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Prototypic Gps-Gsm Integration for Enhancing Public Transportation and Management Services.

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ABSTRACT
This paper proposes and implements a solution for enhancing public transportation management services based on GPS and GSM. Travel time information is a vital component of many intelligent transportation systems (ITS) applications. In recent years, the number of vehicles in India has increased tremendously, leading to severe traffic congestion and pollution in urban areas, particularly during peak periods. A desirable strategy to deal with such issues is to shift more people from personal vehicles to public transport by providing better service (comfort, convenience and so on). In this proposed system we introduced advanced public transportation systems (APTS) for public service. Advanced public transportation systems (APTS) are one of the most important ITS applications, which can significantly improve the traffic situation in India. One such application will be to provide accurate information about bus arrivals to passengers, leading to reduced waiting times at bus stops. This needs a real-time data collection technique, a quick and reliable prediction technique to calculate the expected travel time based on real-time data and informing the passengers regarding the same. The scope of this proposed system is to use global positioning system data collected from public transportation buses on urban roadways in the city of Chennai, India, to predict travel times. The performance of the proposed system is found to be promising and expected to be valuable in the development of advanced public transportation systems (APTS) in India. The work presented here is one of the first attempts at real-time short-term prediction of travel time for ITS applications in Indian traffic conditions.
Keywords: GPS, GSM, Public transportation management services, Bus Station Module, In-BUS Module, BASE Station Module, BUS Stop Module, Rush statistical analysis

I. Introduction

With the increasing number of people in cities, already existing problem of poor transportation services has grown to an alarming extent. Due to non-availability of prior information about the buses arrival schedule, people have to wait longer on bus stops especially in morning when they have to reach the offices in time. The buses are overloaded for most of the times which often results in some kind of fault occurrence in buses and people get late further. According to a survey report issued by Regional Transport Authority in year 2001, the available seat capacity on public transport to population in Andhra Pradesh is 1:38 as compared to Delhi 1:7, which shows the deficiency in capacity of public transport in Delhi [1]. In addition, rapid population growth and spatial expansion in Lahore is adversely affecting this ratio. Consequently the dissatisfaction with the level and quality of public transportation service has leaded those people who can afford it to turn to private modes of transportation. By the end of year 2005, the private modes of transportation in Delhi have contributed 93% (motor cycles=56.06%, motor cars and jeeps=31.52%, taxies=0.95%, rickshaws=4.56%) as compared to public modes of transportation [1]. Owing to poor infrastructure of roads in country, the annual growth rate of vehicles has created problems in controlling the traffic flow resulting in traffic congestion on roads. Also with the increased number of vehicles, the content of carbon mono-oxide and particulates matter concentration is found to be 10 times higher than World Health Organization (WHO) in central parts of Delhi city thereby deteriorating the environment and causing lung diseases [2]. To reduce the number of private vehicles and improve the public modes of transportation in Delhi, the idea of introducing Light Rail Transit (LRT) is proposed [3]. It is estimated that 231,000 passengers will use LRT every day. This will also help in reducing the accidental rate (A total of 802 fatal accidents are recorded in Delhi for the year 2004) [1]. Although LRT seems to be a promising solution for enhancing public modes of transportation, it is costly to deploy. Another approach would be to introduce a technology based transportation management system that will help the passengers in getting informed about the exact schedule of buses and send recommendation report after performing rush statistical analysis on per stop basis to Indian Government for regulating the transport services. In this paper, a transportation management system is developed for enhancing public transportation services based on integration of GPS and GSM. GPS is used as a positioning device

while GSM is used as communication link between different modules. These modules include BUS Station Module, In-Bus Module, BASE Station Module and BUS Stop Module. Bus Station Module contains a GSM engine interfaced to PC and transmits the bus index and its license plate number to BASE Station. At the same time, it turns on GPS receiver installed in the bus. The bus then starts transmitting its location to the BASE Station. The BASE Station comprises of a GSM engine interfaced to a microcontroller for processing user request of bus location as well as a number of other GSM engines interfaced to various PCs each reserved for a separate bus to update the location information of that bus. The buses location data from BASE Station is sent to each bus stop. BUS Stop Module after receiving buses location data through GSM engine displays it on dot matrix display installed at each bus stop. The block diagram of the proposed system is shown in Fig 1

