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Efficient Parking Management Using the IoT Technology

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***Abstract*—** Parking management in the populous country like India is very arduous. Most of the time, finding a parking lot with vacant spaces is a critical task which requires a lot of time and efforts to be made. Thus, after analysing the problem closely, we came up with a system that can effectively solve the problem of parking in metro/big cities using the IoT technology. The IoT architecture, in turn, will efficiently handle the parking space & overcome the problem of traffic caused by irregular parking on the roadsides, thus, managing time of the people. The architecture uses small-sized ultrasonic sensor which sizes about a bottle cap slotted with a wireless sensor node to send data to the Raspberry Pi, which further process the collected data and send it to the cloud. A Web App/Android App will measure the distance between user's current location & nearby parking lots within the specified distance range using Haversian algorithm that works along the earth's radius. The system also allows the user to reserve a parking space for a duration of time in advance.

***Keywords*-** IoT, Parking Management, Sensor Technology, Wireless, Raspberry Pi

I. INTRODUCTION

In India, with a population of 1.3 billion and approximately 25.3 million motor vehicles running on the road, finding a vacant parking space in the destined nearby area is usually very cumbersome, requiring a lot of time and effort. Lack of information about proper parking areas cause people to park their vehicles on the road side in a very haphazard manner which results in the problem like traffic jam, vehicle damage, improper utilization of road area & sometimes, even accidents.

The use of IoT in the parking management system is the integration of sensor technology, wireless network technology and software development to facilitate the proper utilization of parking resources available in the country.

This paper defines a system that uses Ultrasonic Sensor nodes along with the Raspberry Pi model which after several processing steps returns the list of the vacant parking lots & parking spaces nearest to the user's current location or the location asked by the user via Android App/Web App. It tracks the location of the user via GPS technology or by IP address-to-location conversion (in case GPS isn't available) & also let the user add any destination near which they want to find the available parking spaces. The system finds out closest empty parking lots using the Map API with the pointers marked on the it & returns this information to the user.

Section I gives a brief introduction to the system followed by Section II which contains the related work which has proposed other models for efficient parking management using other technologies. Section III focuses on the methodology defining system architecture & system design. Section IV highlights the proposed system, its hardware, software& server end with working mechanism & system function overview. Section V focuses on the results & discussion about the system's feasibility & operation followed by Section VI that concludes the research work with future directions.

II. RELATED WORK

The work done on this topic earlier involves the systems that use models based on cloud technologies, RFID (Radio-frequency identification), ZigBee, embedded system & sensors network and digital image processing**.** These models have used various algorithms to find the minimum distance to reach a vacant available parking space.

1. A Cloud-Based Smart-Parking System paper proposed a system that helps users automatically find a free parking space at the least cost based on new performance metrics to calculate the user parking cost by considering the distance and the total number of free places in each car

park. This cost will be used to offer a solution of finding an available parking space upon a request by the user and a solution of suggesting a new car park if the current car park is full. [1]

2. Smart Routing: A Novel Application of Collaborative Pathfinding to Smart Parking Systems. In this paper, smart parking system provides guidance to the drivers to find available parking spaces to avoid increasing parking issue. Traffic authorities in many metropolitan cities have initiated parking guidance and information (PGI) systems, providing drivers with up-to-date information on the available parking spaces and direct the drivers accordingly. The information is provided to the driver over the internet. The systems provide the location of the available car park spaces based on the driver's current location in intended area or his destination. Global Positioning system (GPS) is used to trace the driver's route to the parking destination, after the parking space is reserved. This results in traffic congestion as multiple users are being directed toward the same parking area at the same time. [2,3]

3. The Research and Implement of the Intelligent Parking Reservation Management System Based on ZigBee Technology. With the increasing development of economy and city modernization level, traffic congestion and parking have become major social issue due to the increasing amount vehicle density. To overcome this parking issue a smart parking system has been proposed in this paper which is composed of ZigBee network which sends the user requested information to PC through a coordinator and further updates the database. Using the internet, the parking information is provided to the application layer to make it convenient for the people seeking for the parking position with the help of web-services. The system consists of mobile client and server-side parking lot. The client requests the server for parking information through web-service interface. Then the server searches for the requested information in the available database and returns the required information to the client using the web-service interface. The real- time update status is available to the mobile client to ensure the correctness of the required information in the process [4,5].

