2016 International Conference on Internet of Things and Applications (IOTA)
Maharashtra Institute of Technology, Pune, India 22 Jan - 24 Jan, 2016

Integration of Smart Phone and IOT for development of Smart Public Transportation System

Shiv. H. Sutar, Rohan Koul, Rajani Suryavanshi
Department of Computer Engineering
MIT College of Engineering
Pune-411038, India
shiv.sutar@mitcoe.edu.in, rohansainath@gmail.com, rajanisuryavanshi6@gmail.com

***Abstract*— As population is burgeoning, there is an increase in the number of vehicles on the road and hence an upsurge in the problems associated with traffic management, especially the Public Transport. There is also an increase in the number of accidents and various other traffic related issues. Intelligent Transportation System (ITS) provides the solution to most of these problems by integrating existing technologies with the underlying infrastructure. With the advent of mobile technology and the ubiquitous cellular network, real time vehicle tracking for efficient transport management has become viable. The futile long wait for a bus to arrive can be avoided by Intelligent Public Transportation System. The omnipresence of Smart Phones and their ever increasing power at a very economical price makes them one of the most attractive options for developing IOT applications. Here, an approach based on the combination of technologies like GPS and Android is discussed which can assuage passengers who commute by the means of public transport. The user is furnished with explicit information about the current location of nearest buses approaching the bus-stop on a mobile application. Using readily available Android API's , technologies like 3G network and SMS based services in the existing mobile phones can reduce the cost and size of hardware required, as well as lead to a better output.**

***Keywords*— GPS, Android, Web Server, ITS, ICT, RFID**

I. INTRODUCTION

Public transport is a service available on sharing basis for the benefit of the general public. It includes city buses, trolley-buses, trams, passenger trains, ferries and rapid transit like metro and subways. Unlike transportation modes like car-pooling, rickshaws and taxis, this system encompasses an entirety of strangers. The main reasons as to why people choose public transportation over other modes of transport are its subsidized rates, environment-friendly attributes and easy accessibility. Firstly, public transport is very economical allowing a large population to have access to it. Using a bus or a train to commute is comparatively cheaper than using a private car [1]. If people have their own car, they have to spend a lot of money on car servicing, repairs, and insurance. There are many discounts available for some individuals, like students and senior citizens who choose public transport as their transportation option to get to work or go to school. Secondly, public transport can preserve the environment by reducing the amount of pollution. With an increase in the use of public transportation, there will be a reasonable dip in the number of private vehicles on the road, therefore, improving the environment and in addition, solving the traffic congestion issue [1]. Furthermore, public transportation has good accessibility in big cities, making it easier to travel to any part of the city, making buses a favorable option to opt for. It provides personal mobility and freedom for people from every walk of life [1].

Taking into consideration the other aspects of public transportation, there are some downsides to this service as well. Public transportation, by its very nature, is far more time consuming than any other mode of transportation. Most trains and buses run in accordance with a scheduled timetable. However, these time schedules are seldom followed. There is always an uncertainty regarding the arrival of a bus. Often, buses break down causing further problem to commuters. Another pitfall we see is that public transportation often lacks organization. Commuters are often confused with regards to bus routes and bus stops. Even if the buses are running on time, they are usually crowded, the reason being, less frequency of the buses. Since the ratio of the buses to the population availing public transportation is disproportionate, overcrowded buses are not a rare sight.

With regard to all problems mentioned above, the simple knowledge of bus related information can solve a number of discrepancies related to public transportation. For instance, the time of arrival and departure of each bus, a comprehensive list of bus-stops, etc. can prove to be very beneficial. Hence, an Intelligent Public Transport Management system is necessary to solve these issues. In order to provide necessary bus data to all passengers, this paper proposes a Smart Public Transport System where all relevant information of the bus will be gathered, processed, and presented to the user. This system includes introducing an installment inside the bus for indicating the approaching bus terminus and the remaining bus route. Moreover, the system helps in nullifying the long waiting hours at bus stops. Along with the uncertainty in time, there is also an apprehension regarding the capacity of a bus [2]. Even if the passenger is aware about the arrival time of the bus, they do not know how many additional people can be accommodated inside the bus. The information will be half-baked and hence of no use. Thus, determining capacity of any given bus is equally important to the arrival time estimation. Therefore, by using high-end technologies, like Android and QR code facility, and integrating them with the existing system, we can provide a good solution to the issues discussed [3]. To summarize, the system will eradicate the uncertainty in arrival time that commuters face every day and prove to be of great assistance in planning their journeys well in advance.

