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IoT Inspired Smart Parking Solution using Blockchain

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Abstract: With the advances happening within the space of urbanization, with inflated demand for dwellings and an inflated variety of vehicles on road, finding a parking spot has become one in every of the foremost pain points for the voters. This is often in the main thanks to the restricted parking areas out there and issue to find a lot throughout busy hours. To beat this limitation, one answer is to form good parking areas that are rather easier to search out and use. During this work, we tend to propose a Blockchain based solution wherever parking pools will be created by developing a clear platform wherever people will hire out their unused land for a stipulated quantity of your time. This additionally has the intercalary advantage of generating revenue from their otherwise unused property. Good contracts over Blockchain enforce the written agreement between the participants making certain monetary transparency within the planned system.

Keywords: IoT, Smart parking, Block-chain, Mysql, Redis server

I. INTRODUCTION

Smart city uses the technologies to enhance the operational efficiency for the general public, helps in accelerating towards the advance quality of life for citizens. Internet of Things (IOT), Automation, and Machine Learning,Cloud computing are the emerging trends which drive towards smart city adoption. Any city that is considered smart-city introduces a smart parking system that uses a mobile app to assist the drivers to locate parking slots, thus can reduce the traffic. The ideal of making a sensible City is now becoming possible with the emergence of the internet of Things. one among the key issues that smart cities relate to are car parking facilities and traffic management systems. In present day cities finding an available parking spot is usually difficult for drivers, and it tends to become harder with ever increasing number of personal car users. This system efficiently reduces traffic congestion in the smart cities and helps in easy finding available free parking space in nearby locations . Problems per parking and holdup is solved if the drivers can be informed ahead about the supply of parking spaces at and around their intended destination. Recent advances in creating low-cost, low-power embedded systems are helping developers to make new applications for Internet of Things.Followed by the developments in sensor technology, many modern cities have opted for deploying various IoT based systems in and around the cities for the aim of monitoring. The smart parking system is implemented using a mobile application that is connected to the cloud. On a real-time basis the user is able to know available nearby free parking locations. The organization of the paper is given as follows: Section I deals with introduction, section II reviews the existing models.

section III describes the system overview and Section IV outlines the system workflow.Section V gives a summary of the paper.

II. RELATED EXISTING MODELS

Today there are many similar smart parking system are available. Most of them are not very much effective. Use of IoT is expanding rapidly. This proposed system uses IoT with blockchain technology. Related existing models are listed below:

A. RFID System

This model of smart parking system has been proposed which utilizes RFID enabled IoT devices. This system uses RFID tags to identify the presence of vehicle and get data on the vehicles. When the vehicle approaches, RFID-reader it initializes payment procedure with data received from RFID-receiver. Pay for the parking slot at the entrance. On paying the fees the barrier open to the pool of parking space. This system leads to the congestion at the entrance.

B. Computer Vision System

This model of smart parking system has been proposed which utilizes Computer vision techniques . Here it uses huge computational process and lack of accuracy of the model which may lead to very high risk on day to day life.

C. Centralized Structure System

Existing works focus on the data used for the smart parking system is centralized; means stored in single server. This results in security issues and this approach leads to attack over the centralized structure. This problem is solved by introducing the concept of decentralization of parking system to resolve the data integrity issues. We connect all the parking services providers under single unified platform. Each allocation of the parking lots are stored as transaction into blocks rather than storing to central database. Attack on database lead to sever threat on privacy of data. And the approach of centralized manner involves third party and cant provide enough lucidity. Our proposed system made with the aim of transparency and inviolable because of decentralized infrastructure.

III. SYSTEM OVERVIEW

In this section, we present an overview of the proposed blockchain-based integrated car parking system. There are three parts in our proposed system: parking service provider, blockchain network, and user. The parking service provider offers PAAS (parking-as-a-service), allocate parking space, cost of the service consumed. The blockchain network holds a public ledger and updates the public ledger with the valid transactions only. A consensus mechanism is used to verify the transactions. The parking user is one who requests for a car park. The integrated smart parking system provides separate application interfaces for each of the participants for communicating with it.

