Ticket based Smart Parking System using Mobile Application in Vehicular Network

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Abstract
The aim of this research work is to propose ticket based smart car/vehicle parking system using Internet of Things (IoT) along with mobile application in vehicular network. Smart Parking mobile app helps in finding a slot to park the vehicle using live information that is obtained from the sensors placed in the parking area. Initially the number of available parking slot in the parking area is calculated and the parking tickets are generated for all the parking slots. To avoid the occupancy of already booked parking slot by a random person, ticket based parking slot allocation is proposed here. Detection of available parking slot is done by using communicative method by considering the total number of parking spaces, number of vehicles parked already, number of cars waiting to park, number of vehicles that about to leave. All information’s like slot allocation, slot direction and billing are collected by the sensors that are placed in each parking row and sent as a message to users mobile phones.

Keywords: Smart Parking System, Mobile Application, Communicative Method, Ticket Generation, Internet of Things.

Introduction
An intelligent smart vehicle/car parking method (or) Smart Parking System (SPS) was developed for managing the traffic that occurred during vehicle parking so that the overall parking capacity is efficiently utilized [1]. This intelligent parking scheme reduces cost of man power and optimal resource utilization for car-park owners. In general vehicle users tries to find a parking place in roadside’s to park their vehicle through experience and by luck they get parking spaces in the streets too. However this process cannot be carried out in existence of high density vehicles in cities. In this case a predefined vehicle park can be found with elevated capacity. Though this process cannot offer optimal solution since vehicle parking could usually be located at some distance from the client/user end.

In current years, vehicle-to-vehicle [2] communication method is used for collaborative route detection to reduce traffic congestion and vehicle-to-infrastructure [3] that manages the parking slots with full cooperation by taking support from the different method of wireless technologies, the communication between them takes place using devices like Zigbee, wireless mesh network, Radio Frequency IDentification (RFID) and Internet [4] that uses IoT for guides city parking management using multi-level multi agents. Conversely, the current SPS not providing an overall optimal solution in detecting empty parking space and does not provide economic benefit, in addition the response time is too high. To resolve the aforementioned problems ticket based smart parking network with mobile application using IoT was proposed. This method proposes and develops an effective ticket based smart parking network that reduces overall response time as well as provides optimal directions to the vehicle parking destination to the user based on IoT.

Related works
Fog computing-based smart parking architecture [5] was proposed to develop SPS in real time environment seeing as VANETs based parking slot allocations are lag in providing better solution since communication between vehicles has lack computational capabilities in providing precise service provisioning. Hence Fog hubs sent at parking areas, helping out one another, empower ongoing parking space data provisioning just as processing the parking requests sent by the user.
The cloud community can additionally upgrade SPS by authorizing worldwide enhancement on parking demands allocation, for example, continuous parking slot openings data. Reservation protocol [6] was proposed to spread the occasions productively with respect to accessible empty parking space. This framework can assign parking spots in VANETs and keep away from the opposition among vehicles. This methodology advances the parking spots to determined vehicles that maintain a strategic distance from the opposition. However, proper selection of vehicles for sending parking lot status is very crucial; this is because a fair parking slot should take into account several factors. Intelligent Parking Service (IPS) [7] commonly provides an agent for SPS that is liable for gathering the dynamic info and complex traffic data. IPS is a part of Intelligent Transportation Systems (ITS) and it reviews various kinds of services that is used for parking guidance, parking facility management.

Smart Parking Allocation (SPA) algorithm [8] was proposed to boost the advantages made by a given parking space while ensuring the nature of parking services. SPA calculation predicts the driver conduct and assessed future parking traffic on basis of considering the past authentic parking records. These forecasts help SPA to all the more likely match the parking requests and the asset of accessible parking networks. Thus improves the usage and makes the parking service more advantage. Though there exists a huge issue on the most proficient method when utilizing sensor information to oversee parking infringement and violations effectively in a brief time-frame window. A formulation for travelling officer problem was created with a general probability-based model [9]. Here a large real-world dataset with on-street parking sensor data from the local city council is taken into consideration. Two solutions using a spatio-temporal probability model for parking officers was considered here to maximize the infringing cars count that caught with limited cost of time. The on-road parking framework is an essential piece of city ventures, as it furnishes voyagers and users with parking spots.

