

Smart Parking System:3S “Scan - Search – Stop”

^[1]Annapurani K., ^[2]Poovammal E, ^[3]Paras Gandhi

Department of Computer Science and Engineering

SRM Institute of Science and Technology, Kattankulathur, India - 603203

^[1] annapook@srmist.edu.in, ^[2] poovamme@srmist.edu.inl, ^[3] parasmaani@gamil.com

Abstract

A mechanical system by which we are able to park vehicles especially four wheelers is called Parking System for example: a multi-storey parking garage. When this parking system is automated, it is called an Automated Parking System (APS), which provides parking for cars on multiple levels, stacked vertically. When the artificial intelligence is introduced as software in the parking system to maximize the number of parking spaces while minimizing land usage, the parking system is called as Smart Parking system. Due to increase in demand of parking space, drivers literally find it difficult to find the same around the city and if in case they are lucky enough to find the space then also they have to win the war against the set-up of parking by co-parkers. To avoid the rough competition among the drivers "Smart Parking System" is the concept being introduced, which refers to the implementation of a system that allow drivers to find parking slots with help of technology that will save their time and effort. The proposed work focuses on technology in which some of the technology advancements like Radio Frequency Identifier (RFID), Quick Response (QR) Code and Navigation Tools are used to make their day to day fight easier. Implementations of the Smart Parking System with the shortest path algorithms and pricing mechanism can be done which can make the monotonous parking system intelligent enough to let the user relax out their stress which develops as soon they think about hitting roads.

Index Terms—Pricing Mechanism, QR Code, RFID, Shortest Path Algorithm, Smart Allocation.

I. INTRODUCTION

Parking is an expensive process in terms of either money or the time and effort spent for the spot chasing. The purpose of the proposed work is to introduce the technology into the existing manual parking system to make it automated and convenient for parkers. The idea is to handle the reservation request by using concepts like evaluating shortest path live, which will make people find their reserved slot more conveniently after entering into the arena.

The proposed work, smart 3S: Scan, Search and Stop starts with customer looking for parking and after reaching to a parking place, is supposed to scan Quick Response (QR) code pasted, in form of a large printout, at the entrance. After that, user's mobile application will hit the server url given by the QR code and asks the server to save the details of the user, in case he agrees to park his vehicle inside the premises. Thereafter, the customer will see a graphical interface of the parking area from where he needs to tap on the auto selected slot given by the server. The application software will help him to find his parking slot via local area navigation network, where the smart Search happens. User needs to show the booked slot screen to the security person of the parking lot for his authenticated entry into the premises. The Radio Frequency Identification (RFID) tag pasted on the car will have the information of allowed entry time of each and every user and the user is allowed to enter into the specified location within the buffer time duration and do the smart stop. The system should be developed to provide an option to pre-book the slot, counted as pre- reservation, to be taken in as future work. This idea eliminates the drawbacks of existing system using RFID chip only or systems with Light Emitting Diodes (LED) and Infra Red (IR) sensors etc.

The working of Smart Parking System (SPS) will be elaborated further in the paper as how it is going to be helpful for the drivers, parking management in the road sides. The objective of

this work is to allow drivers/users to park their vehicle in effective way as they will be provided with shortest path algorithm to track their allotted slot for parking their vehicle. The users are provided with an Android application to help in reserving upon viewing the parking slot. Even after entering the parking zone the user need not look around for the slot instead, what he needs to do is to follow the route navigated by the application using in-house Global Positioning System(GPS).

Most of the researches in this domain have focused on how to find the occupancy state of the parking slots [4][7][8][11] and accordingly reserving it and guiding users to reach to that parking place. However, those systems are still not capable of solving the real problems. The competition in parking vehicle is spot chasing which leads to higher traffic congestion and sometimes leaving other parking source vacant. Also this may lead to multiple cars chasing the same spot. It is essential to have the idea about on the occupancy state in parking areas and at the same time it is equally important to utilize that data effectively for improvement in user experience.

