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Smart Vehicle Parking Monitoring System using RFID

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Abstract - With the vast growing influx of population in the developed, industrially and technologically sound urban cities, an urgent need to make the cities smart is surmounted. The cities are made smart utilizing data sharing, artificial intelligence, machine learning, analytics, and thousands of RFID tags and sensors. One of the significant concerns of today's smart cities is the growing need to manage the vehicles on-road as well as to create sufficient and well-managed parking lots to prevent urban areas from traffic congestion. This leads to a call for highly automated parking management system self-sufficient in guiding the driver to an available parking space in the nearby area. In this paper, a real-time prototype of the smart parking system (S.P system) based on Internet of Things (IoT) is discussed. The proposed smart parking system works on an electronic device that collects the parking availability status and assists drivers in finding and selecting the desired parking space among the available parking spaces that effectively reduces the traffic problems and mismanagement across the cities to a great extent.

Keywords: Smart Parking System, Parking Lot, Parking device, Internet-of-Things(IoT), RFIDTags, Real Time Management, GUI Information Centre, Localised parking, Centralised Parking, Smart Cities

I. INTRODUCTION

IoT (Internet of Things) on a broad and technical basis is a new paradigm of interrelated computing devices, technological innovations, digital as well as mechanical machines, sensors, animals and humans with the capability to transfer data over network without any real time aid of any kind of interaction whether man to man or machine to man. IoT or more precisely IOET i.e. Internet of Everything has opened different mean of evolutionary concepts in every possible sector. Internet of Things is an interconnected network of millions of electronic devices like sensors, RFID tags, and many others connected to communicate with one another[1].

Radio Frequency Identification (RFID) and Smart Parking

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RFID is the most fundamental technology enabling wireless data transmissions over networks. Though this technology was available for a long time, recent standardizations and affordability have significantly added to its utility. This technology uses electromagnetic fields for communication and collection of data from the objects with RFID tags attached to them.

Any sector involving the use of RFID tags has witnessed a drastic increase in both efficiency and productivity. It has been widely used in tracking systems, monitoring systems and parking systems, RFID finds its vast and necessary usage in automation which is established using technologies like RFID readers, RFID sensors, RFID controllers, RFID writers and many.

From management, controlling, bill generation to operations, all tasks can be performed with this technology. Check-ins and check-outs get a pace cutting down the time for the cars to stop helping reduce traffic jams, aggression problems in the driver as well as the air pollution. RFID technology combined with automated bill generation method will enable drivers to pay online without having to stop at the exit gate, making the whole process faster than usual.

This prototype uses RFID Tags and RFID readers or sensors. RFID tags are composed of integrated circuit and antenna. The integrated circuit is a microprocessor chip, and the antenna defines the reading range of the RFID tag. These are further divided into active and passive RFID tags. Active RFID tags have own power source, low required signal strength, long communication range, and ample read/write data storage. On the other hand, passive RFID tags have no internal power source. They have short communication range; small read/write data storage capacity and high signal strength. The RFID reader is an electronic device consisting of an antenna to enable communication between tags and a transceiver for data storage**.**

RFID - IoT- Smart Parking: The Connecting Link

IoT is based on decentralized integrations of network devices, identifications, sensors, and other smart technologies interconnected to reduce manual work and increment automation. IoT applications are grouped into several domains ranging from an essential internet connection, education, business, transportation, health and agriculture to smart cities, traffic, remote monitoring, smart metering, and process automation. In accordance

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with the fast-growing world both in terms of magnitude and technology, IoT adds to the overall development of the technical arena. The vision of IoT has made all our thoughts and ideas to evolve into reality [2].

Apart from helping users in day to day life, IoT has made considerable advances in the smart city and business sectors. Today Internet of Things application has become an elementary domain for data streams and big data analysis. IoT has allowed making a secure connection between people and devices at any point in time and every sector possible. The applications further help in real time management, disaster management, automated work management, effective asset utilization, and smoother logistics. Mere IoT does not work; it further requires provisions with ubiquity, reliability, efficiency, and high performance.

