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An Intelligent Bus System Based on Internet of Things for Urban Environments

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***Abstract*—** The Internet of Things is a network of interconnected devices or objects that are provided with the ability to send and receive data, thereby paving the way for a smarter world. The existing bus tracking system is based only on Global Positioning System and provides the current location of the bus in terms of latitude and longitude. The proposed system uses Global Positioning system and the Radio Frequency Identification Technology to track, locate and monitor the buses. The system uses an android application to list out all the available buses operating between the specified source and destination along with the route and their operating time slots. The estimated arrival time of the bus and the passenger's reaching time to their destination, is predicted based on the calculated Haversine distance between the source and destination, GPS location of the bus and the average speed of the bus. An automatic passenger counting system is provided to keep in track of the total number of passengers travelling in the bus and the overcrowded buses are intimated to the users through the android application.

***Keywords*—** Internet of Things, Bus tracking, Passenger count, Arrival Time Prediction, Haversine

I. INTRODUCTION

The main objective and the aim of any invention or technology is that it should always remain as a helping source for the struggling society to make complicated things into simpler ones. It has been stated that the global discoveries are constantly changing the face of technology, and that the technology is changing the world. The innovative and smart ideas can solve a multitude of different complex problems faced by the communities today [1]. The public transport systems have the capacity to satisfy the needs of large masses of urban travelers. Using the public transport for the daily use provides greater benefits to the passengers, environment, economy and to the society. The use of public buses reduces traffic congestion, pollution and fuel consumption since public transportation can convey many people in much less space than the individual automobiles. Moreover public transportation benefits communities financially. But one major reason that tends people to avoid public buses is the lack of reliability that they have on the public transport [2]. Thus providing a reliable and a trustworthy public transportation system is very much essential in order to meet and satisfy the growing needs of the passengers. From the Passenger's point of view, public buses are often considered as complex and difficult to navigate and lack a sense of personal ownership and control when compared to the private cars, buses and cabs. In comparison with the private mode of transportation, majority of the people share a common opinion that travelling on public buses offers a low level of convenience and comfort [3]. The waiting time and the inaccuracy of the bus arrival time are the major concerns that needs to be improved in order to gain the trust of the public regarding the public transport. The main consideration in using the public transport is the long period of time that the passengers have to wait in the bus stops for the arrival of a bus with no idea when the bus would actually arrive at the specific bus stop. The passengers will be left with no information regarding the operating buses between a particular source and destination, their operating time slots, the bus arrival time, the reaching time and the total journey time. Offering services like real-time tracking and estimated arrival time are a common welfare for the passengers.

In order to increase the reliability on public buses, the proposed system uses an android application to display the details of all the available buses between a source and a destination along with their current location and their estimated arrival time. The users can view all the details through the application and can plan their travel accordingly. Thus the proposed intelligent bus system reduces the waiting time of the passengers by providing them the expected arrival time of the bus to a specific bus stop. The exact geographical location of the bus is tracked by using the GPS receiver and the latitude and longitude values are updated in the database. The distance between the current location of the bus and the destination is calculated by using the Haversine formula. By using the calculated Haversine distance between the specified source and the destination along with the average speed of the bus, the arrival time of the bus is predicted. RFID readers and tags are placed in the bus and the bus stops respectively, to determine the exact time at which a particular bus has crossed the specified bus stop. This helps in providing the live status of the bus's location to the passengers. The total number of passengers inside the bus is sensed by using the Infrared sensors and the total count is updated in the database. A maximum count value is predefined and once the total passengers exceeds the limit, the intimation is provided to the passenger that the bus is an overcrowded bus.

The rest of the paper is organized as follows. Section I contains the Introduction of the proposed bus system based on Internet of Things. Section II contains the related work and the various technologies that are being used in existing bus tracking systems. Section III includes the architecture diagram, overall working of the proposed system and a detailed explanation of the various components being used in the proposed work. Section IV includes the results and the discussions of the proposed work and Section V includes the conclusion and the future scope of the proposed bus tracking system based on Internet of Things.

II. RELATED WORK

Mr. AnilKumar J Kadam et al. [1] proposed a smart bus system for smart city using IoT technology. This system increases the trustworthiness in public transport by providing the exact location of the bus and the approximate arrival time of the bus to the user's source location. This work uses GPS to track the bus location in terms of latitude and longitude, and the Euclidean formula to calculate the arrival time.