In our proposed system we utilize different parking allocations from different car parking providers. For simplicity, assume each car parking lot is under some parking lot provider. Every parking lot is connected to a blockchain-based integrated smart parking system. Every parking area has a local copy of ledger (i.e local block). User who needs the parking slot, scans the QRcode. Each parking area in a smart car park is equipped with an QRcode. Users using an android application scan the qr code, generating car parking availability as a transaction. Each car parking service provider has a smart contract that generates the transaction.

If a parking area is changed from ”vacant” to ”occupied”, correspondingly generates a transaction. Similarly, the user can leave the parking slot, through a one-click button on android application. When pressed generates a transaction and changes from ”occupied” to ”vacant”. The transaction is first sent to the local block. The local block sends the transaction in the blockchain network for verification.

IV. LAYERED ARCHITECTURE OF SYSTEM DESIGN

In this section, we present a layered structure of our proposed integrated smart parking solution based on blockchain technology. Layered architecture consists of three layers: IoT layer, Logical layer, Application layer. The proposed layered architecture specify and normalize the typical architecture of the blockchain based integrated smart parking systems.

A. IoT Layer

IoT layer is the hardware component of the proposed system. It is a computing device as well as a mechanical device capable of sending data to and from servers. It is capable of working without the interaction of human-to-human or human-to-computer interaction. This proposed system works based on Arduino UNO, ESP8266 node mcu (WiFi module), servo motors, IR sensors and other necessary components. Servo motors are attached to a barrier capable of opening when the user scans the QR code displayed on it. The data from IoT and to IoT is managed by node mcu components. It receives and sends data to the cloud. Node mcu ESP8266 works on http protocol and web-socket protocol. The command to open the barrier from the server is received at the IoT is made through listening to the web-socket.

B. Logical Layer

Logical layer which provides simplified API’ to access data stored in persistent storage. This allows the client modules to be created with a higher level of abstraction. Logical layer comprises Mysql Databases, Algorithm for finding nearest parking providers, Reliable socket communication over websocket protocol. MySQL is based on a client-server model. Details regarding user, details on parking space providers, IoT machine details all are stored in Mysql database.

The Web Socket specification defines an API establishing "socket" connections between an IoT, android client and the server. There is a continuous connection between the client and the server and both of them can start sending data at any time. WebSocket Protocol helps in websocket communication. WebSocket communication helps in two-way communication between IoT and Server. Thus helps in notify the IoT Instruct to open or close barrier gates and transfer other information to and from IoT and server. The protocol contains an opening handshake followed by basic message framing, layered over TCP. The goal of this technology is to provide a tool for IoT and Android applications that need two-way communication with servers that does not rely on opening multiple HTTP connections.

C. *Application Layer*

In the client–server model, the client is usually considered the front end which simplifying the underlying component by providing a user-friendly interface.

1) *Android Application:* Android application is used by user who needs the parking slot. Android application is capable of searching nearby parking location and we used Haversine formula to predict the nearby locations. Qrcode is displayed at the barrier of each parking. Android application is used to scan the QRcode, if user needs to occupy the parking lot. This initialize the blockchain transaction for “occupied” and “vacant” slots.
2) *Web Application:* Web application is build on React js with the help of redux. It uses MVP architecture. Redux helps in maintaining data within the application. Web application helps the Parking provider to provide details on parking slots. Details such as price, type of location, time of each slot and so on.

V. SYSTEM DESIGN

This section discusses the required design principles for our proposed system.

A. *Decentralized Process*

The prime objective of using blockchain is to implement a decentralization which can overcome the attacks created by the centralized system. Decentralized record or database and smart contracts assures the secured data transmission. The system assures security with the use of smart contract and public ledger, which make it impossible to access personal and other confidential information. However, blockchain integration and decentralization process will make the communication process reliable and smart enough with the cooperation of different parking center.

B. *Process Management*

To implement the integrated parking system, a decentralization process is required. The decentralization process can confirm an efficient, responsive and reliable system. The proposed system imposed a layered architecture, which maintains the interaction process that transmitting data to the distributed ledger using the request of a user or parking provider. Finally, heavy usage of cryptography and hashing mechanism in the blockchain network ensures the proposed smart parking system a trust-less system. The trust-less system indicates that the participants can execute Transaction without the need of a trusted third party equation.

