

Smart Parking System Based On Reservation

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Abstract: *With the increase of economic behavior and the upgrade of living standard, the ratio of people in India who own automobiles and motorcycles have recently increased giving a boost to Metropolitan Traffic. Therefore, parking issues will be a big challenge to facilitate traffic network and ensure urban life quality. Searching for parking space in most metropolitan areas, especially during the rush hours, is difficult for drivers. The difficulty arises from not knowing where the available spaces may be at that time; even if known, many vehicles may pursue very limited parking spaces to cause serious traffic congestion. In this paper, we design and implement a prototype of Smart Parking System based on Reservation (SPSR) that allows drivers to effectively find and reserve the vacant parking spaces. By periodically learning the parking status from the host parking database management in parking lots, the reservation service is affected by the change of physical parking status. The drivers are allowed to access this cyber-physical system with their personal communication devices. Furthermore, we study state-of-the-art parking policies in smart parking systems and compare their performance. The experiment results show that the proposed reservation-based parking policy has the potential to simplify the operations of parking systems, as well as alleviate traffic congestion caused by parking searching.*

Keywords: smart parking, modeling, simulation, QR (Quick Response) Code;

1. Introduction

Searching for a vacant parking space in a metropolitan area is the daily concern for most drivers, and it is time consuming. It commonly results more traffic congestion and air pollution by constantly cruising in certain area only for an available parking space. For instance, a recent survey [1] shows that during rush hours in most big cities, the traffic generated by cars searching for parking spaces takes up to 40% of the total traffic. To alleviate such traffic congestion and improve the convenience for drivers, many smart parking systems aiming to satisfy the involved parties (e.g., parking service providers and drivers) have been deployed. The current smart parking or parking guidance systems only obtain the availability information of parking spaces database which is managed by reservation authority, and simply publish the parking information to direct drivers. However, since these systems cannot guide the drivers to their desired parking destinations, even sometimes make the situation worse, they are not “smart” enough. For instance, when the number of vacant spaces in an area is limited, more drivers, who obtain the parking information, are heading for these spaces. It will cause server congestion. It is, therefore, strongly desired to provide an effective strategy to address these concerns.

In this paper, we design and implement the prototype of a Smart Parking System based on Reservation (SPSR) using android, It not only broadcast real-time parking information to the drivers as part of a communal application, but also to provide reservation service as part of user-targeted service. The drivers can retrieve parking information and reserve their desired vacant spaces via Wi-Fi or Internet. The rest of this paper is organized as follows. In Section 2, we discuss about several existing approaches and challenges for smart parking systems. In Section 3, we present the detailed architecture of proposed reservation-based smart parking system. In Section 4, we explained the results through extensive simulation. Future

scope shown in section 5 and paper concluded in Section 6.

2. Literature Survey

In this paper, we mainly focus on designing a new smart parking system that assists drivers to find parking spaces in a specific parking district. In addition, an important goal of the system is to reduce the traffic searching for parking, hence reduce energy consumption and air pollution.

2.1 State-of-the-art Parking Management

Traffic searching for parking comparison under different parking guidance strategies. Many parking guidance systems have been developed over the past decade [2][3]. In this subsection, we study several existing parking guidance approaches and explain their limitations. Furthermore, we simulate these different parking management strategies under realistic traffic and parking conditions, compare their performance, and show results in section 4.

2.1.1 Blind Search

Blind searching is the simple strategy applied by users when there is no parking information. In this case, the drivers keep cruising for parking spaces within a certain distance to their destination. The drivers will stop searching until finding any available space. Otherwise, the drivers will extend the searching area and continuously look for vacant spaces in the neighboring parking lots.

2.1.2 Parking Information Sharing (PIS)

This mechanism is commonly adopted by the current state of the smart Parking system design [6]. After the smart parking system publishes the parking availability information to the drivers in certain area, the driver will decide their desired parking destination where the parking lot has available spaces, according to the obtained parking

availability information. However, if the number of vacant spaces in a parking lot is very limited in busy hours, it is likely that the number of drivers in demand for these parking spaces, which is based on parking information. This phenomenon is called “multiple-car-chasing-single-space”, which may cause severe congestion.

