iParking- An Intelligent Android-Cloud Based Smart Parking Reservation System using Smart Phones Supportive to Smart City

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ABSTRACT
Locating a parking area in most of the metropolitan areas, especially during the rush hoursis difficult for anyone at the present time. The iParking system proposed in this paper allows us to find and reserve the vacant parking slots through oursmart phones and moreover supports the principles of "Smart City." The design and implementation of the system called Reservation Based Smart Parking System (RSPS) is based on cloud computing and android application and finds availability of nearest parking slots. The objective is to reduce the time in finding the parking slots and avoid unnecessary traveling. The technology proposed in this paper usesInfrared Sensors (IR Sensors) for detecting the occupancy of parking slots. The iParking uses Radio Frequency Identification Devices (RFID) to identify and track a car. The methodology proposed in this paper can easily be compared with the existing parking system in terms of reducing the searching time and fuel.

General Terms
Proposed RSPS is using well known technologies Cloud Computing, Android mobile Operating System and RFID sensing to identify and book the nearest parking slot.

Keywords
Smart City, RSPS, Global System for Mobile Communications (GSM), RFID, iParking, IR Sensors, Android Operating System, parking slot

1. INTRODUCTION
The Problem is to design an intelligent Android-Cloud based smart parking reservation system to reserve or book places for parking in a specific area which will help to resolve the parking issues in Metropolitan areas.

Advancements in computer and communication technology and the birth of mobile phone not only gives ease in our day-to-day life, but also gifted us with a variety of multimedia applications to visualize complicated graphical user interface on cellphones. Pre-booking of parking using RSPS is an excellent example of such applications.

Following are some of the benefits of iParking:

- Book the parking slot inthe specific parking area
- Online payment of parking rather than paying on the spot
- Automatic parking administration and control
- Protected and Secured parking
- Easy supervision of the entire system
- Easy analysis of occupied and unoccupied parking places

2. LITERATURE REVIEW
Parking-System proposed by Hongwei Wang and Wenbo He [1] in 2011 using light sensors to provide a continuous measure of parking status and GSM cellular network for obtaining the information of parking has given a balanced solution to the service providersand the users. However, The bottleneck to this system arises when multiple drivers are simultaneously making reservations. Thus, the system has to synchronize the parking information and handle each reservation request; this reduces the system performance and may cause conflicts as well.

Innovative Smart-Car Parking- proposed by Jin Teong Ang and others [2] in 2013uses the Near Field Communication (NFC) function of the Smartphone as a parking ticket. Communication of such systems will occur when the Smartphone is placed near the NFC reader.The drawback of this system being that it may not be compatible with other devices and the security risk seems to be quite high.

Thanh NamPham and others [3] in 2015 proposed Cloud-Computing Parking-System. It has cloud-based smart parking system and develops a network architecture based on the Internet-of-Things. In this system the vehicle sends a request message to the system, the system then searches the best car park, the system further sends response message to vehicle, vehicle interiors and authenticates and finally the car park sends response message to the vehicle.The disadvantage of this system being that the shortest distance between the vehicle, and the car park needs to be found for each vehicle. Obliviously, this is a very tedious task.

Cloud-Computing and RFID based Parking-System proposed by Wei Xie and others [4] in 2013mainly uses RFID tags using radio signals to identify the tags connected with the pervasive cloud which is providing readers with the information storing and querying. It uses mobile readers to

access the public cloud through wireless VPN for accessing the data related to the tags which assure the security, safety and helps to authenticate each tag with the fixed readers.

Android-Based Parking-System proposed by Renuka and Dhanalakshmi [5] in 2015shown the use of RFID application. RFID application is used to debit the amount ofparking charges through RFID. It uses the Parking Guidance and Information (PGI) system to tell the dynamic information of vacant parking slots and guides the users. These vacant slots are detected by Infra-Red (IR) sensors. The parking information is further displayed in the VMS (Variable-message sign) board at major roads or intersections.The disadvantage of this system being that, the parking slot allotted to the user may not be available by the time user reaches the assigned parking area.