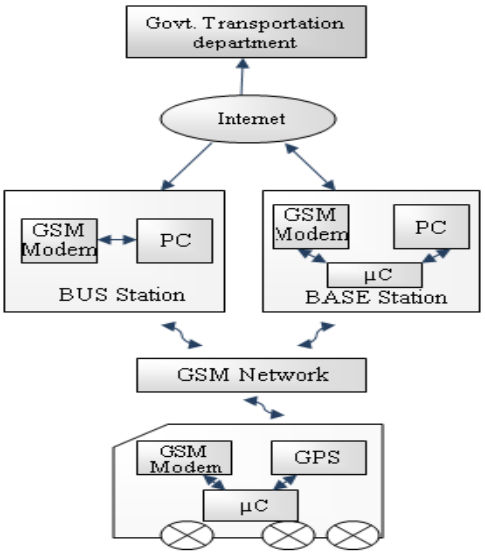

Fig 1

II. Hardware Specifications

The following hardware components are used in building the entire system:

2.1 GPS Receiver

In order to keep track record of bus, a Garmin GPS35 receiver, powered from the bus main battery, is installed in each bus. The Garmin GPS35 is a complete GPS receiver and embedded antenna designed for a broad spectrum of OEM system applications. The GPS35 tracks up to twelve satellites at a time while providing one-second navigation updates and low power consumption. Its far-reaching capability meets the sensitivity requirements of land navigation as well as the dynamics requirements of high performance aircraft. Internal memory backup allows the GPS35 to retain critical data such as satellite orbital parameters, last position, date, and time [4]

2.2 GSM Modem

A wireless link between the modules is provided with Samsung 14i GSM module. Samsung 14i offers advance GSM connectivity and supports EDGE/GPRS and HSCSD with automated GSM connection establishment It is equipped to provide reliable remote connections and offers application level watchdogs, inbuilt self-check mechanisms and a reliable Virtual Machine (VM) for JAVATM. Samsung 14i also supports reliable inbuilt internet protocols: TCP/IP for reliable data transfer, UDP/IP for audio and video streaming and HTTP for accessing web pages. The module can also be connected to an external GPS device that supports National Marine Electronics Association (NMEA) standard. The inbuilt NMEA parser can parse the location data from the output that it receives from the GPS device. External microcontroller can use AT commands to communicate with Samsung 14i and simple remote I/O applications can easily be controlled via text messages [5].

2.3 Microcontroller

AT89C52 microcontroller is selected because it is a powerful microcomputer which has low power consumption and provides a highly flexible and cost-effective solution to many embedded control applications. It has 8K bytes of in system reprogrammable flash memory, 256 bytes of internal RAM, 32 programmable I/O lines, three 16 bit timers/counters, eight interrupt sources and a programmable serial channel [6].

2.4 Memory

256K Nonvolatile RAM (NV-Ram) DS1230Y-85 is used for storing data in In-BUS Module (in case of sparse GSM coverage) and at BUS Stop Module for displaying on dot matrix display. NV-RAM is selected because it combines the best of RAM and ROM: the read and write ability of RAM and non-volatility of ROM. The DS1230 Nonvolatile SRAM is 262,144-bit, fully static, nonvolatile SRAM organized as 32,768 words by 8 bits. Each NV SRAM has a self-contained lithium energy source and control circuitry which constantly monitors VCC for an out-of-tolerance condition. When such a condition occurs, the lithium energy source is automatically switched on and writes protection is unconditionally enabled to prevent data corruption [6, 7].

2.5 Battery Backup

In-Bus Module is provided with an internal battery so that whenever power from main battery is disconnected, microcontroller continues to transmit

the location to BASE station. A message is also sent to BASE station to notify it about the disconnection of main battery. When the power is resumed, the internal battery begins to recharge.

2.6 Alarms

The microcontroller unit in In-BUS Module sends different alarm signals for different events to BASE Station Module.

2.6.1 On Backup Battery:

When the main battery is switched off, a notification is sent to BASE station.

2.6.2 Stoppage:

When the bus is stationary for more than a specified time, BASE station is informed by a stoppage alarm. In case of an accident or any other fault occurred in bus, the driver can notify the BASE station by pressing a button in bus.