Author Zhanlin et.al. [10] presented the generic concept of using cloud-based car parking capability specially in smart cities, and that is importantly deployed on the Internet of Things (IoT) paradigm. The corresponding IoT sub-system includes sensor layer, communication layer and an application layer. To demonstrate the provision of car parking services with the proposed platform, a cloud-based intelligent car parking system for use within a University campus is described along with details of its design and implementation, in [9].

Tanmay et.al. [2] talks about a scheme which has been declared as the reservation based vehicle parking system to overcome the problem of unnecessary time consumption in finding the parking slot in populated areas. In this system dealt by Tanmay, one can reserve the parking by using a short message service (SMS).

The author Knack [5] implemented a system that allows the driver to find a parking slot and reserve it. Yet, the driver needs to do the entire process on their personal hand-held device having the mobile operating system android. The reservation results in generation of QR code which encodes the unique details of the user.

Shoup [6] discussed about a parking system in major cities, particularly with dense traffic, directly affects the traffic and people's life. Author Shoup insists on introducing a method of parking system, which takes care of resource allocation, reservation, and pricing. His work tried to solve the parking problems by offering guaranteed parking reservations with the lowest possible cost and searching time for driver and also, in turn brought in the highest revenue and resource utilization for parking managers. New pricing policies are also proposed which can be implemented in practice.

Venkateswaran et.al. [11] approached and researched on a special system for smart parking reservation and security maintenance in a commercial car parking area in an urban environment. This system mainly designed to avoid unnecessary time consumption to find a vacant lot in a car parking area.

Hang et.al. [3] claims that smart phones which contain rich set of sensors can be used for providing different services to the user. Driver assistant services such as road traffic information signal information, road surface disruption and traffic situation present ahead in drivers path are the few among the many services.

Basavaraju in [14] researched on the time spent in identifying the parking lots and also about avoidance of unnecessary travelling through filled parking lots, in a parking area. Avoiding the unnecessary travel path helps in reducing the fuel consumption which in turn reduces carbon footprints in an atmosphere.

Concept or technology used in [8] is Internet of things to reserve the slots. Renuka & Dhanalakshmi [13] explain about the use of an android application in parking system for parking reservation. The mobile app developed allows to reserve the vacant parking slot in the specific parking zone with an ease where protocols used are based on the concept of Internet of Things (IOT).

In [16] Eken discussed about the services provided to passengers by transport systems which are two kinds : (i) route and schedule information such as maps, schedules, and information on connections (ii) basic information such as fare policy, stop locations. Eken's idea is for the smart bus tracking system with the fact that any passenger with a smart phone or mobile device with the QR code reader can get best service out of it. The user can scan QR codes placed at bus stops to view estimated bus arrival times, bus's current locations and bus routes on a map.

Amir. et.al.[1] focused on parking resource allocation, reservation, and pricing where authors

guaranteed parking reservations with the lowest possible cost. The mathematical model developed using mixed-integer linear programming (MILP) by the authors has the objective of minimizing the monetary cost and maximizing the utilization of parking resources. Amir O. Kotb et.al. introduced a car parking system, with static resource scheduling, dynamic resource allocation and pricing models.

Ahteshamul et.al [12] declared an efficient way of managing the parking system using the concept of Internet of Things (IOT). An android application parker was developed, which can interact with RFID chip tagged to each car and the sensors deployed in each parking slot. The user of the parker mobile app can book the slot according to her/his wish..

II. SMART PARKING ARCHITECTURE

A. Quick Response Code

A hardware machine-readable code/information tag is shown in fig. 1, consisting of an array of black and white squares in different dimensions. Generally these Quick Response (QR) code is used for storing URLs or other information for reading by the camera on a smart phone or a scanner. When it comes to automation of any projects, the QR code is becoming the preferred choice in comparison to bar codes due to its fast readability and greater storage capacity. The applications such as item tracking, product identification, document tracking and marketing started to develop the habit of using the QR Code technology.



