Development of an IoT Based Parking Management System

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Abstract
Nowadays the idea of Smart Cities had become very popular. With the advent of Internet of Things, the concept of smart cities can be readily achievable. An extensive research is on-going in the field of Internet of Things to increase the quality of services offered in cities and to improve the productivity and reliability of urban infrastructure. IoT is addressing the most common problems faced in cities i.e. car parking and traffic jams. In this paper, we present an Internet of Things based Parking system for Smart Cities. The proposed Smart Parking system introduces a smart way to resolve the small module that actually counts i.e. Parking Area. We designed a system based on IoT for real time monitoring of the empty slots for car parking within a certain area using a mobile application with which a person can book a slot in a parking place. Also the payment will be generated based on the time spent by the user in that parking slot. The gate to the parking area opens with the unique id given to a particular user which also ensures safety for the parked cars. Implementing this system will in turn reduce the consumption of fuel, which would reduce carbon footprints in our environment leading to an eco-friendly surrounding.

Keywords: Internet of Things, Smart Parking, NodeMCU, Android Application, Lift System

Introduction

In the recent, the concept of smart city [1] has gained appreciation. The ideology of producing a Smart City is now becoming viable with the exposure of the Internet of Things. The key aspect for the exposure of smart cities is comfortable parking facilities and systematic transportation and management [2]. There are several aspects in smart cities; one of the important considerations of being a smart city is the Smart Parking facility. In these days, people are finding it difficult to avail parking slot to drop their car. It is always an exhausting issue for drivers to find a particular space to park their cars. It tends to become harder with ever increasing number of private car users. These circumstances can be considered as an opportunity for smart cities to

undertake actions in order to improvise the parking resources. Whether it is a shopping mall, Airport or a multinational company, facilitating parking is a major part of any infrastructure. The survey of drivers found that 81% say it often takes them 20 minutes or more to find a parking slot, with 45% describing parking as their biggest motoring headache [3]. The Internet of Things is a wider area in which the each and everything can be made connected to the network using some medium of data sharing. The project which we have developed a model of parking system with a four parking slots could be reserved using the mobile application. The concept of Internet of Things (IoT) started with things with identity communication devices. The devices could be controlled, tracked or monitored using remote computers connected through Internet. IoT extends the use of Internet providing the communication, and thus inter-network of the devices and physical objects. Internet means a vast global network of connected servers, computers, tablets and mobiles using the internationally used protocols and connecting systems. Internet enables sending, receiving, or communicating of information. IoT generally comprises of inter-network of the devices and physical objects. These objects can gather the data from isolated locations and interact to units managing, acquiring, organizing and analysing the data in the processes and services. In simple terms IoT can be explained in form of an equation stating:

 Physical Object + Controller, Sensor and Actuators + Internet = Internet of Things

The project which we have developed is a model of parking system with four parking slots which could be reserved using the mobile application. The rest of the paper is organized as follows: Section II talks about the Literature survey. Section III presents the vivid description of the hardware and the software part of the system. Section IV describes the implementation and working of the system. Section V describes the App and the database. Section VI shows the results and Section VII concludes the paper and Section VIII talks about the future scope of our work.

Literature survey

Several techniques have been proposed to find out the parking space in the nearby locality.

Kepuska and Humaid AL Shamsi in august 2016 [4] came up with an idea of smart parking system. They have applied wireless protocol. In our project we have taken the ideology of this project.

Andrea and Lorenzo in February 2014 [5], came up with an idea "A concrete proof-of-concept implementation". They implemented it in a city called Padova. They have applied IoT in the field of creating smart cities. Our project considers [5] as the forerunner as we use the similar ideology with advancement in smart car parking system.

Kiruthika and Dr. D.Surendran [6] in February 2016 had suggested smart car parking system using sensors and internet of things (IoT), but their system had left out the ideology of time allotment. In our proposed model we have successfully implemented the booking of slots with a stipulated time allotment system. So by this way our idea will be efficient and there would not be any chaos faced in time allocation.

The system developed by Faheem, S.A. Mahmud, G.M. Khan, M. Rahman and H. Zafar, [7] in October 2013 was the survey of car parking system. They have suggested to make use of video sensors. In our proposed system we have used IR sensors with the application of IoT. So our system will have more efficiency with less cost.

