BUS GUIDANCE SYSTEM USING INTERNET OF THINGS

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ABSTRACT

Buses are the common mode of transportation all over the country because they ensure safety as well as cost-effective mode of commutation for the passengers. Albeit there are plenty of bus services available, the passengers get stranded in terminals due to lack of proper information about the buses for their desired routes and even when travelling through the exact buses, they tend to get down at wrong terminals due to lack of information. We present here Bus Guidance System (BGS) using Internet of Things to improve the means of travelling more comfortable and user friendly.

KEYWORDS

Passengers, Bus, Terminals, Routes, Destination, Internet of Things.


INTRODUCTION

Buses are widely used in almost every part of the country. People prefer buses because of its high frequencies as well as its cost effectiveness for travelling from one part to another within a country. On the other hand from commuter’s point of view it is really intricate and difficult to navigate through such an overwhelming amount of buses and routes. At times, there is delay in arrivals as well as operation of standby buses due to traffic and other administrative issues. This causes havoc in use of public transport by tourists, senior citizens, differently-abled and younger generations.

In recent years, there is a steep growth in mobile and internet users. There are even plenty of tools, which provide online reservation and navigation to different places of the state. But still it lacks in providing a proper guidance for the bus commuters because those systems are mainly designed for the flight commuters. The key things required for a mediocre traveller are:
- Which bus to board?
- Whether the exact bus has arrived at the terminus?
- When will be the next bus to the specified route?
- What is the distance and duration to the specific place?
- When to get down?
- Where to contact in case assistance is needed?
- Trace the exact location of the bus intended for the destination.

The Internet of Things (IoT),[1][2] is a recent model for communication in which the objects of everyday life will be equipped with microcontrollers, transceivers for digital communication and suitable protocol stacks that will enable interaction with other objects and with the users becoming an integral part of the Internet.[3][4][5] This paper completely presents the technical aspects for providing a way out for the above mentioned issues using Internet of Things.

It also gives an insight on applying Poisson probability function to calculate the average waiting time for passengers in the bus terminus.

Bus Guidance System

Most tools at present use only static data available in internet and does not provide dynamic information’s based on user’s location. In the rest of the section, we will outline the working of the BGS for improving transportation ease.

System Overview

It provides the following functions, which are not currently provided by any other system:

1. Continuous and dynamic monitoring of the location of the bus intended for the specific destination.
   a. E.g. Bus number 56 having unique ID of “B4321” moving towards specified destination can be monitored from anywhere using Cloud with help of the information tracked in servers using the GPS installed in the buses.
2. Provide complete list of buses with timings and routes when the passenger scans the QR-Code or enters the ID provided at the bus terminus. A complete description about QR codes is given in.[6]
3. Provide a notification when the specific bus has arrived at the bus terminus.
4. Provide navigation by connecting to GPS,[7] installed in buses using Wi-Fi[8] or by connecting with server.

System Architecture

The complete system works on IoT. Each and every component interacts with each other. The three different components used send and share messages with each other, thereby implementing the concept of Internet of things.

The Entire System Relies on Three Components

1. GPS based transceiver installed in buses.
2. Smartphone application installed in the phone of the passenger, which provides excellent user interface.
3. Server to maintain the complete database about the buses and its corresponding informations.
Early receivers did not perform well in covered areas but gradual improvements were made to the receivers to make signals. Early receivers did not perform well in covered areas but gradual improvements were made to the receivers to make

**Working of GPS:** The GPS [9]-[11] satellites send out signals to a GPS receiver. These receivers continuously receive these signals. Early receivers did not perform well in covered areas but gradual improvements were made to the receivers to make them work in indoors too. GPS operation is based on time reference, which is provided by atomic docks installed in the satellites.

Each satellite sends individual data that has time and location details. Synchronization is there between these satellites to send all the signals at the same time. The signals having speed of light arrive at different instants due to varying distances of satellites. The distance satellites can be determined by the amount of time the signal takes to reach the receiver. A minimum of four satellites is needed to calculate the exact location. There are a minimum of 24 satellites all the time and a few additional spares. The satellites are at a height of about 11,500 miles traveling at 9,000mph.

**Working of Wi-Fi**

Radio signals are the crucial source to make Wi-Fi networking possible. These radio signals transmitted from Wi-Fi antennas are received by the devices, which support Wi-Fi such as mobiles or computers. Whenever a device receives a Wi-Fi signal, it establishes a connection between the user and the network. Access points are the main source that transmit and receive radio waves. Antennas having a range of 300-350 ft are used in public areas, whereas that of very small range can be used in bus as the distance involved is less.