4. Based on Embedded system in this paper the design and implementation with a prototype of Reservation-based Smart Parking System (RSPS) that permits drivers to effectively locate and withhold the vacant parking spaces in mentioned. This system use cluster based algorithm which helps in periodically learning the parking status from the sensor networks deployed in parking spaces, the reservation service is influenced by the change of parking status. The drivers can access this said cyber-physical system with their personal communication devices. The system implemented is cost efficient smart parking system for multi-level parking facility using WSN (IR Sensor) and develop an android based application, by cluster based allocation method and performs automatic billing process. The system monitors the availability of idle parking slots and guides the vehicle to the nearest free slot. Cost is minimized by keeping the number of sensors low without sacrificing the reliability. Energy consumption of each mote is kept in check by allowing the systems to sleep periodically and by reducing their communication range. This system's reservation-based parking policy has the potential to smoothen the operations of parking systems, as well as mitigate traffic congestion caused by searching for parking. [6]

5. Using RFID and GSM Technology: In this paper, a solution has been provided to the problems encountered during parking a vehicle at commercial parking lots. This problem has been resolved using Parking Reservation System. The Parking Reservation System is an access control and automated Reservation system that provides ID based parking slot provision system. The unique identification of the Vehicle entering using RFID tags permits tracking of vehicles entering and exiting the parking premises. It helps the system to know whether the vehicle or its owner is registered to prioritize allocation of parking spaces to incoming customers. [7]

III. METHODOLOGY

A. System Architecture

The architecture of the system is shown in the Fig. 1, which shows how the various activities are carried out in the system. It shows all the three major components of the system, based on which the complete processing of the system takes place.

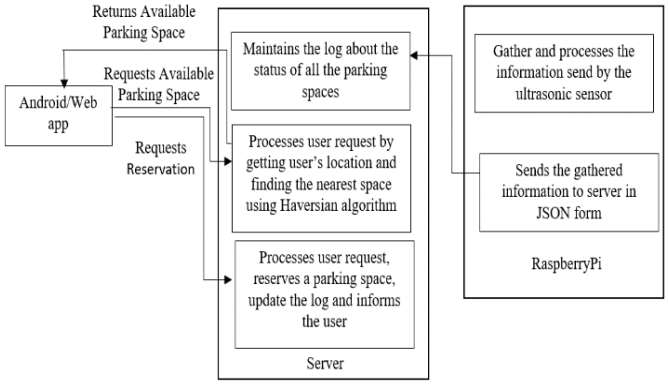

Fig. 1 Architecture of proposed system

B. System Design

The Fig.2 shows the system design which briefly describes all the modules of the system & the method of how they interact with each other.

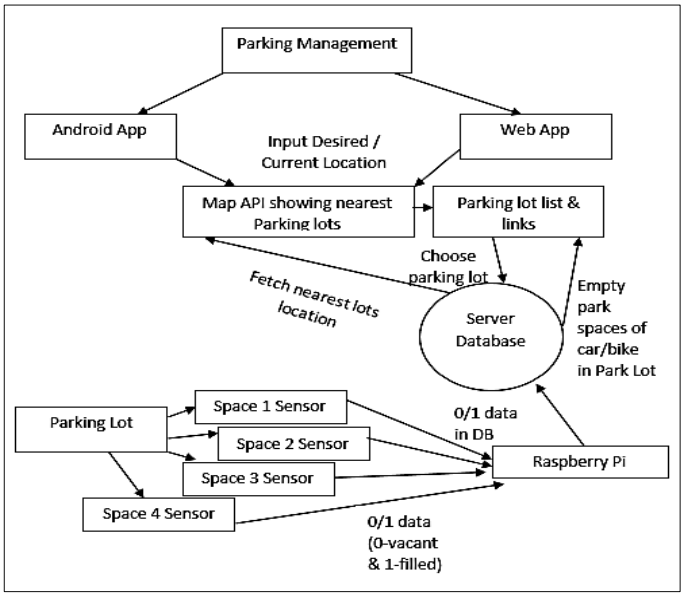

Fig. 2 Proposed System Design

IV. PROPOSED SYSTEM

The proposed system uses the IoT technology to get the information about the status of the parking spaces and uses algorithms to locate the nearest available parking space and return that list to the user. It further allows the user to reserve the convenient parking space and prove route to reach that point.

A. Hardware End

The system comprises of a credit card sized computer called the raspberry pi along with ultrasonic sensor, Wi-Fi module & a battery slotted on a single PCB board. The sensor constantly monitors the parking space within the given distance and using the wi-fi module, sends the data in JSON file format in regular time intervals to the online server. The battery attached to sensor module powers up the Ultrasonic sensor & the wi-fi module.