2.1.3 Buffered PIS (BPIS)

To address the problematic “multiple-car-chase-single-slot” phenomenon, some designers of smart parking systems modify the PIS mechanism. They intentionally reduce the number of vacant spaces, when publishing the live availability information to keep a buffer. Therefore, though there may be more drivers pursuing the limited available spaces, the system has some extra spaces to avoid the conflict. But it is difficult to determine the number of the buffer spaces. If the buffer is too small, the problem of “multiple-car-chase-single-space” will not be eliminated. If it is too large, the utilization of parking spaces will be low.

As alluded to above, the blind search system is an open loop system, where users make decision without looking at the state of the system. The PIS and BPIS strategies allow drivers to make decisions based on the system state (e.g., parking availability information). However, the phenomena of multiple car-chase-single-spaces cannot be fully eliminated. To reduce the traffic searching for parking, we suggest a reservation based system, where drivers make reservations through the parking management system. If a driver makes the reservation successfully, it guarantees an available parking space for him, and the driver can park at the reserved space without searching. The reservation-based system allows drivers to select the most convenient parking space under their budget constraints.

2.2. Existing Parking Systems

2.2.1 Vision Based Method

Monitoring detection technology can be divided into two categories. The first estimates the number of remaining vacant spaces for the entire parking lot by counting incoming and outgoing vehicles. The second monitors the status of each individual space and can be used to guide a car to a vacant space. To detect the status of an individual parking space different methods have been utilized[15], such as ultrasonic sensors placed at each space (thus it requires many sensors), or surveillance cameras placed at a high position.

2.2.2 Sensor Based Method

Another detection technology uses sensors to detect vacant spaces in a parking lot. Different factors play a role in choosing the proper sensor, including size, reliability, adaptation to environmental changes, robustness and cost. Sensors technologies are categorized as either intrusive or non-intrusive.[16] Intrusive sensors need to be installed directly on the pavement surface, so digging and tunneling under the road surface are required. Non-intrusive sensors only require fixing on the ceiling or on the ground. Ultrasonic sensors are categorized as non-intrusive sensors.[17] Ultrasonic sensors transmit sound waves

between 25 kHz and 50 kHz. They use the reflected energy to analyze and detect the status of a parking space. Ultrasonic waves are emitted from the head of an ultrasonic vehicle detection sensor every 60 milliseconds, and the presence or absence of vehicles is determined by time differences between the emitted and received signals.

2.2.3 Two Tier Parking & Automatic Multilevel Car parking System

Two Tier Car Parking System is ideally suited for people having 2 cars.[18] They can use parking space for a single car to park both their cars using the Two Tier Parking System one above the other. The system consists of a single platform which allows the car that is not used very frequently to be parked on the upper level and the one that is used frequently on the lower level. G offers 2 variants for the Two Tier Parking System - Hydraulic System and Electro-Mechanical System. Automatic Multilevel Car Parking Systems can be fully automatic or semi-automatic. They can be manned or unmanned systems (i.e. operated manually or using computers). These systems can be installed above or below the ground thereby making optimum use of available space. Another advantage in this case is that human intervention is not required for parking the car.

2.3. Performance Metrics

In order to evaluate the performance of the strategies implemented in smart parking systems, we introduce the following metrics, which reflect the willingness of drivers, and our concerns on traffic congestion and environmental protection.

2.3.1 Walking Distance

Walking distance is defined as distance from a driver's selected parking space to the destination. This important factor reflects the willingness of drivers when selecting parking spaces. The driver commonly wants to choose the most convenient parking space where it is closest to his destination. In the proposed model of SPSR, the drivers select the parking spaces depending on this factor, which indicates their satisfaction.