3. SYSTEM IMPLEMENTATION

3.1 Scope

This Android application allows drivers to book their desired parking slot from Android application which additionally supports the principles of "Smart City". It is mainly focused on reducing the time in finding the parking spots by avoiding the unnecessary traveling nearby the parking area.

3.2 Aim

To find a safe and secure parking slot based on users' information and RFID verification while allotting the parking slot reserved by the user.

3.3 Objective

The main objective of this systemis to authorize the admin to communicate and use the RFID base Android Application to book the desired parking slot with the help of proper GUI of available vacant slots. The information related to the booking from the user has to be sent to Admin through the server. The Admin should easily verify each user and the parking place through RFID sensors. Further, user should get the updated data on Android Application as admin is updating the data regarding parking slots collected from sensors.

3.4 System Overview

The bird's eye view of the design is as shown in **Figure 1.** The Database, Admin, Android Application and Hardware units are integrated in a such way that the multiple activities such as collection of sensors' and users' information, Communication and decision making can be used to update the database, execution of designed algorithm and collectively taking of a decision of allocation of parking slot after being paid by the user.

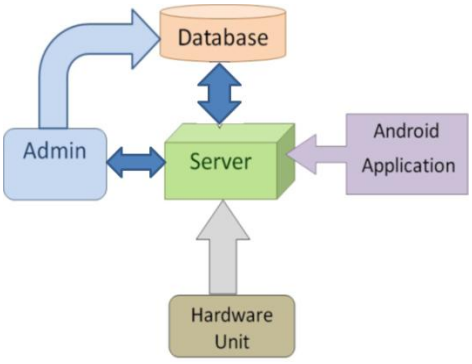

Fig 1: System Overview

4. SYSTEM ARCHITECTURE

The system architecture proposed in this paper consists of three main modules, Android Application, Administratorand Hardware Unit. The **Figure 2** illustrates each of these modules.

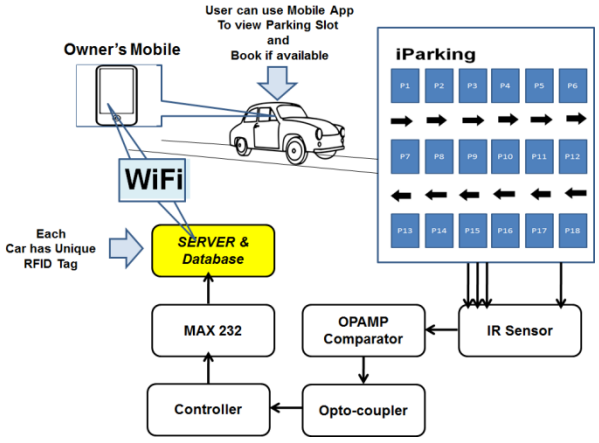

Fig 2: System Architecture

The main module consists of an algorithm coded in Java, whereas Hardware Unit consist of an interface of IR sensors to the server. Android Application is running on users' mobile helps the user to view and book the available parking. Brief outline and execution of each of these units are as follows:

a) **Android Application:** As the user proceeds through the Android application for pre-booking of the parking slot in the respective area of the city like malls, theatres, or reserved parking areas, user can see the pictorial view of the parking slots through android application with the help of GUI. After proceeding, user can book the convenient parking slot by choosing it from the view of parking slots through GUI and the information about the booked slot will be stored in the server.

b) **Admin:** As soon as the user books the parking slot through the Android application, Admin can access the information related to the booked slots. Admin PC will have the same GUI like the android application's GUI.

c) **Hardware unit:** Once a user enters with a car in the parking area having RFID **tag** on it, admin will get the details of user and his car from **RFID reader**and then the user can park the car to the respective slot which was earlier chosen by the user from the application. As soon as the car is parked, the parking slot containing the **IR sensor** senses the occupied space and helps to give details of that area to the admin side. This takes place through serial communication.

