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IoT based Smart Parking System

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***Abstract* - This paper discusses problems faced with traditional parking lots. It also lists the impact and inconvenience caused because of inefficiency in traditional parking spaces. In this paper, the authors have suggested and designed a Smart Parking System using IOT Technology, which will allow the users to find a vacant parking slot in a given area. It also avoids needless traveling through already filled parking lots. In this paper, the authors present a novel parking system with IoT over Wi-Fi and RFID. The authors suggest an IOT based solution to the issue using a mobile app, IR sensors, RFID, and Arduino as key components. With the solution's help, users can easily look for nearby parking lots alongside real-time availability in each parking lot. They can also block the desired parking slot through the app, followed by reaching the parking lot and authenticating using an RFID tag. Upon exit, the amount to be paid is determined using the time the service was used, which is determined using IR sensor data, and payment is processed using the linked in-app wallet. This technology improves the overall efficiency, reliability, and convenience and reduces the precious resources in searching for parking spaces and pollution.**

Keywords- IoT (Internet of Things), Sensors, RFID, Arduino Nano, Smart Parking, Smart Cities, Traffic Congestion, Android Application

I. INTRODUCTION

The most basic definition of the internet of things (IoT) encapsulates anything that can be connected and controlled or monitored over the internet. IoT includes a network of sensors, smart devices, actuators which makes our day-to-day work more manageable. Activities and processes can be remotely tracked, monitored, and controlled over the internet. IoT extends the use of the internet by creating a network of 'Things' that can interact. It provides a vision where things (home devices, sensors, wearables) become intellectual; with the help of cloud computing, IoT becomes highly scalable and smart. Any number of nodes can be added or removed from the network; data can also be fetched, analyzed, and monitored in real-time, reducing human intervention and efforts. A significant problem that citizens worldwide face today is finding a nearby parking lot and then finding a space inside the lot, especially in multi-level parking lots; this issue is magnified. Whether it is an airport or a mall, easing parking of vehicles is significant to any establishment. The survey of drivers conducted by IBM found that 81 percent of drivers say it frequently takes them over 20 minutes to find a vacant parking slot, with over 45 percent of drivers describing parking as their biggest motoring issue.[11]

Our proposed system will make locating, booking, navigating, and paying for parking hassle-free, effective, seamless, and convenient. Today, in the era of technology, when most things are becoming smart through the use of technological advancement and the internet, public parking spaces are still a long way from smart. Developing and implementing an efficient, reliable, and proficient parking system in real-time is still a big issue for any parking facility. This problem can be resolved by connecting the parking lots to the internet through IoT and using sensors, as discussed in the paper.

II. OBJECTIVE

This project aims to provide customers with a user-friendly online platform to book the nearest parking spots for their vehicles before arrival. Moreover, it will give users continuous updating information of parking spots available with the use of the application. The proposed system will also have easy and enhanced security checks using RFID tags with a seamless payment e-wallet system that overcomes the queue problem. Lastly, it has been attempted to provide a flexible 24/7 booking facility through our project.

III. THEORETICAL BACKGROUND

The problem statement has been divided into two parts for ease of understanding. The first part will focus on customers' challenges while using current parking facilities, and the second part will describe the challenges faced by parking lot owners and organizations. Firstly, in this era where time is of utmost importance, where one can find anything or anyone in the world within seconds using just a smartphone and a few clicks, still, it takes minutes and many efforts to find an available Parking space. This is primarily a big issue for people who are short on time going out for some important

meeting or leisure. Waiting in long queues for entry, locating and finding a parking space, and then waiting in queues again for payment is a big challenge. Not just time, searching for parking space wastes fuel and contributes to Co2 emissions and harming the environment. Secondly, many parking lots are left unfilled or are not used to their max potential due to inefficient staff, or improper geotagging and difficulty of also locating, congestion inside parking lot is common sight because of time-consuming processes at check-in and at billing during check-out which reduces efficiency and revenue potential of the parking IoT.

