J John Paul[1], Amir Anton Jone[1], Martin Sagayam[1], I Sybiya Vasantha Packiavathy[2], Jesintha E[1], Jemimah Rinsy J[1], Hien Dang[3,4], Marc Pomplun[4]

Department of Electronics and Communication Engineering, Karunya Institute of Technology and Sciences, India (1)
Department of Biotechnology, Karpagam Academy of Higher Education, India (2)
Faculty of Computer Science and Engineering, Thuyloi University, Hanoi, Vietnam (3)
Department of Computer Science, University of Massachusetts Boston, MA, USA (4)

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IoT based remote transit vehicle monitoring and seat display system

Abstract. *In remote villages, the conventional transit system with fixed chart timings, makes life very difficult for them to wait at the bus stops for a long time, as most buses do not follow the timings. In the proposed system, an IoT based remote monitoring system which helps in providing real time information regarding bus timings and seat availability to the traveler's mobile app which ensures proper resource and time management. The IoT based system provides real time information regarding the bus location periodically through GPS module and its seat availability is sensed by a group of IR sensors as the bus crosses every terminal. This information is processed using raspberry pi controller which in turn updates the LED dot matrix display outside the bus. The same information is also sent to the cloud platform, through which the information can be pulled to the user's mobile app. This system provides an easy and efficient way of access for everyone, especially aged and paralyzed people are highly benefited as they get the confirmation on their seat availability in advance before their travel. The developed prototype was tested and implemented and is well suited for remote transit monitoring and also a cost-effective and is practically implementable comparing with the existing conventional methods.*

*Streszczenie. W odległych wioskach konwencjonalny system tranzytowy ze stałymi rozkładami jazdy bardzo utrudnia długie czekanie na przystankach autobusowych, ponieważ większość autobusów nie przestrzega tych czasów. W proponowanym systemie zdalny system monitorowania oparty na IoT, który pomaga w dostarczaniu w czasie rzeczywistym informacji o rozkładzie jazdy autobusów i dostępności miejsc do aplikacji mobilnej podróżnego System oparty na IoT okresowo dostarcza informacji w czasie rzeczywistym o lokalizacji autobusu za pośrednictwem modułu GPS, a dostępność miejsca jest wykrywana przez grupę czujników podczerwieni, gdy autobus przejeżdża przez każdy terminal. (**System zdalnego monitorowania pojazdów tranzytowych i wyświetlania miejsc siedzących oparty na IoT**)*

Keywords: IoT, Location tracking, Raspberry pi, Seat availability
Słowa kluczowe: Internet Rezczy IoY, rozkład jazdy

Introduction

A smart transit system is one of the major thrust areas under the government's initiative for smart city. India's urban population constitutes about 40% and require a comprehensive overall developments in the entire infrastructure. Public transport still remains a boon to people as they still prefer local buses for their day to day transport. But waiting for long hours at the bus stations uncertain of the bus status, creates strain in most people's life [1]. Moreover buses remain crowded or with few passengers making it very unsuitable and inefficient management of resources. Henceforth the need of the hour is to provide real time information of the bus arrival/departure. An ideal solution is proposed by implementing an IoT based real time transit monitoring system. The prototype has a mobile app, which helps to acquire the real time location of the bus on google map. The proposed system also provides the availability of the number of seats in the bus. This effectively helps the commuters (aged/disabled) to properly schedule their transport which is an added advantage.

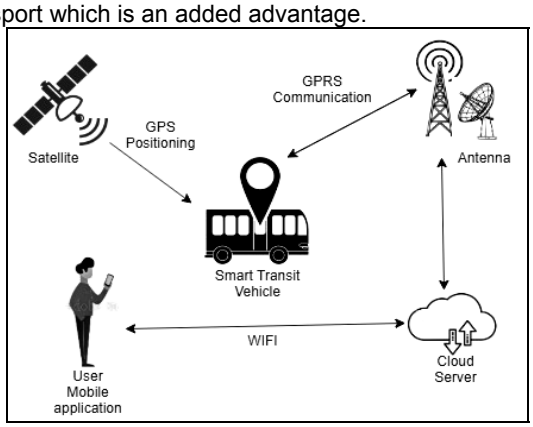

Fig.1. Overview of Transit vehicle monitoring

Fig.1. illustrates the overall perspective of a real time transit monitoring system. This real time aggregated data can help the transport officials to identify the crowded bus stops, where additional buses can be deployed and thereby improving the revenue of the public transport and reduce the fuel consumption by reducing the number of busses plying to less crowded bus stops.