5. SYSTEM IMPLEMENTATION

5.1 Admin User Interface

The Screenshots of user interface and menu at the Admin Side are as shown in **Figure 3(a), Figure 3(b), Figure 3(c),** and **Figure 3(d),** for User Interface of Main Menu-First Page, User Interface of Main Menu- for Scanning RFID, User Interface of Main Menu- for understanding Parking Status- Slot Available and User Interface of Main Menu- for understanding Parking Status-Slot Bookedrespectively.

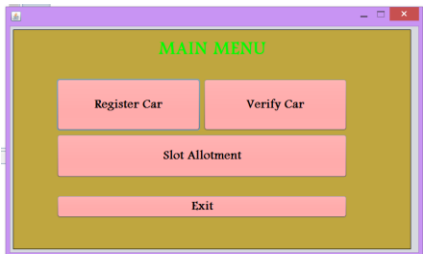

Fig 3 (a): User Interface of Main Menu-First Page

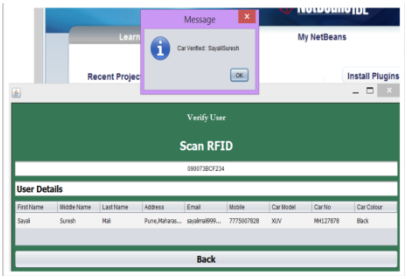

Fig 3 (b): User Interface of Main Menu-First Page

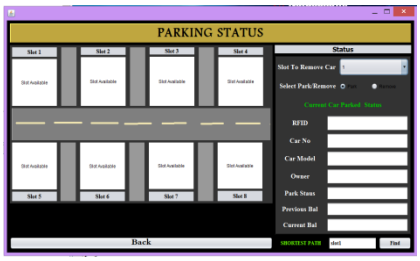

Fig 3 (c): User Interface of Main Menu-First Page

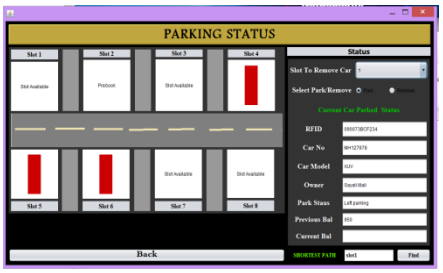

Fig 3 (d): User Interface of Main Menu-First Page

5.2 Android Application User Interface

The Screenshots of user interface and menu at the Client Side (Mobile Application) are as shown **in Figure 4(a), Figure 4(b),** and **Figure 4(c)**, forApp-Icon Called Parking Client, Login Screen of App and Screen After Loginrespectively.

The user has click the App and registered to App if previously not registered or open the App for understanding of free parking slot. If parking slot if free, user can book the slot y paying the appropriate parking charges.

Figure 4 (a) and **Figure 4 (b)** shows an Android Application run on an Android based mobile phone for prompting the user with available slots and occupied slots respectively . These screenshots shows the changing view as the user proceeds towards booking of slots.

Figure 4(a): App-Icon Called Parking Client

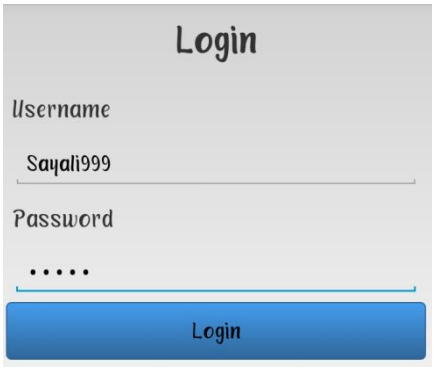

Figure 4(b):Login Screen of Android App

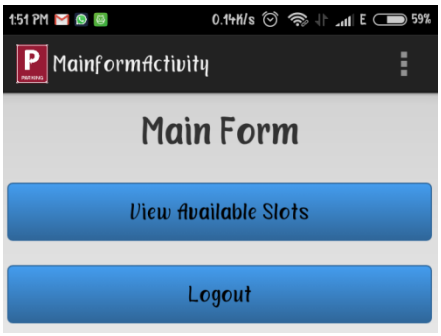

Figure 4(c):Screen After Login

6. SYSTEM FUNCTION

Functionality of the system is as per the user's requirements; this defines the system features which are specified below:

User can open and use the Android Application if the user wants to book the parking slot in the respective area of the city (malls, reserved parking areas, theatres, etc.).User will be able to see the parking slots of particular area from android application's GUI (user will have a pictorial view of the parking area) as shown in **Figure 4(a).**

User can book the desired parking after choosing it from the application's GUI.

As the user enters in the respective parking area with a car having (hardware unit) RFID tag on it will help to scan and get the details of the user and his car from RFID reader and then the user can park the car in the respective area which was earlier chosen by the user from the application. As soon as the car is parked, with the help of Hardware unit containing the

IR sensor, these IR sensors sense the space which is occupied by some object and helps to give details of that area where the car is parked to the admin side. This takes place through serial communication. The occupied are also prominently visible on users' mobile as shown in **Figure 4(c).** Therefore, for the next subsequent users will get an idea about the occupied parking slots.

Now Admin side can have all information of car, In time of car, details of parking space which can be handled and also stored in the Database which is already connected to the Server. The server keeps all information of android application, hardware unit and admin side.

The system shall be available 24 x 7. When data or information is requested, it shall be presented on the screen within 3 seconds. Also, a system shall be able to accommodate at least 25 simultaneous users at a time. Overall, the system must be interactive and user-friendly.The mobile devices should be kept password protected even though there is an in-app password security measure. The user should not be asked to reveal his/her bank account details. A One-Time Password (OPT) is used before any transaction for security. Each time the user consumes the application, it is mandatory for him/her to give his login ID and password.

Hardware Experimental Setup used in the project is as shown in **Figure 5**. RFID Reader (Marked as '1'), and IR (Infrared) Sensors (Marked as '2') in **Figure 5** shows the prototype used in the experimental setup. Overall the implemented hardware kit along with the assembly of all the individual units supports the required simulation of parked and un-parked locations while doing experimentation.

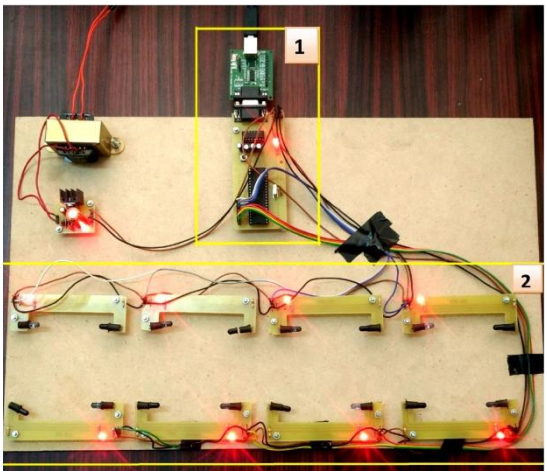

Figure 5 : Hardware Experimental Setup

7. SYSTEM RELIABILITY

Reliability:
There are two levels of reliability. The first is meeting the right requirements. A careful and through systems study is needed to satisfy this aspect of reliability. The second stage of system consistency involves the actual working delivered to the user. At this level, the systems reliability is intertwined with software engineering and development. There are three approaches to reliability.Avoid errors from taking place in software. In error detection and correction approach, errors are recognized whenever they are encountered after compiling each phase of code and followed by correcting the a error by the effect of the error, if the system does not fail. In error toleranceapproach errors are recognized as soon as they occur, but enable the system to keep running through degraded performance or by applying values that instruct the system to continue the process.

Maintainability:
The key to reducing the need for maintenance while working, then the following tasks can be considered as essential key points-

1. More accurately defining user requirement during system development.
2. Assembling better systems documentation.
3. Using more efficient methods for design, process, login and communicating information with project team members.
4. Making better use of existing tools and techniques.
5. Maintenance of each tool of hardware among its wired connection.
6. Managing system-engineering process effectively.