A two-stage approximate dynamic programming framework [10] was introduced to decide the ideal charging methodology, using the anticipated transient future data and long haul assessment from historical information. All the vehicles are wanted to be charged to full preceding the departure time determined under compelled complete charging limit. The uncharged sum is dependent upon a noteworthy punishment cost. Recreation situations are made by displaying the vehicle appearance conduct as Poisson measure, including appearance time, takeoff time, and appearance condition of charge. New SPS [11] was proposed on premise of using intelligent resource allocation, reservation, and pricing. This framework offers the considerable solution for parking issues by offering ensured parking reservations in prior with the most reduced conceivable expense and scanning time for drivers and the most noteworthy income and asset use for parking supervisors. Also fair pricing policies are also introduced for this system based on mathematical modeling using Mixed Integer Linear Programming (MILP) with the target of limiting the all out fiscal expense for the drivers and boost parking asset use.

GIS based Nearest Pocket for Prices Algorithm (NPPA) [12] was proposed and it was a spatially express calculation mostly settled for on- and off-road parking costs that ensures a predetermined uniform degree of occupation over the whole region. NPPA was applied at setting up versatile parking costs that ensure 90% parking inhabitancy in the Israeli city of Bat Yam. The parking costs can be set up for the Autonomous Vehicles (AV) at a goal of a link that exists through the streets, though for the human drivers adequately huge zones of the uniform parking costs are best. So as to address the issues in decrease of the parking impression of vehicles, utilizing on charge and low-level driving robotisation to dramatically increase the vehicle density that left in a given territory a practical framework was proposed [13]. Here the initial two represented for the development of business opportunities, the later inquiries represented for the private responsibility for vehicle. An alternate methodology of vehicle coordination dependent for huge scope datasets of parking slots in particular situations and under differing request designs was assessed.

A precise and ongoing video framework for future IoT and keen urban community’s applications was proposed [14]. The data is joined here utilizing Deep Convolutional Neural Networks (DCNNs) and vehicle following channel over numerous picture outlines in a video arrangement. This procedure mainly focussed in evacuation of commotion that is presented by impediments and detection failures. Congestion balancing parking guidance system was proposed [15] that give that
provides guidelines to the driver to chase after the ideal objective with the mean to diminish the absolute separation that is voyaged while looking for a free parking space. The framework requires just restricted foundation data, and neither requires parking spots to be instrumented, nor vehicles to speak with one another. In particular, the framework uses stopping opening data on every road. The framework likewise represents the additional expense of not finding a free space, which is normally communicated as the extra separation that should be ventured out to locate an accessible parking space.

A calculation that builds the productivity of the current Cloud Based Smart Parking System (CBSPS) [16] was suggested that creates and organizes the design dependent on IoT innovation. This framework encourages clients consequently to locate a free parking spot in any event cost dependent on new execution measurements by estimating client parking cost with regards to separate and the absolute number of free places in every vehicle leave. This cost will be utilized to offer an answer of finding an accessible parking spot upon a solicitation by the client and an answer of recommending another vehicle leave if the current vehicle leave is full.

A distributed Parking Slot Allocation Framework (PSAF) [17] based on adaptive pricing algorithm and virtual voting was proposed. This model was developed on premise of thinking about virtual voting and hashgraph agreement calculation. Whole clients and parking area proprietors can without much of a stretch come to agreement irrevocability by using this circulated PSAF technique that uncovers about the assignment of a parking spot with the utilization of negligible data transmission. This PSAF model gives a reasonable, quick and cost-ideal stopping opening designation strategy. The ideal requesting of portion demands is additionally kept up dependent on agreement timestamp. A versatile evaluating model was proposed notwithstanding improve the general income of the parking area proprietors and comfort of the clients/users.

Proposed Method

Ticket based Smart Parking System using Mobile Application (TSPSMA) is proposed to park the vehicles in an efficient way for Smart Parking Applications. The parking network includes sensor nodes that act as routers as well which passes the information that form as the infrastructure for associated users. Smart Parking Network (SPN) infrastructure that allows sensor networks to be connected through wireless technologies. The sensor nodes itself a self-configuring and self-healing linked network. Sensor nodes are connected to the Internet by gateway functionality through the linked server.