VI. COMPONENTS

The three main hardware components used are ESP8266 micro-controller, IR sensors, servo motors. a user must install the Android application to reserve the parking space. when the reserved booking id is matched with the parking slot id, then the data would be processed by the server and esp8266 wifi module, then it would be sent the information to the servo motor for controlling the barrier in the parking space. the ir sensor provides a signal when the car is parked and the barrier is closed

A. *Arduino Uno*

Arduino Uno is a microcontroller board. Has 14 digital input/output pins (of which 6 can be used as PWM outputs),a 16 MHz ceramic resonator, 6 analog inputs, a USB connection, ICSP header, reset button and power jack. It contains everything needed to support the microcontroller;

Fig 1: arduino uno

B. Esp8266 Microcontroller

ESP8266 is a wifi module SOC (system on a chip). Provide full internet connectivity in a small package. ESP8266 is a Wifi module, using the standard AT Command set Firmware using the serial UART, or directly serve as a Wifi-enabled micro controller, by programming a new firmware using the provided SDK.ESP8266-based boards.

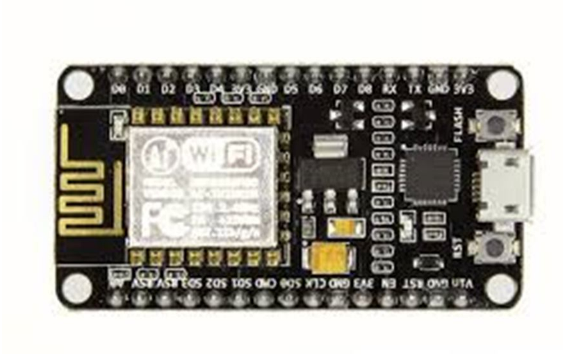
D0 D1 D2 D3 D4 3V3 GND D5 D6 D7 D8 RX TX GND 3V3
FLASH
RST
Vin GND RST EN 3V3 GND CLK SD0 CMD SD1 SD2 SD3 RSV RSV A0

Fig 2: Esp8266 microcontroller

C. IR Sensor

Infrared sensor is a sensor to detect the presence of an object in-front of the device. IR sensor have 2 parts. The Light Emitting Diode (LED) and receiver. IR sensors measure the infrared radiation, which is emitted by the IR sensor itself. IR sensor is capable of emitting and measuring the received IR radiation. Potentiometer on the IR circuit board can be adjusted such that the distance from the object to be detected.

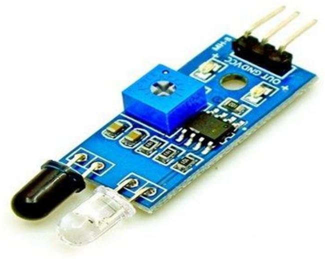

Fig 3: IR sensor

D. Servo Motor

Servo motor uses a rotary actuator to control the barrier in front of each parking slot. Shaft of the motor is attached to the barrier. When the user scans the qr code the IoT controller signals the motor to open the gate by an angle of 45 deg. The servo motor receives a control signal to rotate the shaft to a desired position. And applies power to the DC motor until the shaft reaches that position. With the highest precision IoT controller turns the shaft of the motor.

