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Technological Implementations in Public Transit Systems Worldwide

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ABSTRACT

The focus of this paper is on the various public transportation systems around the world and the technological implementations that make the usage of these transit systems easier for the public in their respective countries. This paper discusses the existing technologies that are being used, and also the newest technologies that will be used in making these transit systems easier and convenient to use for the general public in the countries around the world. There has been an increase in advancement of technologies and new inventions in the field of computer science and their applications in transit systems as well for making their use reliable for the population of the country. This paper also discusses some case studies from all over the world citing examples regarding the topic of this paper.

Keywords: Public transportation systems, Internet of things, mobile devices, sensing technologies, Global Positing system, Bluetooth

I. INTRODUCTION

All around the world, people commute to other places, may it be their workplace or some other destination through the means of public transport. Public transportation systems serve as the lifelines of the countries that they are operational in, since it makes commuting from any place to any other destination that much simpler. Also, for those people who do not have any other means to commute, the public transit systems are a boon to those people all around the world.

In metropolitan cities around the globe, such as Chicago, Tokyo, and many cities in our country as well, like, Delhi, Mumbai, Kolkata, all of these have a variety of transit systems that the majority of the population uses on a daily basis to commute to and fro from their homes to their workplace. Furthermore, in such crowded cities, public transit systems provide a cheaper, better alternative to go from one place to another without any hassle, and mostly, on time.

For example, in our country, the capital city of Delhi boasts of more than 36 lakh commuters who commute using public transportation systems alone. The public bus transport systems in Delhi handle around 90% of such commuters who use public buses to travel. The rest of the population of Delhi mainly uses the Delhi Metro, which is a connection of suburban rail networks that have routes all over the Union Territory, spanning up to outside the border region of Delhi.

With new technologies that are being invented for implementation in public transportation systems, the most common of them is the usage of the Global Positioning Systems (GPS) for tracking the vehicles used in public transit systems, and for ensuring the timeliness of the availability of the buses as well. Other technologies include the use of electromagnetic systems in monorails, or suburban railways to build faster and better rail networks. The use of smart contactless cards in place of ticketing machines is also being implemented in our country, and such systems are also being developed around the world.

The purpose of this paper is to provide an overview of key emerging transit technologies. Section II focuses on Background study, followed by Factors affecting trends in technology of transit systems in Section III. Section IV explains Current state of Intelligent Transportation Systems, Section V finally concludes he paper.

II. BACKGROUND STUDY

For bus tracking many designs have been designed and implemented. In the case of implementation or in the

case of the system design all proposed methods and implementations are unique. There is a real time bus monitoring system having Global Positioning System (GPS) module which is put in the buses for transmission of the real time location of bus to receiver station which is installed on the bus stops as explained by Kumbhar, et.al. 2016. The centralized control unit receives the GPS data of the bus location and it activates Light Emitting Diodes (LEDs) in the approximate geographic positions of buses on the route. This device does not require an external power source, it is portable and sustainable and removes energy costs. (Khan and Mishra, 2012) proposed the embedded system which is a single board system having GPS and Global system for mobile communications (GSM) modems and Advanced RISC Machines (ARM) processor to track vehicle. This system has large capability, low operation cost and sturdy expansibility. Chandurkar, et.al. 2013 proposed a real time bus monitoring and passenger information system. The system gives current location of buses and estimated arrival time at different stops in their respective routes. The link updater is used to find the bus position and the present route of the bus. The estimated arrival time is updated at control unit and this information is shared with passengers using display board at bus stops. A real time query system for public transport service using Zigbee and RFID has been proposed by Manikandan and Balakrishnan, 2012 which is suitable to passengers demand and provides information such as bus location, bus number and number of persons inside the bus in real time. This system provides efficient as well as low cost public transport system. Kumbhar et al., 2015 suggested the design of punctuality enhanced bus transportation system using GSM and zigbee. This solution improved the service quality of operational efficiency and passenger was also able to get the information about the respective bus. The tracking system can inform the location and route travelled by vehicle and that information can be monitered from any other remote location. The system also includes the web application that provides exact location of target. This system facilitates to track target in any weather conditions.