Kai Qin et al. [2] proposed the Design of Intelligent Bus Movement Monitoring and Station Reporting System. The system uses the GPS module to monitor the bus movement and GPRS module to send the location information to the control center. The software part of the proposed work includes the flow chart for reporting the station reporting and network access. The system promotes the development of city transportation by carrying on real time control and management of the city vehicles.

Muhammad Umar Farooq et al. [3] proposed a GPS based Public Transport Arrival Time Prediction system. The system provides real time Automatic Vehicle Location (AVL) data and displays the excepted arrival time of each bus on the respective bus stops. The system uses GPS and GSM module to track the vehicle and thereby provides a real time locating system. An optimal and efficient time prediction algorithm is used in the server side to estimate the accurate arrival time.

Ahmet Sayar et al. [4] proposed a smart bus tracking system based on Location- Aware services and QR codes. The system uses QR codes to view the bus location and is also based on technologies like GPS and interactive google maps. The SMS and e-mail services are used by the passengers to receive free alerts about the expected arrival time of the bus. A class of training set is used for predicting the bus arrival time.

Pengfei Zhou et al. [5] proposed a system for Predicting bus arrival time with mobile phone based participating sensing. The work focuses on presenting a novel bus arrival time prediction system based on crowd participation. The obtained evaluation results achieves outstanding prediction accuracy than the other GPS supported systems. The proposed work is energy friendly and is generally available.
Sujatha k et al. [6] proposed the design and development of android mobile based bus tracking system. The system provides an economical, flexible, and reliable system for bus tracking by using GPS and GSM. An android application is used to update the arrival time of the bus to the users. The user can obtain the vehicle's position information through track request. Effective location information is obtained through the feedbacks collected from the users. Alternate routes are also suggested when a particular route is blocked.

III. METHODOLOGY

A. Internet of Things Overview

The fast emerging technologies of the present world includes the Embedded Systems and Internet of Things, which acts as a powerful tool in solving a variety of complex real world problems. Internet of Things is a network of interconnected devices or objects that are provided with the ability to send and receive data. Internet of Things paves way for smarter world and leads to automation. The major and an essential factor behind all the smart devices is the amount of data. The more the system is able to collect and sense from its environment, the smarter it becomes. IoT reduces the human to machine interaction and provides a way for increasing the machine to machine interaction. The various applications of the IoT devices are broadly categorized as consumer, commercial, industrial and infrastructure spaces.

B. Arduino UNO

Arduino UNO is an open-source and single-board microcontroller that is capable of performing a specific task. Arduino is provided with sets of digital and analog input/output pins which are termed as General purpose input/output pins. The Arduino used in the proposed system is based on the ATmega328 and it provides 14 digital input/output pins in which 6 can be used as Pulse Width Modulation pins, 6 analog pins, a 16MHz ceramic resonator, an ICSP header, a USB connection and a reset button. Arduino is programmable with the open-source Arduino IDE, through which programs are written and are uploaded to the Arduino board. Arduino IDE provides a simple and a clear programming environment and Embedded C and C++ are the programming languages that can be used. The ATmega328 controller provides serial communication and has a number of facilities for communicating with a computer, another Arduino board or other microcontrollers.

C. IR sensor interfacing with Arduino

Infrared technology addresses wide variety of wireless applications. The main areas are sensing and remote controls. IR Sensor is an electronic device, which emits and detects infrared radiations to sense objects in the surroundings and thus IR sensor acts as an object detector. The infrared rays are invisible to the human eyes and have the wavelength longer than the visible light wavelength, but smaller than the microwaves. The various elements of the IR sensor includes the Infrared source, Transmission medium, optical component, Detector and signal processing.

In the proposed system, IR sensors are kept at both the Entry and Exit doors of the bus. When a passenger enters the bus, the IR detects the entry and sends signal to the controller and the count value is incremented. Similarly, when a passenger leaves the bus, the IR sensor detects the exit and sends the signal to the Arduino and the count is decremented. Thereby the total passengers inside the bus is calculated and shown to the passengers waiting for the bus. When the count exceeds the maximum value, intimation is given to the passengers that the bus is overcrowded, through the android application, so that the passengers could avoid the crowded bus and can rearrange their plans accordingly.

D. GPS interfacing with Arduino

GPS, a navigation device is capable of receiving information from satellites and provides the exact geographical position of the device. GPS receivers are also used in automobile navigation system. It provides continuous real time, 3D positioning, navigation and timing worldwide. The working principle of Global positioning system is based on the 'trilateration'. The position is determined based on the distance measurements between the GPS receivers and the satellites. A minimum of four satellites are used to determine the position of the GPS receiver on the earth. The target location is confirmed by the fourth satellite and the other three satellites are used to trace the location of the object. The fourth satellite is used to confirm the target location of each of those space vehicles. Global positioning system consists of satellite, control and monitor station and a GPS receiver. The GPS receiver takes the information from the satellite and uses the method of triangulation to determine the object's exact position.