IoT-based parking systems allow the user to prebook a parking place. Mobile application helps in finding the available parking spot. In this whole system, an IR sensor is utilized to map the vacant spaces and is unveiled at the entry and exit gate. The RFID tag is provided to authorize a person's entry to the parking place.

A. Survey

We surveyed to better understand parking-related problems in India, the respondents across the country filled out the forms and the outcome of the same is discussed in figure [1]. The majority of respondents highlighted the biggest issue while parking vehicles is finding empty parking due to the unavailability of free slots (88.5%) followed by ineffective payment methods (26.9%).

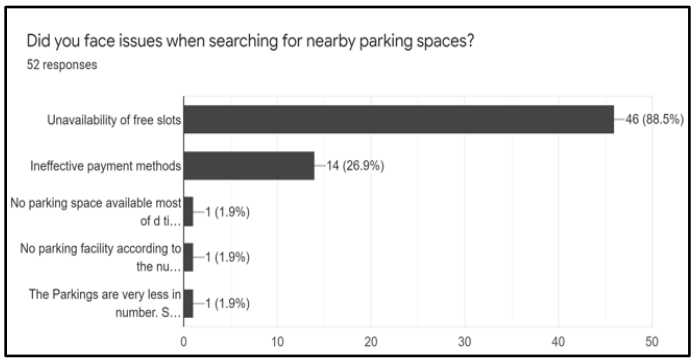


Figure 1: Issues with traditional parking

Another question regarding difficulty in finding parking vehicles in multistory parking figure [2] to which 80.8% of respondents agreed that they face issues.

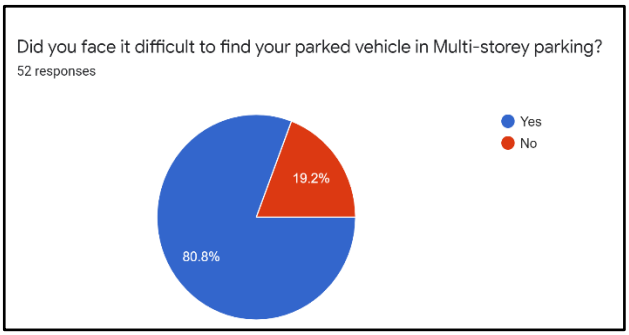


Figure 2: Multistorey parking issues

Further 61.5% of respondents agreed that they have to wait in long queues for finding parking space figure [3]

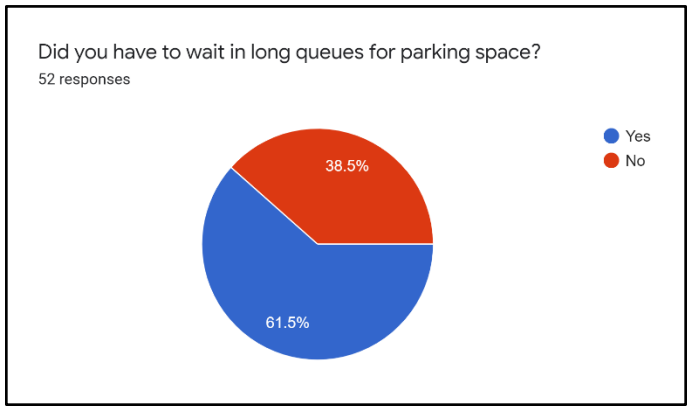


Figure 3: Long waiting times in the parking

IV. LITERATURE SURVEY

There are many areas where IOT based smart parking system has been implemented. Some studies deployed the IOT based parking system using Arduino, ultrasonic sensors, and cloud servers. These studies have employed a systemaccessed by the mobile application to determine the available slots and get the real-time update of parking space. The application proposed that four slots will be checked for availability in real-time and the webpage turns green if the slot is available, turns red if all the slots are full [1], [2] & [3]. In studies [3], [4] & [5], RFID technology is used at entry and exit points to minimize human intervention and cost. These systems send a timestamp at both points to the cloud server. One study [6] explained the use of mixed-integer linear programming (MILP) at each point defined in a time-driven sequence. This study converted parking planning into a linear problem and had a different approach to solve the problem. The studies that showcased IoT module as well as the use of Mobile Application for customers also been done with a feature of payment through wallet [3] & [7]. In the study [8], features such as Cars Check-in with QR code scanning, Cars Checkout with automatic cashier machine for payment, and image processing at the entrance were incorporated. Further, the IoT module deployment with a website for viewing and choosing the parking space is mentioned in the study [9]. In the paper [10], techniques such as RF wake-up sensors, motion detector wake-up sensors, and positioning sensing are used to make real-time monitoring parking with automatic billing.