Vijayalashmy et al., 2014 proposed Global Navigation Satellite System (GNSS) based bus monitoring system. The main objective of this system is to reduce the waiting time of passenger at bus stop by sending information about the location of buses to the passenger through SMS. GNSS based web application is developed which provide real time location of bus on Google Maps along with speed. Manikandan and Niranjani, 2014 implemented real time public transportation information using GSM query response system. The system is skilled to track a large number of buses concurrently, detect their service routes and predict arrival time to down station with an acceptable accuracy. The microcontroller acquires data from the GPS module and sends to the control point by using the GSM module. Raja et. al., 2014 proposed a bus position monitoring system to facilitate the passengers' need to get a seat in the bus.

The wireless communication technologies like GSM & GPS are used to send the information about number of seats available in the bus to bus station and current location of bus on the route. Real time passenger information system uses variety of technologies to track the location of bus in real time and generate the prediction of bus arrival at stops along the routes. In this paper, they have presented a smart bus tracking system which is based on GPS, GSM, QR coding and Google's map. The proposed system, estimates the arrival times at specific bus stops by tracking buses and informs the users through e -mails and SMSs. The system helps to passengers from unnecessarily waiting at bus stops and enables them to use their time more efficiently.

III. FACTORS AFFECTING TRENDS IN TECHNOLOGY OF TRANSIT SYSTEMS

General trends in technology can have a major influence on transportation and provide context in which public transportation agencies operate. Major current developments in technology and their implications for public transportation are discussed below.

1. **The Internet of Things:** The Internet of Things (IoT) is a system of interconnected computing devices, mechanical and digital machines, objects, animals or even people that are assigned unique identifiers and are made capable to transfer data over a network without requiring human-to-human or human-to-computer contact. By allowing objects to be sensed and controlled remotely, it creates opportunities for more direct integration of previously disconnected objects, activities, and

systems. It is estimated that the IoT will comprise of approximately 50 billion objects by 2020. This computer-to-computer communication has major inferences for public transportation, with the potential to advance system efficiency and target service more precisely to user needs.

2. **Mobile Devices:** A mobile device is a general term for any type of handheld computer. These devices are designed to be hand-held and enormously transportable. Some mobile devices—like tablets, e-readers, and smart phones are powerful enough to do many of the things that previously only a desktop or laptop computer could do. The creation and power of mobile devices provides many opportunities to increase efficiency for public transportation providers and improve the transit user experience. These include improved communication, data collection, mobile payment, and integration of transit with other modes of travel.
3. **Explosion of Data:** In addition to the expansion of Internet-connected automation, the IoT is also expected to generate large amounts of data, require quick gathering of that data, and create a need to index, store, and process such data much more efficiently. The additional data generated by interconnected objects such as vehicles, sensors, and smart phones will enable public transportation agencies to understand and communicate with their customers in extraordinary ways, while enabling the agencies be more transparent to their customers. New capabilities will, in turn, create a need for staff and systems to analyze, manage, store, and protect a vast amount of new data. This presents a challenge, particularly for smaller transit agencies.
4. **Shared Use Mobility (SUM):** Shared-use mobility includes transportation services that are shared among users. The term describes all shared vehicles and transportation services – including public transportation, taxis, bikes, cars, ridesharing, shuttles, and even parking spaces. Transportation Network Companies (TNCs) represent a subset of shared-use mobility. TNCs provide paid, planned and prearranged rides using a digital platform that connects a probable passenger with a driver using a personal vehicle.

