Smart Local Bus Transportation System based on IoT

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***Abstract*—**Internet of Things (IoT) is a platform that the device used to be smart, every day is processed to be smarter, and every day communication becomes more informative. IoT is still growing and continues to be researched by some researchers. Various models, platforms and applications are proposed and designed in such a way as to benefit society. This paper was developed by conducting surveys on issues oriented towards the utilization of IoT related to the development of intelligent public transport. The architecture presented proposes solving real-life problems by building and disseminating powerful ideas. The purpose of this study is to explore opportunities and challenges for the application of IoT on public transport. In this paper, we focus on to an IoT system that is used to build intelligent transportation bus system (IBTS). IoT based intelligent transportation systems are designed to support the Smart City vision, which aims at employing the advanced and powerful communication technologies for the administration of the city and the citizens.

Keywords*—Internet-of-Things (IOT), WSN, Transportation system, Public transportation, Smart city, Intelligent Bus Transportation System (IBTS).*

I. INTRODUCTION

In the past two decades, the proliferation of modern technology has made a huge impact in the lifestyle of the people. Emerging technologies have developed features that are tightly aligned with people's interests like: being compact, easier to use, feature-rich, connected to the internet, being fast and smart. The availability of affordable sensors, together with the proliferation of internet infrastructure enables an interesting technology called the Internet of Things (IoT). IoT had resulted from context aware computing [1], that aims to allow people and things to be connected anytime, anywhere with anything/anyone. In other words, devices and application have the ability to communicate each other without/less human influence. There is also significant interest and attention towards IoT from the industry [14]. This interest has triggered the development of myriad of sensors for different applications like location sensing, weather forecasting, biomedical applications, and many more. Many companies has come out with their custom board targeting IoT applications [14], [11]. ITS is plays one of the major role in contributing towards smart city development. In most developing countries like India, public transportation system (bus) are the main source of travel for many commuters living in urban as well as rural. Our project theme is to develop a prototype for ITS, which will be useful to track a vehicle through GPS [18], payment of tickets, crowd analysis inside the bus through NFC [19] and finally, the ambience inside the bus can be measured with temperature and humidity sensor [13]. Within our IoT infrastructure, the data collected from our sensors is sent through the internet and processed by the monitoring system to make useful decision and send it to the display system (as per our application requirements). We have grouped the entire architecture into has three systems namely; the sensor system, monitoring system and the display system. The sensor system utilizes GPS, NFC, temperature and humidity sensors, which are always connected with the internet via a GSM network [17] to track the location, commuter and ambience inside the bus. The monitoring system is not only intended to extract the raw data from the sensors database and convert it in to a meaningful context but, it also used to trigger some events with in the bus as well as provide information to the bus driver. The display system is used to show the context data to all the commuters in the bus stop regarding bus and travel information

II. LITERATURE SURVEY

Intelligent Public transport, especially the bus transport system is one area which requires the smart sensing and communication technology to enable commuters to enjoy the benefits of hassle free transport. Though most of the bus services provide a pre-planned time table for travelers, the information is only limited. The information requires constant updates based on the current traffic scenario. Also, accurate arrival time and updated information on the crowd onboard will be beneficial for travelers. In countries like India, where majority of travelers depend on public transport for communication, there is an urgent need to address the problem of intelligent transport system. By combining information technology, advanced communication techniques and smart sensing system, it is possible to address the growing demand of connectivity. IoT presents a unique framework to achieve the required degree of connectivity.

Authors in [2] present a survey of over 100 papers which highlight the application of IoT in various domains such as health, sports, transportation and agriculture. Based on the survey on the transportation domain, the authors have identified usage of GPS and RFID tags as primary the mechanism of location tracking. Also, GSM/ GPRS have been used for communication of information to users in the form of SMS.