In [12], the authors have developed a car-parking system based on smart-phone for Dhaka City. They developed a prototype of a parking system based on reservation technique and for the real-time update of parking IoT, they made an application using Java SE. For security, they used a two-layer security check based on ultrasonic sensors and nameplate recognition

using the camera. Their model resulted in helping users to search nearby available parking spaces. In [13], the authors have used facial recognition-based technology using a camera at the entrance of the parking area. They used a method for detecting objects in motion and scans the driver's face at the entry to determine whether the entry should be allowed or not. Further, they used certain Machine Learning algorithms such as PCA, LDA, and Viola-Jones methods for detecting the face of the driver. The work introduced in [14] explores the various smart systems that use the Internet of Things to communicate with the environment. The authors highlighted the importance of IoT in logistics, supply chain management, automation, and other remote applications. In their paper, they mentioned the usage of IoT in Smart Living, Smart Agriculture, Smart Parking, Smart Cities, Smart Industry, Smart Environment, Smart Energy, and Home Automation. In [15], the authors focus on power management and reducing the energy consumption of the streetlights. With the background idea of having a cleaner planet, the authors in this paper compared the street light intensity with the prevailing weather conditions for controlling the consumption of power by the lights. They used the Artificial Neural Networks algorithm for the management of power that resulted in minimizing the power required for efficient working of the streetlights. The work in [16] focused on the Cloud Computing technique and machine learning algorithms for the resource allocation management used for very large data processing systems. They believed that optimum allocated resources help to predict the workload demand better and reduce time, cost, memory, and power. They achieved a higher performance model with optimum allocated resources after they used a network simulator for their model.

In the following table [1], the work done in the above literature is compared with our proposed system.

Table 1: Comparative Analysis of Existing V/s Proposed System

Works	Comparative Analysis	
	Existing Systems	***Proposed System***
[1], [2] & [3]	IoT-based parking system using Arduino, ultrasonic sensors, and cloud servers.	IoT-based smart parking system with Arduino Nano, IR sensors, EM18 RFID readers, ESP Wi-Fi Module, and cloud servers with Mobile Application.
[3], [4] & [5]	RFID technology at entry and exit.	Uses RFID for vehicle/user identification with no human intervention.
[6]	Use of mixed-integer linear programming (MILP)	Simple Arduino & full-stack web-based programming.
[3] & [7]	IoT Module with Mobile Application and payment through wallet	Mobile Application for pre-booking the nearest parking lot and payment through rechargeable e-wallet provided in the application.
[8]	Cars Check-in with QR code scanning and Cars check out with automatic cashier machine for payment.	RFID-based security check at both entrance and exit and payment through e-wallet feature in the application.
[9]	Website for choosing the parking space was made.	Mobile Applications can be used to locate the nearby parking spaces and pre-booking.
[10]	RF wake-up sensors, motion detector wake-up sensors, and positioning sensing are used for the real-time update.	IR sensors at each parking spot with the help of an ESP Wi-Fi module are used for real-time monitoring.