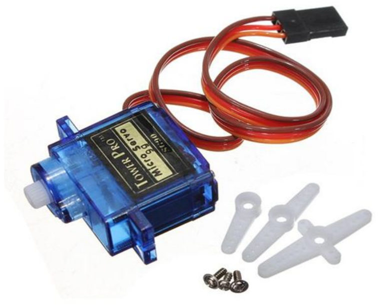

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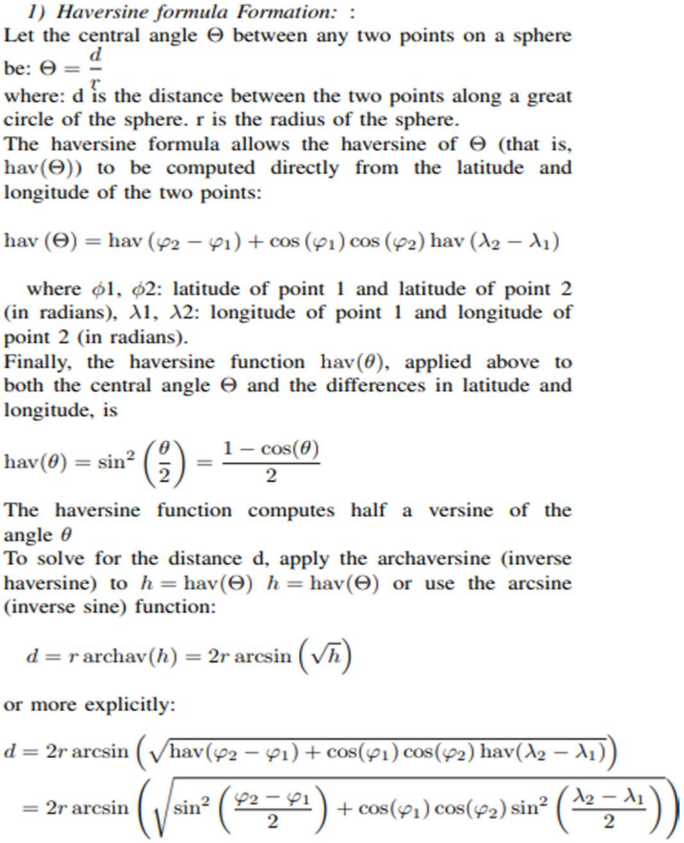
Fig 4: Servo motor

VII. PROPOSED SYSTEM WORKFLOW

In this section we describe the proposed system wok flow with blockchain and IoT.The participants in the proposed system are blockchain IoT and android application.Each components of this system has it's own purpose.the parking providers will update the parking space and the information will be updated in the blockchain network.

A. Prediction of Nearest Location Workflow

To find the nearest location, the system uses the Haversine formula. Giving latitude and longitude haversine formula calculates the greatest radial distance. Comparing this distance with the radial distance limit we calculate nearby parking location. Haversine formula is a special case of spherical trigonometry. Law of haversines, relates the sides and angles of spherical triangles.



1) Haversine formula Formation: :
Let the central angle Θ between any two points on a sphere be: $\Theta = \frac{d}{r}$
where: d is the distance between the two points along a great circle of the sphere. r is the radius of the sphere.
The haversine formula allows the haversine of Θ (that is, $\text{hav}(\Theta)$) to be computed directly from the latitude and longitude of the two points:

$$\text{hav}\,(\Theta) = \text{hav}\,(\varphi_2 - \varphi_1) + \cos\,(\varphi_1)\cos\,(\varphi_2)\,\text{hav}\,(\lambda_2 - \lambda_1)$$

where $\phi1$, $\phi2$: latitude of point 1 and latitude of point 2 (in radians), $\lambda1$, $\lambda2$: longitude of point 1 and longitude of point 2 (in radians).
Finally, the haversine function $\text{hav}(\theta)$, applied above to both the central angle Θ and the differences in latitude and longitude, is

$$\text{hav}(\theta) = \sin^2\left(\frac{\theta}{2}\right) = \frac{1-\cos(\theta)}{2}$$

The haversine function computes half a versine of the angle θ
To solve for the distance d, apply the archaversine (inverse haversine) to $h = \text{hav}(\Theta)$ $h = \text{hav}(\Theta)$ or use the arcsine (inverse sine) function:

$$d = r\,\text{archav}(h) = 2r\arcsin\left(\sqrt{h}\right)$$

or more explicitly:

$$\begin{aligned} d &= 2r\arcsin\left(\sqrt{\text{hav}(\varphi_2-\varphi_1)+\cos(\varphi_1)\cos(\varphi_2)\,\text{hav}(\lambda_2-\lambda_1)}\right) \\ &= 2r\arcsin\left(\sqrt{\sin^2\left(\frac{\varphi_2-\varphi_1}{2}\right)+\cos(\varphi_1)\cos(\varphi_2)\sin^2\left(\frac{\lambda_2-\lambda_1}{2}\right)}\right) \end{aligned}$$

This distance is calculated for each of the entries in the database and compared with the radius limit of 5000 mtrs. This filtered list is considered as the nearest location from the users current location.

B. Mysql Query

Mysql query to filter out nearest parking location from database:

```
SELECT id, (6367*acos(cos(<gps latitude>)
*cos(radians(latitude))
*cos(radians(longitude)-radians(<gpslongitude>))
+sin(radians(<gps latitude>))
*sin(radians(latitude))))
AS distance FROM MainApp_Organization where
distance < 5000.0
ORDER BY distance LIMIT 0, 20
```

This nearest location is returned as json to android application with every details of the parking provider which includes price, location, available parking location.

