

A Survey on Bus Tracking System with Arrival Time Prediction

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Abstract— In major cities public buses serve as a main source for public transportation System. It has been found that much research work has been carried out in this field using GPS-GSM technology to detect the bus and GPS technology to extract the location of the bus. Taking these aspects into consideration we have proposed a Bus Tracing System with Arrival Time Prediction, by which the commuters can get the bus information like, (i) the exact location of the bus. (ii) The arrival time of the bus. Also the commuters are provided with a user friendly mobile android application to get the information about the bus.

Index Terms—Bus Tracking, Arrival Time Prediction

I. INTRODUCTION

Public vehicles serve as a main source for public transportation. For individuals, public transportation provides mobility to those who doesn't drive their own vehicle, including access to jobs, education, and other services.

However in our existing transportation system, there is no means to provide information about the bus to the commuters. This results in people wasting lot of time in bus stops. In order to overcome the shortcoming of existing transportation system, we propose a system (Bus Tracking System with Arrival Time Prediction) by using the existing technology like GPS and GSM which provides the commuters with the exact bus location and arrival time of the bus. The commuters can make use of the mobile Android application and access this information. Such information is valuable for both new and frequent traveler. The Survey provided here focuses on two areas:

1. Bus Tracking

In bus tracking module we are using GPS-GSM technology to track the exact longitude and latitude positioning value of the bus. Using input of GPS we map the bus current location. GSM is used for connectivity purpose between GPS and Arduino board at bus module, Arduino board and server at server module.

2. Arrival Time Prediction

To calculate exact arrival time of the bus using following some factors like predefine map, predefine time and number of intersections, signal poles

Arrival Time is equal to Summation of

- (Distance between client and bus)/(Average Speed at which bus is moving)
- (Number of bus stops in between)*(Average time of passenger gets off and get on)
- (Number of traffic signals in between)*(Average queuing delay)

II. BUS TRACKING

Nikos Souliotis et al. present real-time information about public transport's position using crowdsourcing [3]. Crowdsourcing means the act of a company taking a function performed by employees and outsourcing it to large network of people in the form of an open call. Here, passengers itself act as both service provider and service recipient. They should have a smart phone with GPS and internet connection. The system uses Google Directions API. Using this API, people can provide the name of a route and this service returns a file in JSON format that contains all the information about this route. Google Maps free service does not give the real bus route. They mentioned that it is necessary to know the beginning and end points to create each route. In order to create correct path, some points (way points according to Google) should be specified. Using this data new path will be created. But Google restricts user to use at most 8 waypoints for each route creation. Opportunity for the users is they have to be informed about the location of the buses. It is suitable for public transport vehicle with no suitable equipment like GPS or internet access. The problem with this approach is in order to operate there is the need of providers who provide information about the route number of bus and direction in which bus is moving.

Cemil Sungur et al. focus on developing smart bus station-passenger information system using GPS and Web-service [2]. The system enables the people to monitor the positions of the vehicle and travel duration both from inside the vehicle and the bus stops. System consists of the embedded mini-computer based system and digital monitor. The location of the vehicle is determined by GPS module integrated with mini-computer system implanted in the public transport vehicle and transfers that information to the central server through web services. Bus stops were installed with digital monitors and the embedded minicomputer based systems. This embedded mini-computer communicates with the central server through web services and

display bus name with arrival time on digital monitor. Using this system, commuters are not able to get the location information about particular bus which they want to get on. This approach does not allow user interaction with the server. Here, it is necessary for people to go to the bus stops to get information about next bus. Proposed system expects more hardware requirements.

Rajesh Kannan Megalingam et al. introduce "smart, public buses information system" [1]. Here, GPS_GSM technology is used to implement it. The proposed system has Bus Transmitter Segment (BTS) installed in every bus consists of a GPS module, Arduino board and a GSM modem. GPS module gives latitude and the longitude of a particular bus. This data is processed by the Arduino board. GSM modem transmits this result to the bus terminus. The receiver part of system is called as Bus Terminus Controller Environment (BTCE) which is installed at the bus stop consists of GSM modem, Arduino board and server. This part receives the data, calculates the exact position of the bus and time it will take to reach the bus stop. This information is stored in the server and passengers can access this information through internet using smart phone application. This information also displayed on the display board installed at bus stop. Using this, availability of buses to any particular place can be known. ATDT(Arrival Time Delay Time) algorithm is used to determine the arrival time of the bus and the expected delay time. But the arrival time predicted by this algorithm changes continuously if bus is not moving or stuck in traffic. So arrival time predicted by this algorithm is not reliable. Hardware requirements are high, so less cost efficient. The implementation of this system is not complete and restricted to the BTS module. Only coordinates of position of bus are transmitted to mobile phone via GSM.