V. METHODOLOGY

The development of our system is divided into parts, as explained by the following flowcharts:

B. Entry Process Flowchart

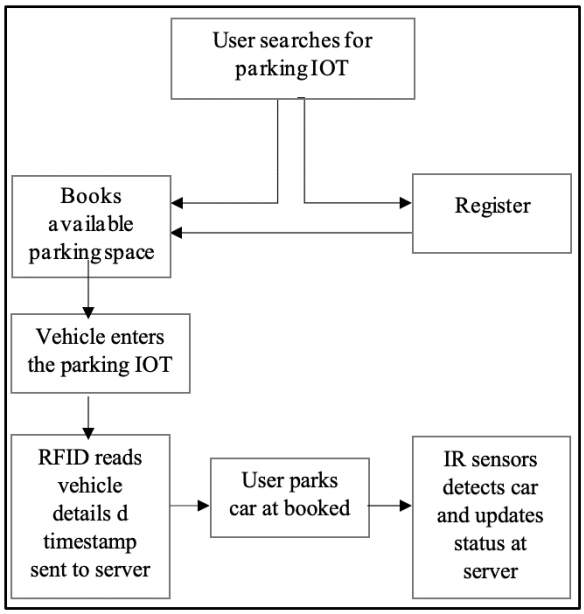


Figure 4: Entry Process Flowchart

Figure [4] depicts the methodology and steps that must be followed by any user/customer to access our online parking service. With the help of a mobile application, users can search for the parking lot available near his/her area, followed by user authentication. Now, here, the mobile application checks whether the user accessing the service is a registered user or not. If yes, he/she can continue with their booking process; else, if unregistered, the user must register himself/herself on the mobile application using the New User Register page with

a valid Driving license or copy of RC. Only after successful registration on the application, user can access this service.

After the online registration and booking process (briefly explained in further sections of the paper), after a desirable time, the vehicle's physical entrance in the Parking lot will be there, followed by the security check. The RFID will do security checking. RFID will read the vehicle details, adjacently, timestamp of entering a parking lot vehicle will be sent to the cloud server. The entrance process is further proceeded by the user parking their vehicle at the booked slot, followed by detecting. Vehicle at that slot by the IR sensors and updating of status (i.e., the slot has booked) on the mobile application/server.

C. *Exit Process Flowchart*

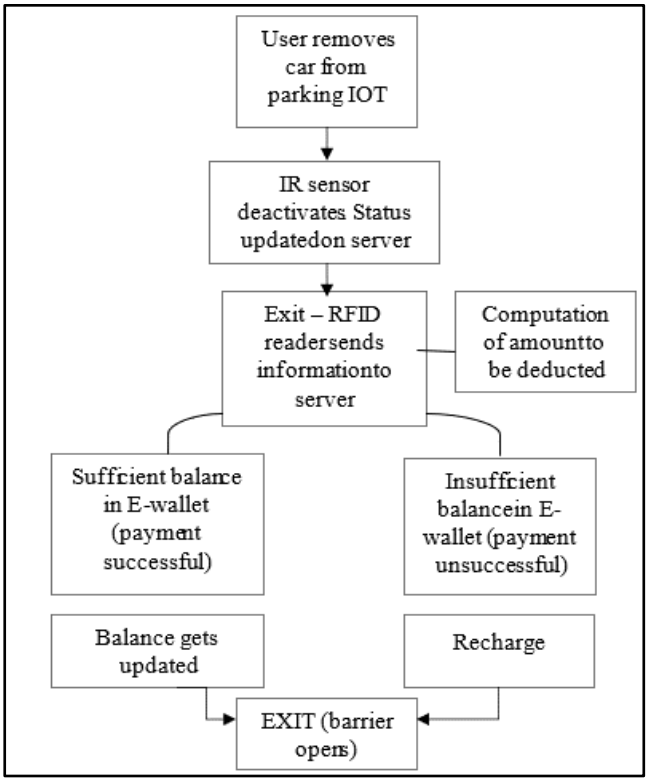


Figure 5: Exit Process Flowchart

Figure [5] depicts the exit process that will start when the user removes his/her vehicle from the parking slot. As soon as, the vehicle gets removed from the respective parking spot, the IR sensor will get deactivated and its status (i.e., this spot is now open for booking) will get updated on the mobile application/server. This will help the new user accessing the application and finding for the spot. He/she can book the slot as soon as the previous vehicle is removed. This quick procedure will help the owner not miss its revenue because of time lag.