Figure 1: Quick Response Code

B. Radio Frequency Identification

Smart parking application which uses RFID technology as shown in Fig. 2, requires no human intervention and is used for vehicle detection. The application can be developed for automatic parking fee collection system. This technology helps the drivers to quickly check-in and checkout from the parking lot and also makes the parking secure.

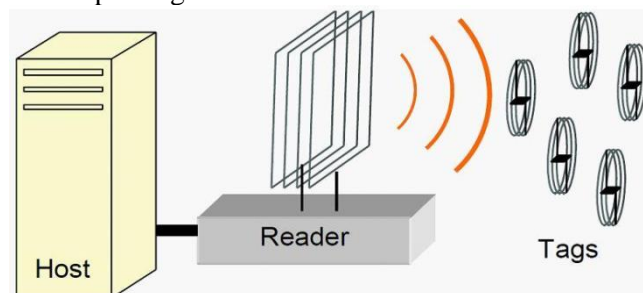


Figure 2: RFID connectivity Diagram

The main components of RFID system that are used for the purpose are RFID labels, RFID readers installed in every bay of the parking lot as shown in Fig. 3(a). to 3(d), a software system and a barrier to have the gate control. The transaction management, reporting and operational tasks can be

controlled by the software.



Figure 3 (a-d): Three Dimensional Views of parking slot

C. Smart Parking System

Smart Parking System architecture starts with the scanning of QR code as shown in Fig.4. After identifying the authenticity of the user, the same application will help the user, to find the vacant parking slot and to reach to the chosen parking slot, with the assistance through GPS data.

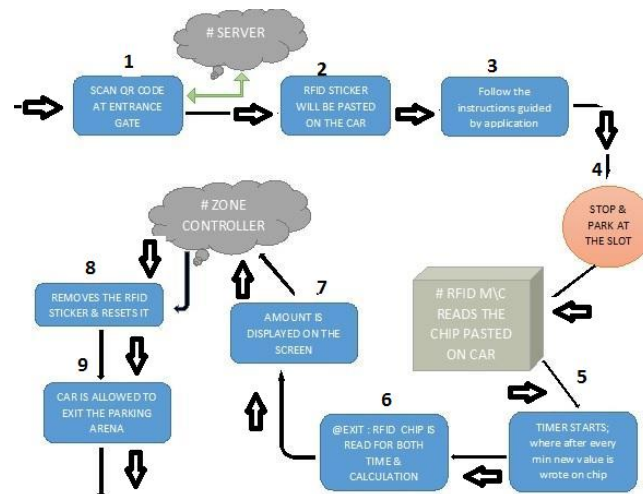


Figure 4: Smart Parking System

QR code is scanned at the entrance gate of the parking zone which will give the availability status of vacant slots to the user and at the same time the software application will communicate with server to save the details of the user temporarily. In the mean time, the user needs to show auto generated slot to the person in charge of the parking lot. RFID tag having current time in it will be pasted on the user's car with user identification number. This user identification number may be a permanent number for the regular user or temporary number. The software application running in the user's mobile will show the simulated view of the parking slots in the respective zone highlighting the allotted slot. Once the user taps on the highlighted slot, guidance for his/her navigation to the parking slot from the current position will be given by the software. As soon as the user parks the car, which is having RFID chip pasted on it will eventually enter into the RFID machine readable zone as is shown in Fig. 3(a). The RFID reader is kept or fixed somewhere hidden from the user or staff for its security reasons as shown in Fig. 3(b). This machine sooner tells the server to lock the particular slot and make the slot as occupied.

