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Comprehensive Updates for Bus Information in Cities and Suburbs (Cubics)

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Abstract: Public transportation is an absolute necessity in the congested world of today, particularly in heavily populated countries which also have heterogeneous traffic conditions on the roads. While a major cultural change would be required to turn people towards public transportation, people in general do not choose public transportation system also because of the unreliable service and schedules and overcrowded vehicles particularly in peak hours. While a lot of work had been done towards Automatic Vehicle Location (AVL) and Automatic Passenger Count (APC) for public transport systems, Comprehensive Updates for Bus Information in Cities and Suburbs ("CUBICS") is yet another, low-cost effort towards providing essential information regarding buses at the stops, namely the vacancy position and the stop it is located. This project enables commuters to estimate the vacancy in the bus and the time it may take to reach their stop, all from the comfort of their homes or offices, with the help of a web-based interface. This is implemented using Arduino Uno and Raspberry Pi computers, GSM modules and RFID tags, piezoelectric sensors, and the necessary signal conditioning circuitry. The Arduino Uno boards were placed in public transport vehicles while the Raspberry Pi acted as a central processing unit. GSM modules form the mode of communication between the bus in transit and the bus stations and/or transportation agency offices. Programming of Raspberry Pi was performed using Python, an "interpreted, interactive, object-oriented, extensible programming language", and the remote shell client PuTTY was used to access Raspberry Pi and execute the code. The prototype also included the piezoelectric sensors and the output indicated if any load was placed over the sensors. The output information indicated the arrival of the "bus" at known bus stations, while the load sensors' output could be combined with this information for a comprehensive update. Successful performance under the test conditions held promise for scalability of the system for a practical world scenario.

Keywords: CUBICS, PuTTY software, ttyUSB0, Automatic vehicle location (AVL), Automatic passenger count (APC)

I. INTRODUCTION

It is important for commuters as well as transportation agencies to track the position and/or arrival and departure information pertaining to public transport vehicles such as buses. The occupancy of buses can also help the commuters to choose whether to take a bus or wait further, while the transportation agencies can schedule the public transport vehicles to better serve the needs of the commuter's routes. This project thus aims to develop a comprehensive system that provides, through a web-based interface, real-time updates pertaining to the buses in transit. The current system enables users to receive Comprehensive Updates for Bus Information in Cities and Suburbs (CUBICS). When a bus reaches a bus stop, the RFID tag present in the bus stop is read by the RFID reader present in the bus. This information pertaining to the bus stop is sent to Arduino. When passengers aboard the bus and occupy the seats, piezoelectric sensors under the occupied seats send an output voltage to the Arduino. Arduino combines the information from the piezoelectric sensors and the RFID reader and sends this information to the GSM module 1 which is present on the bus. The obtained information on GSM module 1 is then communicated to the GSM module 2 present at the receiver. This obtained message is sent to Raspberry Pi. The Raspberry Pi creates a file containing the obtained message and uploads it to the WWW. Thus, commuters can receive updates on bus arrival and vacancy and thus can make an informed decision about boarding the bus.

II. METHODOLOGY

In the model, it is assumed that RFID tags are the bus stops as practical application needs RFID tags to be set up at each bus stop. Hence more tags can be integrated in the model for representing more bus stops. The bus should have RFID tag reader, piezoelectric sensors and the corresponding circuit, Arduino Uno board and a GSM module on board. Hence the block containing the above modules in the model is supposed to be the bus. The piezoelectric sensors represent seats in the bus. Information from piezoelectric sensors and the RFID reader is transmitted to Arduino board from which it is sent to the GSM module on bus for transmission. The GSM module transmits the information to another GSM module which is connected to Raspberry Pi. R Pi acts as central data monitoring unit for all the buses. However, in the current model, functioning of a single bus is shown. R Pi is connected to a router for hosting the information on World Wide Web which can be accessed through an URL.