In the proposed work, GPS is mainly used for tracking the location of the bus. Each bus is provided with a GPS module that is interfaced with Arduino UNO. The exact geographical position of the bus is tracked and the passenger is provided with a map link in the mobile application along with the obtained latitude and longitude values, by which the required bus can be tracked and monitored.

E. RFID interfacing with the Arduino

Radio-frequency identification technology automatically identifies and tracks the RFID tags attached to the object. The RFID technology consists of two major components, the RFID reader and the RFID tag. The main elements of the RFID reader includes RF signal generator, antenna and the receiver or the signal detector.

In the proposed system, each bus is provided with the RFID reader and is interfaced with the Arduino UNO. RFID uses the radio waves to read and capture the digital information stored in the tag. The object is provided with the RFID tags and when the object comes in the range of the RFID reader, the RFID tag in the object sends the feedback signal to the reader. In the proposed Intelligent Bus system, RFID tags are placed in the bus stops and when a bus crosses the bus stop, the reader senses the tag and passes the signal to the controller. The RFID tag can be read from several feet away and unlike the bar code reader, the tag need not to be in the direct line-of-sight of the RFID reader. The RFID can work in different frequency range and RFID belongs to the group of technologies commonly referred to as "Automatic Identification and Data Capture mechanism".

Low Frequency(LF) RFID– operate in the range of 30 KHz and 300 KHz and have the read range of up to 10cm. LF-RFID have a shorter read range and slower data read rate. High Frequency (HF) RFID – operate in the range of 3 MHz to 30 MHz and have the read range of up to 10 cm to 1 m.

Ultra-High Frequency (UHF) RFID – operate in the range of 300 MHz to 3 GHz and have the read range up to 12 m and have faster data transfer rates.

The RFID tags are classified as Active and Passive tags, depending on how the RFID tag communicates with the RFID reader. The active RFID tags have their own battery and power source whereas the passive tags do not have any batteries. In case of passive tags the signal received from the RFID reader acts as the power source. The proposed system uses passive RFID tags since they are cheaper, smaller in size and are more flexible than the active tags.

F. LCD interfacing with Arduino

A Liquid Crystal Display is a flat, thin display device that uses the light-modulating properties of liquid crystals. The proposed model uses a 16x2 LCD module display. A 16x2 LCD can display 16 characters per line and there are 2 such lines. Each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, command and data. The command register stores the instructions given to the LCD and the data register stores the data to be displayed. The command is an instruction given to LCD such as initializing it, clearing its screen and setting the cursor position. The data is the ASCII value of the characters to be displayed. In the proposed system the LCD is used for displaying the messages to indicate the operations that are carried out in the system. The messages that are displayed in the LCD screen includes, the total number of passengers in the bus, the name of the bus stop that the bus crosses and the estimated arrival time of the bus.

G. Working

The overall working of the proposed system can be provided as a sequence of five steps. The total passengers count in the specified bus is calculated using IN and OUT IR sensors. Then the GPS Receiver receives the data from the satellite. RFID Reader reads the bus stop information. The data from the controller is then transmitted to the server through Wi-Fi chip. The Wi-Fi chip then sends the data to the required server and finally the user receives the location of the required bus through the android application. The Arduino UNO single-board microcontroller is placed in the bus and is interfaced with RFID reader, LCD, GPS module, IoT chip and IR sensors. The Arduino transmits and receives data to/from the modules connected to it. The data from the Arduino is then send to the server via through the IoT chip. The proposed system for tracking and monitoring the public transport using GPS and RFID technology are capable to deliver the results and the information in an efficient way.