Further a group of students from the CMR engineering college in January 2015 [8], came up with the idea of smart parking system using sensors but they did not use IoT and parking cost was neglected. This problem is overcome in our project.

Renuka R. and S. Dhanalakshmi in their paper proposes a system based on Android which allows the drivers to reserve the parking spaces for a certain time duration and this system slots. This system lagged due to wastage of assets and money if the person didn't reach there within stipulated time [9]. But in our system the booking by the user will be cancelled automatically if the person fails to reach the parking area within the pre-arranged time limit.
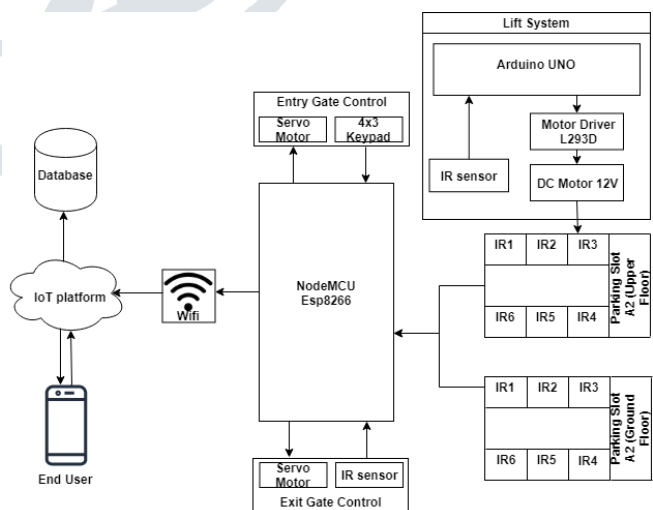
Description of the system

The proposed IoT based parking management system has various hardware and software parts interconnected. The block diagram of the Parking Management System is illustrated in the following Fig. 1. The system comprises of four distinguishable processes:

Android Application for Online Booking

Initially, the user has to register the details in the mobile application to store his necessary details into the server. After the credentials have registered, user is allowed to login to his account, and book a slot for parking his car. After booking a slot, he is given a lapse time limit of 15 minutes within which he has to enter the parking slot. Once the user clicks the 'BOOK' button the timer starts and the status of this particular slot has changed from *Free* to *Free** If the user could not reach to the slot within the specified time limit, the online booking gets cancelled. Fig. 2.a) represents the flowchart of Online Booking System. For each parking slot, IR sensors [10] are deployed and IR sensors would detect the number of parking slots. Number of free and booked slots are graphically displayed in the application.
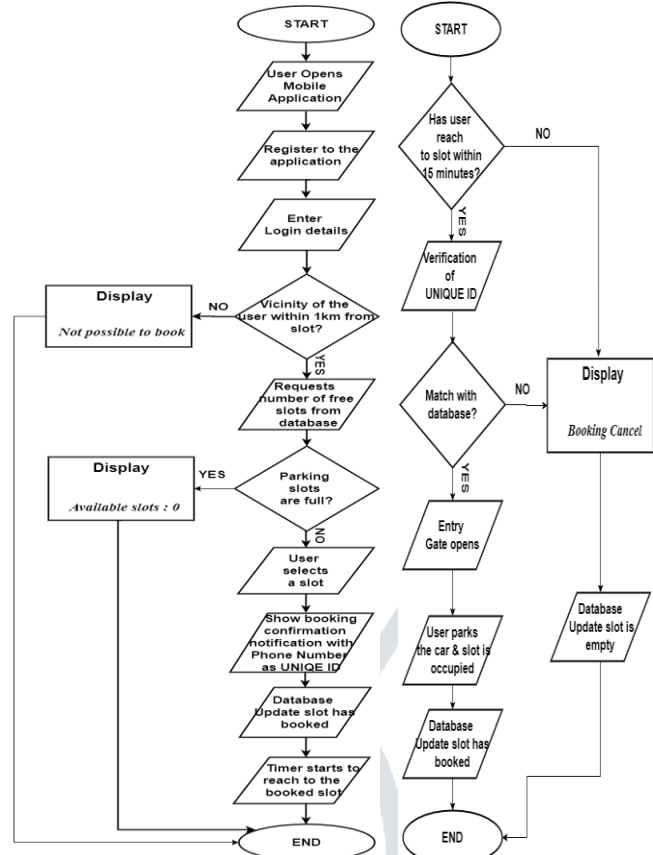
Fig. 1. Block Diagram of the System

Verification & Entry Gate Control

When the car of the user reaches the parking slot, his phone number is verified with the number entered at the time of registration using a 3x4 Keypad [11].