Ruth E. Anderson et al. have developed a transportation information system using existing technologies namely GPS and SMS infrastructure [9]. This system was developed in order to address the transportation problem faced in Kyrgyzstan, a developing region which has a poor infrastructure and limited resource. In this system a box device is installed in the bus, which has to be turned on and update the route information by the driver. This box system tracks the bus location using GPS technology and transmits the data to the connected server. The user is provided with this information. For predicting the route they have used simple algorithm based on the concept of building a model by merging together multiple runs of the route. However this algorithm has not considered the varying traffic flow. And this system is not field tested.

B. Janarthanan and T. Santhanakrishnan has proposed a real time bus monitoring and passenger information system which displays the real time location of the bus in the city [10]. They have made use of GSM, GPS and LCD screens. GPS installed in the bus collects the data. Then this collected data is processed by the microprocessor and then the information is transmitted using the GSM infrastructure to the LCDs installed in the city bus stops. All the data collected by the GPS device is stored in the centralized control system. In this system the information about the Bus Location is displayed in the LCDs that are installed in the Bus stop, however it would even better if the bus location information along with expected arrival time is transmitted to the user Smartphone rather than displaying it in the LCD.

Süleyman Eken et al. have introduces a location-aware intelligent bus stop system that any passenger with a smart phone or mobile device can scan QR codes placed at bus stops to view bus arrival times and buses current location on maps [7]. They have used C4.5 algorithm for estimation of bus arrival time. GPS system and Google maps are used for displaying current location of the buses. Registered users get the routes and bus arrival times through SMS and E-mails. When the passengers scan QR codes, placed at bus stops, they can see approximate bus arrival time, and bus's current location. Users can also select and see the routes for different buses on the map. To locate any bus on a map, its latitude and longitude values are acquired from GPS receiver in every bus. Google helps with its map images. However placing QR codes in each and every city bus stops and updating the bus route information is not a feasible task.

Thiyagarajan ManihattyBojan et al. have proposed an intelligent transportation system using IoT and making use of internet as a backbone infrastructure [8]. In their work they provide the information of the smart bus to the people. They provide information's like Bus current location, Number of passengers and ambience of the bus. They have made use of different types of sensors in their system, i.e. sensors like i) GPS-to track the bus location, ii) NFC -to have passenger count. Every passenger should register themselves and get a Mifare card. This MiFare card communicates with the NFC reader and the information is transmitted to the data base. Temperature and Humidity sensors are used to sense the atmosphere. All these information are transmitted to the server through Internet and Displayed on the LCDs placed. However they have not used any time prediction algorithm to predict the arrival time of the bus and it is not Feasible to make use of those above mentioned sensors.

M.A Hannan et al. propose and implement a smart bus monitoring system using some communication technologies [11]. The main ideology of this project is tracking the buses in city areas. This system uses RFID (radio frequency identification), GPS and GPRS tracking technologies. RFID technology improves the overall performance of the system at affordable price. Here every bus having a black box component and the reader can be placed in every bus stop, when bus come near to bus stop the reader captures the data on tags and transmit the data to the CPU using GPRS technology. The received data should be processed and displayed in the monitor interfaced with GIS in form of map. It can be reduce the manpower required at the monitoring center.

Sourindra et al. propose a “Darideepa” to tracking the bus information [13]. Passenger gets the tracking information about subscribed bus and it provides tracking information to passenger regarding vehicle in some situation like buses are cancelled due to strike, breakdown and route change. VMD (variable message display) system is used to tracking the bus. Every minute passenger receives notification of subscribed bus when he put on the bus the notification should be stop automatically.

Tomas Gerlich et al. propose “tracking transit with easy tracker” [14]. Several transit agencies are deploying bus tracking and arrival time prediction through this system easily finding the bus stop, schedule and estimated route. GPS Smartphone can be placed in bus for tracking the bus and it can send the information to back-end server, most of the operation should be carried out in server only. The driver follows their usual route then only it's easy to tracking the bus stop information.

Sai He et al. propose intelligent bus system for vehicle positioning in urban areas [12]. This system reduces the transmitted power and transmission diction using RSSI technology. RSSI does not require any external device to track the vehicle position. RSSI transmit the data to centre server for computing data in database, get the real-time position of the vehicle then display real-time position of the vehicle on the electronic map by GIS.GPRS, ZigBee used to transmit the traffic information to back-schedule system.

Liang Xu proposed the system that helps for china people and provides the dynamic bus transportation using 3S technology (GPS, RS, GIS) [17]. The advantage of GPS is display real time bus location and operating condition, while RS shows the detailed situation of the road with remote sensing technology and GIS combining GPS and RS can help to solve the problem of bus travelling through the computation and analysis of the data. This system leads problems to protection of our privacy when repeat the inquiries for many times our own information will be discovered by others and they not achieved the mobile application for individual.