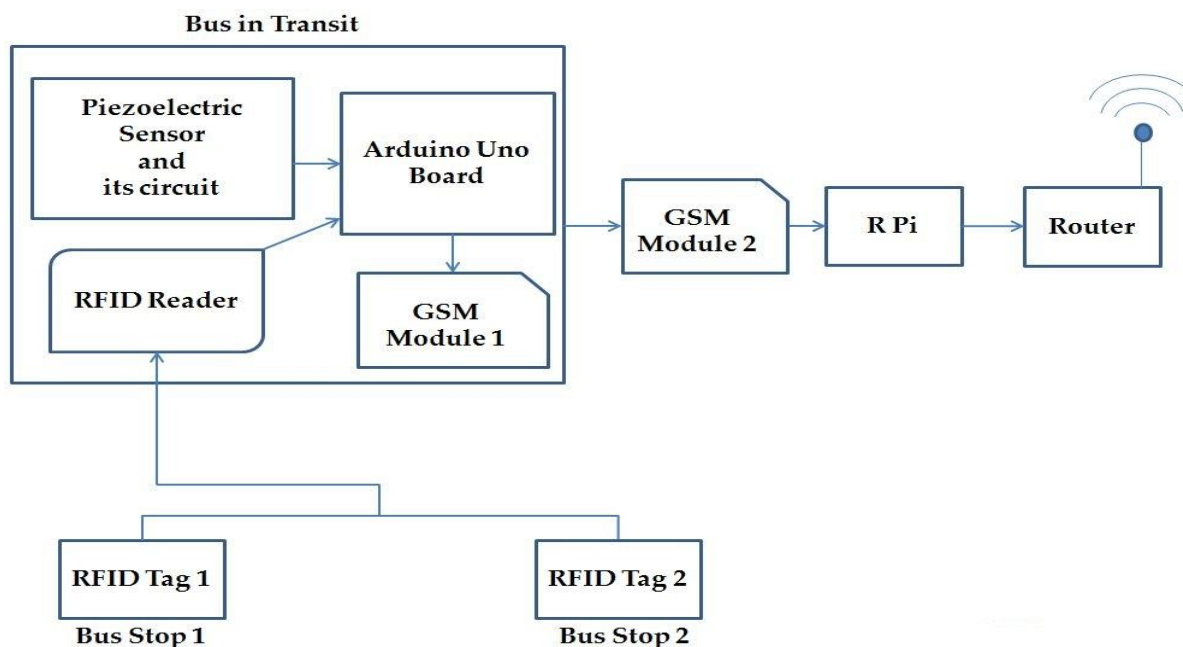


Fig. 1 Block Diagram of CUBICS System

A. Functional Overview

When a bus reaches a bus stop, the RFID reader on the bus reads RFID tag present on the bus stop. This generates a message which contains information pertaining to the bus stop. Commuters would start boarding the bus at the bus stop and occupy the seats on the bus. When the seats are occupied, the piezoelectric sensors beneath the seats send out a voltage that indicates that the seats are occupied. This voltage is received by the Arduino Uno board. Hence the Arduino board has with it the information regarding current location of the bus and the number of vacant seats on the bus. The information from Arduino board is now sent to the GSM module present on the bus from which it is sent to the GSM module connected to the R Pi. Thus, information reaches R Pi and it is hosted on WWW through the router.