8. FEASIBILITY ANALYSIS

Data Flow Diagram(DFD) shown in **Figure 6** is a graphical illustration of the flow of a data through an information system, it facilitates to analyze the visualization of data processing within each level of DFD diagrams, in this three levels of each DFD from 0 to 2 will inform that what information can be input and output from the system.

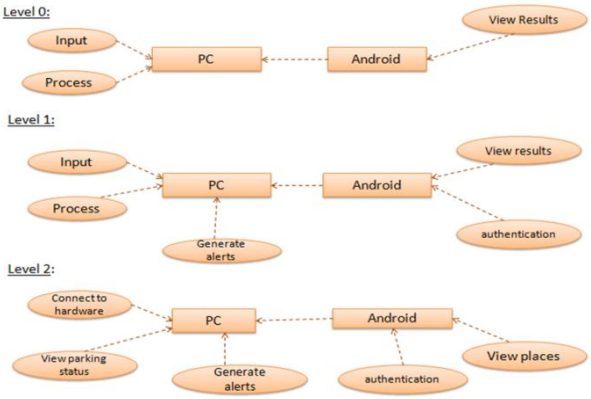

Figure 6:Data Flow Diagram

As shown in **Figure 6**, the simple idea is the data entry of user into android application and performs the operation, so the user gets immediate results and PC handles data operations of input and process. This **'Level-0'**of DFD shows very common and basic data processingstage.

In '**Level-1'** DFD gives an idea of Android Application. When the user enters into this application, he/she has to complete the authorization process for further results. The application generates alerts for every new operation initiated or terminated bythe user. These alerts are very useful to the user and act as a guide while entering the data.

If the operation and process of the whole system exactly go and works as mentioned in DFD '**Level-0'**and '**Level-1',** then the user will be able to see the available slots as shown in '**Level-3'.** Further, hardware unit communicates with the PCand helps user to get authorized information about available parking slots through the respective user interface on their Android Application running mobile.

Figure 7 shows an Entity Relationship (ER) diagram demonstrates the various information to be entered by the user through obile app. Similar kind of entity relationship diagrams

are also possible for other inputs taken through interfacing hardware, administrator module and billing module etc..

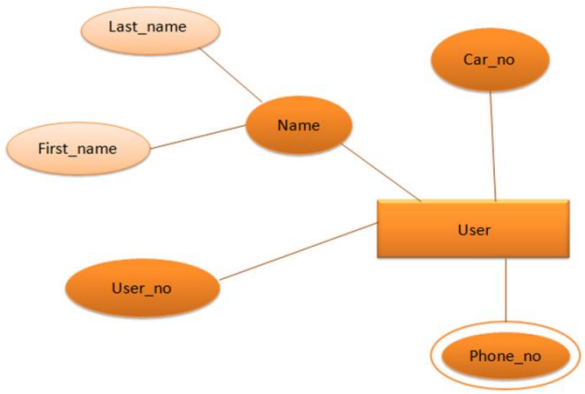

Figure 7:Entity Relationship Diagram

There are several subsystems or modules providing different functions. Unified Modeling Language (UML) use case diagram is as shown in **Figure 8**.