2.6.3 Getting Late:

When the bus is not covering a certain distance in a defined range of time, an alarm signal of getting late is sent to BASE station.

2.6.4 Route Deviation:

When the bus deviates from the assigned route by a given margin, BASE station is notified.

III. System Modules and Network Operations

The entire system/network comprises of four modules: Bus station module, In-bus module, Base station module and Bus stop module. The working and interconnection of these modules is described in this section.

3.1 Bus Station Module:

BUS Station Module is installed at bus terminals from where the bus will depart. It contains a LASER and a GSM modem connected to a PC. When the bus enters the terminal pad, it is detected by the LASER sensor. The operator at the terminal enters the license plate number in database. A count number is then accordingly assigned to the bus e.g., bus leaving the terminal first will be assigned a number 1. The route number of bus along with the Stage number, direction information, assigned count number and license plate number is sent to the BASE Station via GSM. An example of the transmitted header is of the form "12D01APZ3244" where '12' is the bus route number issued by Government Transportation Department, 'D' is downward direction of bus ('U' will be upward direction), '01' is the Stage number assigned to the bus and 'APZ3244' is license plate number of bus. An 'ON' signal is also transmitted to the In-BUS Module installed in the bus for initialization. The flow chart of module software is shown in Fig. 2.

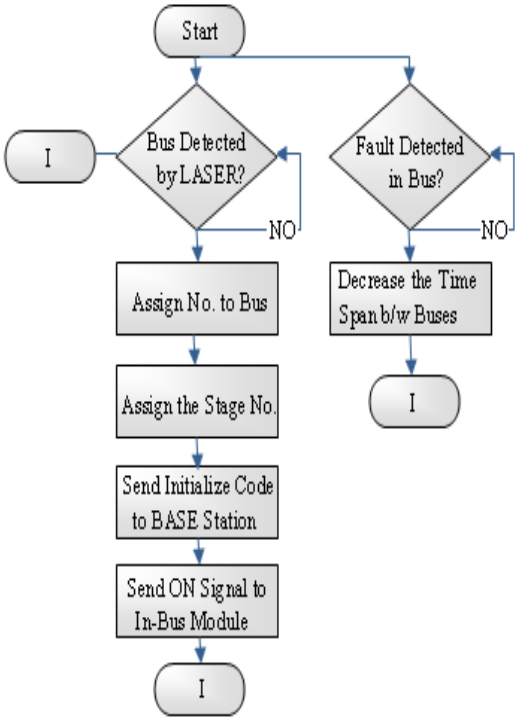

Fig 2

3.2 In-bus Module

In-BUS Module is installed inside every bus and consists of a GPS receiver, a GSM modem, a NV-RAM, infrared object counting sensors, door opening/closing sensors and an emergency button; all interfaced to AT89C52microcontroller. After receiving the initialization signal form BUS Station Module, this module starts transmitting bus location to the BASE Station. At each stop, when the driver opens the door, an interrupt is generated and microcontroller starts counting the numbers of passengers entering and leaving the bus with the help of infrared sensors. This count value on per stop basis is transmitted to the BASE Station. In case of an emergency situation (e.g., when fault occurs in bus), driver can press the emergency button to inform BUS and BASE Station units about the location of bus. The BUS station operator can then adjust the schedule accordingly and send an additional bus for facilitating the passengers. Microcontroller present in this module continuously calculates the difference in consecutive GPS locations. If the difference remains near zero for more than a designated time, then a getting late message is transmitted to the BUS and BASE stations. In case of sparse GSM coverage, location information is stored in non-volatile RAM. After regaining the GSM network, previous locations are updated to the BASE station. The block diagram

for this module is shown in Fig. 3 while flow chart of module software is shown in Fig. 4.