Literature Review

Some recent works are reported related to real time monitoring of remote transit vehicles. The works associated are outlined and their merits and demerits are also tabulated.

(Priti Shende et.al, 2016) proposed a system on a bus tracking system using the RF module, Ethernet module, and LCD. With the help of the local IP address configured to the router, the data which is received is displayed on the website and LCD module in bus stops[1]. The disadvantage of the system is still we dont have any information regarding the availibity of the number of seats in the bus.

(Lavanya R et.al, 2017) proposed a system based on crowd density estimation and bus location prediction using IR sensors, a GPS module interfaced with Arduino UNO. The advantage is that the crowd inside the bus can be known and the time between nearby bus stops[2]. The major disadvantage is number of available seats is ambiguious and uncertain and only a predefined value is obtained.

(Jafrul Islam Sojol et.al, 2018) proposed a system with automated passenger counting system using pressure pad developed by them, Bluetooth HC-05 and touch screen display interfaced with Arduino UNO[12]. The major disadvantage is the values obtained from pressure pad will be inaccurate as it will also detect bags/trolleys if unknowingly placed by the travellers.

(M.A.Hannan et.al, 2012) devised a system[3] on bus monitoring system using GPS, GPRS, GIS, and RFID helps

to track the transit vehicle but doesnot provide information about the number of persons inside the bus or seat availability.

(A. Menon et.al, 2013) proposed a system[4] where time taken for bus arrival is calculated by the difference in time tags between two buses and the same is updated in a mobile app, yet seat availability is not updated which is a drawback.

(D.Conte et.al, 2010) proposed a system[5] on how to count the moving people inside the bus through cameras by salient point detection. But installing cameras increases the cost and detecting the maximum number of people will not be accurate in crowded buses is a huge challenge.

(Bhat Apoorva et.al, 2018) proposed a system for real time monitoring of bus arrival and ticket booking facility through GPS, RFID tags, and sensors[13]. The pratical feasilibility and implentation difficulties are not discussed.

(Marcus Handte et.al, 2012) proposed a system about navigation system for urban bus riders using IoT. In this paper, they have used the Wi-Fi connection to track the passenger details using the MAC address and display the tracking details in the mobile application[6]. The major drawback of this, all people may not access the wifi everytime and in some cases, there are chances of people traveling without mobile phones.

(Tiago Dias Camacho et.al, 2012) has proposed on Advanced Public Transport Systems (APTS). They have implemented a magnetic card or smart card for automatic ticket collecting system[7]. Though they are easy to carry and convenient for people, there are some chances of losing it and forgetting during travel. Hence, this system will not be preferable in rural areas.

(Thiyagarajan Manihatty Bojan et.al, 2014) devised a transportation system[9] based on IoT using GPS, GSM interfaced with Arduino UNO and MEGA with Atmega328, Atmega2560 for tracking the location, NFC technology, and CCTV for capturing and monitoring their travel and LCD with internet connection for displaying in the bus stops.

(Pengfei Zhou et.al, 2012) has proposed a system[10] about the Bus arrival time with the help of mobile towers. They have also used IC cards for the ticket system. This sometimes leads to a problem when there is no proper network with the cell towers during the time of travel.

(BaburaoKodavati et.al, 2011) has proposed a system[11] for Vehicle tracking based on GPS and GSM. In this, they have GSM for sending the details to the mobile phones. But, In this case, there are chances of information not reaching the persons due to improper signal strength and not all mobile numbers of the people traveling inside the bus can be tracked. Hence, GSM is difficult to implement in the buses which run in rural area.