978-1-5090-0044-9/16/$31.00 ©2016 IEEE

The paper is organized as explained further. Section II provides a detailed literature survey on tracking in public transportation using RFID and GPS as well as the older hardware approaches. Section III goes on to give a brief description of the proposed architecture. Section IV presents an android base implementation of the proposed architecture. Section V and VI put light on the conclusion and the future scope of this architecture.

II. LITERATURE SURVEY

With the advent of advanced technologies a lot of countries have started investing in their transportation sector. As a result, extensive research has been carried out in the past few years. The state-of-the-art advancements in wireless communication and ubiquitous Internet capabilities have encouraged the development of Intelligent Public Transportation Management System. In this section we will survey in brief about the work being done in Information and Communication Technologies (ICT) usage in public transport towards tracking and scheduling.

A. GPS Tracking in Public Transportation

Automated Fare Collection (AFC) System also known as the Transit Smart Card System provides us an edge over the manual fare collection system by lowering labor costs and also increasing the efficiency of manual fare collection process. The desire to extract more information than just a simple deduction of fare from transit smart cards has led to the research efforts in extracting other relevant information such as points of origin where a passenger would board a bus and have the data recorded as the passenger's smart card is scanned. To achieve this, a Markov chain based Bayesian decision tree algorithm has been developed in this study, wherein the algorithm is verified with the use of public transportation vehicles that are equipped with GPS tracking and data loggers. Conclusively, it is stated that data collected to represent points of origin when a passenger's transit smart card is scanned, is crucial to the process of transit system planning [4].

In another research the GPS technology is being utilized towards tracking and scheduling of buses. This has been implemented in Ahmedabad India, where the government has deployed a GPS- enabled Bus Rapid Transit System (BRTS) solution to solve their transportation issues in a sustainable fashion. Introduction of the BRTS was motivated by the need for increased reliability and security with prime focus on reducing travel time. The tracking and scheduling of all buses on all routes is controlled centrally at an integrated control center [5].

B. RFID in Public transportation for Scheduling

RFID technology mainly includes three components: RFID Tag, RFID Reader and Middleware logic for interaction with the back-end database continuously. Many applications for RFID technology have been suggested over the past few years. However, these efforts have been challenged with regard to their feasibility, deployment, privacy, security and such other aspects. One such research is focused on applying RFID towards potential passengers passing through a simulated bus door equipped with commercial off-the-shelf RFID readers and antennas, passengers as they board and exit the bus. The research concluded that RFID technology can be effectively used for this type of application; however, there was an issue which hampered the concept. It was found that in case of no line of sight between smart cards and reader in accordance with the radiation pattern and positioning of antenna, there might be some performance glitches as these factors are very crucial and critical to the whole process of recognition [6]. Research was also focused on how RFID Technology can be used to solve trouble faced by Public Transport authorities especially in metropolitan cities by doing research for enhancement of automated tracking of buses that can be very useful in providing useful estimates regarding bus arrival times and in turn provide improved passenger convenience. A real time tracking and monitoring system is employed which utilizes a framework of Event, Condition and Action (ECA). This proves to be helpful in filtering data effective to remove all the unwanted or inaccurate details and then categorize useful data by clustering. Utilization of collected data for prediction of bus movement is also discussed in an effort to improve the tracking system and in turn enhance traveling experience by Public Transport [7].

C. Hardware Based Approaches

Many hardware based approaches have been proposed to solve the problem of bus tracking and scheduling. Most of the approaches use the same basic architecture: Micro controller, GPS module, GPRS/GSM Modem. All these are bundled together to form an On-Board Unit (OBU) which is fitted onto the bus. The GPS collects location data which is sent to the micro controller which in turn sends it to the GPRS/GSM Modem, transmitting data through wireless cellular network to the back-end server. The back-end server is responsible for processing all the incoming data and extracting meaningful information from it like dynamic route tracking.