2.3.2 Traffic Volume

In our proposed model, traffic volume is specifically defined as the amount of traffic generated by parking searching. This factor is not negligible and associated with the traffic congestion and air pollution. The proposed reservation-based smart parking system is design to reduce the traffic volume caused by parking searching, as well as satisfy the need of drivers. We investigate performance of the proposed smart parking system using these performance metrics.

2.4. Challenges

Given the design objectives of smart parking systems that require the coordination among multiple parties, we summarize the main design considerations as follows:

2.4.1 Fake Parking Requests

The system collects and stores the data about the performance metrics including the status of parking space, reservation time, parking location, driver's identity. All data stored by the system is at least stamped with time metadata. As the user is allowed to book only one parking space at a time from one id, it is a big challenge for us if user is trying to book one or many request at a time from one id. To overcome this problem we implemented a queue buffer which persistently checking the new request and compare it with the existing id requests. If any requesting id matches existing id then the request is directly discarded and a message showing 'no more parking spaces available' is displayed.

2.4.2 Users Identity Verification

Verifying users identity is a major security concern as users with no reservation can enter and occupy someone else's parking space. In our proposed system, the user can open the application and verify their identity via the received QR code. Reservation authority sends a QR code to the user as soon as user reserves the parking space. At the parking lot host identifies the user by scanning the QR code generated by authority management system.

2.4.3 Delay in parking

User reserves a parking space for specific time duration (Starting time & ending time). What if the user is unable to reach the parking spot at the aforementioned time? So to overcome this challenge, we provided the time extend option to the user, but user can only extend the time by 15 min from the specified time. User has to pay some extra money to extend the time.

2.4.4 Timer

As soon as reservation time is about to expire, user must be notified about this. To deal with this, SPSR gives prior notifications at regular intervals to the user. For example, if there are only 30 minutes left to reach the expiration time. SPSR will give notification when 20 minutes are elapsed and when 10 minutes are elapsed a final notification is given.

3. Proposed Methodology

In this section, we present the architecture and design of proposed reservation-based smart parking system, which implements a reservation service to reduce the traffic volume caused parking cruise.

3.1. System Architecture and Design

Fig. 1 shows three components in the smart parking model, including parking zones, users and the database smart parking system. The management system determines the parking prices and broadcast lives parking availability information to users (also drivers). Upon receiving parking information, the user selects desired parking lot and reserves a space. As soon as user reserves a parking space, SPSR generates a unique QR code and sends it to the user. As a result, the state of parking resources is changed by users parking decisions.

The parking lot consists of a group of parking spaces. The state of a parking lot is the number of occupied spaces versus total spaces. Every parking lot has access to the Internet to communicate with the management system and users, and share parking information with other parking lots. In each parking lot, the reservation authority is deployed for authenticating the individual user's identity and reservation request.

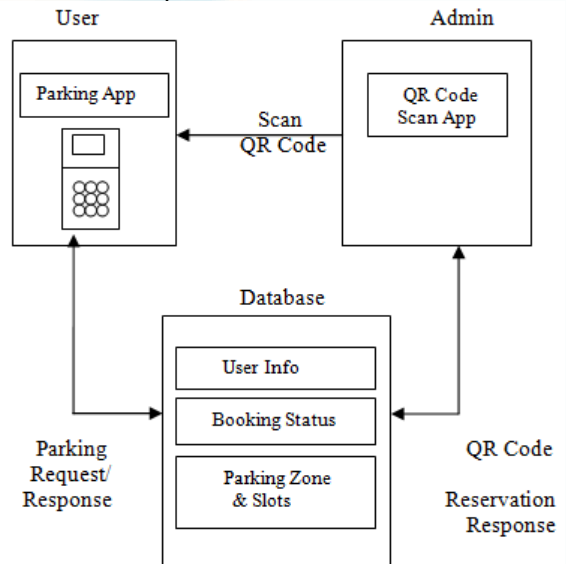


Figure 1: System Architecture

In this case, Reservation authority identifies each user by the unique QR code which has been send by the management system to the user at the time of reservation.