Table 1. Detailed literature survey of the frame work

Author	Platform/ Technology	Methodology	Advantages	Disadvantages
(Jafrul Islam Sojol et.al, 2018) [12]	Bluetooth HC-05, pressure pad and touch screen display interfaced with Arduino UNO	An Automated passenger counting system	No paper receipt is needed to ride on the bus. Enables transport authority to obtain accurate bus fare from bus drivers and helpers remotely	Pressure pad (sensor) doesn't give the accurate results, as it weighs any object/bags placed in the seat
(Lavanya R et.al, 2017) [2]	IR sensors, a GPS module interfaced with Arduino UNO	Crowd density estimation and bus location prediction	The crowd inside the bus and the time of the transit between nearby bus terminals can be known	The number of seat availability is not known, and the passenger count is also not accurate
(Priti Shende et.al, 2016) [1]	RF module, Ethernet module, and LCD	Local IP address is configured to the router, the data which is received is displayed on the website and LCD module in bus stops	Persons need not gather to see which transit comes for their travel. Improves the transportation safety and the quality of services to the Public in rural and urban cities of India.	Feasibility of its practical implications are complicated and ambiguous. Also the availability of number of seats is not determined
(Thiyagarajan Manihatty Bojan et.al, 2014) [9]	GPS, GSM, humidity sensors and LCD implemented with Arduino UNO and MEGA,	The location and the passenger count obtained are displayed in the LCD. The humidity is detected and switches the AC automatically through relay circuit.	The driver gets the notification of the humidity inside the bus to turn on AC, The passenger can fix their ease of travel based on the information provided in LCD.	The obtained information is updated only in the bus terminals, so the user is updated with information only after they reach bus stops.
(Marcus Handte et.al, 2012) [6]	Wi-Fi connection and MAC address	Navigation system for urban bus riders using IoT	The system has the ability to seamlessly interconnect bus passengers with the real-world transit infrastructure	All people may not access Wi-Fi everytime and there are also chances of people travelling without mobile phones.
(Tiago Dias Camacho et.al, 2012) [13]	GPS, RFID tags, bidirectional sensors implemented with Arduino UNO	Navigation system for the bus passengers that has the ability to interconnect passengers with the real world.	Through email ids the passenger can login and check out the bus details and also remotely book tickets	Practical feasibility and implementation difficulties are not discussed

Proposed System

Fig.2. shows the overall architecture of the proposed IoT based smart remote transit monitoring and seat display system, a user-friendly approach that allows travelers to take easy decisions about their journey. It has two sections: Transmitter section and Receiver section. The transmitter section has two IR sections, one at the bus entry and other at the bus exit, GPS module and LED dot matrix display. The IR sensors identify the passenger's entry and exit.

The GPS module identifies the location of the bus with the latitude and the longitude values. These numerical values are updated in google maps to obtain the current location of the bus. The LED dot matrix display is placed outside the bus displays the bus route along with the

number of seats available in the bus. The bus location along with the number of seats available is uploaded to the cloud server through Wi-Fi protocol stack. The receiver section features a mobile app or web browser through which the information of bus location and seat availability is updated to the user. So this helps in reducing the waiting time for the people for long time at the bus stops.A concise description of the major components of the system are given below:

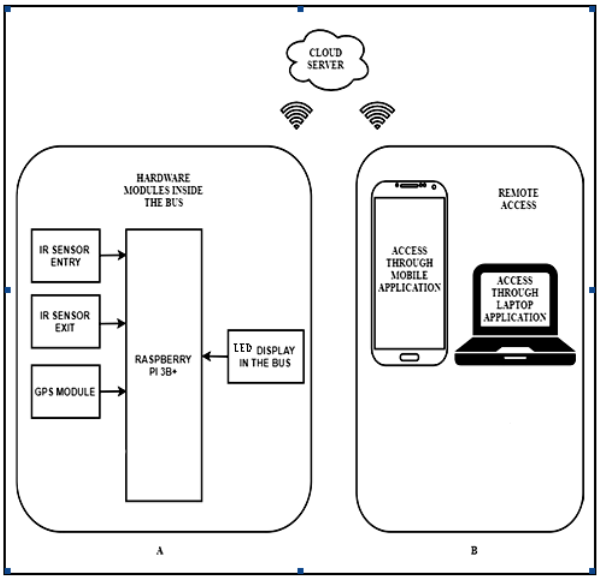

Fig. 2. Overall architecture of the proposed model (A) – Transmitter (B) – Receiver

IR Sensors

The IR sensor is used to detect an obstacle/person with the help of IR light rays (700mm - 1mm) and comes with an IR transmitter and IR receiver module. When an object/person enters the range of the IR range in between the IR transmitter and IR receiver, the IR rays are clogged and are focused back to the IR receiver through which it identifies the person/object. In our proposed system, IR sensors are used for detecting the passenger's entry and exit which helps in updating the count of the passengers inside the bus.