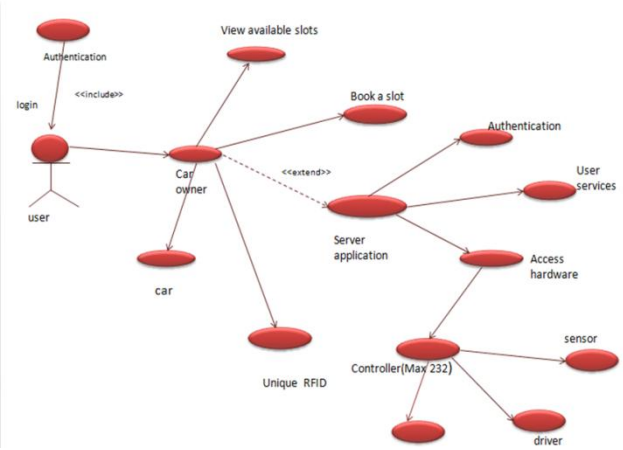

Figure 8:Use Case Diagram

The user (actor) registers for a parking reservation by signing in with username and password, which is further authenticated. The car owner has a unique RFID that has also been registered to the Server application during registration.User can view the available slots and book according to his/her convenience.

The information is transferred to the admin through the server, and is authenticated when the user arrives at the destination. Server application has an access to the hardware as well, which includes a controller (Max232) covering multiple functionalities like the IR sensors providing information about the vacancy of the slots, RFID device confirming the registered and unregistered cars.Additionally, user services like manage and update for cash payment and delete for updating of the user record.

The sequence diagram shown in **Figure 9**also called as the event diagram describes about the interactions between the classes in terms of the exchange of messages over time.

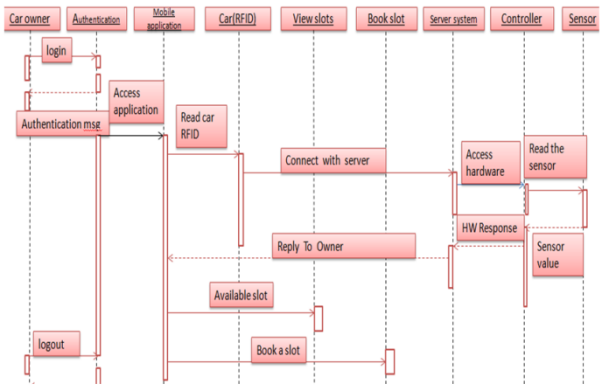

Figure 9:Sequence Diagram

Sequence diagram helps to predict how a system will behave discovering the responsibilities of each class as well as it has proven to be a good way to visualize and validate various runtime scenarios. The class mentioned in the UML object type box describes the role of context in the scenario. The activation or execution boxes which are shown in the form of boxes over the dashed lines (lifelines) represent the time required by the object to finish the task.

For example in the given scenario, the car owner's registration and authentication time are less. The arrow messages between two lifelines depicts the asynchronous messages as they don't need any reply for interaction, instead they continue with their own tasks without any acknowledgement.

The Systems Development Life Cycle (SDLC) diagram is as shown in **Figure 10.** SDLC also referred to as the application growth life-cycle, it is used in system engineering, information system and software engineering to explain a procedure to plan, create and when these both procedures gets done the testing is conducted of the whole software for receiving accurate results. Also the deploying is done of an information system.

The systems development life-cycle concept applies to a range of hardware and software configurations as a system can be composed of hardware only, software only, or a combination of both.

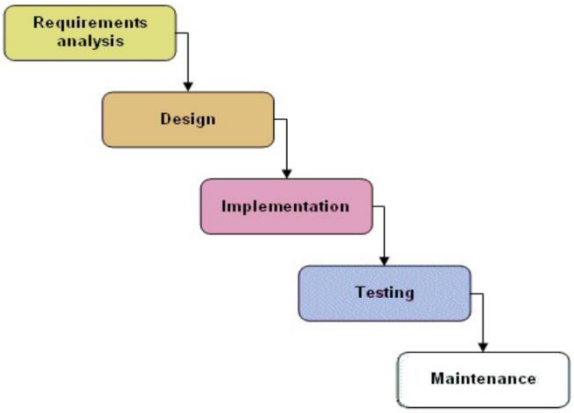

Figure 10:SDLC Model Diagram

There are 5 phases in proposed ***'WATERFALL'*** model described in **Table 1**.