Once the reservation order is confirmed, the reservation authority updates reservation information to hold the related space for the user. Upon retrieving the parking information, the system updates the state of the parking lot. Based on the state of parking lots, the system (1) analyzes their occupancy status and congestion level, (2) determines the parking prices according to their pricing scheme, (3) broadcasts the prices to all users periodically, and (4) stores the parking information, QR code and prices for further analysis. The system serves as the centralized decision-making body in a planned economy. It makes all pricing decisions regarding the state of parking lots and user demands [14]. This system is a closed-loop system to dynamically adjust parking price, balance the benefits between users, and service providers and reduce traffic searching for parking. By placing the reservation authority on the gate each user has been identified by the QR code, when user reaches the parking spot. Host demands for the QR code and verify the details by scanning the QR code. Since user does not need to communicate with his desired parking lot host to make his reservation, rather he directly scan the QR code by host QR code scanner and verify the details just like a centralized system. Due to this the communication overhead of reservation is highly reduced. Also, since each parking lot manages its own reservation information, it makes the reservation requests from users easily to be synchronized, comparing with reservation synchronization in the system.

3.2. Hardware

The system hardware is organized into three main components, the QR code scanner, the central server and the mobile device, as shown in Fig 2. In the following, we discuss the detailed design and implementation of each component, along with the specification of communication between them.

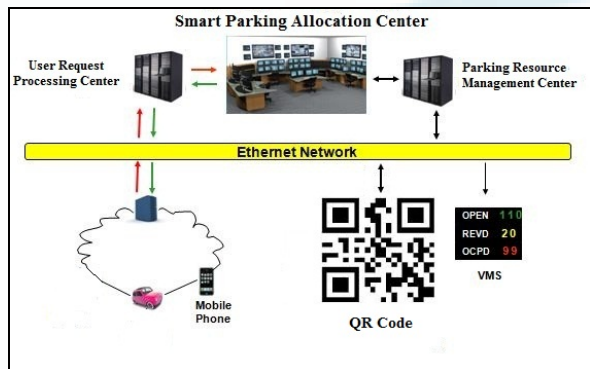


Figure 2: System hardware components

The system consists of 3 Hardware components viz. 2 Android Smartphone's and a Central Server. One Android Smartphone is for user which would have parking App and another one is for the admin at the parking lot for Scanning QR code. Both the Phones should have internet connection. The Central Server is connected to both the Smartphone's for performing various SQL operations.

3.3. Software

Fig. 3 shows the design of software architecture of user API, primarily defining the Android application, which is the central location of the system to user applications and functions also the Host application as the point of control and configuration for the distributed system. Primary software elements are discussed in the following.

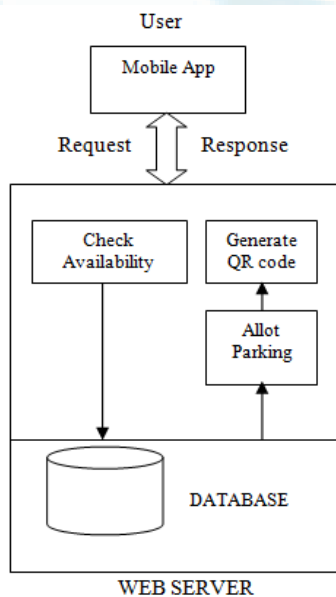


Figure 3: User API

Main System Architecture shows the parking of Smart Parking System based on reservation. The applications are build on Android Platform. Two different apps are used in SPSR. One is at the user end and another one is for the admin at the parking lot. The Parking app in the user's phone is used to reserve space in desired parking lot. User has to first create an account to be able to use the services provided. Once account is created, user can login with its mobile no as username and password. User can then select appropriate parking lot and check availability. If free spaces are available then user can proceed with space reservation. One user is allowed to reserve only one space.

For booking, user has to enter its vehicle's identification number with the start time and end time of reservation. Once Parking space is reserved, a QR code is generated which is used for authentication at the admin end. User is provided with a service that allows user to delay the start time (arrival time) by 15 minutes. If the user is not able to arrive within the extended time then the reservation is discarded. User is also given a chance to delay the ending time. Prior notifications are send to users phone to indicate that reservation time is about to expire (ending time is about to reach). User is then given a chance to extend the ending time. Additional Fares are calculated accordingly for the extended hours.