Location Identification

The Global Positioning System (GPS) is used for tracking the location of an object. For getting an accurate location, it follows trilateration principle. Here we have used GPS SIM28 with external antenna for clear satellite range. The module tracks the bus location with the help of latitude and longitude values and updates them on a google map.

Display System:

In the proposed system, we have used MIT App Inventor and Firebase to develop the mobile application. The information about the bus location, passenger's count and seat availability can be accessed through mobile phones or laptops remotely. The LED Dot matrix comes under different sizes, example 8x8, 16x16. Here we use 32x8 matrix by connecting four 8x8 in series for setting up scrolling text display in the bus.

Figure 3 represents the Flow chart of the proposed system.

Two IR sensors are used for detecting the passenger's entry/exit. One sensor is placed at the entrance and the other sensor is placed at the exit.

- When a person enters the bus, the IR sensor1 at the entry, sense the information of person entry and increments the count value. In the same way when someone exits the bus, the IR sensor2 at the bus exit will sense the information of persons exit and decrements the count value. So every time when there is an entry/exit, the availability of the seats are calculated from the total seats and IR sensors 1 & 2. The total seat count is known and it's a constant value and initially the IR1 & IR2 values are initialized to zero. Availability of seats = Total seat count – (IR1 - IR2)

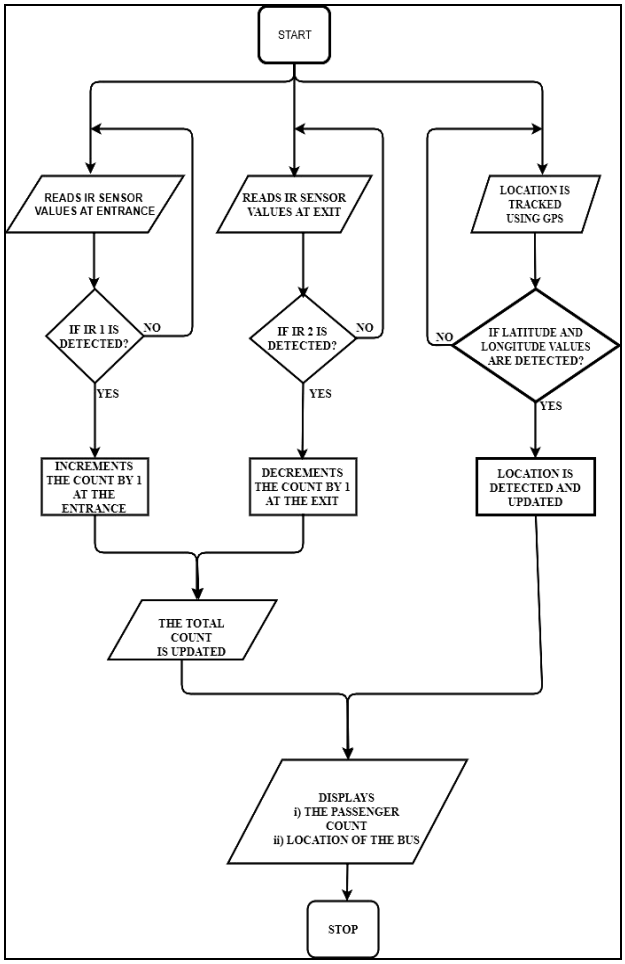

Fig. 3. Flow chart of IoT based remote monitoring transit system

- The location of the bus is tracked using the GPS module. After detecting the latitude and longitude values of bus location, these values are updated to google maps through google APIs. The updated information on the number of passengers along with the bus location is displayed on the LED dot matrix as well as in the mobile App/web browser.

Results and Discussion

Hardware Implementations

IR Sensor

The IR sensors are used for indicating the person's entry and exit. This helps to avoid huge crowds and reduces the chances of accidents due to overcrowding. This also helps the higher authorities in identifying the crowded areas and to provide additional transit vehicles in those areas. The system provides real-time information about the passenger count available inside the bus. The passenger count keeps updating in the python shell for every passengers entry and exit. Figure 4 shows the value of count incrementing whenever a passenger enters the bus and figure 5 shows the value of count decrementing whenever a passenger

exits the bus. The figure 6 shows the output of every passenger entry and exit in the python shell window.