Table 1. Table captions should be placed above the table

Sr. No	Description of the Phase
1	**Requirement Analysis :** It is the required to gather, in which the essential data required for the project implementation are collected This phase also includes analysis of collected data to get an idea about design next subsequent phases. .
2	**System Design:**Software System Design phase consists of designing of an algorithm for input, process and output of information as per the users' requirement.
3	**System Implementation:** It is the Construction phase where the necessary hardware and software is constructed to get the required interface.
4	**Testing of a system:** Various test cases are given to test the developed system for all possible situations to get the required output. Various scenarios are created to get the filling of real time system.
5	**Maintenance of a system:** The maintenance phase is continuous process of maintaining the system as per the need. Small modification in the hardware or software design is also possible in this phase.

In the proposed project we have attempted this model and respective methodologies and addressing path to accomplish the every task in the software and hardware components to get the required functions. It also helped the project to resolve the problem issues that prepared every task easier to be complete with precise outcomes and improves the performance of the entire system.

Feasibility of the proposed methodology mainly examines the expected output of the system through careful analyzing of technical, economical and risk feasibility as follows:

a) Technical Feasibility: The use of network and secured communication via Internet within periphery of existing network by authorized users is quite obvious. The system is going to be developed with:

- Well-known Client-Server architecture,
- Easily accessible coding in Java,
- Plenty of available resources,
- Maintenance of Hardware and its use,
- Practical experimentation and
- Guaranteed verification of estimated output.

Therefore, the stated methodology, experimentation and validations are technically feasible.

b) Economical Feasibility: Economical feasibility of this project helps to make analysis of the estimate cost or development cost considered towards the ultimate income or profit from the required resources of the system can easily be available. Components cost needed in the system are as follows:

- Cost of computer and android mobile phones,
- Cost of Operating system,
- Cost of application software and
- Cost of data collection.

As the implementation of this system does not require any expensive customized devices, external interface and dedicated commercial software, the required system is quite economically feasible.

c) Risk Feasibility: There is risk factor in this entire system even if it fails or working abruptly will not produce any serious problems or issues in the progression of parking of vehicles.

9. MATHEMATICAL MODELING

Input:

Let M be a set as:

$M \equiv \{SRDB, LODB, CL, SRB\}$ …… (1)

Where,

SRDB=Server Data Base responsible for storing user information related to cloud interactions,

LODB= Local Data Base that a user owns. It consists of data tables having data related to the car and their parking slots,

CL= a set of all clients using the server database and mining services from the server. & (cl1 , cl2 , cl3, ...cln) Є CL.

SRB= Server Base-components of the system for which the server is dependable to register, authenticate and providing links to the end user.

However, all above variables are going to be modified with various input information from the user such as user id, name, car number, car name, address, country, contact, email, available parking slot, etc.

Output:

Here, the function 'Tagread' and AU plays important role in not only taking the information through RFID (ReadTag) but also authenticating the user (AU) as:

Tagread = ReadTag (input _ Tagread) ……. …….(2)

AU = AuthenticateUser (uid, Tagread) ..…….….(3)

Therefore, SRDB is initially derived from 'Tagread' &'AU'.

Now, the variable SRDB given in equation (1) is going to be modified as SRDB' due LODB1 and LODB2 which are given as:

LODB1 = ManageCars (cid, car name)……...(4)

LODB2= ManageParkingslots (slot, vacant, reserved)……(5)

LODB = LODB1 + LODB2

User Classes: Admin, Server and Android applicationare three different modules. Different classes used in these modules are as follows:

Classes For Admin:

1. Authentication(Username; Password)- This method is use for checking authenticated user with its unique username and password stored in the database.

2. Get ADCvalue() - for getting digital values about parking slots.

3. UpdateBalance() - When user's car will arrive then there should be deductedof balance or when user will _ll the balance. Balance should be updated in his account.

4. Delete User() - For deletion of user.

5. Add User()- For addition of new user with his all information about car and itsusername and password.

6. Live Monitoring() - For live monitoring of parking slots so that there will be correctinformation about parking slots which will be displayed on the GUI of the application.