By entering the phone number using 3x4 Keypad the server checks the booking status of thar user, if the booking status

Fig. 2. Flowchart of Online Booking   Fig. 3. Flowchart of Verification & Entry Gate Control

is Temporarily booked and that particular slot is Free* then only the entry gate will open using a Servo Motor [12]. The system can monitor the state of every parking slot by deploying a sensor node on that slot. Accordingly, sensor senses the status of parking slot and send the status to NodeMCU [13]. The NodeMCU collect the data from all sensor node and upload to Firebase server from where data is sent to each user via the mobile application. User can check the parking status from anywhere using internet via that application. Flowchart of this process is given in Fig. 3.

Lift System

If the slot is in the upper floor then a lift is used to move the car from ground floor to upper floor. The project has two lift systems, one for moving the car from ground floor to first floor and the other to bring down the car from first floor to ground floor. Inside the lift there will be an IR sensor that will sense the presence of the car in the lift. When the presence of car is detected by the DC motor of the lift will be rotated by the Arduino and the lift will move. Fig. 4. represents Flowchart of Lift System.

Exit Gate Control

When a car is successfully parked in the slot, the status of this particular slot has changed from *Free** to *Occupied* and the Booking status of the user is *Slot Occupied*. Then parking time starts. And when the driver returns to the car and takes his car, the parking time will be stopped and the receipt is sent to his mobile. User can then pay using his e-wallet through online or offline payment. Then at the exit gate the IR sensor detects the vehicle and then the gate is opened by the Servo Motor. Once these processes are completed then the parking slot is updated as *Free*. Flowchart of Exit Gate Control process is shown in Fig. 5.
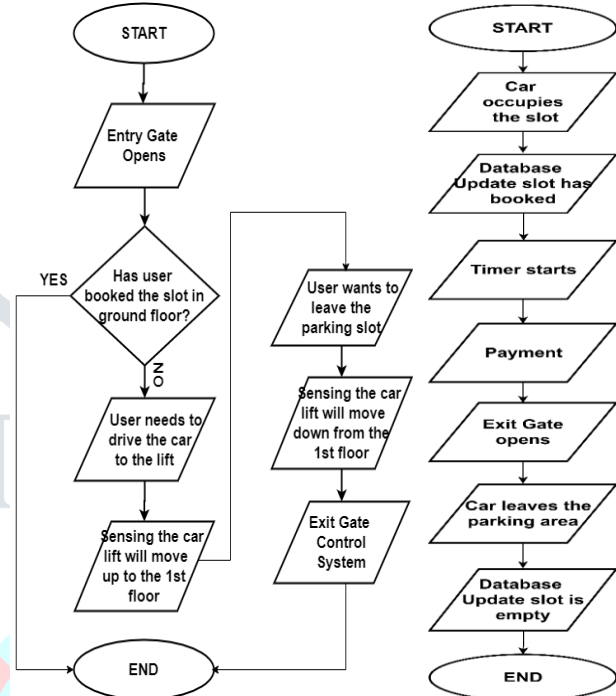
System design

The proposed system has two distinguishable parts: the hardware circuitries (containing the NodeMCU, IR sensor module, Servo Motor, 3x4 Keypad, Arduino UNO, 12V DC Motor, Motor Driver L293D and LED) and the software tools to write and upload programs to Arduino compatible boards (Arduino IDE) and to create the mobile application (Android Studio and JDK 8) as well as to maintain the database (Firebase). Fig. 6. shows the circuit diagram comprising of different hardware components.