The GPS gives the exact location of the bus and the latitude and the longitude values are obtained. The GPS sends the geographical position of the bus to the controller, which is viewed by the user through the use of an android application. For better tracking of the bus, the RFID technology is also used. The RFID technology gives the current running status of the bus and arrival time of the bus at the various intermediate bus stops. Each bus contains RFID Reader, interfaced with the controller and each bus stop is provided with passive RFID tags. When a tag comes in the range of RFID reader, the reader reads the tag information and sends it to the controller. The controller then sends the information to the cloud server through Iot chip. The user then logs in to the server and gets the information about the exact location of the bus. The use of RFID in the proposed system helps in obtaining the exact time at which a particular bus has crossed a particular bus stop, by which the estimated arrival time and reaching time can be calculated based on the distance and the average speed of the bus. The arrival time of the bus to the passenger's location is calculated by using the speed, distance and time formula.

$$\text{Time}=\text{Distance}/\text{Speed}$$

The distance between the source and the destination is calculated by using the Haversine distance formula.

$$a=\sin^2(\Delta latDifference/2)+\cos(lat1)*\cos(lat2)*\sin^2(\Delta lonDifference/2)$$
$$c = 2*atan2(\sqrt{a}, \sqrt{(1-a)})$$
$$d = R*c$$

where,

$\Delta latDifference = lat1 - lat2$ (difference of latitude)
$\Delta lonDifference = lon1 - lon2$ (difference of longitude)

R is radius of earth (i.e.) 6371 KM or 3961 miles
d is the distance computed between two points

In the proposed work, the speed is taken from the trimmer potentiometer. Also the speed can be adjusted by using it. By varying the speed, the corresponding arrival time can be calculated. But in real time applications, the speed of the bus is lively monitored by using the speed sensors. Based on the Haversine distance and the average speed of the bus, the arrival time of the bus to the user's location is determined. Haversine formula provides the great-circle distance between two points on a sphere. The calculation is carried out based on the latitude and longitude values of the points and by using the radius of the Earth. Thus the proposed system reduces the waiting of the passengers in the bus stop by providing an intelligent bus tracking mechanism. The proposed system also provides the crowd density of the bus. This is done by using the Infrared sensors which keep in track of the total number of passengers inside the bus. IR sensors are used for passenger counting and they are placed at both the Entry and Exit doors. When a passenger enters the bus, it is detected by the sensor and the signal is sent to the controller. The passenger count is incremented. Similarly, when a passenger leaves the bus, the passenger count is decremented. Thereby the total passengers inside the bus is calculated and the data is sent to the server via Iot chip. When the total count exceeds the predefined maximum value, an intimation is given to the passengers that the bus is overcrowded.

The overall architecture of the proposed Intelligent Bus system is provided in the Figure 1. The architecture consists of two main sections, namely the bus and the bus stop. The bus has the Arduino single board microcontroller and the other components including IR sensors, GPS receiver, LCD, RFID Reader, IoT chip are interfaced with the Arduino.