III. SERVICES OF SMART PARKING SYSTEM

The Major services of the smart parking system are designed by suitable coding and each service is independent to other's functioning. Each service is discussed in the sub sections

A. Smart Allocation

Smart Allocation refers to the term or technology stunt that allocates the entity/property to the requester as per the availability of the resources. Basically, the user's category type for the reserving a parking slot is given as input and consequences are marked down over the user's mobile application. The types of users are classified as regular and rare users. The unique identification numbers allocated to them are auto generated numbers. Permanent numbers are used by the customers who most often use the mobile app for booking the parking slot such as employees of the nearby offices or residents of nearby apartments without specific parking space. The rare users or the visitors to the parking zone are assigned with temporary identification numbers. In every transaction, at the entry gate of parking zone, all the details of customer are checked and assistance will be provided based on the demand and usage of the parking premise.

The smart allocation system saves the time of the customers by allocating them the slots immediately as soon as they enter the parking zone. The information about the customers possessing permanent identification number are stored in the server database. Hence the registered regular users need not do much formality when compared to the rare user /visitor, who is expected to fill few data for checking. Under the generalize process, a first time user needs to register himself / herself in the database. While registering, he /she needs to mention the type of vehicle he /she drives along with some basic information for security reasons. Authentication of the type of vehicle is done manually, every time, the user uses the parking. Fig 3(c). depicts the scenario where the user either about to park the vehicle or exiting from the parking . In both the cases RFID tag is not in readable zone of the machine, hence machine search is on. As soon as car enters the readable zone of RFID reader, it stops investigating for new tag as shown in Fig 3(d) and the server is intimated about the parking and the server is responsible for considering it across all its clients.

B. Data Flow in Smart Allocation Service

Smart Allocation Logic System as sown in Fig. 5 refers to the steps taken in the allocation logic where the user's request is the first input. The users is called as parker who wants to park is vehicle and his / her request is forwarded to the Center Request Control (CRC) module, which in turn communicates with the server, to check the category in which the user is registered with. The server in turn contacts Allocation Master, Parker and Parking Zone Authority. Allocation Master (AM) identifies and vacant slot and freezes the same slot for the user whose request is under process and communicate with the respective user to guide him/her for the navigation route to reach the reserved slot. Also, the server activates the Pricing Manager (PM) to manage the pricing details. In case temporary user or the first time user, the slot allocation in the parking zone will go through the same process except for the fact that the users will be asked to fill some additional data while submitting their requests.

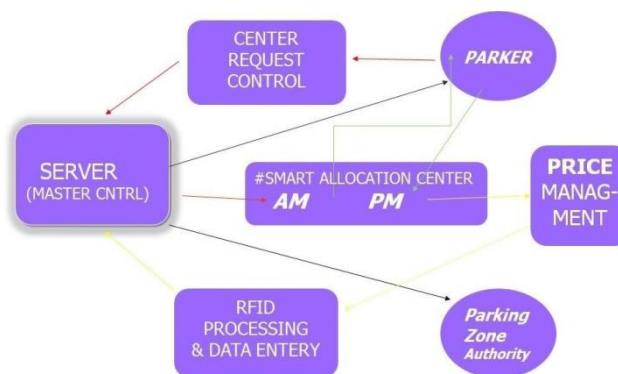


Figure 5: Smart Allocation

IV. ALGORITHMS IN SPS

Algorithm is the step by step procedure followed to reach the desired result. In the sub sections the algorithms used in the Smart Parking System (SPS) are discussed.

A. Shortest Path

The software application's role in SPS is initially to identify and allocate the nearest vacant slot with respect to user's current location. The second task is to guide the user with navigational path to reach the allocated the parking slot as quickly as possible. The algorithm used to find the nearest location from the user's current location to the allocated parking slot is called as the shortest path algorithm. The registered user looking for the parking slot should not face the difficulty of reaching the allocated slot quickly. Among all the algorithms available to find the shortest path, the best algorithm is chosen after comparing the results obtained, based on exploration and major usage . The best one which suits well is the algorithm by Dijkstra (1959) and that was implemented in this work. Fig. 6, shows a shortest path drawn from source to destination.

