

Resource Allocation using Game Theory to reserve a secure parking lot in Smart Parking System

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Abstract: The ever-increasing population has led to increase in city traffic. As a result, the process of searching a parking lot becomes tedious. It is time consuming task leading to discomfort. The fuel consumption is on an increasing side due to such scenarios. The increase in vehicular traffic creates a negative impact on the environment. In order to resolve these issues and satisfy the increasing demand for the parking areas, parking management organizations are trying to implement better and technologically advanced solutions. In proposed system, a new concept for a "smart parking" system is introduced. Two approaches are used for efficient selection of slot in parking system. One approach is game theoretic approach with reservation which helps to select cost efficient parking slot. This system allocates and reserves optimal parking spaces to drivers. The allocation is based resource selection game by considering each user's objective function that combines proximity to destination, current statistics of traffic and parking cost while also ensuring that the overall parking capacity is efficiently utilized. In the game, the gamers are supposed to be rational and pursue the max personal interest. The end of the game is to get Nash Equilibrium in which situation every gamer chooses the best strategy the parking lot based on parking policies mentioned. Fairness is also achieved by setting reservation period according to current statistics and releasing parking slot after timeout. Other approach is heuristic method needed to select alternate best parking slot with considering cost. Also protects privacy of users by avoiding the exchange of confidential information by using token approach.

Keywords: Smart Parking system, Game theory, Resource allocation, Fairness

1. INTRODUCTION

Increasing number of population and increases number of vehicles leads to several problems. On a daily basis, it is estimated that 30% of traffic congestion in an urban downtown area is caused by vehicles searching for parking space [1]. This not only causes waste of time and fuel for drivers looking for parking but also contributes to additional waste of time and fuel for other drivers as a result of traffic congestion. Traffic also causes burning gasoline and producing tons of carbon dioxide.

Lot of research has been done to increase parking efficiency and parking behaviour. Number of prototype models were developed to understand parking behaviour. Competitive alternatives are well known in advance to drivers in such model. Traffic authorities in many cities have developed parking guidance and information (PGI) systems for better parking management. PGI systems present drivers with dynamic information on parking within controlled areas and direct them to vacant parking spots. Parking information may be displayed on variable-message signs (VMS) at major roads, streets, and intersections, or it may be disseminated through the Internet. E-parking provide facility to reserve a parking slot before or during a trip. Bluetooth technology automatically

authenticate reserved parking space and parking payment.

Current parking system have several limitations. Mentioned as follows,

- Parking guidance system fails to provide a vacant parking slot to driver as there is possibility that all vacant space gets occupied before driver arrives destination.
- Though mobile application provides real time parking information but it may have safety and security issues as drivers need to be alert all the time.
- Even if a driver is successfully guided to a parking space, such a system increases the probability of finding any parking space at the expense of missing the opportunity for a better space.
- From the traffic authority point of view, parking space utilization becomes imbalanced. Parking spaces for which information is provided are highly utilized and cause higher traffic congestion nearby, whereas other parking spaces may be routinely left vacant.

Challenges for smart parking are stated as follows,

- Existing parking guidance system unable to find vacant parking spot but driver compete for

vacant slot. Vacant slot may get occupied by the time driver arrive.

- Existing system gives data about real time parking availability but driver need to take concise effort to get that information.
- Great majority of the reservation-based systems do not have proper reservation management, which takes a significant portion of parking spots "vacant" but "unavailable" and ultimately leads the systems "unfair".
- Driver may miss opportunity to get good parking space as existing system help to find any vacant slot.
- The system has to manage all of the parking resources, maintenance, and payments. It has to efficiently filter parking information through drivers' interests. If the drivers' interests are not well defined, the system shall be able to adapt and still provides a minimal level of service quality.

2. RELATED WORK

Many smart parking systems have been developed based on different technologies such as agent based, wireless sensor-based system, fuzzy logic-based system, GPS based system, vehicular communication-based system, vision-based system and hybrid system. First Automated parking come in existence in 1920 in U.S. cities. In Japan in 1923. In 1983 Automated Parking Automated Parking garage was built in New York. Parking System Summary of national and international smart parking system is given in Table 1.

Driving on Indian roads is not easy and even worse is the struggle to get a parking space. With the growing population of vehicle owners in the country, the alarming parking issues have highlighted the importance of smart parking solutions that India seriously needs now.

Table 1 Smart Parking System

Sr. No.	Name of Project	City	Launched	Features
1	MOBINET	Munich	9/1998	Event Oriented Forecasting model for on-street and off-street parking
2	PARK Smart	New York	10/2008	Street line adopts a time synchronized mesh protocol (TSMP) to allocate bandwidth for each device according to an anticipated frequency-time schedule.
3	SFpark	San Francisco	4/2006	75% occupancy rate is achieved in any parking area by a dynamic pricing policy.
4	Park Right	London	10/2012	It analysed the on-street parking data in Melbourne to find out parking violations, that is, all the parking behaviour that do not comply with the parking rules.
5	Nice Park	France	1/2012	Collect parking information and provide extra traveling information so that drivers can choose an alternative transport from their parking spaces.
6	Berlin Pilot	Berlin	9/2015	Siemens and its partners have developed a radar sensor system that offers drivers a quick, hassle-free way to find vacant parking spaces in the urban area.
7	Parkzebra	Bengaluru	9/2017	ParkZebra helps company perform better by adding ease and efficiency to campus parking through IoT technology.
8	GetMyParking	Delhi	7/2015	Serve all stakeholders involved for better urban mobility by planning, designing, integrating, executing, and maintaining smart parking ecosystem suitable to that city
9	ParkingRhino	Bangalore	2014	ParkingRhino provides real time smart parking solutions with business analytics and real time dashboard.
10	ParkWheel	Gurgaon	2015	It provides customized smart parking solution for corporates, apartments, malls, societies etc. through intelligent RFID system.