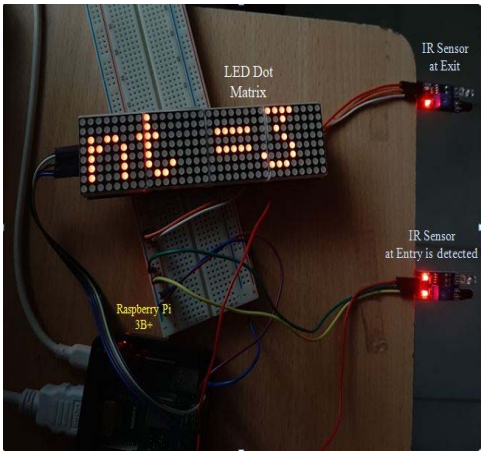

Fig. 4. Incrementing the count at the entrance

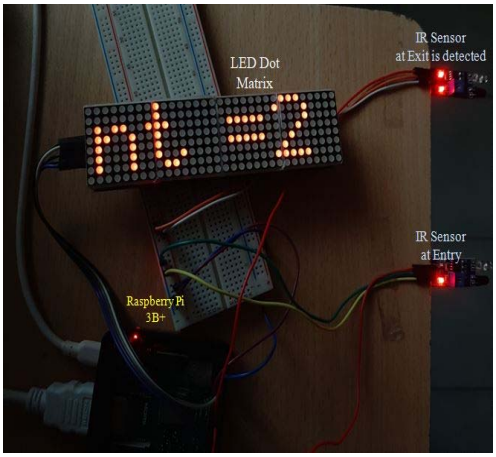

Fig. 5. Decrementing the count at the exit

GPS

GPS module locates the latitude and longitudinal values and these values, through google APIs are updated to the google maps and the exact location is updated to the user on a mobile application (app). Maps are user friendly graphical user interface and an easy visualization tool. Figure 7 shows the Location updation on the google maps with latitude and longitudinal values displayed.