At the exit gate, again, the system will repeat its security check with the help of an RFID reader, which will send the status and the new timestamp to the server. The server system will compare both the timestamps (i.e., the entrance and exit timestamp) and, based on its difference, will calculate the amount to be paid by the user for accessing the service. An effective E-wallet system will carry out the payment method with a recharging option.

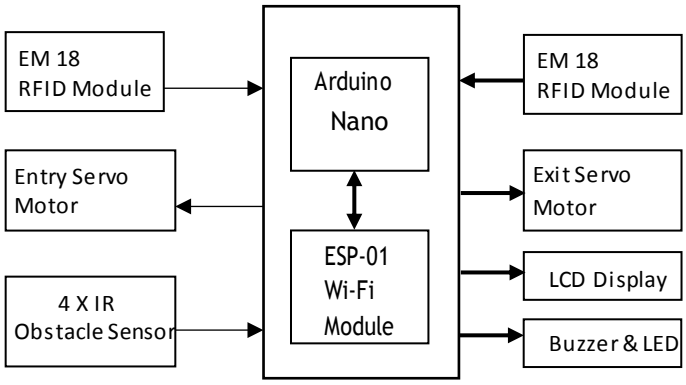


Figure 6: Block Diagram

In figure [6] the entry and exit checkpoint have an EM 18 RFID Reader Module and a processing board acting as the brain of the project (Arduino Nano/ Uno) connected to it. Each parking slot has a PIR Sensor and a LED lights (Red/Green) to indicate if a parking spot is available or not. The entry and Exit side have a servo motor to drive (Open/Close) barrier gates to allow entry and exit of vehicle from the parking lot, they are connected to Arduino Nano processing board. Arduino Nano is interfaced with ESP-01, via serial communication for IoT applications and connecting to the internet over Wi-Fi. 16X2 LCD is connected to Arduino Nano using I2C for display function. Buzzer and LED are connected to Arduino for indication purposes.

A mobile platform connected to hardware requires the users to register one time using their ID proofs. Also, E-wallets are linked for faster and seamless payment. Server-Side scripts execute to book parking slot selected on the app, calculating the duration for which the vehicle was parked and the total billing amount to be paid, also payment for the same can be done from the linked wallet.

VI. DISCUSSIONS

A. *Challenges*

Challenges of implementing smart parking in cities include lack of proper IT infrastructure followed by learning curve involved to make citizens well versed with the technology, also reliable internet connectivity and proper maintenance, updates and security are prime concerns.

B. *Characteristics*

IoT Based Parking System can detect the occupancy status of parking slots in multi-level parking lots and it offers a Touch N

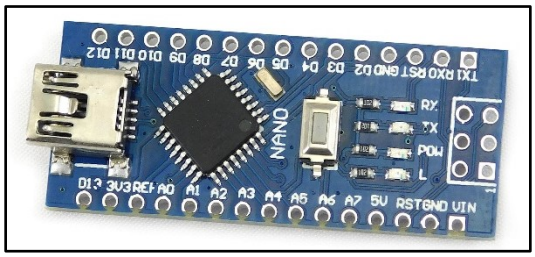
Go module to facilitate payment of parking fees and there are parking monitoring and management software to coordinate and operate the various features.

C. Components Features

EM 18 RFID Reader Module

Figure 7: EM 18 RFID Reader Module

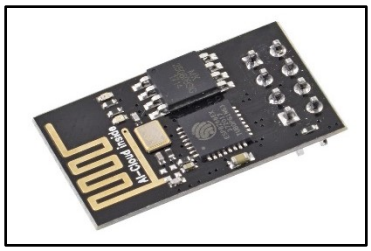
It has Serial RS232/TTL output and operating frequency is 125KHz with an identification range between 5-8 cm and it does not require line of sight figure [7].



Arduino Nano

Figure 8: Arduino Nano

It has 8 Analog pins among which 6 pins are PWM pins and a crystal oscillator of 16Mhz and supports different ways of communication, which are: Serial Protocol, I2C Protocol, SPI Protocol figure [8].