IoT's application in parking is mainly based on an automated system capable of providing a real-time database for the proper management of traffic congestion. The huge increment in the number of vehicles in urban areas along with mismanagement and congestion has become a significant cause for the tremendous increase in parking-related problems and its after-effects like road rages and conflicts between drivers and government officials or parking lot security [3]. All these problems urge for the need of an automated parking system that provides a platform to the drivers for selecting among available parking spaces in the nearby slots. This kind of system not only helps in tackling traffic-related problems but also helps in:

- Reduction of fuel consumption
- Saving time
- Improving drivers' experience
- Proper and organised use of parking spaces[4]
- Reduction in air pollutions

A well and smartly managed car parking system leads to a reduction in fuel consumption, decreased vehicle's emissions, which help in reducing levels of pollution to a noticeable extent. As fuel consumption is directly proportional to vehicle miles travelled, it also attributes to vehicle travel being reduced. Smart parking system enables proper utilization of parking spaces along with guaranteed safety. With the smart parking apps and websites, drivers can easily track empty parking slots nearby, thus effectively managing vehicle travel time and cutting down search time. Illegal parking of vehicles along the roadside would also decrease.
Moreover, the smart car parking system helps in predicting future most effective parking patterns from the information gathered. It can also be made more cost-effective and user-friendly based on the results of experimentation with car parking.

There are many connectivity options for smart cities ranging from low power extensive area network (LPWANS) and cellular networks. An eloquent amount of research is available in the of smart parking suggesting ways to provide solutions to parking navigation, parking space availability detection, parking application system design and structure, etc. However, two significant factors, that have not been paid the required attention to, are the detection of improper parking and automatic collection of parking charges through parking bills generated at the end of the month.

IoT Solutions to Smart Cities

Smart cities can be enhanced by Internet of Things(IoT) solutions consisting of the following:

- Sensors are built and installed in an automated from within the infrastructure to sense various conditions.
- Any smart city platform, whether smart traffic monitoring system or smart parking system, is responsible for the collection of data its proper analysis and interpretation for fruitful results, thus providing visualizations to the front end users.
- Flexible network connectivity is a crucial component in helping devices to communicate efficiently with the various smart platforms.

II. LITERATURE REVIEW

Hisamitsu Kurogo [5] proposed a parking system for practical simplification of traffic management and improvement in transport efficiency based on a study of the parking management system. In [6], a system to detect places of present congestion and predict places of future traffic congestion was proposed to avoid traffic jams by providing prior information to the drivers. Present day Google Maps does the same interpretation work. An automated check in and check out based parking system was presented in [7]. This was based on RFID and RFID reader. Many wireless sensor networks (WSNs) based prototypes for parking system were also proposed with the main focus on the establishment of the sensor nodes at parking lots to detect and update the parking spaces status [8].

A more advanced version Vehicular Adhoc Network (VANET) was proposed in [9] helping drivers with the information of real-time navigation, anti-theft protection, and prediction of driver-friendly parking spaces. Bluetooth and Wi-Fi along with webcams in the parking lot to provide information about availability via an SMS was also used to create parking systems [10]. The parking system proposed in [11] provides an energy efficient model that helps in reducing parking time by providing the information of nearest parking availability enabling easy and quick parking. It also has an add-on feature that turns the parking lights on as soon as any car comes in motion in the parking lot.

Another parking system based on linear programming is generated based on availability, allocation, and charges applied. This

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system cuts down the time for searching the most relevant parking space for the user [12]. In [13], Heterogeneous Smart WSNs, a series of WSNs connected were used in the parking system.

Table 1: Overview of Models for Traffic Management

Reference Number	Year	Model
5	1995	Simplification of traffic management and improvement in transport efficiency
6	2001	System to detect places of present congestion and predict places of future traffic congestion
8	2006	WSNs based prototypes
9	2009	Vehicular Ad Hoc Network (VANET)
10	2013	SMS based parking system
11	2013	Energy efficient parking model
12	2016	Parking system based on time saving
13	2018	Heterogeneous WSNs based smart parking system

II. PROPOSED WORK

The major highlights of this smart parking system are summarised as follows:

- Designing a smart parking system based on IoT with RFID technology.
- Proper, easy, and fast check-ins and check-outs in any parking area.
- Increasing system functionality, , and efficiency.

Figure 1 is a block diagram representation of the proposed prototype of Parking lot model. According to this parking system, each parking space is installed with a parking lot model at the back end of the parking space.