VIII. RELIABLE SOCKET COMMUNICATION

WebSocket is a communication protocol that enables communication of computers. It provides full-duplex communication over TCP connection. Websocket works differently from HTTP. Websocket works at port 80 and 443. It supports HTTP proxies and intermediaries. Websocket is also capable of supporting HTTP requests. It works on both wsgi and asgi configuration. Websocket handshake change HTTP protocol to Websocket protocol.

Proposed system is build on Django, python framework. Django is based on requests and responses: the browser makes a request, Django calls a view, which returns a response that's sent back to the browser.

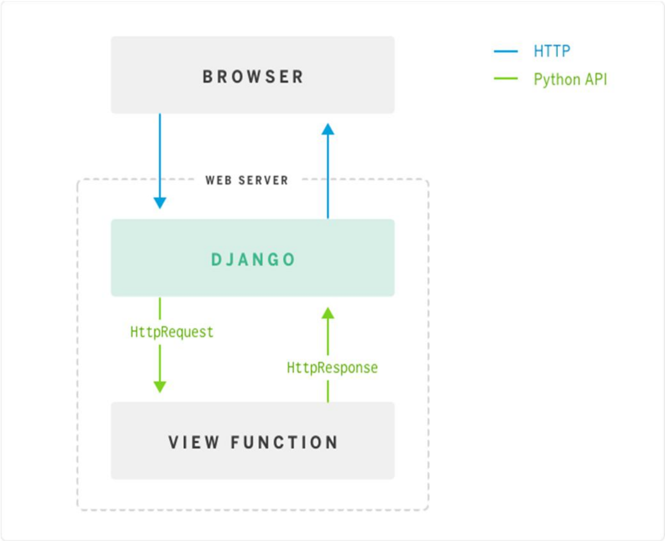


Fig 5: How wsgi communicates

It is not the case with WebSocket! HTTP protocol works based on request. The connection is maintained only for particular request. If a request is completed connection is no more active And possible to send or receive data to and from the client without request from the client. ASGI interface works similar to normal HTTP views. ASGI enables tasks to run on the background on same server. Tasks are queued up which is called Channels. Producers push messages on to the channels. And allows one consumer listen on that channel. Channel uses Redis as channel layer.

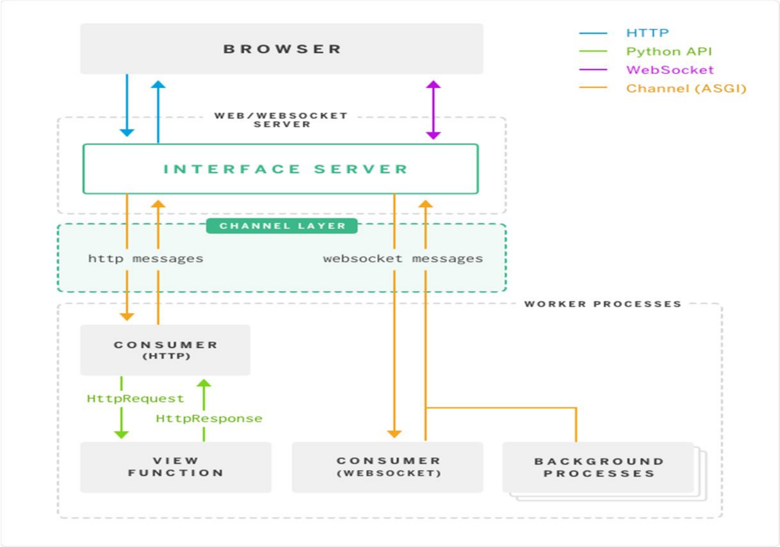


Fig 6: How redis server communicates

The system uses redis server for fullduplex websocket communication with IoT. Redis is data structure and in-memory server. It is advanced key-value store. It is used as distributed shared cache. Redis works at default port 6379. It creates TCP connection over the port 6379.