Pham, Micheal,Chi [8] suggest a novel vehicle tracking system consisting of the GPS module, which is used to obtain the vehicle's coordinate and the GSM modem, which is used to transmit the location to the user's phone through the mobile network. The Global System for Mobile Communications (GSM) is the second-generation digital cellular mobile network [9]. It is widely deployed around the world. Although improvements to GSM such as the next generation systems have been rolled out to cater for faster data centric traffic, backward compatibility to GSM is still maintained. Due to its wide availability, it is chosen as the medium for transfer of location information. The simple and inexpensive Short Message Service (SMS) allows users to send up to 160 characters. For the purpose of this project, the SMS is more than sufficient for sending the location information. The hardware components used by Pham, Micheal, Chi[8] in their implementation include the state-of-the-art u-blox NEO-6Q GPS receiver module and u-blox LEON-G 100 GSM module. A micro controller, the Arduino Uno [10] is also employed to control both modules and to provide an easily customizable platform for any required application. Other micro controllers like Arduino Mega [10] and RaspBerry Pi are also being used for the development of vehicle tracking applications on a large scale .These boards provide an easy user-friendly development environment to create effective applications in a simple manner.

III. PROPOSED ARCHITECTURE

Hardware approaches to ITS are too dependent on the quality of the sensors and the micro controllers used. Moreover flexibility of such approaches is also less along with the complexity involved in the bundling together of the various components into a single hardware framework. The hardware based methods also suffer from problems due to electrical noise, maintenance, wear and tear etc.

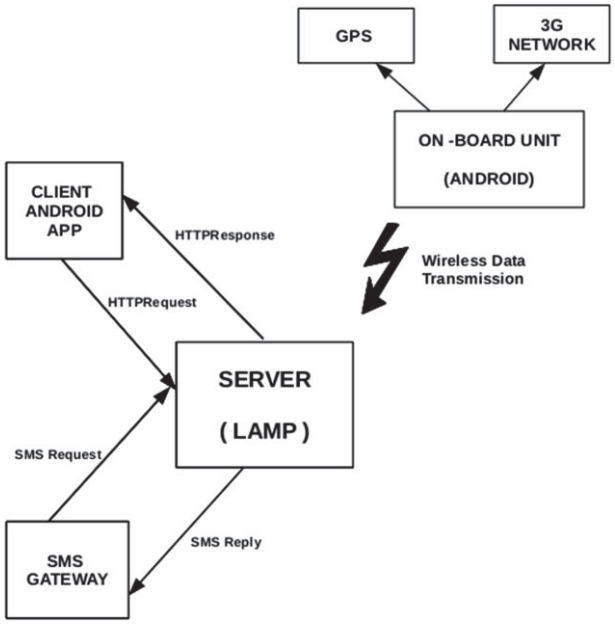

Fig. 1. Block Diagram showing the high level view of the system

Keeping in mind all these issues, we propose a simple Android and IOT based approach which can provide dynamic bus tracking information to the bus-stops as well as the commuters in an efficient manner. We propose an architecture which is basically divided into three parts. The On Board module which consists of an Android Smart phone equipped on the bus, basically used to track the position of the bus using the inbuilt GPS of the phone. The collected location information is then sent to a server using 3G network of the phone. The back-end consists of a server module which receives continuous data from the On Board Unit. The received data is used to extract meaningful information which is then used to service various queries. The client module consists of an Android application as well as a SMS based system which can be used by commuters to track the location of the bus in real-time as well as plan their journeys in advance. Apart from this we also propose installation of static QR codes on each bus-stop. QR codes prove to be an effective measure to provide information to passengers regarding the buses going through that bus-stop. Fig.1 shows the complete block diagram of the proposed architecture in an abstract manner. It provides further insight into the working of the complete system as a whole.

IV. IMPLEMENTATION USING ANDROID

We present a very basic implementation of the proposed concept using Android OS. We have used Android Studio version 1.0 [11] tested on a Android Phone supporting minimum API 15 (IceCream Sandwich).By targeting API 15 and above ensures that the application will run on approximately 90.45% of the devices that are active on the Google Play Store. We have also used phpMyAdmin version 4.0.10 as the WebServer.

