

# A System for Monitoring and Reporting Excessive Passengers in Public Buses Case Study: Tanzania

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## Abstract

In Tanzania, there has never been a technology for automatic monitoring and reporting excessive passengers in public buses. Despite having some stationing police at different locations for manual check up, the increase in prevalence of excessive passengers still persists. The finding of this study indicates that many deaths and injuries when accidents occur are caused by two major factors which are passengers overloading and not wearing seat belts. Many people are losing their lives and some are severely injured when accidents occur. The purpose of this work has been to develop a system for monitoring and reporting excessive passengers in public transport in Tanzania. It is based on Passive Infrared Sensor (PIR), Global Positioning System (GPS), and Global System for Mobile Communication (GSM) modem. The system is connected with SQL Server database which receives and stores all information. The system monitors the number of passengers boarding in public buses and reports to the respective authorities when a certain preset number is exceeded. This helps to control excessive passengers. Hence reduce the number of deaths and severe injuries when accidents occur, also helps eradicating bribery as through manual check the bus attendant can bribe the traffic police officer, communications to the traffic police officer will be improved as well as the bus owners, and improves the current system for manual check. Finally the passengers can find a sufficient level of mobility and satisfy their important needs for the efficient movement under safe and comfortable conditions.

*Keywords*-Microcontroller, GSM Modem, PIR, GPS

## 1. Introduction

The GPS/GSM/PIR system-based on monitoring and controlling passengers system is a system that make use of Passive Infrared Sensor (PIR) infrared motion analyzer which counts passengers who get in and out of the public buses, Global Positioning System (GPS) to determine the precise location of a buses to which it is attached [1] and Global System for Mobile Communication (GSM) modem which transmit the information [1] to a database and then to the respective authority such as traffic police. The central database which sends the message stores all information for the system such as latitude and longitude with their respective location name, different traffic police stations with respective contact numbers, user name and message sent by the system.

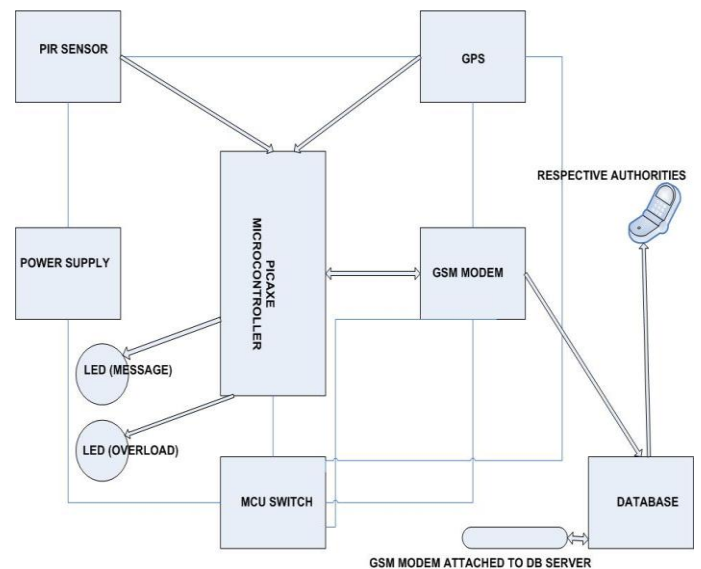


Figure 1: Block diagram

Automatic counting of passengers is very important for both business and security applications[2]. Passengers counting are

a very important need for transport operators. Indeed, they seek reliable and precise counting information in order to plan and manage in the most appropriate way human, financial and material resources [3]. Excessive loading of passengers in public buses has been a problem in developing nations, particularly Tanzania. The importance of excessive passenger tracking system cannot be ignored because it helps to reduce deaths and casualties as we know that excessive passengers is one of the major causes of many deaths and casualties when accidents occur in buses with excessive passengers. It is clear that, at some point; we need to limit the number of extra passengers to be accommodated [4]. This paper addresses the challenge by designing and developing a system which will automatically detect extra passengers specifically in public buses. The system can accept a number of extra passengers that can be accommodated in emergencies above which the respective authorities will be alarmed and appropriate actions put into effect.