A. IoT Workflow

In this section, we describe how the IoT works with the system. The main components in the IoT network are mobile app, web application, and the IoT hardware devices which include ESP8266 microcontroller, IR sensor, and servo motor. The network mainly focuses on the transfer of data between the mobile app and web server and data transfer between web client and web server. When the application scans the QR code the data sent through cloud and checks whether the corresponding parking id space is available or not. The microcontroller sends the replay to server and server checks for the available parking spaces and book parking spaces and then sends the data to the microcontroller if the transaction is valid. The microcontroller process the data information and the corresponding output signal is given to the servo motor of the parking location to control the barrier for entry and exit of the vehicle.

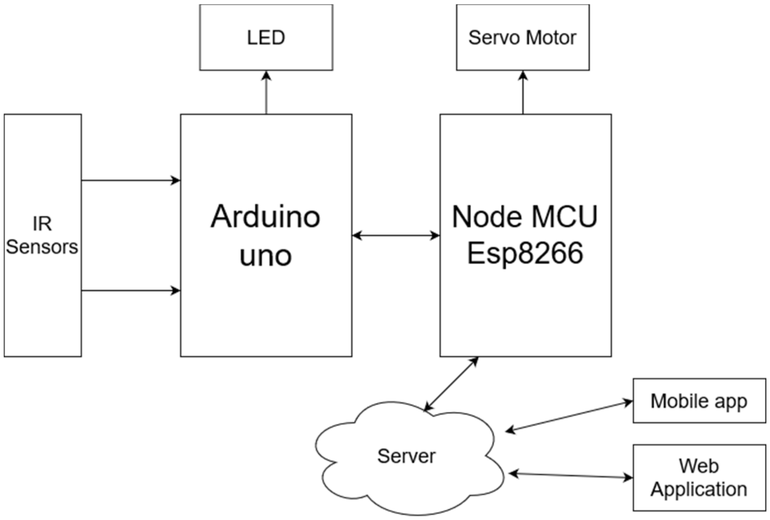


Fig 7: Iot workflow

B. Android Workflow

Figure 1 and 2 shows on the android mobile application starting page (user login and registration page) and application options(dashboard and search).