To understand the idea of evaluating the shortest route on Google maps, based on the internet research, Google application draws points on the live map specially where there is a blind turn or end of the straight road. Then from the database, road measure is picked and a skew diagram is drawn as shown in Fig 7, where *A* refers to the source /origin and *G* refers to the end point / destination.

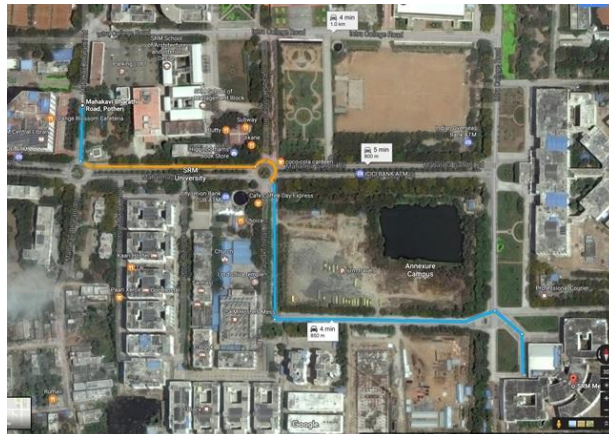


Figure 6. Shortest Path Logic

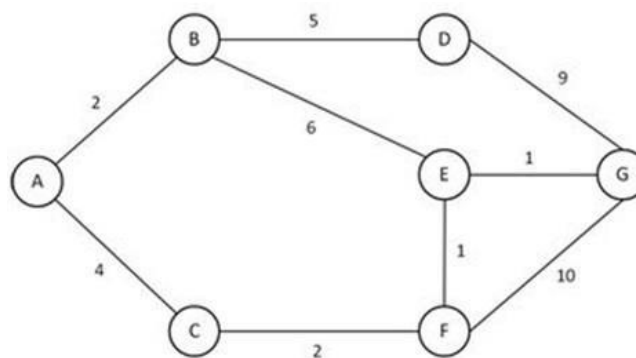


Figure 7. Shortest Path Evaluation

After drawing points on the map as source and destination, skew diagram drawn is simplified as per the algorithm shown in fig 8. After completing the calculation from the skew diagram the shortest path is drawn and shown to user on their mobile app.

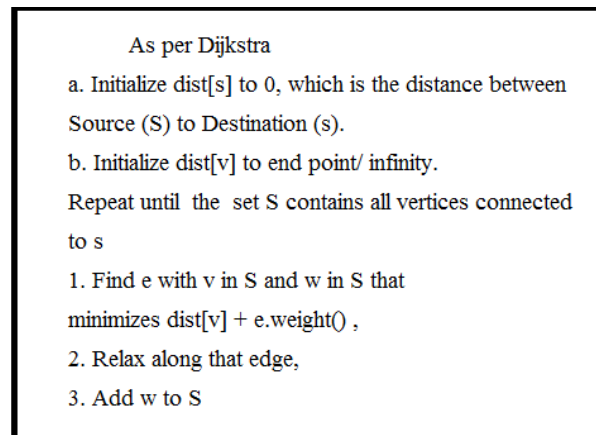


Figure 8. Dijkstra's algorithm

B. Server Allocation

Allocation of server refers to the master mind that decides the customer's category and comes into action when the user enters into the parking premises and had thrown a request using his smart phone. The user's request of finding out the parking slot will land on Smart Resource Collector, where based on the type of user, the vacant slot is identified. If regular user / office staff of nearby area preferred locations are searched rather than looking for shortest distance from the current location. But , if the user is visitor, then preference is given to the closest available vacant slot and that identified slot is allocated. Also, this allocated slot is communicated to the user along with further navigation assistance. The navigation assistance will help the user to reach the allocated slot without any hassle and help him / her saving the time.