**EVALUATION OF FUNCTIONING**

**Design**

The main goal of the study was to get exact idea about the accuracies of the data obtained from GPS. To achieve this goal, GPS data from 5 different cars were taken when they were simultaneously passing 3 different fixed points. Cars were used for testing purpose because seeking permission for trials in buses was a complex procedure.

The secondary goal was to find the efficiency in filtering data from the database based on the query of the passenger. To accomplish this, a sample database was constructed using WAMP server and results were obtained based on different inputs. The tertiary goal was to evaluate the mathematical model for a set of arrival times of buses in different bus terminus.

**RESULTS**

The experiment done on five cars revealed that the real time tracking using GPS were almost accurate at all the times. The users were able to get complete whereabouts about the cars at any instant. This ensured that the goal of determining the accuracy of GPS was achieved successfully.

**Fig. 1: System Architecture**

Mathematical model for calculating probability of average waiting time. In probability, statistics and related fields, a Poisson point process or Poisson process is a type of random mathematical object known as a point process or point field that consists of randomly located points located on some underlying mathematical space.

The Poisson point process has the property that each point is stochastically independent to all the other points in the process, which is why it is sometimes called a purely or completely random process. The Poisson probability distribution function can be used for finding the probability of the average waiting time for a passenger in the terminus in order to get a bus.

**Functioning of the System**

**At terminus:** Passenger scans the “QR” code from the terminus using the application. Once the scan gets completed the complete list of buses with their numbers, routes and timings are provided in a tabular form to the passengers. The passengers are free to choose any one of the buses listed to get the current running status of the selected bus. The application in the passenger’s mobile provides an alert automatically when it senses using Wi-Fi that the bus intended for the specific route has arrived at the terminus.

**In buses:** Passenger can choose their destination from the list of available destinations, so that the application provides an alert when the bus reaches the chosen destination. They can also know about the distance and travelling duration of their desired location. Passenger’s stay connected inside the bus using Wi-Fi.

**From any point in the world:** Passenger can search for availability of buses between two locations through the application at any time. They can also track running status of any bus using the specified ID of the bus.

**Working of GPS:** The GPS [9]-[11] satellites send out signals to a GPS receiver. These receivers continuously receive these signals. Early receivers did not perform well in covered areas, but gradual improvements were made to the receivers to make

**Fig. 2: Sample Results**
Hyperlinks are provided beneath the bus numbers, which provide access to tracking webpage.

**Fig. 3: Results on clicking hyperlink**

The application also ensured that time taken for data retrieval from cloud was very less as filtering was based on “ID” of the bus terminus, which was used as a primary key in the database. The results of mathematical modeling by considering the arrival times of buses were as follows:

<table>
<thead>
<tr>
<th>Time</th>
<th>5:30</th>
<th>5:34</th>
<th>5:40</th>
<th>5:50</th>
<th>6:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:10</td>
<td>6:15</td>
<td>6:30</td>
<td>6:42</td>
<td>6:50</td>
<td></td>
</tr>
<tr>
<td>7:02</td>
<td>7:05</td>
<td>7:13</td>
<td>7:16</td>
<td>7:25</td>
<td></td>
</tr>
<tr>
<td>7:40</td>
<td>7:55</td>
<td>8:02</td>
<td>8:10</td>
<td>8:16</td>
<td></td>
</tr>
</tbody>
</table>

**Table 1: Bus Arrival Time at Terminal A**

<table>
<thead>
<tr>
<th>Time</th>
<th>6:30</th>
<th>6:35</th>
<th>6:38</th>
<th>6:58</th>
<th>7:01</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:14</td>
<td>7:16</td>
<td>7:40</td>
<td>8:00</td>
<td>8:01</td>
<td></td>
</tr>
<tr>
<td>8:04</td>
<td>8:28</td>
<td>8:28</td>
<td>8:44</td>
<td>8:47</td>
<td></td>
</tr>
<tr>
<td>9:10</td>
<td>9:04</td>
<td>9:24</td>
<td>9:44</td>
<td>10:00</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2: Bus Arrival Time at Terminal B**

**Fig. 4: Arrival Times of 20 Buses at Two Different Terminals**

A keen observation of the above figure reveals the differences between the two patterns. These distinctions become much clearer when one plots the histograms of the inter-arrival times of buses arriving at both stations and compares it with the calculated exponential probability distribution functions. Those comparisons are shown respectively in Figure 5 and Figure 6.