1. *Raspberry Pi*- The raspberry pi consists of 40 GPIO (General Purpose Input Output) pins, 4 USB ports, quad-core processor with 1 GB ram along with various useful ports and interfaces. It runs on the supply of 5 volts. Fig. 3 shows the Raspberry Pi 2 model B used in the project to serve the purpose.

Fig. 3 Raspberry Pi 2 Model B

2. *Ultrasonic Sensor*- An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object.

Fig. 4 Ultrasonic Sensor

The ultrasonic sensor checks whether the parking space is vacant or occupied & then the Wi-Fi module sends 0/1 status (0-vacant & 1-filled) to the Pi. This data is then forwarded to cloud server after processing. Each sensor node has a unique ID to differentiate it with other sensors of the same parking lot. Sensor nodes in the parking lot create a wireless sensor network for communicating with Raspberry Pi which serves as the embedded web-server.

3. *Wi-Fi Module*- The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor.

Fig. 5 Wi-Fi Module

These components along with a few other add-ons will be integrated onto a single PCB board to make a sensor node that will collect data about a single parking space in the lot. This module looks as follows as shown in the Fig. 6.

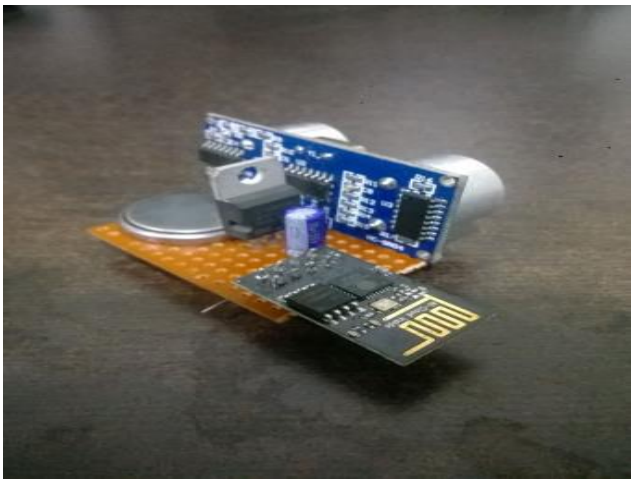

Fig. 6 Sensor Node

B. Software End

The Android App & the Web App (for non-Android users) provide the interface to users to view nearest non-full parking lots along with their location, distance (in km), route & time to reach by showing corresponding markers on the Map API within certain range from the user's desired destination. This information can also be viewed in the list format as links which when clicked will navigate to display the empty spaces in the parking lot at that time, separately for car/bike. On refreshing, the updated status of the parking lot will be shown. The marker will also show if the Parking is paid or unpaid.

C. Server End

System uses a MySQL database running on the server to store the following-

1. Login Information of Users.
2. Parking Lots Location, Coordinates (Latitude & Longitude of their exact location) & the status (F/NF, i.e. full/non-full) of all the parking lots in the city/area, to be visible on the maps. (Only non-full parking lots will be visible to the user.)
3. Parking Space Information of each Parking lot. This contains space ID (Sensor ID), Type of vehicle (Car/Bike) & status (Filled/Vacant) as 1/0 respectively. Each parking lot has one dedicated table in the database to maintain its information.

The database table corresponding to each parking lot on the server updates itself on the regular interval using the JSON data. The "status" field in the database table 2 is reflected by the data contained in tables of type 3, i.e. "Parking Lots" table is affected by data changes in "Parking Space" table. If all the records of "Parking Space" table corresponding to a lot contain value "1" in their "status" field, then "status" field of "Parking Lots" table will have the value "F" & thus this parking lot's information will not be visible to the user on the map until its "status" value changes to "NF". The PHP scripts have been used to establish bi-directional data communication between the server and user Interface & Uni-directional data communication from Raspberry Pi to the Server database.