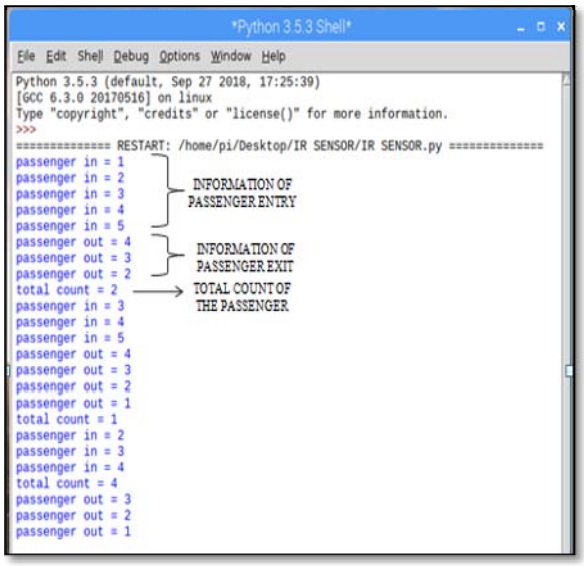

Fig. 6. Output of passenger count

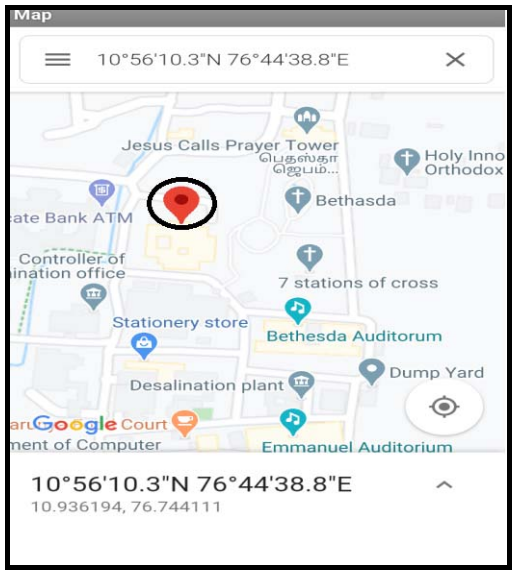

Fig. 7. Location updated in maps

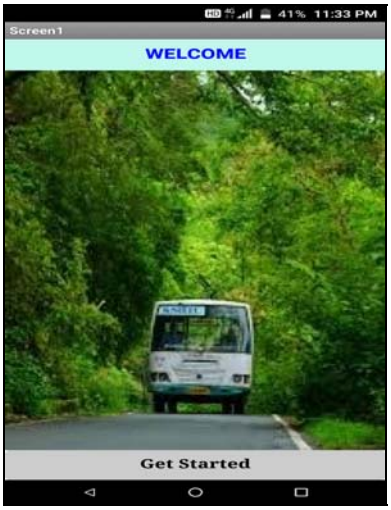

Fig. 8. Front page of the app

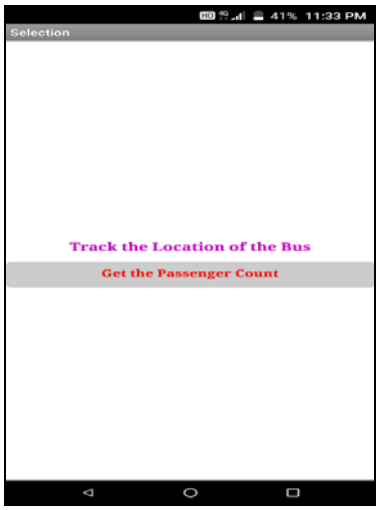

Fig.9. Selection page of the App

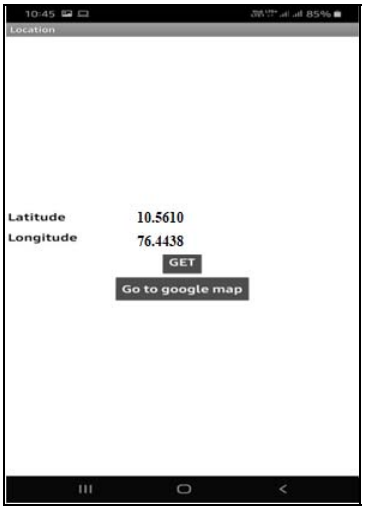

Fig. 10. Latitude & Longitude

Values updated in the app

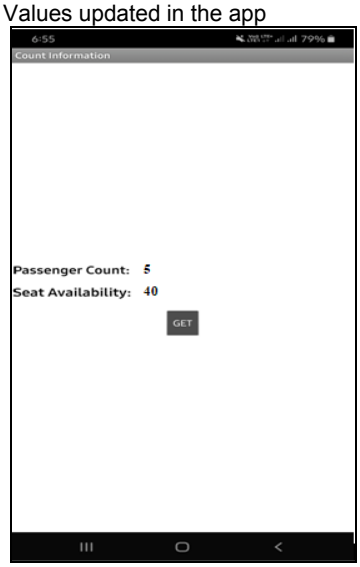

Fig. 12. Passenger count & seat

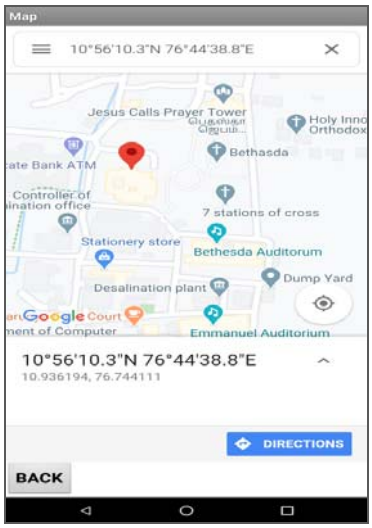

Fig. 11. Google Map displayed in the mobile App.

Table 2. Comparative analysis of the various components

Author	Arduino UNO/ Mega	Raspberry PI/ Camera	GPS	GSM	Pressure Pad	IR Sensor	RFID	Website	Display	App Developed
(P Shende et.al, 2016)[1]	x	✓	x	x	x	x	x	✓	✓	x
(Raju L et.al, 2017)[2]	✓	x	✓	✓	x	✓	x	✓	x	x
(Jafrul Islam Sojol et.al, 2018)[12]	✓	x	✓	x	✓	x	x	x	x	x
(Bojan et.al, 2014)[9]	✓	x	✓	x	x	x	✓	x	x	x
(Bhat Apporva et.al, 2018)[13]	✓	x	✓	✓	x	x	x	x	✓	x
Proposed System	x	✓	✓	x	x	✓	x	x	✓	✓

Software Implementation

Mobile Application (App)

Mobile app plays a vital role for remote monitoring and there are various app development platforms such as MIT app inverter, Android studio. MIT app inverter was a cloud based tool with easy drag and drop options was used for developing mobile app for our proposed work. The app starts with a Welcome note and updates us with the information related to bus location and seat availability periodically. The mobile application has three step process for the users to access the information remotely.