Cloud computing and IoT are the terminologies used for intelligent systems. Authors in [3] have provided a clear differentiation between Cloud and IoT based on parameters such as reachability, computational capabilities, role of internet etc. Also, the authors have presented the advantages of integration of cloud computing and IoT, termed as Cloud-IoT.

Benefits of integrating the two technologies for performing large scale data analysis have also been highlighted. Authors in [4] have presented a survey on usage of smart phone-based sensing for intelligent transportation systems. Embedded sensors in smart phone such as accelerometer, gyroscope, and global positioning system (GPS) have been applied for obtaining traffic information, driver behavior information and vehicle information.

Solution provided in literature can be broadly classified into software-based solutions and hardware enabled solutions.

A. Mobile application-based solutions:

Mobile phone application based on GPS has been presented in [5, 6, 7, 8]. The limitation of such applications is that additional information such as crowd, bus arrival time etc. cannot be incorporated.

B. Hardware enabled solutions:

Based on the study, it has been identified that some of the solutions provide only location tracking based on GPS signaling and usage of GSM for information alert to the user [9,10,12,15,16,20] whereas others employ RFID technology.

Radio frequency identification system (RFID) is an automatic technology and aids machines or computers to identify objects, record metadata or control individual target through radio waves. Connecting RFID reader to the terminal of Internet, the readers can identify, track and monitor the objects attached with tags globally, automatically, and in real time, if needed. RFID is often seen as a prerequisite for the IoT [21]. RFID has been used in bus information systems for obtaining information such as Bus ID, crowd etc. in addition to location tracking. Authors in [22, 23, 24] have used RFID for the proposed solutions.

Now a day, we prefer NFC payments, which are similar to the RFID technology. This NFC technology is more simple and easy for transactions.

Previous works provide some insights about an smart bus system but none of them proposed/demonstrated a complete system. Through this work, we intend to propose a new IoT system which will track the vehicle with GPS system, people with NFC system and the ambience in the vehicle through temperature and humidity system. In the following sections, we will discuss about our system architecture and components for a smart bus, following with our idea to integrate multiple smart buses to make an efficient IBTS.

III. PROPOSED SYSTEM ARCHITECTURE

The system architecture is classified with respect to sensing, monitoring, and displaying systems. All operations are performed by keeping Internet as the backbone. There are different sensors used in this system. All these sensors produce raw data which will be stored in a central database. as shown in Figure 1. This raw information need to be carefully monitored, analyzed and then made into a meaningful context. If any issues, actions are taken automatically by the system. At last, the meaningful context is displayed to the public.

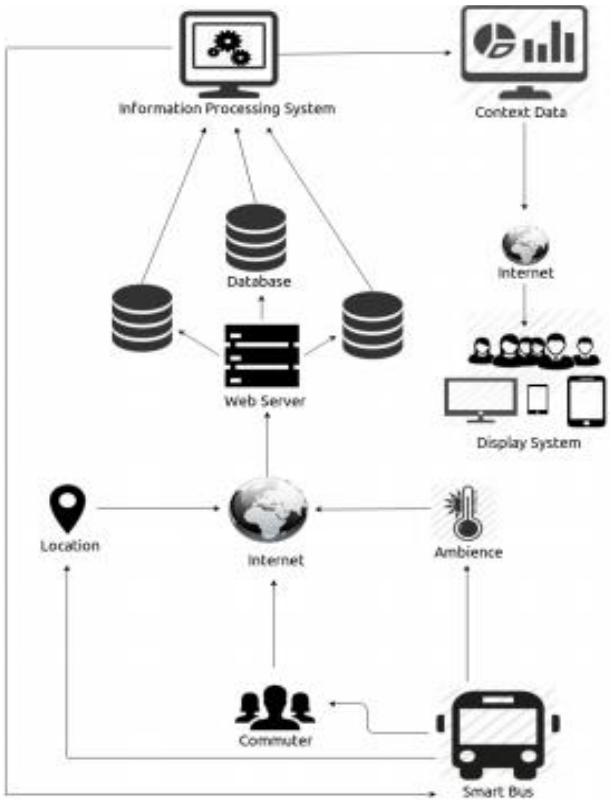

Figure 1: Architecture Diagram

A. Sensor system:

The sensor forms the brain for the system. One of the major function of the sensor is to acquire and send the vital data to the monitoring system. The sensor system has multiple sensors that are used to collect very specific information. We have classified the system in three important aspects like:

• Location Subsystem

• Commuter Subsystem

• Ambience Subsystem

In the following sections, we will be looking on these aspects in detail for a single smart bus.

B. Location subsystem:

The location subsystem is essentially a vehicle tracking system that allows the monitoring system to identify the vehicle's current location. Our system uses three modules, GPS receiver, Global System for Mobile communications (GSM) modem and a microcontroller to track the location of the vehicle.

A GPS is made up of constellation of satellites orbiting around Earth. Each satellite has an atomic clock on its board, so it knows the precise time. Here we use GPS shield provided by Adafruit Industries, which is a low power module that draws only 20mA current, half of most GPSs. The GPS has -165dBm sensitivity, 10 Hz updates, 66 channels and has both internal patch antenna as well as connector for external active antenna. The GPS captures NMEA sentences from the satellites. In the

NMEA sentence, we can find few parameters like latitude, longitude, speed, time stamp, etc.

The system utilizes GSM module from Arduino which has a M10 by Quectel radio modem and uses AT commands to communicate with another device. The GSM module can help to make/receive voice calls, send/receive SMS messages and 175 allows to connect with the Internet through GPRS wireless network. A SIM card is very essential for the GSM module to operate.

Microcontrollers play a vital role in our application. We used Arduino UNO and MEGA with Atmel's microcontrollers ATmega328 and Atmega2560 in it. A software program written in C programming language is compiled, then stored in the flash memory of the microcontrollers.

C. Commuter subsystem:

The commuter subsystem predominantly uses NFC technology. The system consists of 3 modules such as NFC reader and Mifare tag, GSM and Microcontroller. NFC is a set of short-range (typically up to 10cm) wireless communication technologies designed to offer light-weight and secure communication between two devices.

Before starting a journey in the smart bus, the commuter need to apply for his a Mifare card, which is a unique card for each commuter. During the application process, all the personal information (Name, address, Id proof, photo, email, phone etc.) of the commuter are acquired and then a unique id is issued to the commuter. Now, the commuter needs to credit his/her travel card with some money. This can be done online through payment gateways. At the start of the journey, the commuter taps the Mifare card in the NFC reader and enters the details through the serial console of Arduino. Once the details are furnished, it is acquired by the NFC reader and sent to the database through the GSM module. Then the details of the commuter along with the sum of amount (credited or debited) is stored in the database. The confirmation of NFC payment and tickets can be generated through a thermal printer or through an SMS to the commuter's phone.

D. Ambient subsystem:

In our work we are also interested to analyze the ambience inside the bus. This is because, in countries like India and China which has large population with varying climatic conditions on various parts of its geographical locations. So, when many people get in a bus, the climatic temperature outside the bus and inside the bus varies to a substantial extent. By placing temperature and humidity sensors, after a certain threshold it can automatically switch the air conditioner on through relay circuit or it can indicate the driver to switch on A/C because of intense temperature in the bus.

E. Alcohol detection subsystem:

Here, Alcohol sensor is used to detect the driver's behavior whether driver has consumed alcohol or not. If driver is drunk and drives, then status report is given to depot manager and manager can make alternate arrangement and can stop the bus at next junction. This can be a good approach to avoid accidents and can save more lives also.