## 2. Material And Method

In this paper work, we made use of M2M technologies and GPS/GSM/PIR module which is a device that operates mostly under Machine to Machine (M2M) platform. M2M simply involves devices that can communicate over a network without human interference [5].

### GPS

The Global Positioning System (GPS) is based on a large number of satellites radiating microwave signals for picking up by GPS receivers to determine their current location. GPS receivers communicate with a microcontroller. A common path is via the serial port, while the used protocol for transmitting data is called NMEA. In the event that data on latitude and longitude are not fixed (i.e. if a GPS receiver fails to determine its location) or when other data is not determined, the GPS receiver will keep outputting the same set of strings, leaving out any missing data. An example of a complete NMEA string is shown below:

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

Structure:  
`$GPGLL,ddmm.mmmm,a,dddmm.mmmm,a,hhmmss.sss,A,a*hh<CR><LF>`  
 Field      1        2        3        4        5        6 7 8

Example:  
`$GPGLL,2447.0944,N,12100.5213,E,112609.932,A,A*57<CR><LF>`  
 Field      1        2        3        4        5        6 7 8



Figure 2: GPS receiver

### PIR

The occupancy sensors detect the presence of people in a monitored area. Motion detectors respond only to moving objects [6]. A distinction between the two is that the occupancy Sensors produce signals whenever an object is stationary or not, whereas the motion detectors are selectively sensitive to moving objects. PIR is compact and complete, easy to use Pyroelectric Infrared (PIR) Sensor Module for human body detection, incorporating a Fresnel lens and motion detection circuit, has high sensitivity and low noise.

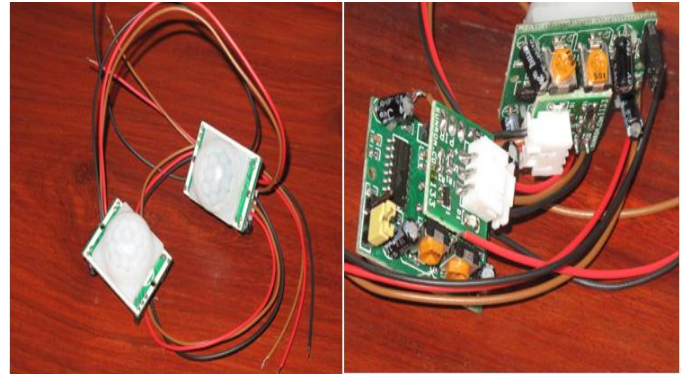


Figure 3: PIR sensor

### GSM

A GSM modem is a specialized type of modem which accepts a subscriber identity module (SIM) card and operates over a subscription to a mobile operator just like a mobile phone [1]. GSM uses a process called circuit switching. This method of communication allows a path to be established between two devices. Once the two devices are connected, a constant stream of digital data is relayed. GSM network consists of three major systems: the switching system (SS), the base station subsystem (BSS) and the mobile station (MS). The working of GSM modem is based on commands, the commands always start with AT (which means Attention) and finish with a <CR>character.

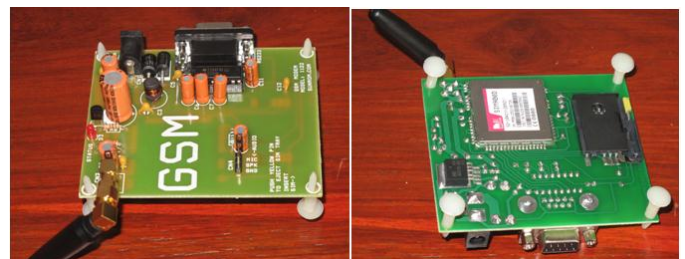


Figure 4: GSM Modem

### Microcontroller

A microcontroller is often described as a ‘computer-on-a-chip’. It is a low-cost integrated circuit that contains memory, processing units, and input/output circuitry in a single unit [7]. Microcontrollers are purchased ‘blank’ and then programmed with a specific control program. Once programmed the microcontroller is built into a product to make the product