Step 1: Mobile App Front page (Welcome screen)
Step 2: Selection page (Location/Passenger count)
Step 3: Information regarding the Location/count

A user friendly GUI page contains the “welcome note” and “Get started button”, to proceed further as shown in figure 8. The user once enter his login details, he is given access to the next page which contains the various buses in the specific route. After selection of the bus, the user can now get the option to track the location of the bus and get the seat availability as shown in figure 9. Once the user selects the option to “Track the location of bus”, he will be given access to the next page which will give the latitude and longitude details of the bus as shown in figure 10. To view the latitude and longitude values on the google maps, the information is obtained by selecting the option the option of “Go to google map” which gives the exact location of the bus as shown in figure 11. In order to get the seat availability the user has to select “Passenger count” which takes to the next page with the passenger count and seat availability as shown in figure 12. The availability of the seats can also be found by subtracting the passenger count from the total number of seats available in the transit.

Conclusion and Future work

In this paper, a prototype of a smart remote transit vehicle monitoring system is developed to help the remote villagers in tracking the bus location and to identify the passenger count before the arrival of the bus. The previous works [1], [13] find its difficulty in implementing practically, while [9] gives out a better approach for implementation practically, but information (bus location and seat availability) is updated only in the bus stops. This makes again difficult for the people to know the information only when they the bus stops. The results obtained from the IR sensors and the GPS module on a mobile app shows that the prototype is robust and more precise and can be practically implementable and cost effective. The systems will be intelligent enough using IoT framework effectively helps in reducing the percentage of the accidents caused due to overloading of the passengers and also makes peoples life stress-free in remote places. Table 2 shows the comparative analysis of our system with the previous works. In the previous systems, only notifications are sent to the remote user through a GSM module. In our system we have developed mobile app adding all others features previously reported which makes it a robust method for real time monitoring with easy graphical user interface (GUI). As a future scope, camera modules will be included in the system, with image processing algorithms to make the system more precise by taking decisions after comparing the input from the sensors with the image data’s. Also cameras can be used as an additional feature for the purpose of surveillance inside the buses.

***Authors**: Mr. J John Paul, Department of Electronics and Communication Engineering, Karunya Institute of Technology and Sciences, India. johnpaul@karunya.edu*
Mr. A Amir Anton Jone, Department of Electronics and Communication Engineering, Karunya Institute of Technology and Sciences, India. amir@karunya.edu
Dr. K Martin Sagayam, Department of Electronics and Communication Engineering, Karunya Institute of Technology and Sciences, India. martinsagayam@karunya.edu
Dr. I Sybiya Vasantha Packiavathy, Department of Biotechnology, Karpagam Academy of Higher Education, India. sybizion@gmail.com
Ms. Jesintha E, Department of Electronics and Communication Engineering, Karunya Institute of Technology and Sciences, India. jesinthae@karunya.edu.in
Ms. Jemimah Rinsy J, Department of Electronics and Communication Engineering, Karunya Institute of Technology and Sciences, India. jrinsy@karunya.edu.in
Dr. Hien Dang, Faculty of Computer Science and Engineering, Thuyloi University, Hanoi, Vietnam, Hiendt@tlu.edu.vn And Department of Computer Science, University of Massachusetts Boston, MA, USA, thithuhien.dang@umb.edu
Prof. Marc Pomplun, Department of Computer Science, University of Massachusetts Boston, MA, USA, marc.pomplun@umb.edu

***Corresponding author**:*
Dr. Hien Dang,
Hiendt@tlu.edu.vn
Faculty of Computer Science and Engineering, Thuyloi University, Hanoi, Vietnam,
Department of Computer Science, University of Massachusetts Boston, MA, USA.

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