In Table 2 different technologies used for smart parking system are studied and analysed.

Sr. No	Technologies	Features	Services Provided
1.	Agent Based	1 Dynamic Distribution and Complex Traffic Environments	Bargaining, parking guidance and route negotiation etc.
2	Fuzzy Based	Human-like intelligence and expertise	Intelligent parking methods e.g. parallel parking and perpendicular parking etc
3.	Wireless Sensor Based	Low cost implementation with lower power consumption	Detection and monitoring of the parking facility etc
4.	GPS Based	Real time location-based information and guidance towards destination	Provides information about the locality and availability of parking facility
5.	Vehicular Communication	Provision of parking information distribution service for mobile vehicles	Antitheft protection, real time parking navigation service etc
6.	Vision Based	Good for car searching in large parking lots Lot occupancy detection	parking space recognition, parking charges collection etc.

The system assigns and reserves an optimal resource (parking space) for a user (driver) based on the user's objective function that combines proximity to destination and parking cost, while also ensuring that the overall parking capacity is efficiently utilized. The allocation is updated at the next decision point ensuring that there is no resource reservation conflict and that no user is ever assigned a resource with higher than the current cost function value. All methods assign a single user to one server/resource at a time and aim to minimize a user delay cost metric. In this problem, multiple users are allocated to multiple resources and a key objective is the average minimum user cost.

From other point of view, in researchers have used the games theory to design a parking guidance system. The main focus of researchers is on the influence of the amount of information on drivers' decisions. The game is changed by manipulating payoff matrix so that a driver's failing costs also influences a winner driver's cost. Due to this, drivers try to cooperate with each other to decrease their own costs as far as possible. In this method the competing players' final costs are reduced and therefore the efficiency is increased. Researchers have defined a condition of the game in which drivers utilize other driver's information (in other locations) to find a space as close as possible.

3.. METHODOLOGIES

Proposed parking consists of two main models, architectural model and software model. It consists of following modules,

- *User interface module:* It manages the communication with the customer, for example, accounting, reservation, cancellation and billing. This module communicates with the function module through the communication module.
- *Communication module:* This module simplifies the communication process and performs error control, for example, verifying the checksum and correcting errors.
- *Function module:* It maintains information about the registered customers, state of each parking spot: 'available', 'reserved' or 'occupied', current parking reservations, record of transactions for each customer, such as past reservations, usages.
- *Parking space controller module:* It consists of sensors, and a unit controller. This system is triggered when a car parks or leaves the parking spot. When a customer parks/ leaves car in/from the parking space, the sensor detects the action and sends information to the unit controller that triggers proper actions
- *Monitoring module:* The current status for each individual parking spot is recorded in the relational database. This module periodically queries the database for reservations and determines if some customers did not arrive as scheduled by their reservation.

- *Control module:* It processes the information and sends the information to Centralized supervisory system.

billing information and directional details to the user's mobile phone.

The realization of a “smart parking” system relies on four main requirements,

- Parking Space detection
- Vehicle-to-infrastructure and Infrastructure-to-vehicle communication
- Reservation Guarantee
- Optimal Allocation

Efficiency of parking guidance system is improved by using proposed system by achieving fairness. In given proposed system, decision making process for choosing the parking space has been done using two methods: Dynamic resource allocation based on game theory and priority heuristic. In first method, parking cost is minimized based on available information and fairness is achieved by monitoring reservation period. Second method help to find alternate parking space which is not best but good. The proposed system helps to find relatively alternate parking space with lower cost. The proposed system maintains privacy of user by using token system using anonymous credential systems and certificateless public key cryptography.

4. CONCLUSION

A “smart parking” system is proposed that exploits technologies for parking space availability detection and for driver localization and that allocates parking spots to drivers instead of only supplying guidance to them. The system focused on determining an efficient and optimal allocation strategy for both users and the system by using game theoretic approach to minimize cost and enhance fairness. Heuristic models to search best alternate parking space. The designed models were compared to previously designed works on the four aspects of total number of drivers, the number of on-street parking spaces, and the difference in costs between on-street and private parking and security of user. The influence of each factor on the efficiency of the system was compared. In the parking space selection game, since the number of drivers that participate in the competition has been chosen much more optimally in comparison to previous works the efficiency of the model was also much higher than them. In priority heuristic gamble, since in previous works the number of competitors was selected without paying attention to the number of on-street parking spaces, the number of drivers who failed was very high. In this model this weakness is covered and the number of competitors is selected in a smarter way. This can

- *A displaying unit-* It receives information of parking space from the controller. It then sends the information such as slot allotted, time parked, reduce traffic to great extent and fuel consumption considerably in large cities.

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