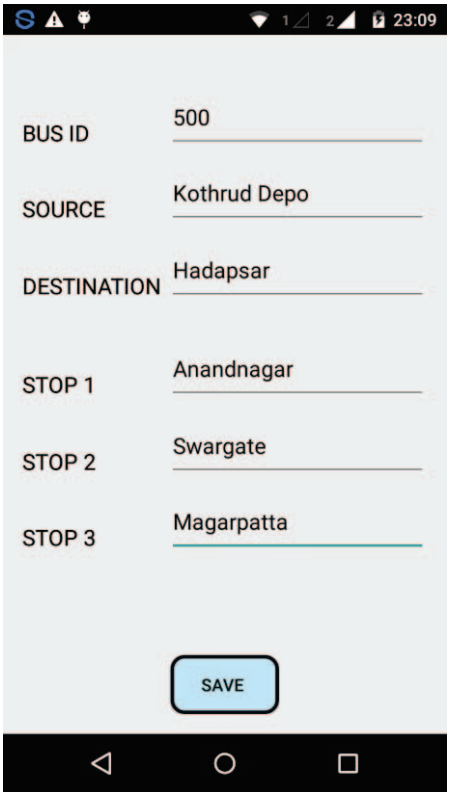

Fig. 2. Android Activity showing one-time information insertion

A. On Board Module

Combining separate GSM/GPRS modules together to form an integrated unit is a tedious task. We can take advantage of the fact that these components are already inbuilt in our Smart Phones. Given the fact that most people nowadays use Smart Phones and that they are available at a reasonable price, makes this approach viable. We propose an application based on Android OS utilizing the inbuilt GPS to track the location of the bus continuously and push it to a server on a frequent basis. Once the application is started for the first time, an interactive Activity [12] pops up asking for the detailed description of the particular bus route. The fields include BusId which is a unique identification being given to each and every bus plying on a particular route , Source Station , Destination Station and the name of each and every bus stop on the route. This is a onetime Activity for the duration of the entire application. Once all the Fields are filled the information is stored permanently as shown in Fig.2. Next time when the application is started it opens up another Activity which simulates the events in case the bus actually starts moving on the roads.

The Activity in Fig.3. shows Last Station from which the bus left, the Next Stop, Distance Remaining till the next bus stop and finally the Estimated Arrival Time (ETA) at the next

bus stop. The location information is fetched continuously using GPS and updated as the bus crosses various bus-stops on its way.

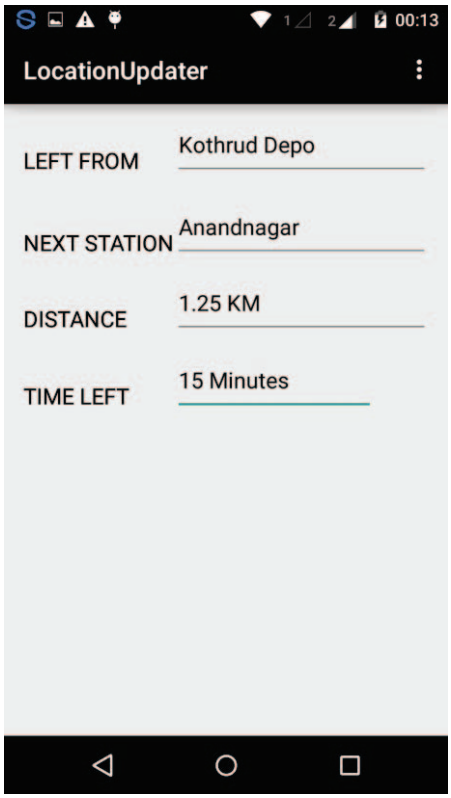

Fig. 3. Android Activity showing distance and ETA on OBU display

Once the bus reaches the destination the application can be reset by clicking on a button by the driver. After this the application begins tracking the route of the bus again in a similar manner as described above. The Smart Phone can be powered by using the 12 V battery of the bus. Since there are issues regarding usage of GPS due to high battery usage and inability to use indoors, we propose to use a combination of NETWORK PROVIDER and GPS PROVIDER service of Android OS. Our algorithm will dynamically switch between both providers according to need. Along with this we can also take advantage of recently launched off line mode of Google Maps. The provider switching algorithm works as follows:

- if gps enabled
  - Get location using GPS PROVIDER.
- if network enabled
  - Get location using NETWORK PROVIDER.
- if both gps enabled and network enabled
  - if accuracy(gps) > accuracy(network) then
    - Get location using GPS PROVIDER
  - else
    - Get location using NETWORK PROVIDER

The calculation of distance as the bus is moving is done by using a simple algorithm which we call as Arrival Time Algorithm. The algorithm works as follows: Two variables for the previous coordinates (prev coordinate) and the new coordinates (new coordinate) are initialized. When the latest location information is received from the OBU, it is assigned to the current coordinate. A condition is imposed to check whether the bus is moving or not. The previous coordinates are compared with the current coordinates to determine whether bus is stationary or not. Accordingly the longitude and latitude values are used to calculate the distance of the bus from the terminus and the expected time of arrival which is then sent to the server

1) Arrival time Algorithm

- Initialize prev coordinate and new coordinate to 0
- Receive new coordinates.
- if (prev coordinate == new coordinate)
  - Start Timer.
  - Calculate delay time.
  - Add delay time to calculate final arrival time
  - prev coordinate = new coordinate.
- Else
  - Process new coordinates.
  - Calculate Estimated Arrival time of the bus . Store it and send it to the server.
  - prev coordinate = new coordinate.

B. Server Module

The Web Server module forms the core of this proposed system. It serves as the back-end tool. The server contains all the information about the routes of all the buses as well as the intermediate bus stops on the route. The server also processes request from a client regarding the estimated arrival time of a bus at a particular bus stop. The server maintains a database of information pertaining to the buses, routes and stops in the form of tables. The server database can be organized in many ways, to reduce memory requirement, improve access speed, or reduce the number of queries. We have used LAMP [13] server in our implementation.

The Android application installed on the bus sends information to the server in JSON [14] encoded format which is stored in the tables created on the server using MYSQL [15]. As soon as the information reaches the server a PHP script is invoked which is responsible for updating the information.

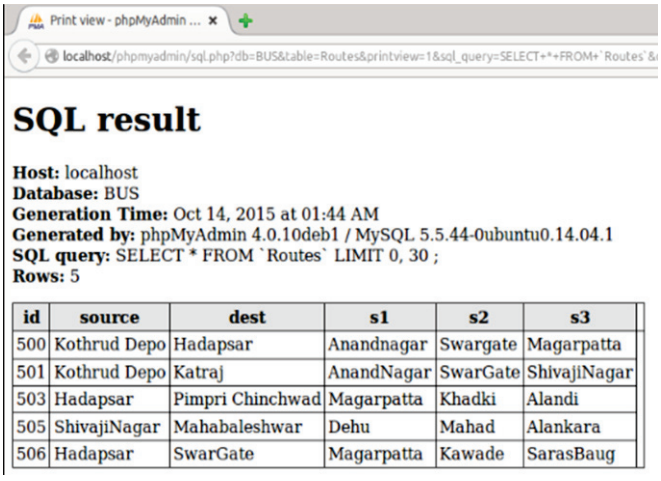

Fig. 4. Proposed Database design using LAMP server

As the bus is traveling on its desired route the server constantly updates the LeftFromStation and NextStation columns in the tables so that if a user queries about the availability of a bus at a required bus stop , using the data in the tables appropriate response can be generated and provided to the inquiring user.

The server is multi-threaded in nature and hence can process multiple simultaneous client requests at a time. As soon as a client request comes in , the server creates a thread to serve that client. The thread is then responsible for handling all communication with that particular client. After the communication is over the thread goes back to the pool.

C. *Client Module*

Despite a lot of development in ITS in the Public Transport sector, the communication gap between a regular user and the information generated from the system remains abridged. Our implementation is aimed towards bridging this gap. We propose to develop an application on the client side which can be used to dynamically track the location of the bus and availability at a particular bus stop along with the ETA. As a result commuters can plan their journey in advance. Also the uncertainty and long waiting hours at the bus stop is completely avoided by this approach. Fig 5 and 6 show the Android application being used on the client side.