Darshan Ingle proposed the algorithm that helps to get the current location of the bus and number of vacant in bus, arrival time of the bus [18]. In this technology he neither used GPS nor internet connection, user sends the SMS to toll-free number and they get information about the bus. It uses silver cloud real time GPS tracker which can track the current location of the bus and data sent via GPRS to the server. Since an internet connection is not required, every user can afford it. Disadvantage is it displays the information in a specific format which is bit difficult to understand.

UmarFarooq et al. proposed a solution for improving public transportation system services based on GPS and GSM in Punjab[19]. System consists of four modules: 1)BUS Station Module, 2)In-BUS Module,3) BASE Station Module and 4)BUS Stop Module. Initially BUS Station Module sends the information containing the bus number and license plate number to In-BUS Module and BASE Station Module through SMS. In-BUS Module consisting mainly of a GPS receiver and GSM modem then starts transmitting number of passengers and its location to BASE Station Module. BASE Station Module contains a microcontroller component and GSM modems interfaced to PCs. They are designed to keep track record of every bus, processes user request about a particular bus location and updates buses location on bus stops. Every bus stop is installed BUS Stop Module and consists of a GSM modem, memory unit and display unit. But the system does not provide bus arrival time.

Suresh Sankarananrajan et al. [24] have proposed a system for bus tracking and ticketing system. Based on their literature survey, they have decided to use GPS, the processed location data will be represented using GMAP in real time and RFID technology in their system. GPS is used to track the bus and RFID tags are affixed to the bus and RFID readers are installed at the bus stop. The commuters can track the bus through their mobile by keying in the route id, and the location is displayed on the using Google Maps. They have also added remainder for topping the credit of RFID enabled ticket. However, this paper doesn't give and detailed information about how they have calculated the arrival time of the bus.

T.Santhanakrishnan et al.[25] has proposed a real time bus monitoring and passenger information system which displays the real time location of the bus in the city. They have made use of GSM, GPS and LCD screens. GPS installed in the bus collects the data .Then this collected data is processed by the microprocessor and then the information is transmitted using the GSM infrastructure to the LCDs installed in the city bus stops. All the data collected by the GPS device is stored in the centralized control system. In this system the information about the Bus Location is displayed in the LCDs that are installed in the Bus stop, however it would even better if the bus location information along with expected arrival time is transmitted to the user Smartphone rather than displaying it in the LCD.

The summery is provided below:

<u>Title</u>	<u>Author</u>	<u>Description</u>	<u>Problem Identified</u>
GPS_GSM Technology	Rajesh Kannan Megalingam et al. [1]	A smart, public bus information system Using GPS module, Arduino board and a GSM modem. GPS module, Arduino board and a GSM modem	Arrival time predicted is not reliable And implementation is not complete and Restricted to the BTS module
Transportation information system	Ruth Anderson et al. [9]	Box system tracks the bus location using GPS technology and transmits the data to the connected server. GPS and SMS infrastructure	Varying traffic condition and this system is Not field tested
Crowd-Sourcing	Nikos Souliotis et al. [3]	Real-time information about public transport's position using crowd sourcing. Google Directions API	The problem with this approach is, in order to operate there is the need of providers who provide information about the route, number of bus and direction in which bus is moving

III. BUS ARRIVAL TIME PREDICTION

Jian Zhang et al. present a study on prediction model of bus arrival time [4]. Here, they mentioned that transit lines include several intersections, base sections of primary roads, secondary roads and other slip roads. So while calculating bus arrival time they considers average travel time through the sections, queuing delay time, time required to travel through the intersection, passengers get off and on time, lost time of bus slow down while entering the bus stop. Only theory is given in this paper. They didn't specify any practical result here.

Hao Chu et al. propose a research on bus arrival time prediction based on multisource traffic information [5]. Multi-source traffic information means synthesizing multiple information which affect the travel time including congestion information, weather information, time information and accident information and so on. They mentioned that they took bus line 910 in Shanghai as platform for this research. This bus line starts from Shijie Road and Jiangwan Cheng to Nanpu Bridge. In this bus line all of the buses have GPS module and all seven stops installed with electronic boards for displaying bus arrival information. Here, BAT (Bus Arrival Time) code is used. They mentioned that difference between actual arrival time and predicted time using BATP model is very small.

Pengfei Zhou et al. present a bus arrival time prediction system based on bus passengers' participatory sensing [21]. By utilizing cellular signals, they implement a crowd-participated bus arrival time prediction system. In this system, there are two types of users. Querying user want to know the bus arrival time and Sharing user willing to provide real-time bus information. When a sharing user gets on a bus, the data collection module starts to collect the information of nearby cell tower IDs. These data is transmitted to the server through cellular networks. Main challenge here is to encourage more participants to bootstrap the system because the number of sharing passengers affects the prediction accuracy this system.