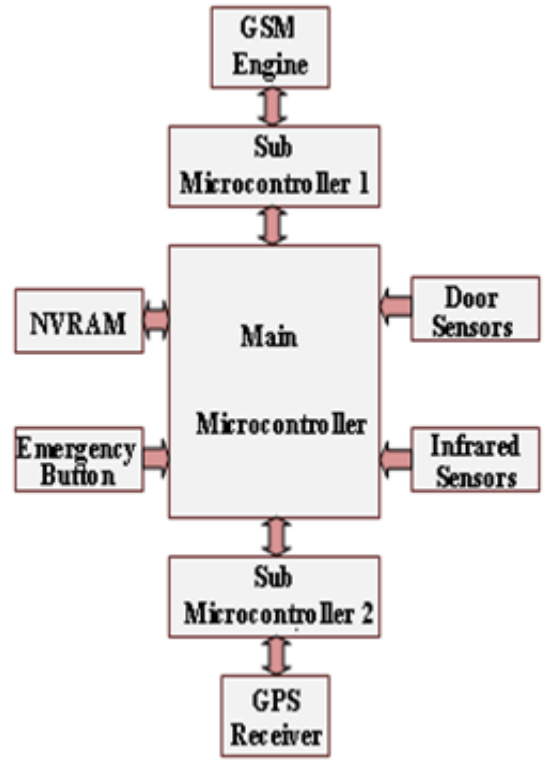

Fig 3

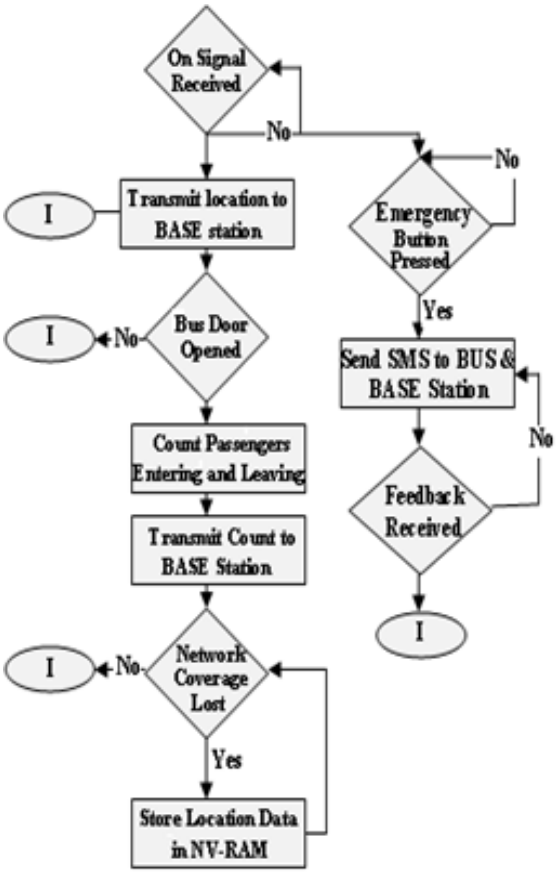

Fig 4

3.3 Base Station Module

This module is the central part of the network. It accepts location information of buses through respective GSM modems and maps the information on Google Map for visualization. It also receives the number of passengers entering and leaving the bus on per stop basis from In-BUS Module for statistical analysis. The message received is of the form "#01, 02, 01, 1726.0830.N, 07826.7869.E". The first string denotes the stage number and next two strings denotes the number of passengers entering and leaving the bus respectively and next two strings denotes the location information; all separated by commas. Another GSM modem is used to get the user request of location information of a particular bus. An example of the query put by the passenger is of the form "14D" or "14D11". In first instance i.e., "14D", '14' is the route number and 'D' designates the direction flag while in second instance i.e., "14D11", additional digit '11' denotes the bus stop number where the passenger is standing. The microcontroller attached with this GSM modem passes on the user request to the PC dedicated for that route number. The PC after processing the request data sends desired location information in form of bus stop name to microcontroller. The microcontroller then transmits this information back to the user. The information that passenger will receive contains the location of all buses out of terminal in desired direction in former query while in case of later query, he will get the location of those buses which are coming towards the particular bus stop number in desired direction along with time information. The time information is embedded in message to account for any delay in processing the user request. An example of the information received by the user is of the form "TV TOWER, BRIDGE TOWN, HIMAYATH NAGAR ,HYDERABAD-2:30 P.M." where first four strings are bus stops names telling where the buses are currently followed by the time on which the location information is get from the map and message is sent to user. BASE station also monitors the emergency situations transmitted from In-BUS Module. In addition to this, the station keeps record of security issues and traffic congestion conditions and directs the driver to change the route if desired. The block diagram of the module is shown in Fig. 5 while module software is shown in Fig. 6.