more intelligent and easier to use. In industry microcontrollers are usually programmed using the assembler or 'C' programming languages [8]. However the complexity of these languages means that it is often not realistic for younger students in education or many home hobbyists without formal training to use these programming methods. The PICAXE system overcomes this problem by use of a much simpler, easy to learn, BASIC programming language. Programs can also be created graphically by use of the flowchart editor. The PICAXE system exploits the unique characteristics of the new generation of low-cost 'FLASH' memory based microcontrollers. These microcontrollers can be programmed over and over again (typically 100 000 times) without the need for an expensive programmer.



Figure 5: PICAXE - 28X2

### MCU UART Switch For GPS/GSM

If the microcontroller has only one UART Serial port and one wishes to interface with two devices each having one serial port then there are two options. First option is to search for a microcontroller having dual uart. Second is a digital switch that we have made which can be used to switch same microcontroller UART pins to each serial device as required. Many applications which use a MCU with GPS and GSM both can be used with this switch. Instead of GSM can be other RS232 device but we targeted to this GSM device and GSM device since this is the most common problem when trying to interface GSM and GPS to same microcontroller having single UART interface.



Figure 6: MCU Switch

implemented and accepted by the end user. The process can involve many stages over a long period. The prototyping development technique was adopted in this study to develop a working system model [9].

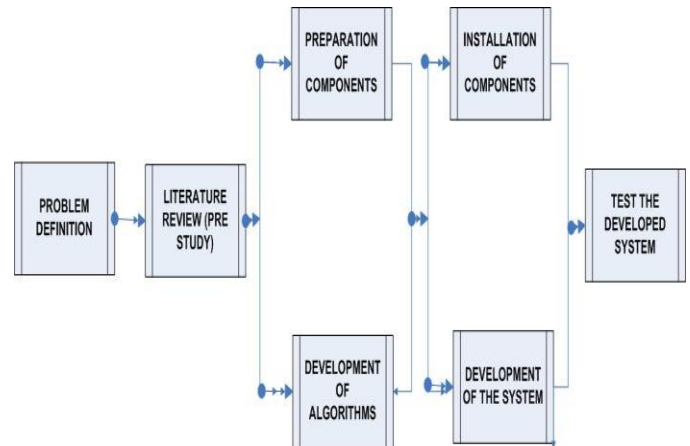


Figure 7: Step by step to develop prototype

Problem definition is widely regarded as the first stage of the system development cycle, a stage that lays fundamental groundwork for ensuing struggle over the construction of useful system [10]. A literature review is an account of what has been done on a topic by accredited scholars and researchers. What works have been done related to this work besides enlarging knowledge about the topic. Preparation for components includes all the components that will be used to develop the prototype; these include the software if needed to complete the system. In this thesis the system has the following components PICAXE, PIR motion sensor, MCU UART Switch for GPS/GSM dual serial port application, GSM modem, and GPS receiver with active antenna and LED. Software such as Microsoft Visual studio 2008, SQL server 2008, Proteus are used. Algorithm is a step by step procedure for calculation or data processing. Starting from an initial state and initial input the instruction describe a computation that, when executed, proceeds through a finite number of well defined successive states, eventually producing output and terminating at a final ending state[8].

### Flow Chart

The first step is to set the maximum number of passengers the public bus can accommodate because not all the buses have the same capacity of carrying passengers. The system is always active if the bus is stationery as we assume passengers can only enter into the bust when it is not moving. Then it will keep counting and always check if the number counted is greater than the maximum number of passengers bus can accommodate. If the number of passengers counted is less than the number of passengers the bus can accommodate it will keep counting but if the number of passengers counted is greater than the number of passengers the bus can accommodate then the system will send message to the database through GSM Modem with the bus registration number , latitude and longitude and then in the database the



location of respective latitude and longitude will be identified and the report will be sent to the nearest traffic police through GSM Modem again and take necessary actions. Installation of components and system development are the next step, where all the components of the system and the complete system are developed. Interfacing microcontroller with GPS, GSM Sensor and loading of software to the microcontroller. Finally we test the system, if the system met all the functionality it is required to perform.