D. Working Mechanism

User can access this system with the help of Android/Web app. Following are the procedures explaining the working of the App-

1. The app cannot run without an active Internet service. So, the user must have an active Internet connection on their device.
2. The user will have to register/login to gain access to the services provided by the application.
3. Once logged in, user can navigate to the map, where his/her current location is detected by the app automatically from the Location service enabled on the mobile device. User can now enter its desired destination, close to which nearest parking lots are to be viewed.
4. The varied coloured markers will be placed on the map to distinguish between current location, destination & parking lots location (Red, Blue & Purple respectively). 3 parking lots closest to the destination along the earth's radius will be marked on the map. The route to each lot can be viewed using Google Maps. Only the parking lots which have any vacant space will be visible to the user.
5. The database on the server has pre-filled Parking Lot locations and their coordinates which will be used via the PHP script to locate 3 nearest parking Lots from the destination as defined by the user.
6. On pressing the button "**Show Parking**", the map will be marked with nearest **3** parking spaces which are non-full along with their location & distance from the destination shown as marker title. The nearest parking spaces are calculated using the Haversian formula along the Earth's radius, given by-

dlon = lon2 - lon1 (Distance b/w 2 longitude values)
dlat = lat2 - lat1 (Distance b/w 2 latitude values)
a = (sin(dlat/2))^2 + cos(lat1) * cos(lat2) * (sin(dlon/2))^2 c = 2 * atan2(sqrt(a), sqrt(1-a))
d = R * c (where R is the radius of the Earth) (Earth's radius is 6373 km) [8]

7. These parking lots can also be viewed in a list format on clicking "**List Parking**" button. This will show the list of parking lots with all the relative information like parking name, address & distance as links.

8. On clicking one of the links, the user will be able to view empty spaces in the selected parking lot as per the selected vehicle (car/bike). Refresh button will refresh the information to latest status of the parking spaces whether newly filled or newly vacant.

E. Function Overview

The complete hardware functioning of the system can be broken down into these modules:

1. *Getting the status of the parking space:* The system contains the ultrasonic sensor nodes, each having a unique ID which helps to determine the status of the parking space whether occupied or vacant. These nodes capture the data by measuring the distance within the specified range. If the sensor returns distance more than 3 feet than the space is vacant else it is full. The distance captured by the system is sent to the Raspberry Pi kit which processes that data and accordingly send the status of that parking lot to the server in the form of JSON file.

2. *Finding the vacant parking lot & space:* The server contains the status of all the parking spaces which are updated at the regular intervals. When a user makes the request via the android app/web app, the user's destination coordinates are used to calculate the distance from destination to all the available parking lots which are vacant, with the help of the Haversian algorithm using their coordinates as fed on the database server and the ascendingly sorted list of the nearest vacant parking lots on the basis of their distance from the destination is returned to the user.

3. *Reserving Space:* When user gets the list of all the available parking spaces he/she can reserve it and they must confirm their reservation within the time i.e. required to reach at parking location plus additional five minutes. Otherwise, the reservation will get cancelled. The reserved parking space will be temporarily marked as "1/filled".

V. RESULTS AND DISCUSSION

The benefit of using this model over any other model is its reliability. If one of the raspberry pi covering one parking lot or ultrasonic sensor of a space fails, even then the rest of the system will continue working because of its distributive nature. The system can effectively work on the lower Internet bandwidth as it uses the JSON files for the information transfer. It is highly accessible to both the android and non-android users as it also has the corresponding web app.

Thus, the system will only provide the user with the ease of locating appropriate parking lot that suits their need the best.

VI. CONCLUSION AND FUTURE WORK

This paper focuses on developing an effective parking management system that will eliminate the problem of irregular parking and time required to find a vacant parking space. This system is complete time-saving & cost-effective solution to the pre-existing parking problem. With more enhanced features added to it, it will not only save time but will also help in saving fuel, avoid mismanagement of vehicles & other issues.

In the future, the system can be incorporated with payment gateways to enable paid parking system & generate revenue from it.

With Smart City projects being undertaken in India, this will provide a smart solution to the parking management ways in the densely populated cities like Delhi, Mumbai, Bangalore, etc. The integration of hardware with the software end over Internet provides a complete new approach to this application. Despite, its high initial deployment cost, the expected output with it will not only help in earning more revenue but also help in cutting cost of problems arising because of traffic & parking mismanagement.

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Ms Ayushi Rathore pursued Diploma Engineering in Information Technology from Aligarh Muslim University, Aligarh in year 2014 and Bachelor of Technology in Computer Science & Engineering from JSS Academy of Technical Education, Noida, in year 2017. She has one paper in an International Conference during her UG. Her areas of interest are cyber security, and development of products which makes the lives of the people easy and make them smarter by using technologies like IoT. She has also worked on projects related to web development, android app development and interconnection networks.

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