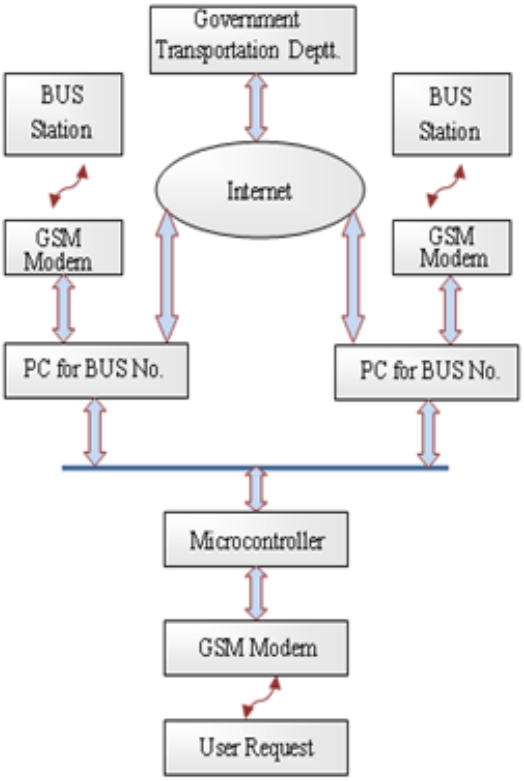

Fig 5

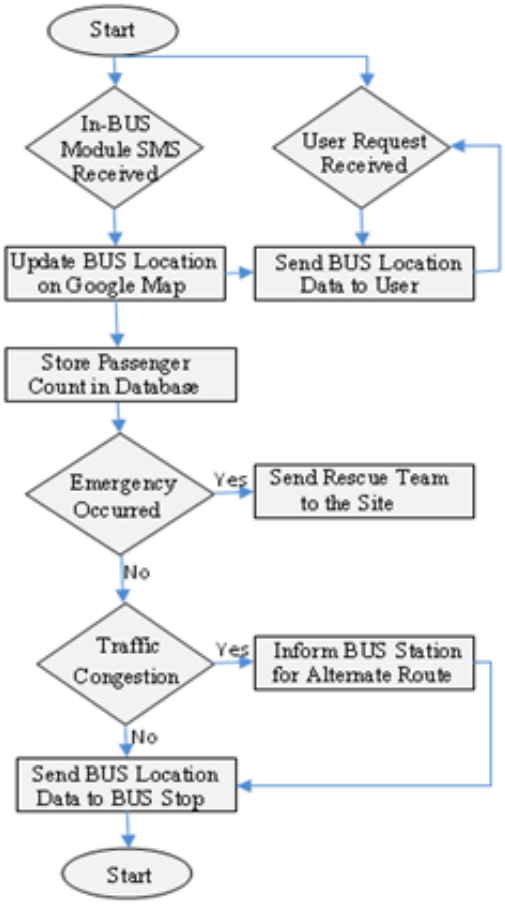

Fig 6

3.4 Bus stop Module

This module is installed at every bus stop to let the passenger know about the location of buses coming towards that stop. It comprises of a GSM modem, a NV-RAM and dot matrix display; all interfaced to 89C52 microcontroller. After receiving the bus location data in the form of stop names from BASE station, microcontroller stores it in non-volatile RAM. A sample message received by BUS Stop Module installed at 'Old Tower Stop' is of the form "11, Visiting Museum; 44, vector Hospital; 88, Singh de share; 11, casual Town; 53, Harahan Court; 07". The message contains information of those buses only which will pass by the designated stop. First two digits of a sub-string denote the bus route number followed by the bus stop name which is the current location of bus coming towards the specified stop. Microcontroller after retrieving the stored information displays it on a 3x15 dot matrix display. The microcontroller refreshes the information with a rate of 10 seconds. In case of an emergency situation, the location of next incoming bus is displayed. The block diagram of this module is shown in Fig. 7 and flow chart of module is shown in Fig. 8.