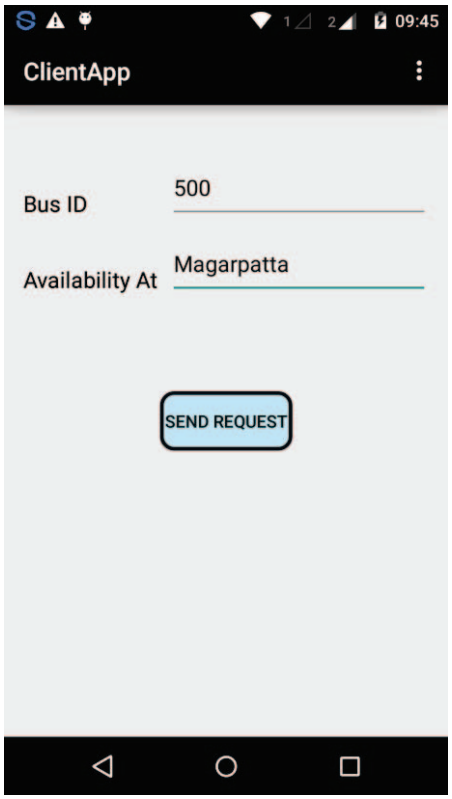

Fig. 5. Android Activity showing Query done by a client.

The user simply enquires about the availability of the bus at a particular bus-stop through the application and the server responds by sending appropriate reply within a small amount of time. If the bus is not available or has passed through the inquired bus-stop the ETA of the next bus on the route is provided. At the same time we also propose a SMS Gateway which can be used by the commuters in case of unavailability of internet or Smartphone. The user can send a SMS enquiring about the availability of the bus and appropriate reply in the form of an SMS will sent back to the user.

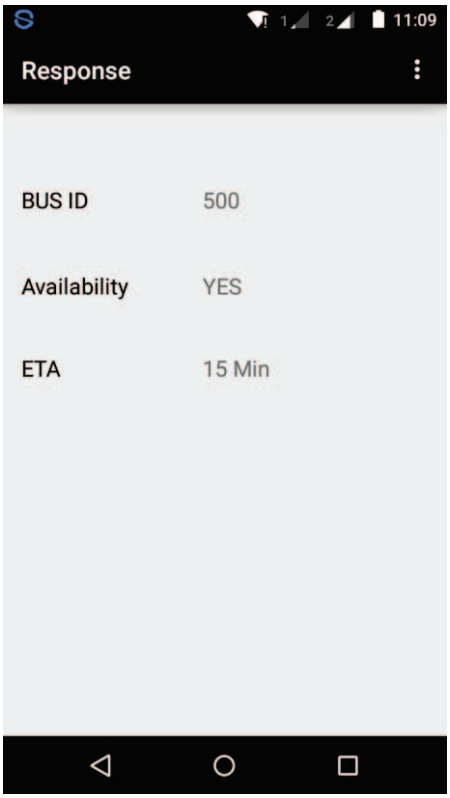

Fig. 6. Android Activity showing Response from server.

We also propose using static QR codes on every bus stop especially in big cities. In case a user is completely new in a city and is not well aware about the routes, he/she can make use of the static QR codes which we propose to install at every bus stop. After scanning the QR code the user can get complete information about the buses going through that particular bus stop along with their source and destination.

V. CONCLUSION

We regard the traffic management not as an individual issue, but as a global issue which needs to be tackled in a tactful manner. This paper presented an efficient framework of Intelligent Public Transport Management System that dynamically tracks the location of all the buses and estimates the arrival time of the next bus on the bus terminus. The estimates are updated at regular intervals, every time the bus sends an update to the server. It distributes this information, on demand, to passengers who send request using a smart phone application or through SMS. The issues with traffic can be curbed as more and more people will opt for the efficient and economical public transportation as a medium of travel on a frequent and regular basis. With the information on demand service, the commuters can plan their journey well in advance, hence saving a lot of time and making the individual more productive. The commotion of the next arriving bus terminal is

also solved by the in bus display module which will give details of the route at regular intervals. To conclude, this system assists commuters, drivers and also the administrators of the transport system in a very convenient manner.