IV. CURRENT STATE OF INTELLIGENT TRANSPORTATION SYSTEMS

An intelligent transportation system (ITS) is an advanced application which strives to provide innovative services. These services are related to different modes of transport and traffic management that enable various users to be better informed and make safer, better coordinated, and efficient usage of transport networks.
ITS is of two types basic management systems and advanced management systems. Basic management systems include car navigation, container management systems, traffic signal control systems, variable message signs, speed cameras to monitor vehicles' speed, automatic number plate recognition. Advanced applications comprise of integration of live data and reaction from a number of other sources, like parking guidance, weather information, etc. Predictive methods are being developed to allow superior modelling and comparison with historical baseline data.

There are various technologies used in intelligent transportation systems viz. Wireless communications, Sensing Technologies and Floating Car Data/Floating Probe Data

Wireless Communications:
Intelligent transportation systems make use of radio modem communication on UHF and VHF frequencies for short and long range communication.

IEEE 802.11 protocols are used for short-range communications of 350m, specifically WAVE or the Dedicated Short Range Communications standard is used by the Intelligent Transportation Society of America and the United States Department of Transportation. Mobile ad hoc networks are used to extend the range of these protocols.

WiMAX (IEEE 802.16), Global System for Mobile Communications (GSM), or 3G are used for long range communications. These methods need wide-ranging and costly infrastructure deployment.

Sensing Technologies
Advancements in the field of state-of-the-art microchip, RFID (Radio Frequency Identification), and inexpensive intelligent beacon sensing technologies, have augmented

the technical capabilities that would assist motorist safety benefits for ITS at a global scale. Intelligent vehicle technologies have been used for sensing purpose. There are many different types of infrastructure sensors viz. in-road reflectors that are installed or embedded in the road or on buildings, posts, and sign boards. To increase monitoring of vehicles, Vehicle-sensing systems have been deployed that comprises of video automatic number plate recognition or vehicle magnetic signature detection technologies. Bluetooth detection, Video vehicle detection and Inductive loop detection are some examples of these sensing technologies.

Floating car data/floating cellular data:
The methods used are Triangulation method, Vehicle re-identification, GPS based methods and Smartphone-based rich monitoring.

- **Triangulation method:** Raw data has been collected using triangulation method in developed countries. The phones used by occupants of the car periodically transmit their presence information to the mobile phone network, even when no voice connection is established. The movement of a car is monitored with the help of monitoring of the signal of mobile phone inside the vehicle. This facilitates gathering of data related to traffic flow. More is the data, greater is the traffic flow.
  The benefit of this technique is that no infrastructure is required to be built along the road; only the existing mobile phone network is utilized. But in practice the triangulation method may not provide accurate results, for example in areas where the same mobile phone towers serve two or more parallel routes (such as a motorway (freeway) with a frontage road, a motorway (freeway) and a commuter rail line, two or more parallel streets, or a street that is also a bus line). Other method is
- **Vehicle re-identification:** Vehicle re-identification methods uses sets of detectors installed along the road. In this technique, a unique serial number for a device in the vehicle is detected at one location and then detected again (re-identified) further down the road. The time at which a specific device is detected by pairs of sensors is used to calculate travel times and speed. MAC addresses from Bluetooth or RFID serial numbers from electronic toll collection (ETC) transponders are used for this detection purpose.
- **GPS based methods: Modern day vehicles are** equipped with in-vehicle GPS which provides position readings of the vehicles to calculate vehicle speed.
- **Smartphone-based rich monitoring:** They are available these days with pre-installed accelerometer apps. The accelerometer data from the smartphones used by vehicle drivers is monitored to know the speed of traffic, density of traffic and quality of road.

Floating car data technology provides many benefits over other methods of traffic measurement which includes cost effectiveness, better coverage, less maintenance and availability even in bad weather conditions.

V. CONCLUSION

We can conclude that the technological implementations do have an effect on the services of the public transport systems. The Internet of Things and Mobile Devices technologies are among important factors that have caused a lasting effect on trends in technology of transit systems. The smooth functioning of these systems can be aided by leveraging the existing technologies and by implementing the new ones. Also, improvement in the services of the transportation systems is attributed to the use of new technologies in the transit systems.

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