The app at the admin Fig.4 end is used to scan QR code generated in users parking app at the time of reserving space. This makes sure that only users with reservation are allowed to park vehicle. Once QR code in user phone is scanned and is found to be authenticated, database is automatically updated and respective Parking slot status is changed from RESERVED to OCCUPIED. Admin can see all parking slot details. Parking slots would be displayed as graphical boxes colored as Red, Green and White. Each color indicates one of the constraints. Green Indicates slot is reserved, White indicates that the slot is free and Red indicates expired slots. Such expired slots have the option of delete which would turn them into free slots.

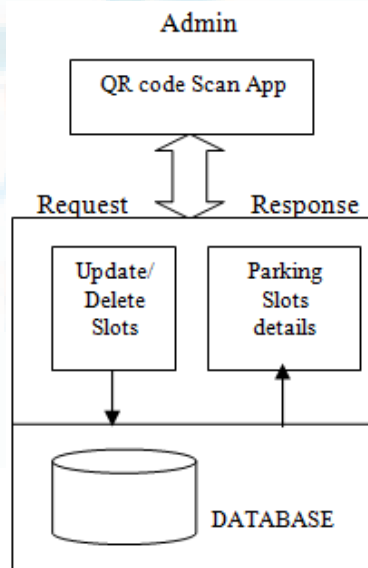


Figure 4: Admin API

4. Evaluation And Results

4.1. Parking Demand and Simulation

In the simulation, we use the real-world traffic traces to generate the parking demand. Here the parking demand is the number of drivers who need parking spaces in the target area. However, in reality, it is difficult to collect the traffic traces for parking in the target area. To monitor the incoming and outgoing traffic for parking in individual parking lot we have considered the no of request virtually, Here we make a general assumption that real total traffic for parking is proportional to the highway or street traffic. Although not all of traffic pursuing parking spaces in target area are from highways or street, and not all highway or street traffic need to park in the target area, the highway case can simulate the state of total traffic for parking. We classify the total highway traffic into incoming traffic and outgoing traffic, which represent the traffic approaching to and leaving from the target area. The incoming traffic serves as the reference of parking demand. Suppose we are having parking lot of 100 spaces and we are getting the request from the 120 users at the same time then simulation is done on the how many users from 100 gets the parking space and how much user not able to park the car because of delay or some reason, So remaining 20 user will get that parking space. If in such condition there are no parking spaces available and request are coming from users then waiting time of the user get considered based on how much time user has waited to park the car. We use the line graph of the incoming and outgoing traffic of the target area to calculate the waiting time for the users to park the car.

4.2. Simulation Set-Up

In our simulation, we use the map of D. Y. Patil Vidyanagari, Nerul as the target area, which is surrounded by the highway NH4. In this area, there are multiple Fig.5 illustrates the incoming and outgoing traffic in two different days. As we see, the peak time of incoming traffic is from 8am to 11pm, and the rush hour of outgoing traffic is during 4pm to 6pm. It matches people's regular schedule, in the morning most people drive to work and go back home after 5pm. Therefore, the traffic trace is reasonable to generate the parking demand in the simulation. So the time between 8am to 11pm having a more traffic so obvious request coming from the users will be more. To handle each user request in a heavy traffic can show the user satisfy with the parking service.

