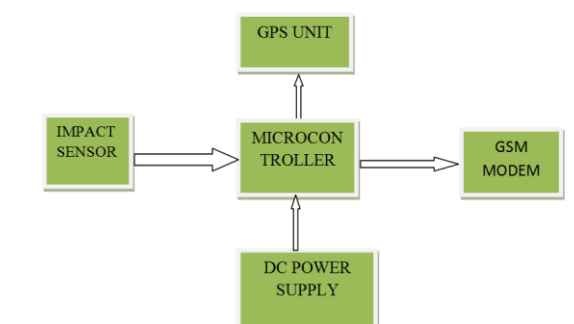

Figure.2: OBPS Unit

III. HARDWARE DESIGN

A: The impact sensor unit

Impact sensor unit consists of large-range dual-axis accelerometer MMA621010EG and small-scale three-axis accelerometer sensor MMA7260QT. MMA621010EG is a proven special car accident sensor which is integrated XY-axis accelerometer and built-in serial peripheral interface SPI bus, compatible with 3.3V and 5V voltage [4].The accelerometer has self-test function, mechanical and its performance can be calibrated before and after the installation.

The sensor can help identify false status which may lead to an accident event notifications situation, to ensure accurate detection of accident event.

B. GPS Location Module

Sunrom's ultra-sensitive GPS receiver model no.1216 acquire GPS signals from 65 channels of satellites and output position data with high accuracy in extremely challenging environments and under poor signal conditions due to its active antenna and high sensitivity. The GPS receiver's -160dBm tracking sensitivity allows continuous position coverage in nearly all application environments. The output is serial data of 9600 baud rate which is standard NMEA 0183 v3.0 protocol offering industry standard data messages and a command set for easy interface to mapping software and embedded devices [5].

Radio frequency integrated circuit is used to detect and process GPS RF signal. Digital signal processing circuit is used to process the IF signal. The standard embedded GPS software is used search and follow up GPS satellite signals. Figure.3: below shows the used GPS Receiver with Active Antenna.

Figure.3: GPS Receiver with Active Antenna

C. GSM modem unit

Sunrom GSM modem model no 1122 accepts any GSM network operator SIM card and act just like a mobile phone with its own unique phone number. Advantage of using this modem is that it has RS232 port for communication and this makes it very useful in developing embedded applications. Applications like SMS Control, data transfer, remote control and logging can be developed easily. It supports dual-band 900MHz and 1800MHz and supports for voice, data, short message and fax service [6]. Figure.4: below shows the Sunrom GSM modem.

Figure. 4: Sunrom GSM modem

D. Microcontroller unit

PIC 18F4520 microcontroller was used as the main controller of the OBPS unit. This PIC 18F4520 has special microcontroller features which includes, flexible oscillator structure, power management mode, and supports up to 40 MHz external oscillator.

The disadvantage of this type of PIC is that has single serial port. To facilitate the interface of GSM modem and GPS unit, MCU UART Switch for GPS/GSM was used. The MCU UART Switch for GPS/GSM is shown in Figure.5: below.
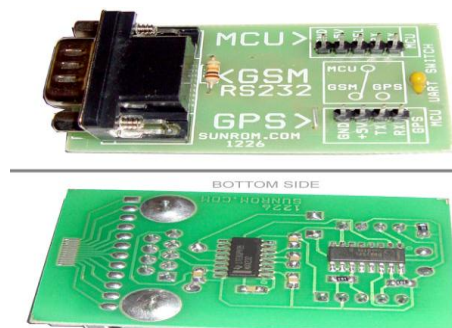

Figure.5: MCU UART Switch for GPS/GSM

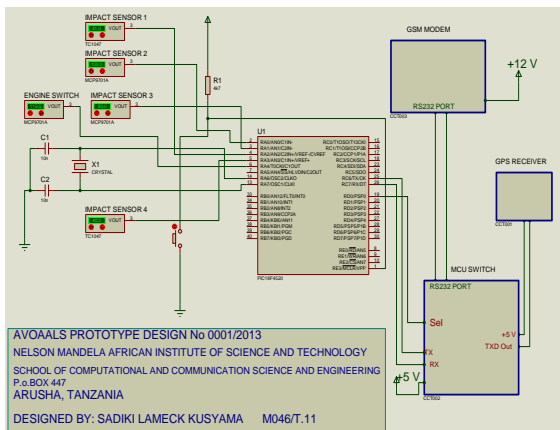The complete design of OBPS unit is shown in Figure 6.

Figure. 6: Complete OBPS circuit design

To facilitate the On board processing system (OBPS) overall functions, a program was written and compiled in mikroc compiler. The program employed embedded AT command to control the GSM modem for sending event information to the control database server (CDS). The OBPS Functional flow diagram is shown in Figure.7:
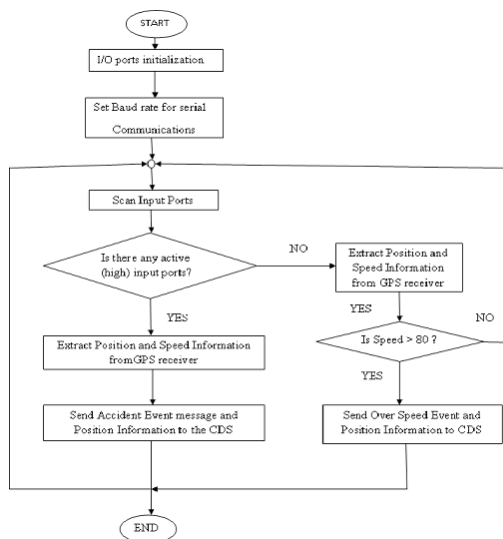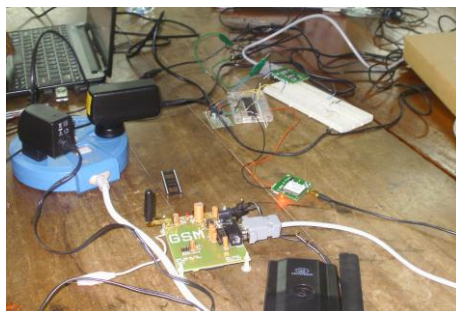