Detecting the available or empty parking space upon a request by the user and providing a solution for searching a new car park network if the current SPN is full. The availability of parking slot is requested by the user through mobile app that requires internet connection. The request is sent to the parking server which stores the detailed information or database of the parking area. The sensors used here is ultrasonic devices that collects the data about the parking slot which is empty or allotted or about to free. The server passes the user’s request to the sensor through wireless medium. Then the requested information is passed to the user through the mobile app from the sensor through the server with the help of gateway or internet connection. Block diagram of TSPSMA is given in figure 1.
Smart Parking app (mobile application) works by reading the current location of smart_phone using GPS that helps in directing the user’s parking space location. On basis of parking space availability the tickets generated for each parking slot and allotted for the prior registered user. Registered vehicles may be parked in the available space and the user may locate the car at any time using the mobile application.

Smart parking app gives precise information regarding available parking space. Each parking slot marker on the map displays a colour and the number of available parking spaces. Communicative method helps in detecting the available parking lot by communicating with sensors. The parking tickets are generated and stored in the database with their respective serial number. The vehicle which entered into the parking area will get the online parking ticket with respect to the serial number. Tapping a map marker will disclose the parking spaces information in that particular area. This detail about the parking spaces includes processing period, tariffs, and previous features.

The parking space with respect to their parking slot ticket can be detected either by entering an address or by using user’s current location through mobile app. The ticket generated for the user if parking slot is available, else the user gets a message regarding unavailability of parking slot. Then the user finds an alternative parking places in case of not receiving parking ticket to his preferred destination. Smart Parking app gives the directions for the selected or allotted parking location which connects turn-by-turn application which is already available on user’s smart-phone.

The parking tickets are generated on basis of the size and type of the vehicle with a particular serial number assigned for the particular vehicle. If the user in need of parking slot to park is vehicle he/she should login to the system through mobile app. Once SPN login is done successfully by the user then the request message is sent to check the availability of free or empty parking slot. Then the system searches for the available slot and send back a response note with the slot information which includes ticket with particular serial ID, parking slot ID and the directions (turn-by-turn) to reach it. Vehicle parking choice is done based on the function $F(\lambda, \gamma)$ which is calculated using vehicle’s current location and the allotted parking slot location. The SPN forwards with minimal $F(\lambda, \gamma)$ probability value in order to park the vehicle if the current SPN is going to be full in order to reduce the response time (wait time).
Algorithm of TSPSMA

**Input:** User Request() for Parking Slot Allocation()

**Output:** Vehicle parking successful if parking ticket ID matches with Parking slot ID

**Begin**

Vehicle reaches SPN

Sensor read data → {Parkslot_ID, Count}

Vehicle raise Park Slot_req();

Identify vehicle's type & size

Search Allocation Parkslot() → {Parkslot_ID, Type, Size}

Update → Server_Collect info()

**Ticket Generation**

Foreach Park_Slot generate Parking_Ticket();

ParkSlot_ID → ParkingTicket_ID();

Filter parking options → type & size

User receives response_msg() with parking ticket_ID through Mobile App

User can enters into SPN only if ParkingTicket_ID → ParkSlot_ID();

**Successful Vehicle Parking**

Mobile_App receives parkslot() direction details

Vehicle follows received parkslot info();

Reaches the allocated parkslot using received info() through Mobile_App

If only one parkslot() available;

SPN forwards minimal F(\(\lambda\), \(\gamma\)) probability value to prior user with parking ticket ID

Prior user can enter into SPN and park the vehicle in his respective parkslot()
When user gets reached to the SPN then he/she must be checked with the parking ticket to enter. The parking toll only opens when the generated ticket serial ID gets matched with the sensor parking slot ID that already stored in the server database. Parking slot info() gets updated for each particular timestamp() respectively.

**Figure 2: Flowchart of TSPSMA**
If the changes in the value of the Parkslot occurs then the percentage of the total free parking spaces gets changed and updated in the server through the sensor node, this server will send a message with the updated information to the currently connected mobile app user. The flowchart of the proposed method TSPSMA is depicted in figure 2 that clearly explains the flow of the proposed work.