C. Server Allocation on Pre-booking

In case, the customer using the smart parking mobile application needs to park the vehicle in the specific parking zone at a specific time and he / she does not want to take chances after entering the arena, pre-booking choice of parking slot can be opted. In such cases, the preferred parking location / side and time will be given by the user while choosing the pre-booking menu. Accordingly corresponding parking slot along with the time duration will be blocked from other users, while the user will be receiving a confirmation in his mobile. Also, threshold buffer time will be fixed and informed to the user, within which the user's vehicle can occupy the allotted slot. Otherwise booked order will automatically get cancelled. The person in charge in the entry gate of parking zone needs to mark down the vehicle number coming in for the parking and immediately the mobile app fetch the details with owners Identity. After cross-verification, person in charge needs to paste the RFID tag on the car and allow him / her.

D. Pricing Mechanism

This subsection covers the prospective of how the implementation of the smart Parking System work is useful for the investors over the existing systems. As far as our proposed work pricing mechanism should focus on the effective assumptions, keeping in mind the convenience of the users. Hence, the calculations of the pricing should include zero tolerance for errors which causes inconvenience to the customer. The prices are to be fixed, as per the scheduled timing and allotted market rates on the parking arena which may be on hourly or on daily or monthly basis. Parking Manager in our system will take care of all the things related to managing the prices . Our proposed Plan even covers the idea of assigning weightage for each user category-type to maximize the revenue generation and idea of fixing the parking fee based on weekends / week days also based on the peak hour / normal hour timing.

Let Q refers to number of parking slots, q_s is considered to be number of static parking slots which are for regular customers, q_d is considered to be number of dynamic parking slots which are for the visitors, R_s refers to the rate charges to book static slot parking for an hour, R_d refers to the rate charges to book dynamic slot parking for an hour. Also in some of the cases where requirement is high for static slots respective rate of those type of slots are higher to those of dynamic ones thus

R_s is greater than R_d specially when parking arena is near to work place or place where user visit for parking his vehicle on daily basis.

It is our part to fix the tariff rate for maximizing the profit as per the equation (1).

$$\text{Max } [z_1, z_2, z_3] = q_s * R_s + q_d * R_d \quad \dots \text{Eqn.(1)}$$

where z is the Revenue to be generated.

E. Intelligent Allocation

Intelligent Allocation system means providing a system generating maximum revenue by utilizing all the available slots effectively while all the users have better satisfaction. At any time the users can move in which make them happy but only after intimating the parking authority via mobile application, which guarantees the security. In order to bring this true, we need to design a system in which all slots are divided into s-type and d-type slots. The s-type is for static type customers, d-type is for dynamic type customers and dividing ratio of the both can be modified, depending on the day of the week and location of the parking arena. If the arena is near to shopping malls or market then we can expect the frequency of dynamic customer would be high and hence the weightage given for d-type slots will be high. If the parking arena is near to big work place then employees prefer coming daily for parking their respective vehicles during almost fixed days and fixed time slots. In such cases, dynamic type user can be allowed to park the vehicle in slots of S-type slots, provided there is no pending request for a static type user in the system. This will give rise to sharing-time based concept to make sure that all the slots are fully utilized to yield maximum revenue.

V. IMPLEMENTATION

Implementing the smart parking system designed requires certain online and desktop open source development tools which are explained in this sections along with their end screen shots.

A. MQTT Lens

The acronym MQTT stands for Message Queuing Telemetry Transport. MQTT is an ISO standard publish subscribe based lightweight messaging protocol for use on top of the TCP/IP protocol as shown in Fig. 9. It is developed for a connection with remote locations where a small code footprint is required. Also, it is preferred when the network bandwidth is not that strong. The publish-subscribe messaging pattern needs a message broker and that is responsible for distributing messages to interested clients based on the topic of a message.

MQTT defines methods / functions to indicate the desired action to be performed on the resource. The resource represents the pre-existing data or data that is generated dynamically. Moreover often, the resource corresponds to a file or the output of an executable code residing on the server.