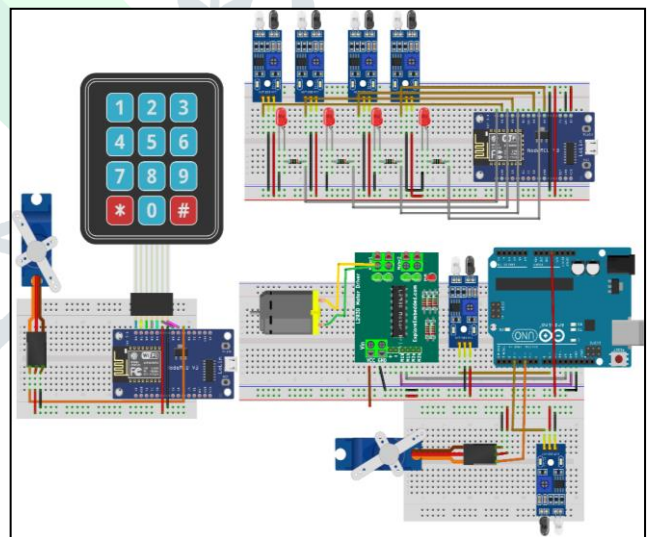Fig. 4. Flowchart of Lift System   Fig. 5. Flowchart of Exit Gate Control

Fig. 6. Circuit Diagram of the System

Mobile application and database

There is a need for assistive technology, which would communicate the availability of parking slots to the users. For this purpose a mobile application is needed. A dedicated database is there to store the information entered by users through the mobile application.

The mobile application named 'CarParkingApp1' is developed using Android bundle and Android Studio application platform. Application Modules are Registration, Login, Parking slot selection, Booking, Showing the status of each slot. If the booked car does not enter to the parking slot within 15 minutes of threshold, booking is automatically cancelled.
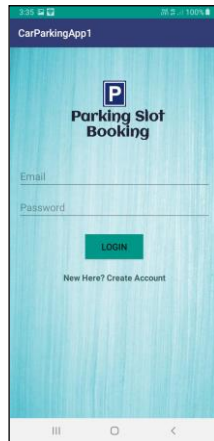

Fig. 7. Registration Page   Fig. 8. Login Page

Registration

If the slot is in the upper floor then a lift is used to move User needs to register himself to the system by filling up the attributes Full Name, Email ID, Password, Phone Number. For logging into the application this Email ID and Password is required. The registration page of the application is shown in the Fig. 7.

Login

Registered users can log in to the application by entering the Email ID and Password given at the time of registration. The login page of the application is shown in the Fig. 8.

User Authentication

Firebase Authentication is used to give unique id to each user. Admin can view all the registered user by navigating to 'Authentication' page of Firebase as shown in Fig. 9. Admin can add user by entering user's data. To delete a user from the system, admin navigates to 'Delete account' of a particular user upon selecting a User UID. Admin can disable the account of a user by clicking 'Disable account'.
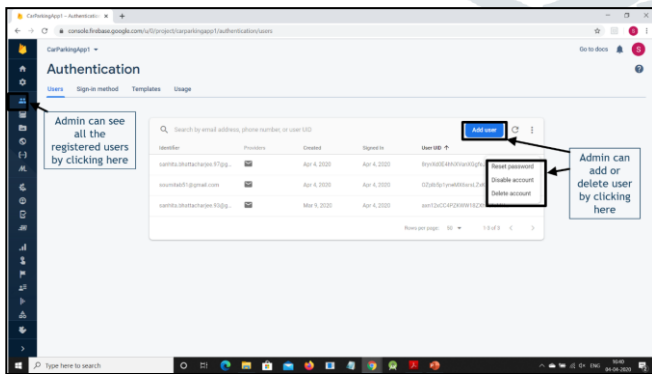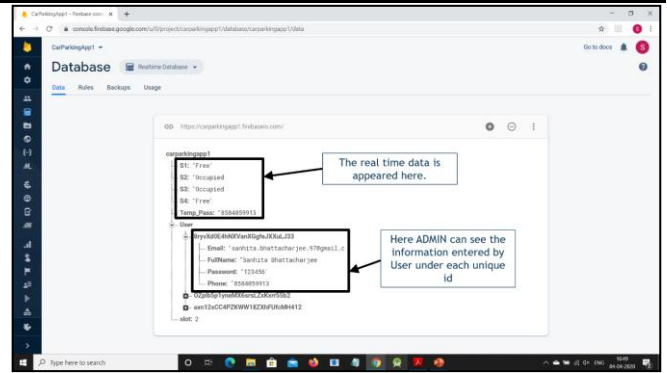

Fig. 9. Authentication

Realtime Database

The status of each slot is appeared in Firebase Realtime Database as shown in Fig. 10. Also admin can view the information entered by each user under the specified unique id by user authentication.