7. Read Tag() - When tag will be read its value will be sent in the form of yes or no. Sothat if the user is authenticated then the tag will send true values and if not authenticatedthen false value.

8. Initialization=w() - For initialization of hardware like IR sensors, analog to digital converters and RFID tags.

9. Logout()- For logging out.

Classes For Server :
1. Check Validation() - Server is connected to h/w model so whatever information willbe sent by h/w. Server side its validation will be checked.

2. Write data() - Database is connected to server, so this function will write the datainto database.

3. Read Data() - Reading information about data of user from database.

4. Fetch Record() - For fetching of records from data.

Classes For Android Application:
1. Login(Username , Password) - For logging from an application using authenticatedusername and password.

2. View Slots() - For the view of parking slots for booking.VIew of vacant and bookedslots.

3. Book Slots() - For booking of parking slots this function will be used.

4. Check Balance() - After booking with slot balance will be checked if there is a balance, then payment of parking will be done and slots should be booked for that user andif no balance then booking should not be done.

5. Logout() - From logging out from the application.

Assumptions:
To use android application, there should be good internet connectivity because the connection of server and android application is via internet. So that there is good internet connection present at user side is assumed. The server should be always active because all the data about parking slots and users is present in the server to be accessed all over. All the hardware working properly is assumed if the IR sensors, RFID tags, ADC converters are working properly. All sensors are working fine because information about cars parked or vacant parking slots will be stored using sensors. All the data about parking slots is dependent on the information sent by sensors. RFID tags present on the car for authentication and Parking is booked and payment is done through the application.

Success Condition:
i. Data by parking of cars will be successfully sent to the server using serial communication.
ii. Admin is able to see the GUI similar to that being seen by the user through android app.
iii. Admin is responsible for continuous updates in data of scenario of parking so data will be handled by admin only so there will be no congestion of data handling.
iv. Connectivity between server, admin, database and android application will be via Wi-Fi, there will be no cables it will be wireless.

Failure Condition:
i. If some IR sensors or RFID tags are not working then there will be issues of management of parking. There will be chaos about vacant slots and reserved slots.
ii. If there is not enough Wi-Fi connectivity, thenthe application will not load.

10. DEPLOYMENT & MAINTENANCE

The purpose of the deployment phase of the SDLC model (software development life cycle) is to put the product into an assembly. After the project team member analyzes the product, and the product passes each testing stage, the product is ready to deploy. This means that the resulted product is ready to be used in real surroundings by all end users of the product.In order to keep a Product running well for a long run purpose, it requires regular maintenance such as hardware equipments used in the product should be checked regularly to sustain for extended time and for precise outcome.

11. INSTALLATION / UN-INSTALLATION

Considering this project the Android application (Parking Client) must be installed on Smartphone to experience its services like pre-booking of the parking slot. For Admin side registering software is necessiry to be installed to supervise and handle the parking areas. If the Client is pleased with the services offered by the application, then he can uninstall the application and also be able to reinstall it again as per the requirement.

User Help: A manual for user help will be provided for Android application to understand its procedure to know-how the application works to grant its services as nowadays it is available on every application and it guides a user with "User Help" manual until the pleasing assistance is been provided. This makes the client's job trouble-free to use the individual application.

12. TIME COMPLEXITY

The Time complexity of this project will be O(n), where big-O notation is used to differentiate algorithm according to how their running time or space requirements increases as the no of inputs grows. Here the 'n' is measured as per the running of no of parking slots.

13. CONCLUSION

The proposed methodology in iParking system can be major rescue to the painful problem of traffic, pollution and urban transportation as the task of finding a parking slot individually becomes more time consuming. The use of proposed graphical user interface in iParking system will make the task simpler for users to discover parking places in typical metropolitan areas which otherwise going to become a big headache. In future this application can be extended for long run as a best service provider for project like a smart city with pollution free aspect along with user-friendly, interesting android application on handheld device like mobile as a part of our life on day-to-day basis.

14. REFERENCES

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