The smart parking system proposed in this paper requires three major components:

1. Electronic meter
2. WLAN or Wi-Fi integrated local parking workstations at each parking facility with access points(APs)
3. Central parking server providing information about parking spaces availability throughout the city

Electronic Meter (EM) is a device consisting of various hardware components for achieving different results. EM has an RFID vehicle tag sensor for detecting the presence of a vehicle in parking space along with ultrasonic sensors. RFID tags are also used in check-ins and check-outs and for the generation of parking bills, in a microcontroller Arduino for the backend codes, in an alarm IC for buzzing in case of improper parking and mismanagement of parking space, in LED for showing the status of the parking lot, whether equipped or available. Further, it has a GSM module connected for communicating with the site officer and driver via SSMs.

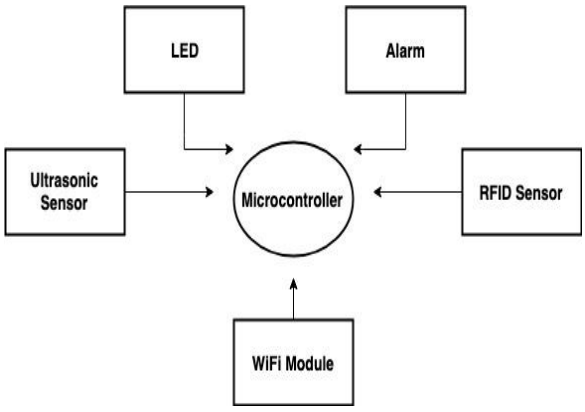

Figure 1. Block diagram representation of Parking lot model

III. SOFTWARE IMPLEMENTATION

The proposed parking system consists of the following four segments. Each segment is interrelated with each other. The next segment works in accordance after proper analysis of the results from the previous segment. The four segments are explained as follows:

Parking Entry System: This module contains parking gates embedded with RFID sensors. The moment a vehicle comes near this gate, the RFID sensor senses the RFID tag on the vehicle and records all the information stored on the RFID tag installed on the vehicle. At exit time, the parking gates again read this RFID tag, update the system for billing, and generate the parking bill or charges to be paid according to the time.This charge is either deducted automatically from the linked account or it comes inclusive in the traffic bill generated at the end of every month.

Parking Lot Monitoring System (PLMS): This software module is set up on the microcontroller Arduino. Its primary functioning is to detect the availability of parking space within any parking area based on the time difference between transmitted and received signal. Here, the ultrasonic sensor sends the detecting signals three times for the proper confirmation of vehicle presence in that particular space. Upon successful detection of a

vehicle, the occupancy of the parking space is confirmed. Then, RFID sensors come to play and reads the RFID tag already installed in the vehicle and the entry time. After all this process, this parking space status shows as being occupied. When the vehicle exits i.e. when the vehicle reaches the exit gate RFID sensor, the exit time is collected, and a bill is generated.Figure 2 shows the exact algorithm for the working of PLMS.

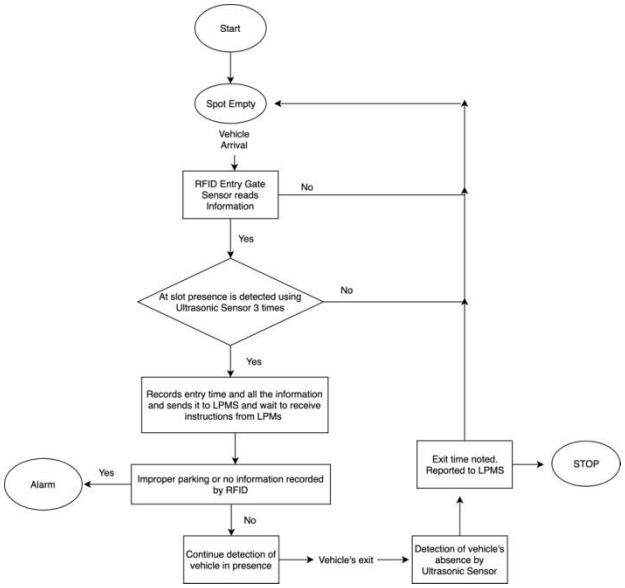

Figure 2. Algorithm for Parking Lot Monitoring System (PLMS)

Local Parking Management System (LPMS): This module is set up on the server of the local parking management system with each parking lot. It monitors the overall statuses of the parking spaces, which can be free, occupied, or reserved. The functions are:

- It matches the RFID sensor collected information with the information recorded at the entry gate to cross check and then stores the parking lot number allotted to it. Once confirmed by the ultrasonic sensor that the vehicle is being parked, its information is collected using an RFID sensor. In case of failure of the RFID sensor at the parking space from collecting the information from RFID tag or failure in sensing the RFID tag on the vehicle, an alarm blows and information then has to be collected manually and fed into the system. This alarm shows sign of improper parking due to which the RFID sensor failed to record the information.
- On the other hand, if the RFID sensor in the parking space can fetch all the information as desired, then the parking space status is changed from free to occupied. As soon as the ultrasonic detector shows the status of the vehicle's absence when the vehicle is removed from that particular location, the parking space allocated to it gets free, and the LED is on.
- In case of the reservation request for a parking space from Central Parking Management System (CPMS), it selects an empty parking lot and then goes to corresponding PLMS. If the reservation is confirmed, the status on application shows reserved, and the vehicle's information is included. In case of parking lot fully occupied, LMPS notifies CPMS about the parking lot status. It is to be noted that the user can reserve parking space 45 minutes in advance. In case of no show, slot remains reserved, and no refund will be given.

Figure 3 shows the complete algorithm of LPMS.

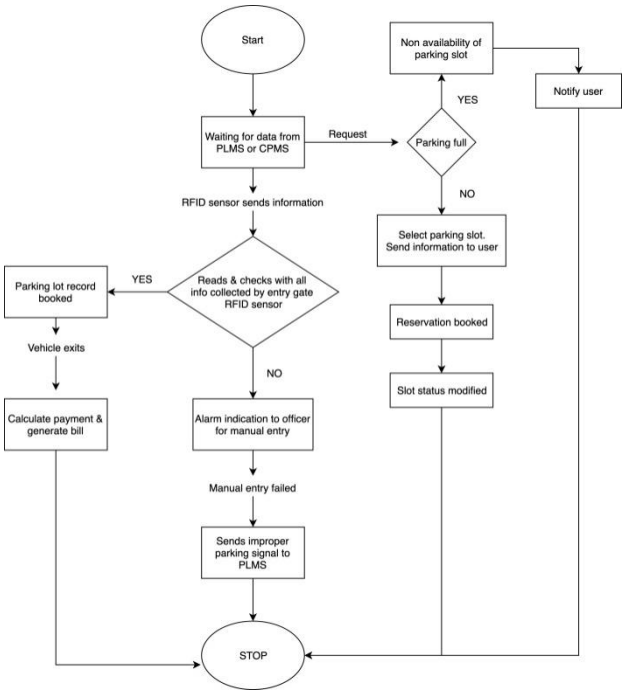

Figure 3: Algorithm of Local Parking Management System (LPMS)

Overall working of this model:

This shows how the exact system would work at the local parking end. Data read from the RFID tags is collected using the RFID sensors at entry gate. This data consisting of the various details of the car like car model number, registration number, pollution and servicing updates is loaded for a parking slot and that slot number is alloted to the vehicle. After this, at the time of parking of this car the ultrasonic detectors senses the presence of any vehicle at that allotted slot and activates the RFID sensor installed there to take reading form the RFID tags. This information ID is then sent to the server which matches this with the details collected at the entry gate. Incase of improper parking or no-collection of information, manual support would be provided. If not, then that is a successful parking. At the time of exit, an automatic bill is generated and the exit gate opens with the parking charges being deducted from your linked account. This is in short the working of LPMS model.

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Central Parking Management System (CMPS): It is set up as the primary parking system with a global IP for communication over the internet. It maintains all the records of parking facilities and parking area statuses. Therefore, it can provide information to the GUI of available parking space on the users' app. When it receives any reservation request, it forwards it to LPMS. Once booked, CMPS can deliver the payment options.

Application/ GUI Information Centre: This is an application designed for the user to book the parking spaces and to locate the parking spaces through inbuilt navigation.

V. CONCLUSION

This paper presents a prototype of a fully equipped RFID-based Parking System that provides solutions to various parking problems. Here the RFID tag referred is assumed to have a modified version than present-day RFID tags on vehicles because it stores all the information required for this module to work. This module will enable the drivers to pre-book the parking spaces to prevent them from traffic congestion and irritation. Further, it will also reduce air pollution and provide an efficient system with no wastage of time and fuel in searching for vacant parking lots.

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Ankita Gupta is currently pursuing her B.Tech. in Electronics and Communication Engineering from G.B.Pant Engineering College, New Delhi, India. She has published several articles as well as a Book Chapter. She has undergone training from Bharat Electronics Limited, Ghaziabad, India. She is presently a member of IEEE Society.

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