ESP-01

Figure 9: ESP-01 Wi-Fi Module

It is a low-cost, compact, and powerful Wi-Fi Module having 512kB Flash Memory with a feature of deep sleep and it supports serial communication and can be programmed using Arduino IDE or AT-commands or Lua Script figure [9].

VII. RESULTS

A. Hardware

We have developed hardware for the prototype on zero PCB. Figure [10] shows the entrance and exit part consisting of an EM-18 RFID reader, SG90 servo motors used to drive barrier, and 16X2 I2C display module. Figure [11] shows backend connections 4 IR sensors, one ESP-01 Wi-Fi module connected to Arduino Nano, and DC 5V supply circuitry.

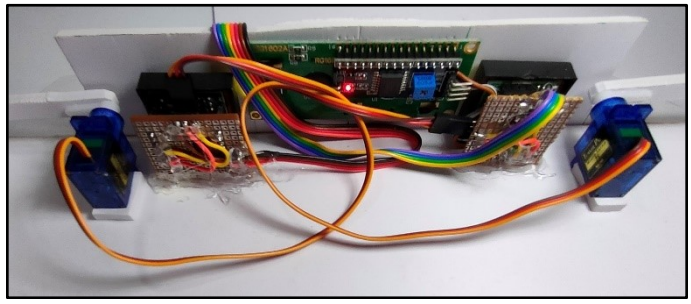


Figure 10: Hardware Development (Entrance and Exit)

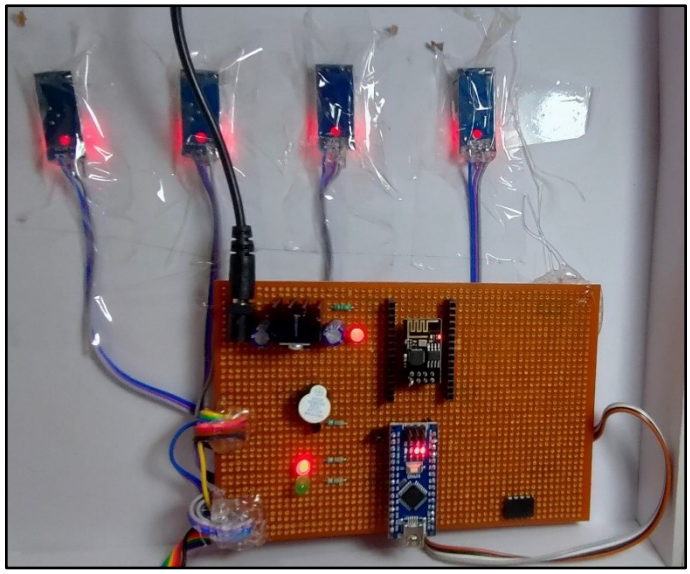


Figure 11: Hardware Development (Backend)

The booking process will start with the use of an Android app figure [13] to pre-book the parking spot. After the slot's successful booking, under a given time frame, the user will reach the parking premises. At the premises, the IoT module is connected to the Wi-Fi module (ESP-01), which will help notify the user about parking on a real-time basis. As soon as the vehicle reaches the entrance gate, an RFID reader connected to the Arduino nano will acquire the entrance's timestamp. The barrier will be open by the servo motor, and the vehicle enters the parking area Figure [10] Further, when

the vehicle is parked at its defined spot, the IR sensor connected to the Arduino will get activated, and LED will turn Red, updating the status of the spot as booked on the server.

At the exit part figure [12], with the RFID reader's help, again, the timestamp will be taken based on which amount will be calculated. As we have included the E-wallet mode of payment, in case of insufficient balance in the wallet, Buzzer that is connected to Arduino Nano will notify the user about the same, indicating he/she have to recharge. Lastly, after the successful payment, a servo motor connected at the exit gate will open the barrier and allows the user to leave the parking premises.

Figure 12: IoT Based Smart Parking Prototype

B. Mobile Application Development

This project provides the user with an application where he/she can book the parking spots before actually reaching the parking premises, i.e., pre-booking.