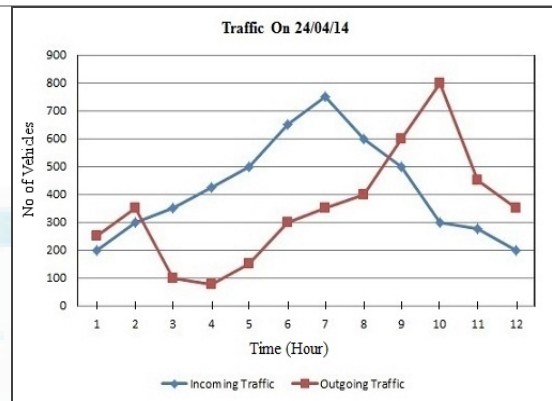


Figure 5: Incoming and Outgoing Traffic

4.3. Experimented Results

The following experimental results illustrate the efficacy and feasibility of the proposed Smart Parking System Based on Reservation (SPSR) in a cost-effective way as shown in Fig. 6

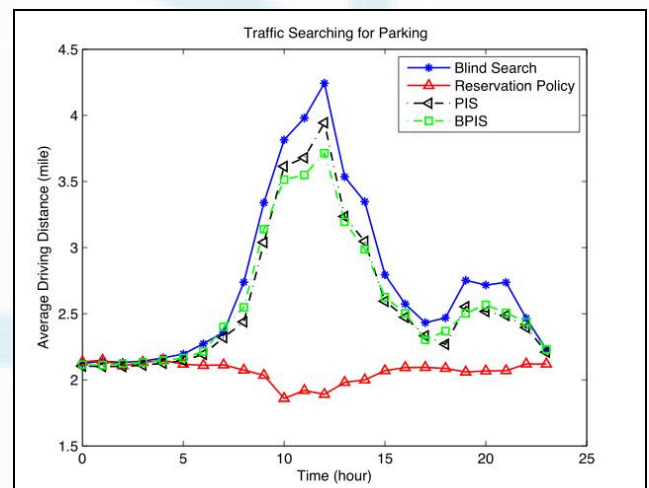


Figure 6: Traffic searching for parking comparison under different parking guidance strategies

We evaluate the effectiveness of reservation policy in terms of following perspectives:

Traffic Searching for Parking: The driving distance under blind search is the worst, especially during the peak hours; PIS and BPIS are better than blind search when traffic flows increase; and the reservation policy is the best compared with others. An interesting observation shown in Fig. 6 of reservation-based policy is that the average driving distance is decreasing at peak time, rather than increasing. That is because, after users learn the states of parking lots, they tend to reserve the nearest parking lot to their destination. During the peak hours, most parking lots are almost fully occupied in central area. Consequently, users have to select the parking lots in surrounding area, which are near to their start points. Therefore, it results in the reduction of average driving distance during the peak hours.

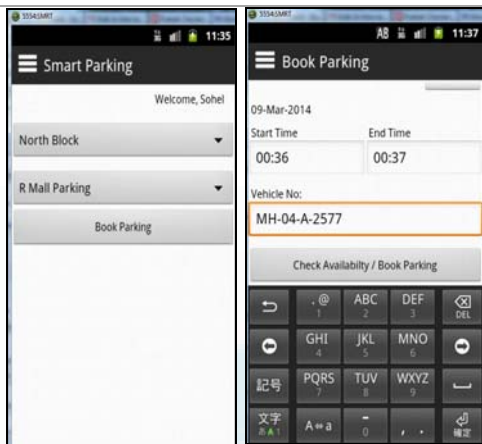


Figure 7: Reservation service

SPSR provides the web service to the drivers, as shown in Fig. 7. The system dynamically updates the parking and reservation information on the website according to the data stored in mirror database. The driver is able to obtain the real time parking information and complete the reservation from the web server.

5. Future Scope

As the paper shows User and Admin application we can embed the Google maps into application so it helps the user to see the direction through maps to reach the correct parking spot. GPS (Global Position System) help the user to find the co-ordinate and right path of the parking spot.

6. Conclusion

In this paper, we have developed a new prototype of Smart Parking System based on Reservation (SPSR) to optimize parking management. In this system, we implement parking reservation policy to balance the benefit of service providers and requirements from the users. Moreover, we have presented the detailed design, implementation and evaluation of the prototype. Based on the obtained results from our simulation study, we conclude that the proposed reservation-based smart parking system can alleviate traffic congestion caused parking searching and reduce the amount of traffic volume searching for parking.

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