MQTT_Wait function is used for a connection to be established with the server and Disconnect Wait function for the MQTT client. The client has to finish any work it is assigned with and make the TCP/IP session to disconnect. Subscribe Wait function is for completion of the Subscribe or UnSubscribe method. UnSubscribe method, requests the server to unsubscribe the client from one or more topics. Publish function Returns immediately to the application thread after passing the request to the MQTT client

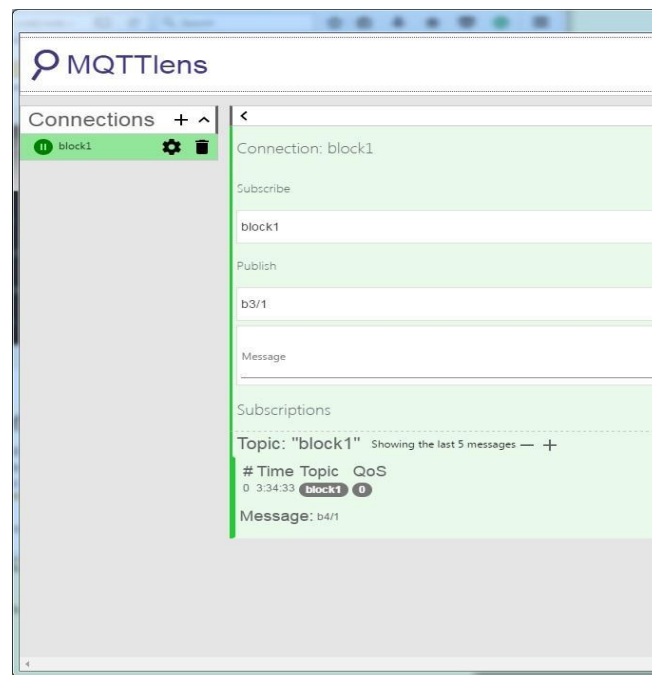


Figure 9. MQTT Server Page

B. Android Application

Android Platform, a mobile operating system is used to communicate with the users of the parking zone. The requirement of any user is a smart phones, which now a days every individual possess. The mobile application has been developed to help the user. Fig. 10 shows the available slots and Fig. 11 shows the booked slot. By clicking on the booked slot, he / she will be guided for his / her navigation to reach the booked slot and park the vehicle