VI. Future Scope

The advancement in Internet and sensor technologies is unlimited and their useful implementation could lead to major breakthrough in the field of IOT. In future, we can implement simple cashless system harnessing the capabilities of the NFC present in the smart phones or RFID technology for small distance communication. This cashless method of payment can give us a count of the number of passengers present on board, which could be used further to estimate the capacity of the bus. These details could also be transmitted to the waiting passengers so that they can plan their journey accordingly. The number of people requesting for the bus details can be further used to decide the frequency of the buses, thereby reducing the commotion and making it a good experience for the commuters. Also instead of providing information about a single bus we can also provide alternate routes to commuters through the enquired bus stop. But since there are some shortcomings in these methods, it can be considered as a future scope which needs to be targeted by improved methodologies.

References

[1] 2015 American Public Transportation Association. Available online at : http://www.apta.com/mediacenter/ptbenefits/Pages/default.aspx

[2] SUN Wen-xia and SONG Ti , ZHONG Hai, "Study on Bus Passenger Capacity Forecast Based on Regression Analysis Including Time Series", 2009 Int. Conf. on Measuring Technology and Mechatronics Automation,2009IEEE, DOI 10.1109/ICMTMA.2009.268

[3] Sleyman Eken and Ahmet Sayar, "A Smart Bus Tracking System Based on Location-Aware Services and QR Codes", Innovations in Intelligent Systems and Applications (INISTA) Proceedings, 2014 IEEE InternationalSymposium,Alberobello,DOI:10.1109/INISTA.2014.6873634

[4] Xiao-Lei, M et al (2012), Transit Smart Card Data Mining for Passenger Origin Information Extraction, I Journal of Zhenjiang University Science C, Vol.13(10), pp.750-760,DOI: 10.1631/jzus.C12a0049

[5] Harter, G et al. Sustainable Urbanization: The Role of ICT in City Development, Booz & Company, Available: http://www.strategyand.pwc.com/media/file/Sustainable_Urbanization.pdf

[6] Oberli, C et al. ,Performance Evaluation of UHF RFID Technologies for Real Time passenger Recognition in Intelligent Public transportation Systems, IEEE Trans. Intell Transp. Syst.,Vol.11(3), pp.748-753.DOI: 10.1109/TITS.2010.2048429

[7] Menzes, B et al (n.d).Challenges in RFID Deployment-A Case Study in Public Transportation,Available from http://citeseerx.ist.psu.edu/viewdoc/download doi=10.1.1.104.3449&rep=rep1&type=pdf

[8] Pham Hoang Oat, Micheal Drieberg and Nguyen Chi Cuong. Development of Vehicle Tracking System using GPS and GSM Modem, 2013 IEEE Conference on Open Systems (ICOS), December 2 4, 2013, Sarawak, Malaysia,DOI:10.1109/ICOS.2013.6735054

[9] A. EI-Rabbany, GPS for Vehicle Navigation in Introduction to GPS: The Global Positioning System,Norwood, MA: Artech House, 2006

[10] Arduino. (2013). Arduino: Main Page [Online]. Available: http://www.arduino.cc/

[11] Android Studio 1.0 Developers Blog Available: http://androiddevelopers.blogspot.in /2014/12/android-studio-10.html

[12] Android Developers Available: http://developer.android.com/reference/android/app/Activity.html

[13] LAMP (Linux, Apache, MySQL and PHP) Available: http://lamphowto.com/

[14] JSON Available: http://www.json.org/

[15] MYSQL : The World's most popular open source database Available: https://www.mysql.com/

[16] Mark Smith, "Intelligent Mobile Application for Traffic Monitoring", ITNG, 2015, 2015 12th International Conference on Information Technology - New Generations (ITNG), 2015 12th International Conference on Information Technology - New Generations (ITNG) 2015, pp. 621-625, doi:10.1109/ITNG.2015.103

[17] X. Yu et al., Transportation activity analysis using smart phones, in Proc.IEEE CCNC, 2012, pp. 6061

[18] P. Widhalm, P. Nitsche, and N. Brandie, Transport mode detection with realistic smart phone sensor data, in Proc. IEEE 21st ICPR, Tsukuba, Japan, 2012, pp. 573576.

[19] S. Reddy et al., Using mobile phones to determine transportation modes,ACM Trans. Sens. Netw., vol. 6, no. 2, p. 13, Feb. 2010

[20] Y. J. Byon, B. Abdulhai, and A. Shalaby, Real-time transportation mode detection via tracking global positioning system mobile devices, J. Intell. Transp. Syst., 13, no. 4 pp. 161170, 2009.