Yidan Fan et al. have made the public transportation more effective to provide more useful societal service and offered the bus arrival time [6]. They made use of GSM network to get the bus information. The bus route is divided into several sections and every bus stations have corresponding cellular base station sequence. After the bus route divided into sections according to the Cell Id (CID) switching point they estimate the congestion level of each road section, then predict the time that the bus will take to arrive on each section through detecting previous bus's driving information along the bus route. This method avoids the need of multiple calculations. However they have used data of only one bus route to verify the model and it requires further observations in order to know about universality and practicality in the model.

Jun Gong et al. presents an approach to predict the public bus arrival time based on historical and real-time GPS data [22]. The main input variables of the prediction model are the bus arrival time and dwell time at previous stops. After analyzing the components of bus arrival time systematically, inputs data can be collected. Initially, the algorithm of data interpolation and processing is implemented to gather the real-time GPS data as the input variables of the prediction models. Then, based on the historical data the statistical model is obtained. Historical data means average running time of each link and dwelling time of each stop at given time -of-day and day-of-week, respectively. Next, to predict the bus arrival time a hybrid dynamic prediction model is proposed. At last, GPS data from bus route 244 located in Shenyang, CHINA are considered for testing. MAPE is used to evaluate these models. The results show that the procedure of processing the data of GPS has greater effect on prediction performance.

Lei Wang et al. propose a bus arrival time prediction using RBF (radial basis function) neural network it can adjusted by online data [15]. The system focuses on the bus arrival time and reduces the waiting of the passenger by releasing the arrival

information to passenger. The Automobile data recorder and Automobile vehicle location devices are placed in each vehicle to identify the location of the vehicle. It combines the historical data with real-time information using RBFNN model. Some of the factors can exported in the RBFNN model is dwell time at stop, number of passenger getting off and on, delay, distance and travel speed between two stops. Online filter method enhance the adaptability from imported instant speed.

Song Xinghao et al. proposed a bus travel time prediction model, in which the delay caused by the signal control and the acceleration and deceleration are considered[23]. Design of Bus travel time prediction model started from bus running process analysis. Initially, combined the existing data collection methods with RFID technologies, divide the bus route into sections. Next step is analyzing the important factors affecting on the travel time in one section. Running time, Delay time at intersections and acceleration and deceleration delay are main factors that affecting on bus travel time in each section. After that propose the analytical models which can explain the relationship between bus travel time and the effect factors. Then determine the travel time of bus using this relationship.

Tongyu Zhu et al. present The Prediction of Bus Arrival Time Using Global Positioning System Data and Dynamic Traffic Information[16]. This is helpful to develop a model based prediction algorithm for bus arrival time. Here, they calculated the total travel times of the buses considering traveltime on links, bus stop delays and signalized intersection delays. Using GPS instruments, real-time positioning information of bus are fetched. Every 20 seconds, data from GPS module are obtained. Using Haversine formula the distance travelled in each of these 20 seconds intervals is estimated. If the bus is near the destination point then directly calculate the arrival time using speed at which bus is moving and distance between the current position and destination point. Otherwise divide the total travel time of bus into three parts - running time, dwell time at bus stops, signalized intersection delay time. Time taken at each of these subsections is estimated. Sum of these times will give total travel time of bus.

Randong Xiao et al. focus on the primary heterogeneous data processing [20]. This primary data includes the data from the GPS units gathered at regular time interval and also consists of latitude, longitude and the actual time and the data of the base map of Beijing including the path information. To enhance the accuracy of prediction, meticulous preparation consists of regeneration of the bus line data set, bus line serialization and modification and sampling point mapping. On the basis of the data processing method, they predict travel time through real-time algorithm.

The summary is provided below:

<u>Author</u>	<u>Description</u>
Jian Zhang et al. [4]	Presented a study on prediction model of bus arrival time. Transit lines include several intersections. So while calculating bus arrival time they considers average travel time through the sections
Hao Chu [5]	A research on bus arrival time prediction based on multi-source traffic information. Synthesizing multiple information which affect the travel time. difference between actual arrival time and predicted time using BATP model is very small
Yidan Fan[6]	The bus route is divided into several sections. then predict the time that the bus will take to arrive on each section through detecting previous bus's driving information along the bus route

IV. CONCLUSION

Bus tracking system will be able to provide passenger with bus location and estimated bus arrival time. User of this system will be able to use the user friendly android application and track bus location.

The current version of bus tracking system is a very solid foundation and we had designed bus system to be extremely flexible for future enhancement. We would like to improve the system database's capacity. Current bus system is tested with 1 or 2 buses on one route. However, we are very concerned if the database can manage to cope with more routes and buses. We hope to see bus system to be able merge a few bus routes and predict the arrival time. This is an important prediction for users that needs to switch buss in order for them to arrive at their destination. We sincerely hope to see that bus system will be part of daily life, as a tool to facilitate their personal time management.

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