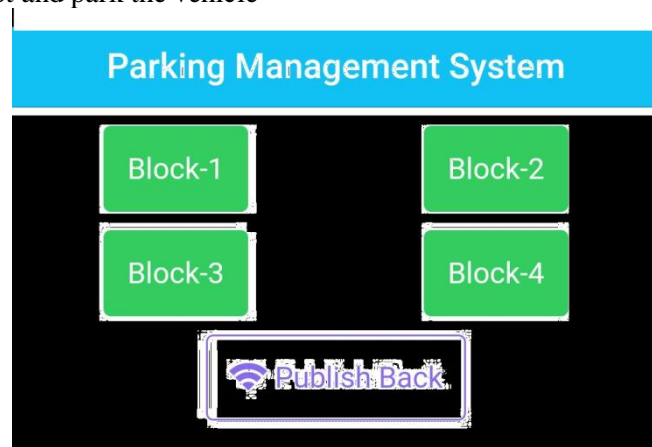


Figure 10. Screen Shot of available Slots

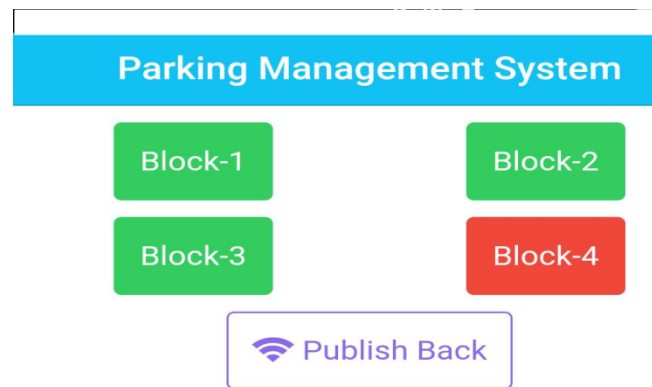


Figure 11. Screen Shot of booked

CONCLUSION

The calculations done and assumptions taken in the system designed are sufficient enough to make the system beneficial to the investor, while improving the customer satisfaction. Also, the arrangement of parking slots considering the types of customers brings in the integrity of the parking zone. Also, automated allocation of any resource in this digitized world is always preferred which in turn reduces malpractices, if any.

If per hour fee for parking of any of the customer's type category is high, then it needs to have high weightage among total slots with the fact that weightage of dynamic type slots can't go below 50% of the total slots. In order to satisfy both types of customers, s-type slots are kept equal to total slots and dynamic as per requirement which is called time-based sharing where if any static slot is free and dynamic type parking request comes in with fixed in & out time, then slot will be given to that requester only when there is no upcoming request for parking from the s-type customers.

REFERENCES

- [1] Amir O. Kotb, Yao-Chun Shen, Xu Zhu and Yi Huang, Parker, "A New Smart Car Parking System based on dynamic resource allocation and pricing", IEEE Transactions on Intelligent Transportation System, vol. 17(S2), pp. 2637-2647, 2016.
- [2] Tanmay Satpalkar, Sagar Salian and Sagaya Stephen, "Smart City parking : A QR code based approach", IJERT Computing Surveys, vol. 5, pp. 20-28, 2016
- [3] H. Wang, W. H. "A reservation based smart parking system", IEEE Info-Com Workshops, pp. 122, 690-695, 2011.
- [4] Subhadeep Patra, Sergio M.Tornell, Carlos T. Calafate, Juan-Carlos Cano and Pietro Manzoni, "Video-Based Over taking Assistance - Now A Reality", Raspberrypi.org, pp.10-17, 2011.
- [5] R. E. Knack, "Pay as you park", Planning, vol. 71(5), pp. 4–8, May 2005.
- [6] Donald C Shoup, Cruising for parking, Transport Policy, vol. 13, 479 – 486, 2006.
- [7] Poovammal E., Nikkesh S. and Suvo G Hazra, " IOT based Smart Parking with improved user experience", Journal of Critical Reviews, Vol. 7(8), pp.1041-44, June 2020.
- [8] N.Hanif, M.Badiozaman and H. Daud, "Smart Parking System using Short Message Services(SMS)", Proc. ICIAs, June 2010.
- [9] Basavaraju S R, "Automatic Smart Parking System using Internet Of Things(IOT)", vol. 5(12), pp. 629-632, 2015.
- [10] Zhanlin Ji,Ivan Ganchev, Martin O' Droma and Xueji Zhang, "A Cloud - Based Intelligent Automatic Smart Parking System for Smart Cities", URSI General Assembly and Scientific Symposium, December 2014.
- [11] V.Venkateswaran, N.Prakash, "Intelligent Approach for Smart Car Parking Reservation and Security Maintenance System", Vol. 3, pp. 248-251, May 2014.
- [12] Ahteshamul Huq Osmani, Ashwini Gawade, Minal Nikam, Swati Wavare, "Research paper on smart city parking system", IJARIE, vol. 2 (3), pp. 2998 – 3000, 2016.
- [13] Renuka .R and Dhanalakshmi, S., "Android based smart parking system using total-location

- reservation”, IOSR Journal of Computer Engineering, vol. 16, pp. 3116-3120, 2014
- [14] S Suleyman Eken, A. S., “Smart bus tracking system based on location aware services and QR codes”, IEEE International Symposium on Innovations in Intelligent Systems and Applications (INISTA), pp. 978-981, 2014.