Working:

Initially, a circuit is designed by integrating the sensors with the microcontroller. After integration, a program is written and burned in the flash of the microcontroller. Once we compile and execute, we can get the raw value from sensors (location, commuter, ambience) in the terminal. For example, we get different data form GPS such as latitude, longitude, speed etc., from NFC, we get the source, destination, cost related values. Furthermore, from temperature and humidity sensor we get temperature and humidity. All this raw information shown in Figure 2, are transferred to the server through the GSM. The GSM modem begins with searching for 2G/3G network. Once the GSM senses the network, it then connects to the GPRS.

Once the internet is connected, the data such as LP (Location Parameters), CP (Commuter Parameters) and AP (Ambience Parameters) are transferred to the database through http protocol. The process of storing happens between, HTTP client and HTTP server. Below is the HTTP client request, on which, it first identifies the server with IP address or domain name through DNS. Apart from the server, we need to mention the port number by which it need to connect with the server.

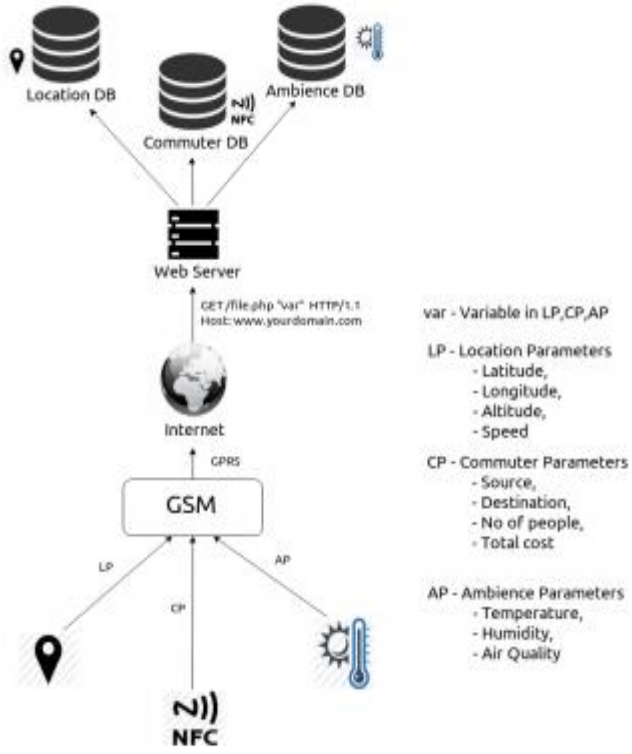

Figure 2: Flow Diagram

As the server is connected, it looks for the file.php, were the PHP file redirects to a database, where the sensor information is stored. For example, if we want to store the GPS parameters like latitude and longitude, the values are passed to the server and the data are store in the Location DB. Similarly, all the sensor information is respectively stored in the server databases.

IPS is the component that convert the raw data in to the context data i.e., the data from the sensors are called as the raw data and a meaningful information extracted from the raw data is called the context data. IPS has the functionality to trigger some event automatically inside the bus and provide information to the bus driver.

The context data from the IPS are given below:

• Current location of the bus in maps.

• Number of people in the bus.

• Number of people expected to get down.

• Temperature and humidity inside the bus.

• Air quality inside the bus.

All the above data are meaningful information that need to be transferred to the display system. The display system is a large LCD screen with an internet connection on it. As the display systems are placed on the bus stops, the information from the context data need to be transferred to the display system through the Internet. Then the commuter in the bus stop will be able to analyses the current location of the bus, number of commuters inside the bus, in which stop maximum crowd expected to get down, the temperature and humidity level inside the bus.

IV. CONCLUSION

The system to be designed is fully secured and smart assisted public system. The implementation of the system is to be done for bus. The proposed system tries to give exact location of local transport vehicles on display screens and on android App using Google map. This helps commuters to reach their destination as early as possible by avoiding the wait time at bus stop or at stations. The system is smart and advanced as it has various features of alcohol detection, GPS tracking, GSM acknowledgment. Through this IBTS system, we can track three important aspects in the bus: location, commuter information and the ambience.

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