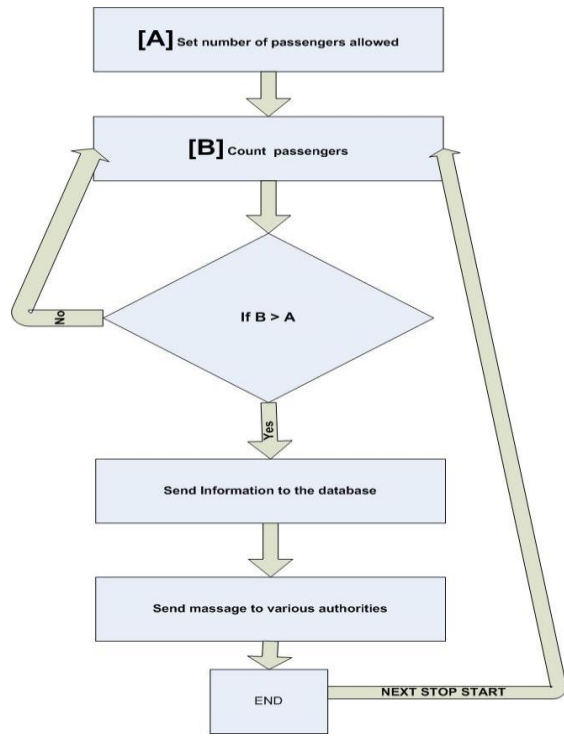


Figure 8: Flow diagram

#### 4. RESULTS

A complete system circuit for monitoring and reporting excessive passengers in public transport

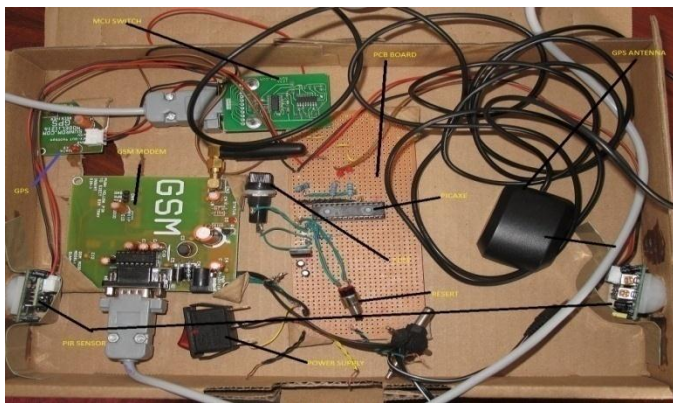


Figure 9: Complete Circuit System

The system has been tested in few places along Arusha to Dar es Salaam road and the results are recorded for some few points. The time for sending messages from the system to the database and from the database to the respective authorities is recorded in the table below. In the peak hours there are slight delay in sending and receiving messages from the system and from the database. During the normal hours there is no delay, the messages are delivered within one minute. The (SIM) card used in the system is Vodacom and the (SIM) card used in the database is Airtel. The system is working for any (SIM) card, Airtel, Vodacom, Tigo and Zantel though Airtel and Vodacom are used because they have good coverage and stable connection compared to the other companies in Tanzania. This means during peak hours there is a delay in receiving messages which is about 4 mins maximum when the system sends messages and when the mobile phone receives the messages. But during the normal hours there is no delay, the messages are delivered on time to all parts involved.