**Fig. 5: Comparison of Inter-Arrival Time and Probability Distribution Function at Terminal A**

**Fig. 6: Comparison of Inter-Arrival Time and Probability Distribution Function at Terminal B**

**OBSERVATIONS**

At station A, the comparison shows that relative to a Poisson process the data has inter-arrival time very close to the mean and few small deviations. This represents regularity in the process, i.e. the tendency of events occur at constant time intervals. The reason is, Terminal A is very close to the bus depot and hence there is very little or no delay in scheduled arrival of buses.

At station B, the histogram moves away from the exponential shape in a way opposite to Station A. Particularly, in comparison to a Poisson process, data of Terminal 2 contains too many deviations in inter-arrival times. This model is indicative of clustering, which is the tendency of points to occur in widely segregated groups. For buses, such condition may be induced by plenty of conditions including traffic congestion, accidents, breakdowns and much more.

The Probability Density Function (pdf) of an exponential distribution is,

\[
f(x; \lambda) = \begin{cases} 
\lambda e^{-\lambda x} & x \geq 0 \\
0 & x < 0 
\end{cases}
\]

Where \(\lambda>0\) is the rate parameter. In this case, it is the mean arrival rate of buses in the terminus. The same probability density function can be used for finding out the probability of average waiting time of passengers in terminus for getting a bus.
CONCLUSION

In this paper, we have presented the Bus Guidance System using Internet of Things, which provides ease of navigation and complete information about buses to the commuters using a user-friendly application. It also provides real-time tracking of buses and an excellent navigation system for its users. The data collected through GPS were almost accurate and the same system can be further implemented in buses across the country. This system can further be extended for dynamic guidance in trains also.

REFERENCES


These results provide evidence that the BGS can be successfully implemented in the buses too and it would be of high use to the commuters of the bus.

Algorithm for Approximation

The error of the GPS position is mainly due to the vicinity of the different satellites. The approximate position error ranges from 2m to 14m. The main GPS error source is due to imprecise time-keeping by the receiver’s clock.

Due to the above mentioned errors, there may be variation in the data available in database and that measured through transceivers installed in buses. Therefore, it is crucial to approximate the data obtained before comparing it with the pre-stored data.

There are plenty of ways of correcting errors in GPS value obtained from satellites. Any one of the techniques mentioned in,[13] can also be used to make corrections to the values obtained from the satellites.

Ephemeris Errors

Ephemeris (or orbital) data is continuously being transmitted by the satellites. Receivers maintain a “directory” of this data for all satellites and they revise this directory as and when new data arrives. The period of updating can be set manually. We can predict what a typical delay might be on a typical day. This is called modeling and it helps at almost all the times.

Error Modeling

Much of the delay caused by a signal’s trip through our atmosphere can be predicted. Mathematical models of the atmosphere consider the charged particles in the ionosphere and the unstable content of the troposphere. The satellites constantly transmit updates to the fundamental ionospheric model. A GPS receiver must factor in the angle each signal takes while entering the atmosphere, because that angle determines the length of the trip through the disturbing medium.

Intentional Errors

As hard as it may be to believe the same government that spent $12 billion to develop the most accurate navigation system in the world intentionally degraded its accuracy. The policy was called “Selective Availability” or “SA” and the idea, behind it was to make sure that no hostile force or terrorist group can use GPS to make accurate weapons. Basically, the developing authority introduced some “noise” into the satellite’s clock data resulting in inaccurate position calculations. Together these factors made SA the biggest single source of inaccuracy in the system. Only the US military receivers are capable of rectifying these errors using a decryption key. Later on, President Clinton committed to discontinuing the use of SA by 2006. The announcement came six years in advance of schedule. The decision to discontinue SA was the latest measure in an on-going effort to make GPS more accurate to all the users worldwide.

<table>
<thead>
<tr>
<th>Number of buses in 1 hours</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean number of buses per minute</td>
<td>$\lambda = \frac{25}{60}$</td>
</tr>
<tr>
<td>Probability that waiting time is less than 10 minutes is, $P(T \leq 5) = \int_{0}^{\infty} (25/600) e^{-(25/600)} dt$</td>
<td></td>
</tr>
</tbody>
</table>

$$= \frac{25}{600} \int_{0}^{\infty} e^{-x} dx = \frac{25}{600} \cdot 1 = 0.41$$