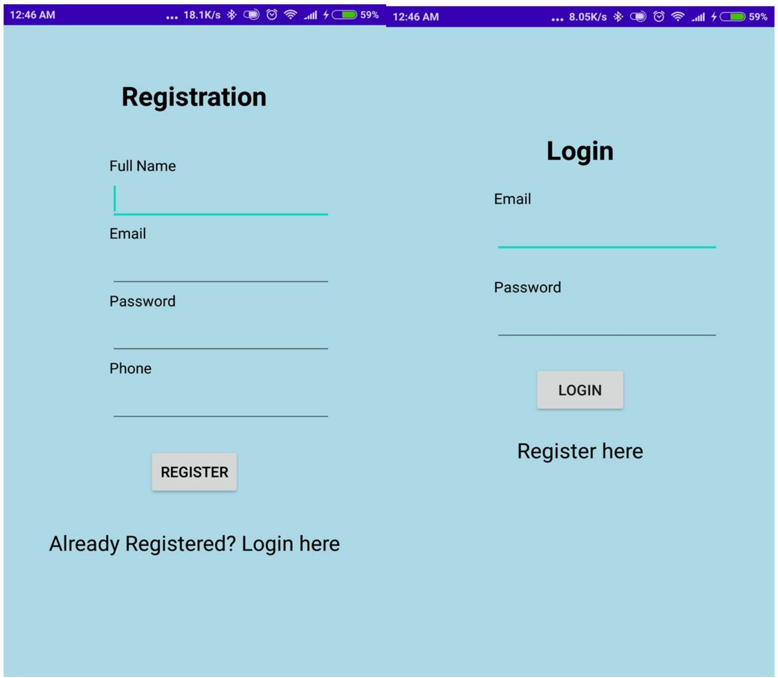


Fig 8: Starting pages of app

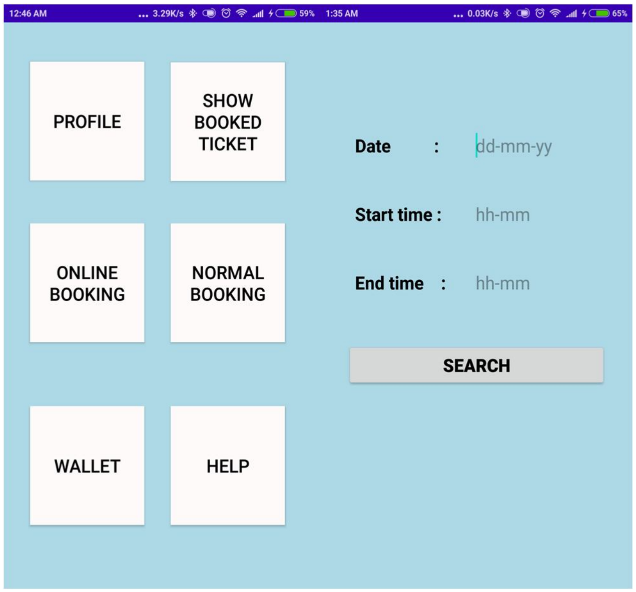


Fig 9: Application Options

Below are the steps that a user needs to follow for advance booking

1) *Step 1:* Select the amount of time for which you would like to park your car.
2) *Step 2:* With the help of above information search for available parking area on and around your destination.
3) *Step 3:* Select a particular parking area.
4) *Step 4:* Pay the parking charges either with your wallet or your credit card.
5) *Step 5:* At the time of parking, scan the QR code available on the gate for entry. \end{itemize}

For current booking

a) *Step 1:* Scan the QR code available on the gate.
b) *Step 2:* Enter the timing details.
c) *Step 3:* Complete payment for parking.

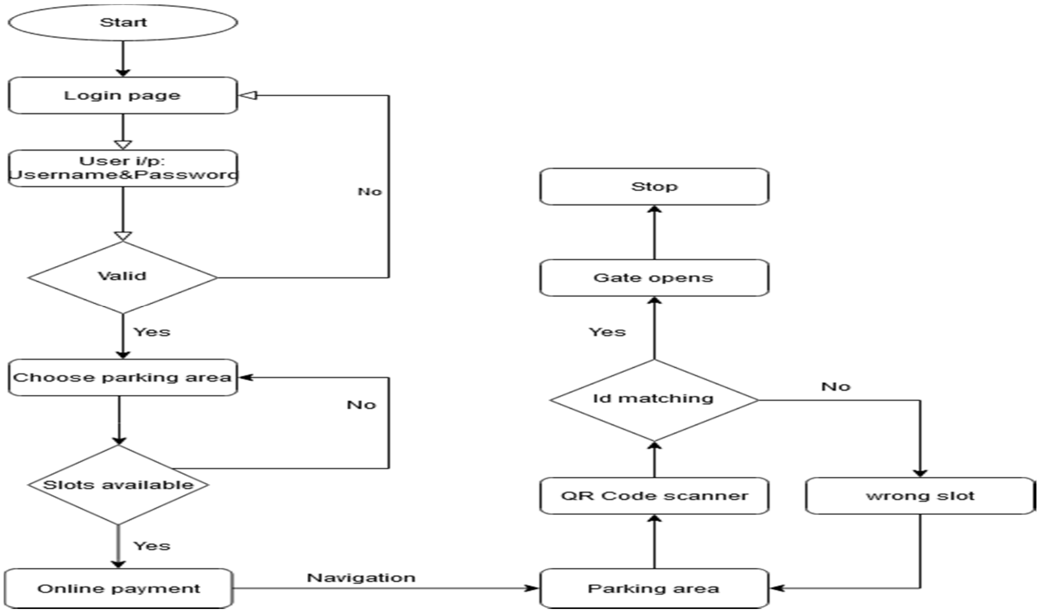


Fig 10: Flow Diagram for Android workflow

Figure 10 explains about the Android workflow for IoT based smart parking management systems.

IX. CONCLUSION

The concept of Smart Cities has always been a dream for humanity. The growth of Internet of Things and Cloud technologies have led to new possibilities in terms of smart cities. Smart parking is the step to making smart cities. It helps in traffic management as well as reduced CO2 annual production. The system we propose provides real time information related to availability of parking slots. Users can search available parking locations from the mobile application without even roaming around the city. From renting out the parking location to public it brings an income for the owner of the parking location. Users from remote locations could book a parking slot for them by using this mobile application. The efforts made in this paper are intended to improve the parking facilities of a city and thereby aiming to enhance the quality of life of its people.

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