**Results and Discussion**

The simulation tool used to simulate the proposed and conventional schemes is Network Simulator-3 (NS-3). NS3 evaluates the proposed mechanism of ticket based smart parking management using IoT scheme with the considered conventional schemes such as CBSPS and PSAF. Standard Ethernet protocol of IEEE 802.11 MAC is used with the data rates of 10 Mbps for simulation function. Data traffic model considered here is constant bit rate that is used along with random way point mobility model for movement of vehicles or cars. The performance metrics that are used to evaluate the scheme are loss rates of packets, Peak SNR, Average delay, congestion rate and response time. Remaining parameters are described in table 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation Time</td>
<td>50s</td>
</tr>
<tr>
<td>Number of vehicles</td>
<td>100</td>
</tr>
<tr>
<td>Simulation Area</td>
<td>1000x800</td>
</tr>
<tr>
<td>Communication Range</td>
<td>250m</td>
</tr>
<tr>
<td>Type of Antenna</td>
<td>Omni Antenna</td>
</tr>
<tr>
<td>Data Rate</td>
<td>CBR</td>
</tr>
<tr>
<td>Channel Type</td>
<td>Wireless Channel</td>
</tr>
</tbody>
</table>

**Packet Loss Rate (PLR)**

Loss rates of packets is defined as the packets that lost during loss ratio of packets occurs due to route unavailability and congestion scenarios. PLR measurement is carried out by calculating total number of lost packets at receiver end to the total packets sent from the source node. PLR estimation is done using equation 1.

\[
PLR = \frac{\sum_{0}^{n} Pkts\ Dropped}{T}
\]  

(1)
Figure 3: Packet Loss Rate

The figure 3 represents PLR of proposed TSPSMA and conventional schemes CBSPS and PSAF. PLR of TSPSMA has low loss rates of packets compared with the conventional schemes. TSPSMA mechanism detects low packet loss that results in low congestion rate as well while routing the information therefore it improves the system throughput.

Congestion Rate

Congestion rate is defined as the rate that occurred during packet transmission over the data channel between the nodes. Network congestion occurs due to low data rate transmission channel. Congestion rate for both the proposed and conventional schemes are plotted in figure 4 that is observed in simulation. The proposed scheme TSPSMA obtains lowest congestion rate (that results in high rates of packet deliveries at the receiver end or vehicle user) while compared with the existing schemes such as CBSPS and PSAF.

Figure 4: Congestion Rate

Peak SNR

Peak Signal to Noise Ratio (Peak SNR) is evaluated to determine the quality level of video of parking location and direction which is obtained through mobile app along with their processed video sequences. The video quality range for the proposed method TSPSMA has better quality that
is measured in terms of dB. The video quality that is achieved is dependable on basis of scheduling of packets with higher priority.

Figure 5 describes shows peak SNR values of the proposed and conventional scheme outcomes during vehicle and parking server communication. The obtained peak SNR values are comparatively low for the proposed TSPSMA scheme while comparing with the schemes such as CBSPS and PSAF. Therefore the proposed mechanism stood the better results in the analysis of communication overhead by taking in account of SNR outcome.

![Figure 5: Peak SNR](image)

**Average Delay**

Average delay is defined as the delay or difference of time that occurs during sending and receiving of packets. The average delay between the packets sent and packets receiving time is measured using equation 2; here ‘n’ denotes number of nodes.

\[
Avg \ _{\text{Delay}} = \frac{\sum_{0}^{n} (PktRecvTime - PktSentTime)}{n}
\]  

(2)

Figure 6 is the graphical representation for average delay that shows delay measures for both proposed and conventional schemes. The proposed scheme TSPSMA has lower delay values compared to the conventional schemes CBSPS and PSAF. The least value of obtained delay characterizes that larger value of the throughput.

![Figure 6: Average Delay](image)

**Response Time**

The response time of proposed TSPSMA system is better than the conventional schemes which are
plotted in figure 7. If the response time is faster then it indicates that the wait time of the user will be automatically reduced.

Figure 7: Response time

In this proposed method the sensor participates equally and gives timely information to the gateway as well as users. TSPSMA scheme obtains better response time when contrasted with the conventional methods such as CBSPS and PSAF.

Conclusion
Ticket based smart parking system using mobile app is proposed here which helps in finding a slot to park the vehicle using live information that is obtained from the sensors placed in the parking area. In order to avoid the occupancy of already booked parking slot by a random person, ticket based parking slot allocation is applied. The number of available parking slot in the parking area is calculated in prior and parking tickets are generated for all the parking slots respectively. Empty parking slots are detected using communicative method by measuring total number of parking spaces, number of vehicles parked already, number of cars waiting to park and number of vehicles that about to leave. Therefore each and every data’s such as slot allocation, slot direction and billing are collected by the sensors that are placed in each parking row and sent to the users through mobile app. Simulation results proves that the proposed scheme TSPSMA has better outcome while analysing the performance metrics with desirable achieved throughput.

References