Test Location	Police Station Received Messages	Maximum delay time to receive messages	Maximum delay time to receive message
		8:00hrs-16:00hrs	16:00hrs-20:00hrs
Arusha Town	Police Tengeru	1 min/message	4min/message
Tengeru	Police Usa	1 min/message	4min/message
Usa	Police Boma Ng'ombe	1 min/message	4min/message
Boma Ng'ombe	Police Moshi	1 min/message	4min/message
Moshi	Police Himo	1min/message	4min/message
Mwanga	Police Same	1min/message	4min/message

Table 1: Summary of results

In the database you can see when a message is received as the screen short below is showing in figure 4.2. It is showing the date, time, message, Latitude and Longitude and status if the message is inserted in the database successfully. The GSM Modem uses Airtel (SIM) card. The GSM Modem accepts any (SIM) card such as Airtel, Vodacom, Tigo and Zantel .

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file:///C:/Users/KILAVO/Desktop/MONITORING AND REPORTING EXCESSIVE PASSENGERS/bin/De...
^RSSI:19
^RSSI:19
+CMTI: "SM",1
+CMTI: "SM",1
OK
+CMGR: "REC UNREAD", "+255759668160", "13/06/26,16:41:56+12"
:BUS:T899ABU:HAS OVERLOADED PASSENGERS:AT LAT:3.387305S:LONG:36.826222E:
OK
+CMGR: "REC UNREAD"
"+255759668160"
"13/06/26
16:41:56+12"
BUS
T899ABU
HAS OVERLOADED PASSENGERS
AT LAT
3.387305S
LONG
36.826222E
+255759668160
"13/06/26,16:41:56+12"
Bus overload message inserted in database
>
^RSSI:19

```

Figure 10: Message captured in the database

The database will automatically search for the location in the stored data and identify the exact location of the bus, then search for the mobile number allocated to the nearest police station and thereafter send message to the respective authorities for appropriate actions to be taken.

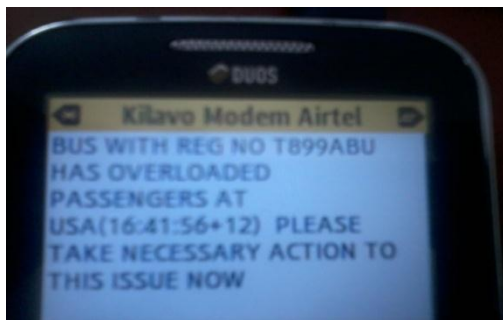


Figure 11: Message sent from the database to the respective authorities

## 5. Conclusion

One of the goals of all actors involved in the public transport business is the creation of a well organized transit system, within which passengers can find a sufficient level of mobility and satisfy their important need for the efficient movement under safe and comfortable conditions. The quality of the services provided to the passengers is synonymous with a wide range of characteristics of the transportation system, such as safety, on time performance, accessibility, efficiency and many others. The system for controlling excessive passengers in public buses has been a great starting point for Tanzanian transportation system. As a result of this research there are many benefits such as:-

- The system will reduce deaths and severe injuries in accidents involving buses with excessive passengers.
- Problems of dealing with excessive passengers in public buses will improve.
- Improving the current system by getting rid of manual check which sometimes fails due to poor weather such as rain, difficult to do manual check at night, it's not accurate because check is done at random, it doesn't check all the buses.
- It will reduce the possibility of bribe as through manual check the bus attendant can bribe the traffic police officer.
- The communications to the traffic police officer will be improved as well as the bus owners.

At times there is a challenge in sending and receiving messages especially during peak hours (17hrs-20hrs) where there is some delay. This can be improved by improving network coverage along the major roads in Tanzania.

## Recommendations

This system for controlling excessive passengers in public buses however entails to solve part of the problem. It cuts down the number of passengers who would be severely injured or even die during accidents in public buses with excessive passengers. Failure to wear seat belts has been proven to be one of the reasons for many deaths and injuries during accidents, not only in public buses but also in private vehicles. There should be a way to develop a mechanism which will ensure that all passengers in public buses enforce to wear seat belts. This will work in synergy with the system described in this study to reduce the number of deaths and injuries in accidents. A passenger satisfaction survey is also important in order to identify their priorities. Their expectations and satisfaction regarding transportation services is also crucial. Network coverage is limited through most of Major roads hence there is an inevitable need to strengthen network coverage along the major roads for this system to be put into appropriate use.

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