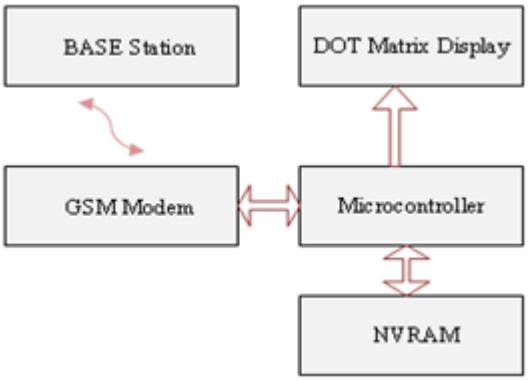

Fig 7

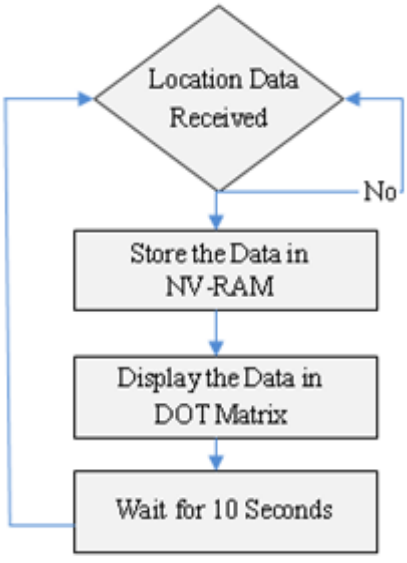

Fig 8

IV. Statistical Analysis and Recommendations

BASE station utilizes the passenger information on per stop basis to carry out the statistical analysis. A GUI, shown in Fig. 9, is developed in MATLAB® to analyze the results [8]. A recommendation report is also generated by the software which highlights the regions of greater emphasis. These are the regions where buses are more overloaded. The solution to the problem lies in increasing the number of buses on routes which are densely crowded or introduce new overlapping routes to compensate the demand. BASE station transmits the statistical data along with the recommendation report to Punjab Government Transportation Department through internet at the end of day or as per request of transportation department.

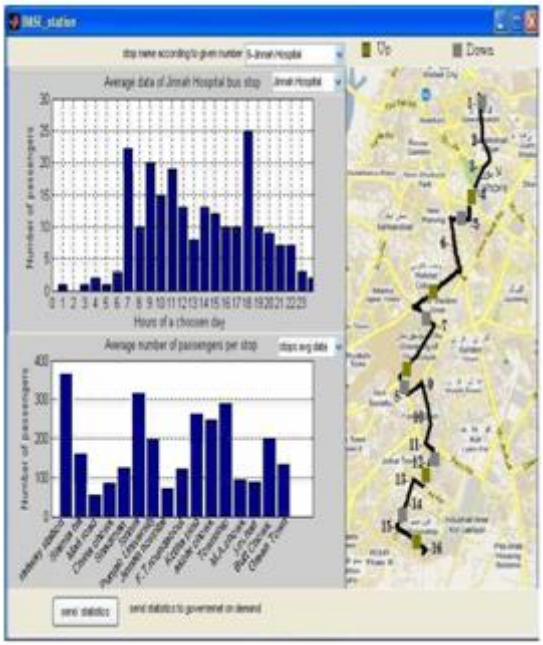

Fig 9

V. Conclusion

In this paper, design and development of a low cost transportation management system based on integration of GPS and GSM data is described. The system comprises of various modules which are wirelessly linked with GSM modems. Cost effective SMS service of GSM network is used for the transfer of data between the modules. A new service, to facilitate the people who use public transport for traveling, is introduced inside the city. The service provides the user with current location information of desired buses based on which the user can adjust his schedule accordingly. The service therefore vanishes the need of waiting at the bus stop thus saving a lot of time. For the passengers not utilizing the service, displays are installed at bus stop to let them know the buses location coming towards that stop. The system is also efficient in handling the emergency situations e.g., in case some kind of technical fault occurred in bus, the operator at bus terminal is informed and the departure time between the buses is reduced.

VI. Future Work

The system can be made automatic by installing cameras at bus terminals which can automatically read the license plate number of buses thereby eliminating the operator. An automatic route guider display can be installed in buses to better update the alternative route in case of serious road congestions. Fare collecting system can also be automated by providing another mobile service to which all the passengers using public transport are subscribed.

VII. ACKNOWLEDGEMENTS

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