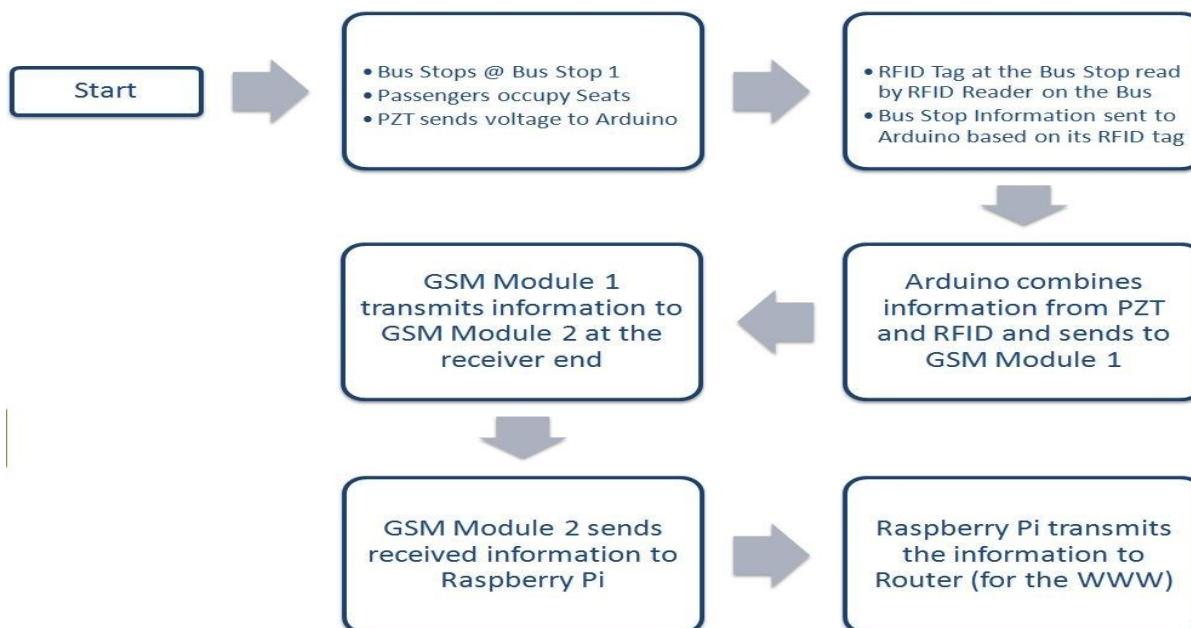


Fig. 2 Process Flow in the CUBICS System

III. PRACTICAL IMPLEMENTATION

The prototype has two blocks: one for transmission of bus information and the other to host it on World Wide Web. The transmission block is essentially the bus when implemented practically. The receiver block receives updates from the bus and hosts the information on the web.

A. Transmission Block

The piezoelectric sensors, RFID reader, Arduino board and GSM module make up this block.

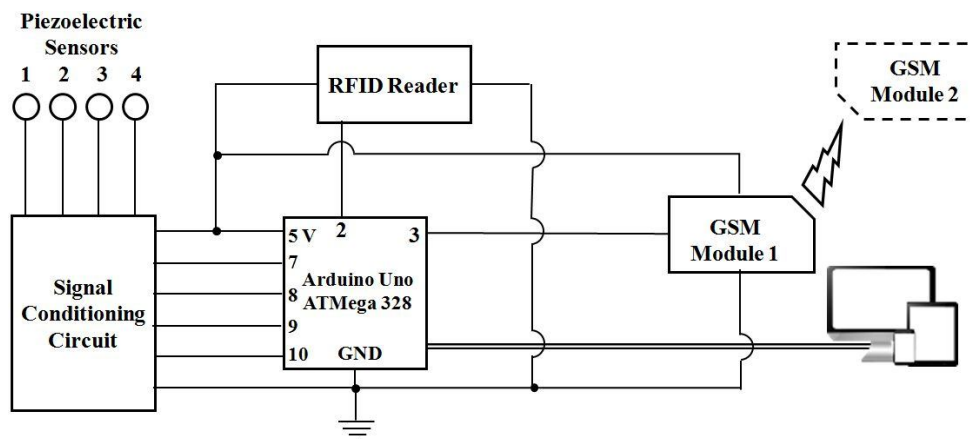
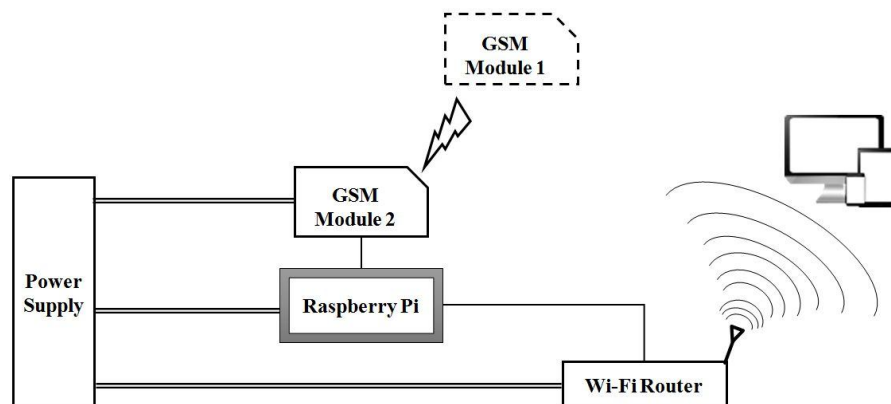


Fig. 3 Transmission Block

The 5 V power supply is given to Arduino board through laptop. The sensors and RFID reader are connected to the Arduino board at the respective pins of the controller as shown in the diagram. The RFID transmission is low frequency transmission of around 125 kHz to 134 kHz.

The piezoelectric sensors produce an output voltage of about 0.8 V when pressure is applied on them. The small and distorted signal requires amplification by a signal conditioning circuit, which uses a BC547 transistor as a Common Emitter amplifier and produces a 5 V signal that is subsequently transmitted to the Arduino Uno.