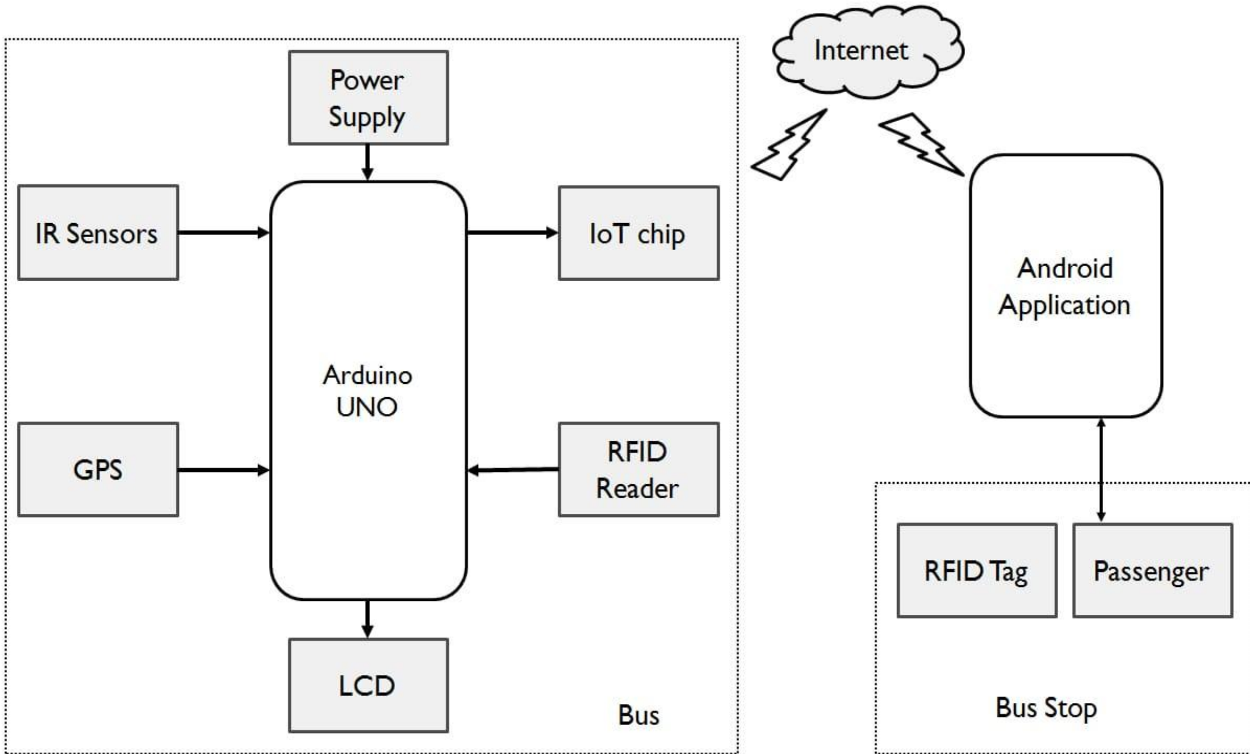


Figure 1. Architecture of the proposed system

IV. RESULTS AND DISCUSSION

The results of the proposed intelligent bus system are obtained on the basis of two parameters.

(i) The distance between the specified source and the destination

(ii) The Arrival time of the bus to passenger's source location.

The obtained results are expressed in both tabular and graphical representation.

A. Obtained Distance

Table 1. Results (Obtained Distance)

Obtained Haversine Distance between source and Destination

Source-Destination	Euclidean Distance (km)	Haversine Distance (km)	Actual Map Distance (km)	Deviation from Actual Value	
				Haversine	Euclidean
A-D	15.83	**17.49**	20	**2.51**	4.17
B-D	13.23	**14.63**	17	**2.37**	3.77
C-D	09.50	**10.51**	12	**1.49**	2.50

Points (Latitude, Longitude)
A (8.1833, 77.5385)
B (8.1740, 77.4377)
C (8.1522, 77.4377)
D (8.0883, 77.5385)

The results were obtained by considering a set of three source-destination pairs, each of which is identified by their corresponding latitude and longitude values. The haversine distance between the source and the destination is the obtained result of the proposed system. On the other field, the Euclidean distance is the distance between the source and the destination as given by the existing system. The actual map value is considered as the reference value, and the deviation of the haversine and the Euclidean distance from the actual map distance is computed.

Observation: The deviation from the actual value in case of haversine is less when compared to that of the Euclidean value. Thus it is evident that using the Haversine formula in computing the distance between the source and the destination had increased the accuracy in the distance computation.

The graph in the Figure 2 represents the distance comparison between the Euclidean, haversine and the actual Map distance. In the graph, the Haversine line is much closer to the Actual map distance, which indicates that more accuracy than the existing system is obtained by using the haversine distance.

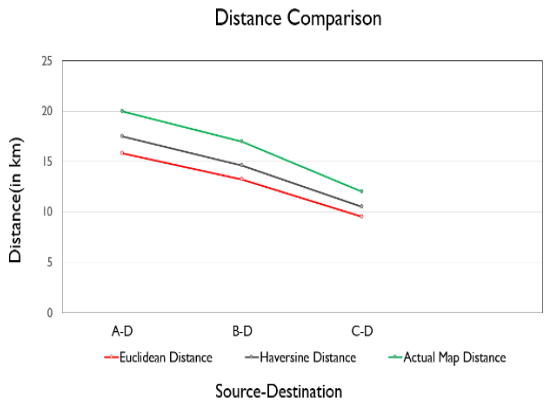


Figure 2. Graphical representation of the obtained Distance

B. Obtained Arrival Time

Table 2. Results (Arrival Time)

Arrival time of the bus to Passenger's Location

Source-Destination	Euclidean Time (mins)	Haversine Time (mins)	Actual Time (mins)	Deviation from Actual Value	
				Haversine	Euclidean
A-D	21.06	**23.19**	26.40	**3.21**	5.34
B-D	17.38	**19.30**	22.40	**3.10**	5.02
C-D	12.40	**14.01**	16.00	**1.99**	3.60

Points (Latitude, Longitude)
A (8.1833, 77.5385)
B (8.1740, 77.4377)
C (8.1522, 77.4377)
D (8.0883, 77.5385)

The graph in the Figure 3 represents the arrival time comparison between the proposed and existing system values. It is visible that the Haversine line is much closer to the Actual time line, indicating that more accuracy in arrival time computation than the existing system is obtained by using the haversine formula.