Fig. 10. Realtime Database

Identifying Free Slot

In the home page user can see his name as shown in Fig. 11 and by clicking the 'View Availability' button user can see which slot is free or occupied. For an occupied slot the booking button is disabled automatically and the 'Logout' button is used for logging out the from account.
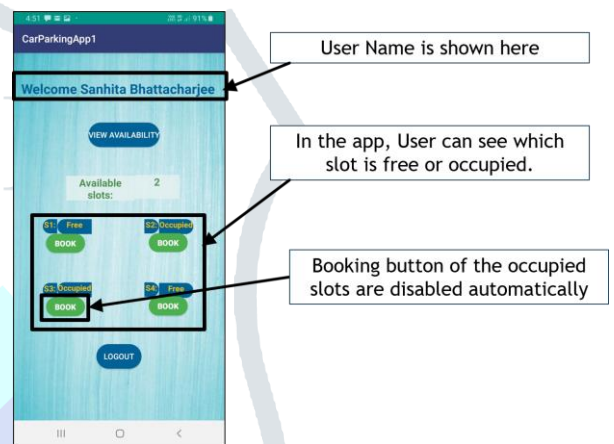

Fig. 11. Home Page

Booking
Visualization

- *User Side*: When User clicks the 'BOOK' button of any slot the text of the particular slot is changed from *Free* to *Free*.
- *Admin Side:* Admin can visualize the booking details of each user as well as the time to time slot availability.
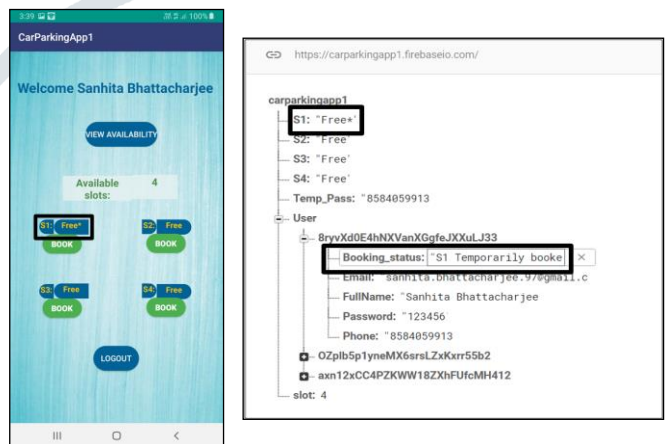

Fig. 12. Visualization (a) User Side, (b) Admin Side

Threshold Timer

After clicking the 'BOOK' button of any slot a time limit of 15 minutes is given to the user to reach to the slot. The threshold timer of 15 minutes is shown in Fig. 13.

Cancellation

- *User Side:* If the user could not reach to the slot within the given time limit the booking is cancelled. User gets the notification **Your booking is cancelled**. Booking cancellation screenshot is shown in Fig. 14 (a).
- *Admin Side:* After cancellation of online booking, the booking status of the user becomes 'None' and the booked slot becomes 'Free' in the database as shown in Fig. 19(b).
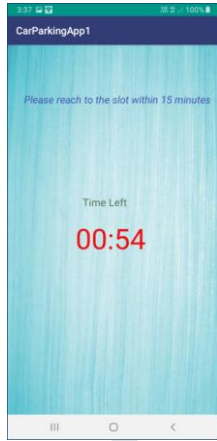