Figure.7: OBPS Functional flow chart

Figure.8: Photograph of OBPS Development at Electronics Laboratory

IV. SYSTEM SOFTWARE DESIGN

To facilitate the Control Database Server (CDS) functions SMS application software was developed. The SMS application software was developed using Microsoft Visual Studio 2005 package. Microsoft SQL server 2005 was used for storing data because of its high-performance query engine, tremendously fast data insert capability, and strong support for various high level programming languages. Using this SMS application software end user was able to receive SMS on any standard mobile phone about event, position of the device, date and time it happened. Also the administrator at the control database server can extracts reports about Accidents and Over speed offenders.

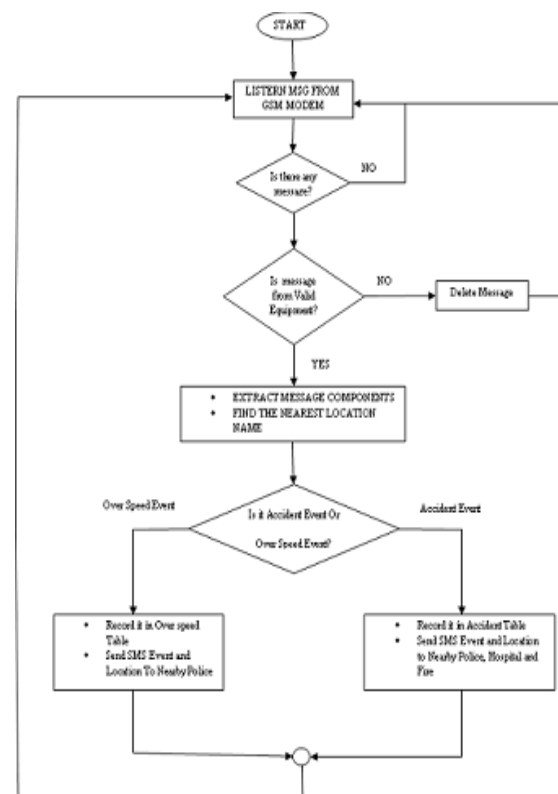Flow chart of the program is presented in Fig.8 below.

Figure.8: CDS Functional flow diagram

Figure 9 above shows the function of Control Database Server (CDS). It accepts the raw message sent by the OBPS (On Board Processing System) which is fitted in the vehicle. The message contains sender's number, type of event, vehicle registration number, latitude, longitude, date and time of event. The positional data received is then converted to a human readable form using Reverse Geocoding technique. Actually a Microsoft Visual Studio file named

dev_Handler.cs is responsible for accepting the raw message which is sent by the OBPS via GSM modem. The sender's number is used to authenticate the device. The raw message components is extracted and finally stored into database. The process of doing the converse, translating a point into a human-readable address, is known as reverse geocoding.

The geocoder will perform a reverse lookup and return the closest addressable location name.

The closest addressable location name may be some distance from the original latitude and longitude values of the query, if the supplied Latitude value and Longitude value is not an exact match for any addressable locations available in the Database.

Therefore the Spherical law of cosines is used to find out the name of the vehicle's location.

The formula is used generally for computing great-circle distances between two pairs of coordinates on a sphere. Spherical law of cosines [7].

$$d=R*acos(cos(lat1).cos(lat2).cos(lng2-lng1)+sin(lat1).sin(lat2)) \ldots\ldots.. (i)$$

d is the distance between two coordinates (lat1, lng1) and (lat2, lng2).

A geocode table implemented in this research work has four attributes, geocode id, Location_name, latitude, and longitude.

After receiving a new position, the nearest location name of the newly received position is found. This is done by running the Spherical law of cosines in the following sql query:

"**SELECT** name, (3959 * acos(cos(radians('lat1')) * cos(radians(lat2)) * cos(radians(lng2)– radians('lng1')) + sin(radians('lat1')) * sin(radians(lat2)))) AS distance

FROM geocode

HAVING distance < 5

ORDER BY distance LIMIT 0 , 1"

This query returns the name of the location which has the shortest distance with the new position.

V. CONCLUSION

This paper has presented an Automatic Vehicle Over speed Accident Alert and Locator System (AVOAALS) using GPS and GPRS services of GSM network, suitable for over speed and accident monitoring applications in Developing Countries. The combination of the GPS and GPRS provides continuous and real time monitoring. The initial and running cost is much lower compared to the traditional SMS based tracking systems. The reverse geocoding technique used by the control database server in this research work enables the use of any standard mobile phone at the receiving end and this eliminates the need of a computer running Google map program. The event triggering technique of data sending reduces the monthly bundle cost for the individual bus owners.

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