B. Receiver Block



The receiver block has GSM module (SIM 900), Raspberry Pi Model B+ and a wireless router.

Fig. 4 Receiver Block

Power is supplied to the GSM module, R Pi and Wi-Fi router through adapters. The GSM module is used for receiving messages and sending them to R Pi. R Pi is connected to the Wi-Fi router and any device which is connected to the same router can access the bus information through an URL.

A code is written in Python for execution in Raspberry Pi. In order access and execute this code, remote secure shell (SSH) client such as PuTTY may be used. Other popular options include OpenSSH, FileZilla, eSSH Client, WinSCP, and Xshell. In this project we used PuTTY software.

Raspberry Pi is connected to the device with PuTTY software through an USB. We can observe a device by the name 'ttyUSB0' format. This 'ttyUSB0' string must be used in the program for serial transfer from Raspberry Pi. After logging into Raspberry Pi on PuTTY software, we can check the files present in folders and execute a file of our interest. Care must be taken and it should be ensured that the file to be executed is present in the current directory.

When the code file on Raspberry Pi is executed, information of bus's position and vacant seats is sent on to the web page in the pre-set format as defined in the code.

C. Programming Considerations

The following process flow is considered while programming the system:

- 1) It is first verified if the message is received at the GSM module.
- 2) The message, as and when received, is read into the Raspberry Pi through serial communication.
- 3) The latest message is stored, while the previous message is erased.
- 4) The message is then presented in the desired display format for the web-based interface.
- 5) This information is stored in a file where the new position can be updated.

IV. OUTPUT RESPONSES OF THE CUBICS SYSTEM

The prototype was tested with 4 piezoelectric sensors each of which is representative of a seat in the bus. When the load is applied on the sensors representing seats 2 and 4, it is shown on Arduino software console that the seats are occupied. The Arduino software also displays the information regarding the location of the bus when the RFID tag is read at the bus stop. A screenshot of this console window, taken off a personal computer/laptop, is shown in Figure 4.2, displaying both the number of vacant seats as well as the location of the busy; the unique RFID tags of individual bus stops which are read (16004E9323E8 and 16004E6FC4F3) are also seen in the screenshot.