Fig. 13. Threshold Timer

Fig. 14. Booking Cancellation (a) User Side, (b) Admin Side

Verification of Unique ID

While entering the parking area user has to enter his phone number as the unique id to open the entry gate by checking the booking status of that user i.e. whether the user booked a slot or not. Here, the entered unique id is the phone number of the user given at the time of registration. The phone number is entered using a 3x4 keypad and the entry gate will be opened by servo motor. Entered number is shown in database.
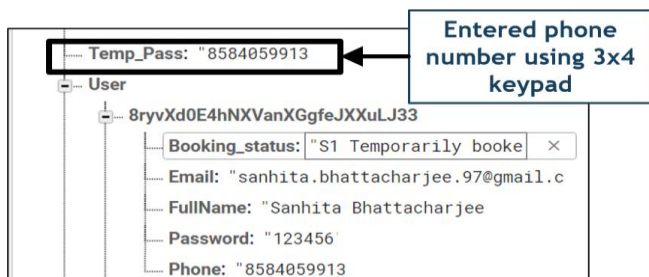

Fig. 15. Verification

Parking of Car

- *User Side***:** After the verification of unique id user has to park his car at the booked slot. Then the user will get notification that the particular slot is occupied. Slot occupied screenshot is shown in Fig. 16 (a).
- *Admin Side:* The booking status of the user becomes booking confirmed for the particular slot and the slot becomes ***Occupied*** in the database as shown in Fig. 15 (b).

Fig. 16. Parking of Car (a) User Side, (b) Admin Side

Results

Prototype Design

To conduct test and analyse the result under different circumstances, a prototype of 4 different parking slots were created and 10 users were registered. The prototype design is shown in Fig. 17. The system is able to handle parallel users. From this it is observed that there is no login issue for different user at the same time. The status of each slot is updated frequently which is effectively used to monitor the free or occupied slot. Our proposed system requires approximately 17 minutes to book and place a car on a particular slot which is very efficient and time saving system.

Fig. 17. Prototype Design

Sensor Installation

One IR sensor is placed on the parking slot below the car. The height of the lower portion of the car must be less than or equal to 20 cm from the IR emitter and IR receiver of the sensor as shown in Fig. 18.
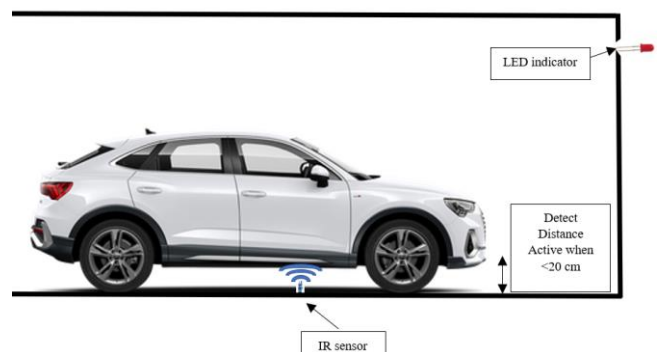

Fig. 18. Sensor Installation

Detection Range

The experimented detection range of IR sensor is tabulated below.

TABLE 1. IR SENSOR DETECTION RANGE

Height from the IR module in cm	LED response	Interpretation
5 cm	Red	Parking slot is occupied
15 cm	Red	Parking slot is occupied
20 cm	Red	Parking slot is occupied
25 cm	Green	Parking slot is free
35 cm	Green	Parking slot is free

Conclusion

The concepts of Smart Cities have always been a dream for humanity. Since the past couple of years large advancements have been made in making smart cities a reality. The growths of Internet of Things (IoT) have given rise to new possibilities in terms of smart cities. In all the well-developed cities it is arduous and barely exorbitant to create more parking spaces for car since those cities have almost reached its exhaustive occupancy. This project is concerned on implementation of IoT based parking management system and detection of available place using IoT technology. By using IoT and sensors with the help of user friendly mobile application, the identification of the parking area will become very easy. This system would in turn reduce the traffic cause by the vehicles in looking out for parking slots. The efforts made in this paper are indented to improve the parking facilities of a city and thereby aiming to enhance the quality of life of its people.

Future scope

Though the proposed system is self-sufficient, there can be further development done. The system can be incorporated with Parking Area Location Detection using GPS. Such a system can detect the nearest parking area available to the user and navigate the user to this slot and test its workability in a real time environment.

A credit card payment gateway for online payment can be developed dedicatedly which can eliminate the cashless transaction and manpower utilization.

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