Figure 13: Mobile Application Interface

The mobile application developed figure [13] to have a signup page for a new user, as shown in fig. The page demands the username, valid mobile number, email ID, copy of the driving license or RC, and password, after which the user can access the service. The application also has a login Page for existing users supported by a password recovery option. After successful signup/login, the user is asked for the preferred location and parking spot he/she needs to park the vehicle. The application will also show the available and booked parking spots. After this, based on the location and spot, the application will provide users with a timeframe under which he/she needs to reach the premises for security check. Otherwise, the booking will be canceled, and the user has to re-book from the available spots.

C. E-Payment System

The mobile application will also have an e-wallet from which the user needs to make the payment when exiting the premises. Given that the payment is to be done only from the wallet if the user's wallet has an insufficient balance, he/she needs to recharge their wallet and then make the payment. Note that the owner will generate profit as an interest in the money kept by multiple users in their wallets.

D. App Flow Diagram

The Figure [14] illustrates the app flow where the user opens the app and books nearby parking based on GPS and real-time availability from IoT sensors in the lot. Once he reaches the parking the authentication is done using RFID and user data and a timestamp is sent to the database. Once the user parks vehicle in the slot the IR sensor starts a timer and once the user removes the timer is stopped and billing is calculated and the same is deducted from the wallet and the barrier opens for the user to exit.

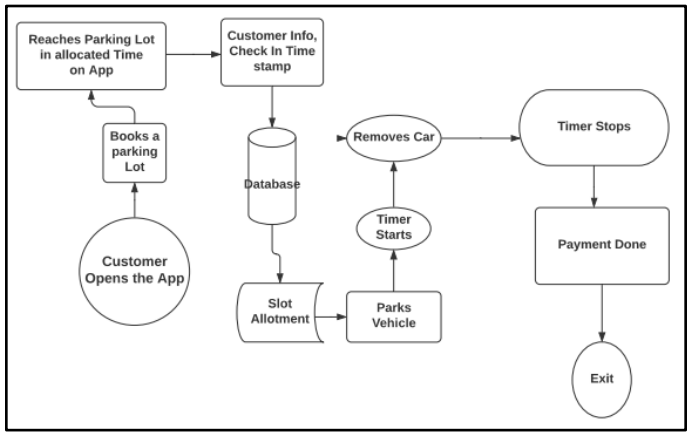


Figure 14: App Flow Diagram

CONCLUSION

This paper showcases a Smart Parking System using the Internet of Things on RFID module and cloud server/mobile

application. The project is broadly divided into two parts, such as mobile application for pre-booking and payment system and another the deployment of IoT module at entry and exit where security check is done through RFID tags. This project's unique features will help people overcome their parking difficulties and manage their time too. The owner will also enjoy profits at every booking. This project's motivation is to make a parking system with no (or minimal) human intervention and digitize the conventional parking space. The advantage of this project includes ease of locating a parking space as instead of looking around and searching, parking lots are tagged on the mobile app, real-time availability of parking slots can be checked online to save time and resources of manually travel and look for the same. Moreover, Parking slots can be booked in advance, reducing the uncertainty and ambiguity of not getting vacant parking slots on arrival to the parking lot. Payments are made automatic reducing time, congestion, and scope of human error giving the easy setting and cost-effective solution.

The advantage of using RFID over number plate image capturing as discussed in [12] is this method is less susceptible to error and fault-tolerant. Using Human face for recognition as discussed in [13] comes with its share of complications and privacy concerns. Also, RFID is more accurate and easily transferable. A couple of limitations of the project is that it requires first-time users to collect RFID tags as opposed to the image capturing method to start using the service manually and relies on constant internet connectivity to function. Though this project finds its application at the multi-story parking lot, where it is challenging to locate vacant parking space, this technology can save an enormous amount of time, inconvenience, and pollution that is generated while searching for parking space. Additionally, Commercial parking spaces can utilize this technology to facilitate smooth check-in and check-out and make transactions hassle-free.

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