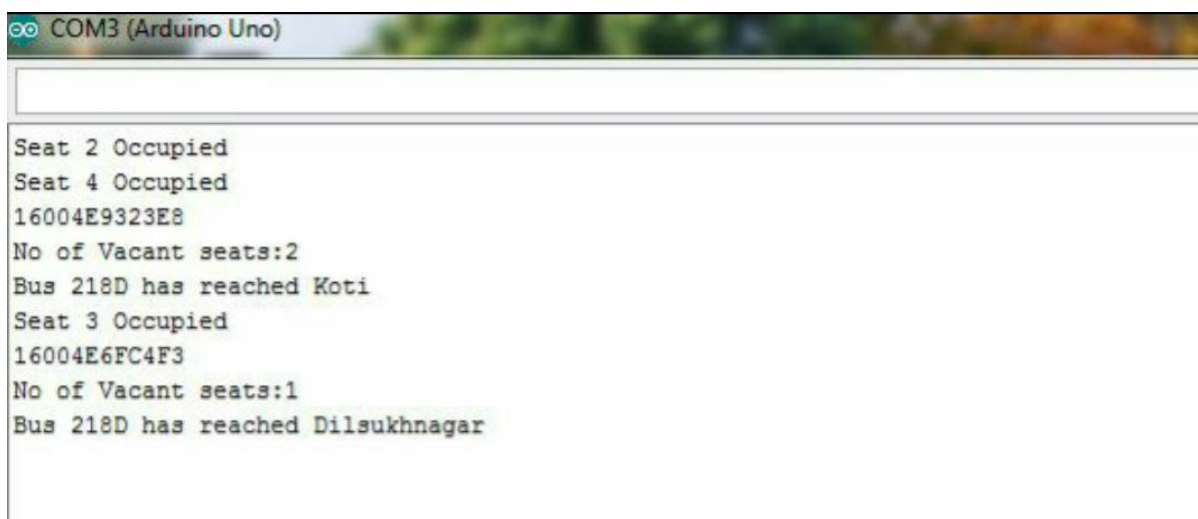


Fig. 5 Screenshot of Arduino console showing the seat occupancy

The same information is also sent from GSM module 1 on the bus for transmission to the GSM module 2 in the receiver block. A mobile phone with a SIM card for GSM module 2 may be used in place of a typical GSM module, which then receives the information as a text message as shown in Figure 6, which is a screenshot of the mobile phone display. The Raspberry Pi in the receiver block enables the display of the information on a web page which is hosted on a unique IP address that can accessed by anyone who has the URL. This information may be displayed at the bus stops in display boards or can be accessed by commuters and transportation agencies from their preferred web browsers at their homes and offices. The web-based interface showing such information is shown as Figure 7, taken off a laptop's web browser.

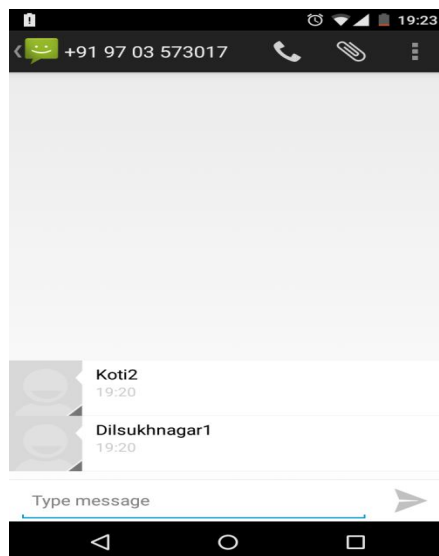


Fig. 6 Screenshot of the mobile phone/ GSM module 2 showing the bus location

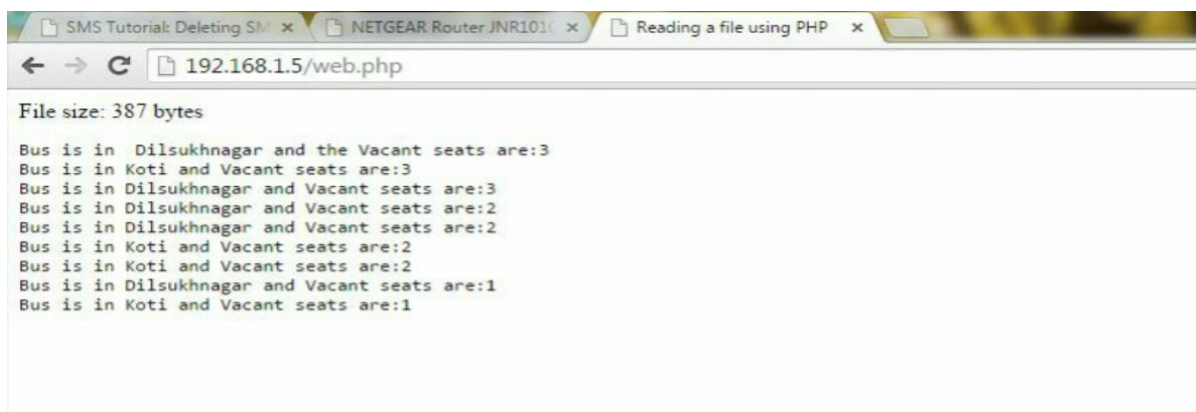


Fig.7 Screenshot of the Web-based display pertaining to the bus location as well as the seating availability

V. CONCLUSION

Comprehensive Updates for Bus Information in Cities and Suburbs (“CUBICS”) is crucial to ensure that public transport systems occupy the mainstream mode of transit and commute, since it is also due to lack of reliable information that people choose private transport over public transport. The proposed design and implementation worked efficiently in predicting the vehicle location at the bus stop as well as passenger count. The chosen methodology involved RFID tags and GSM modules for vehicle location detection and communication as well as piezoelectric sensors to count passengers based on seat occupancy. Thus, cost effectiveness was ensured to be one of the key drivers to take up this project work. This project can be implemented as a pilot initiative and can later be integrated with advanced modules and advanced methodologies. The extensive scope for further enhancements of the project work indicates the crucial nature of this kind of pilot project work that suits the Indian scenario. The fact that most of the research has been done outside of India stands as a proof that developing such a system as CUBICS is of immediate necessity to Indian public transportation systems. Thus, the current project is one of the first steps after many other countries which had a head-start of over a few decades in these aspects of implementing automatic vehicle location (AVL) and automatic passenger count (APC) for public transportation systems.

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