C. Performance Analysis

The performance of the proposed system is analyzed on the basis of accuracy in the distance and arrival time computation. The obtained accuracy in the distance and the arrival time is computed by the formula, given in the below figures.

The values in the Haversine Time field represents the obtained arrival results of the proposed system. On the other field, the Euclidean based arrival time is shown as given by the existing system. The actual time field is taken as the reference value and the deviation is computed in both the cases.

Observation: The deviation from the actual time in case of haversine is less when compared to that of the Euclidean based calculations. Thus the required result is obtained by providing higher accuracy in the computation of both distance and arrival time by using the Haversine Formula.

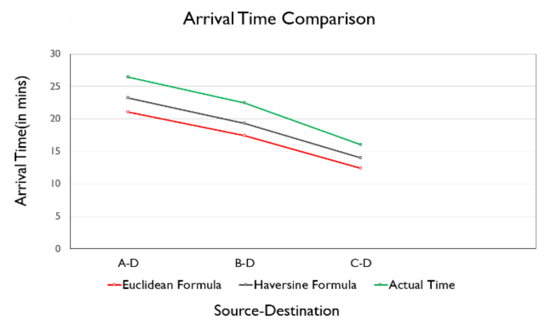
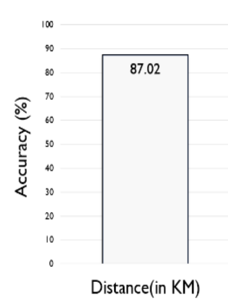


Figure 3. Graphical representation of the obtained Arrival Time

(i) Accuracy in Distance



$$Accuracy = \frac{Obtained\ Distance}{Actual\ Distance} \times 100$$

✓ Case A-D:
Accuracy=87.45 %

✓ Case B-D:
Accuracy=86.05 %

✓ Case C-D:
Accuracy=87.58 %

Average Accuracy=87.02 %

Figure 4. Distance Accuracy

An average accuracy of 87.02 % is obtained in the distance calculation.

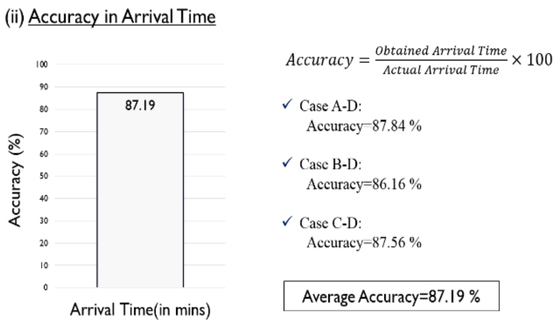


Figure 5. Arrival Time Accuracy

An average accuracy of 87.19% is obtained in the arrival time calculation.

D. Performance Comparison

The performance of both the existing system(based on Euclidean formula) and the proposed system (based on Haversine Formula) is compared and the comparison results are represented in the bar graph.

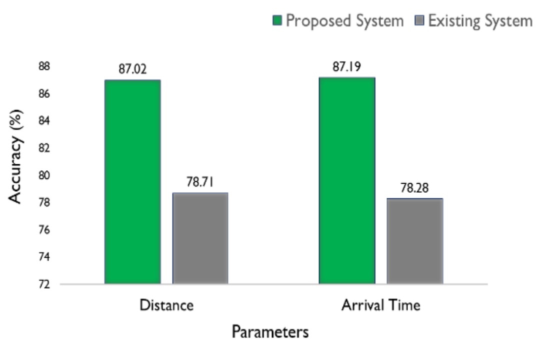


Figure 6. Performance Comparison

The proposed system has shown an increase of 8.31% of accuracy in distance computation and an increase of 8.91% of accuracy in arrival time computation.

V. CONCLUSION AND FUTURE SCOPE

Thus the proposed system provides the exact location of the bus and the precise time at which a particular bus has crossed the specified bus stop. The distance between the source and destination along with the arrival time is provided to the passengers. Thus the waiting time of the passengers in the bus stops is reduced. The passengers will also be aware of all the operating buses between the specified source and destination, along with their operating time slots. In addition, the total number of passengers in a bus is also monitored and the overcrowded buses are indicated to the passengers. Thus the proposed intelligent bus system provides a better way to track and monitor the public buses in the urban environments and provides the passengers with the estimated arrival time of each bus, thereby reducing their waiting time. More efficient and cost effective methods to improve the accuracy of the distance and arrival time calculation can be carried out as a part of the future work. The future work also includes the prediction of the bus arrival time based on real time traffic analysis.

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