Internet-of-Things Based on Smart Car Parking System in Traffic Congestion

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ABSTRACT

Billion objects and services can be connected through the Internet of Things (IoT) at anytime, anywhere, and for a variety of purposes. The existence of smart cities is now a verified issue that requires in-depth research. One of the main issues with smart cities is traffic congestion from the large number of cars on the road, which makes it difficult to find parking and causes people to arrive late for work. This study examines the IoT smart parking system, which is comprised of sensors and other distance-measuring devices linked to a WiFi-enabled networking device. It is also part of a smartphone application and cloud service that provides users with the information they need to locate an empty parking space. The study suggests a smart car parking system that will help consumers find parking spots and cut down on the amount of time they have to spend looking for the closest lot. It also gives users the status of traffic congestion on the roads. This expense will go towards providing the user with a way to request a parking spot when one is available, as well as a way to recommend a new parking lot if the present one is filled. The program reduces user waiting time and increases the likelihood of successful parking, according to the simulation findings. Additionally, we successfully put the suggested system into practice outside of the lab.

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1. INTRODUCTION

Globally, there are more cars on the road, which is a reflection of the world's tremendous industrial progress. From 841 million automobiles in 2008 to over 1.6 billion cars in 2035, it is predicted that there will be substantial growth in the global car population. Governments are striving to upgrade their current transport systems and infrastructure since there is a shortage of available parking spaces in many public venues these days, including stadiums, marketplaces, hospitals, retail stores, and airlines [1]. But municipal planning's glacial pace of development has made the problem much more widespread. In most modern cities, finding empty parking spots is a regular difficulty, particularly during busy periods like festivals. People visit their automobiles, which leads to a high number of cars contending for a few available parking places and security for their parked cars. This problem primarily arises in modern cities.

Additionally, finding an empty parking space takes up a lot of time in indoor parking lots, which clogs the traffic. When each parking lane has several parking spaces, the situation gets worse. Air pollution from stopped cars, whether in indoor or outdoor parking lots, is another problem. The majority of people also drive their vehicles for transportation, which increases traffic in urban areas and makes it more difficult for other drivers to locate a spot. Efficiently reducing data transmission costs and saving energy while delivering real-time information fast is a critical issue that needs to be addressed right away. The necessity for a new method of locating open parking spaces has led to an increase in interest in smart car parking systems in several nations.

The Internet of Things (IoT) can address these issues since it can be built to collect sensor data for smart city points of interest monitoring. Researchers have recently looked into the possible applications of the Internet of Things in urban computing and public transportation. To give drivers real-time information about adjacent automobile parking bays that are available, several models have been proposed. Additionally, a few of them suggested a way to gather data and send it to a cloud processing center, which would then determine the answers and deliver them back to the parking lots. There are very few studies that have collected data on available on-street parking spaces for cars more efficiently.

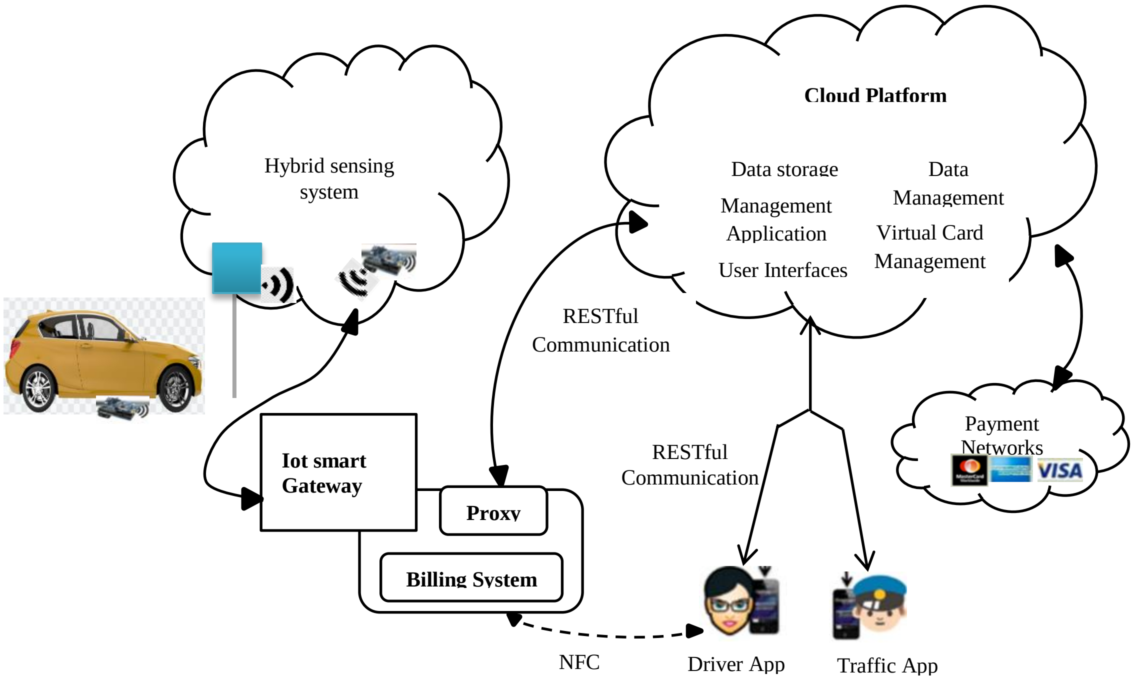

Figure 1.1. General Architecture of Smart Parking Systems

The research conducted to date has concentrated on cloud computing rather than in-network level processors [2]. Implementing the SPS design by the architecture depicted in Figure 1.1. As can be seen, it consists of four primary components: (1) the cloud platform; (2) the IoT Smart Gateway; (3) the Hybrid Sensing Network (HSN); and (4) the user interfaces for data management and visualization. Furthermore, even though the payment network (5) development is clearly outside the purview of our work, it has been reported for completeness.

Nowadays, it's never easy for drivers to locate a parking space in a city; this problem only gets worse as more and more people drive private vehicles. This presents a chance for wise communities to take steps to improve the effectiveness of their parking assets, which will decrease the amount of time people have to look for parking, reduce traffic, and reduce fatalities [3]. If drivers are aware in advance of the abundance of parking spots at and around their intended location, problems related to parking and traffic congestion can be resolved. The development of new Internet of Things applications is being aided by recent developments in the production of low-cost, low-power embedded devices.

As a result of advancements in sensor technology, numerous contemporary cities have chosen to install a variety of IoT-based monitoring systems inside and outside of their borders. There are more creative ideas for parking systems, according to a recent survey conducted by the Global Parking Academy.

Our proposed smart parking system makes use of a cloud-connected mobile application to provide real-time parking space availability information to users. The remaining sections of the paper are structured as follows: Section 2 discusses the factors that lead to Cloud-IoT integration; Section 3 presents the state-of-the-art in smart parking system technology; Section 4 explains the system's implementation and operation; and Section 5 concludes the paper.

2. LITERATURE REVIEW

Hilmani, A., et.al [4] In this research, a mobile sensor network comprising detection nodes, sink nodes, and gateways are proposed as a means of implementing a novel parking monitoring system. The purpose of installing detecting nodes in the middle of each parking space is to send their availability conditions to the parking control server. The self-organization protocol used in this system forms a star topology, enabling data to be sent from every detection node to the sink node in just one hop. Due to its tendency to quickly emission the farthest nodes during a single leap to the sink node, this approach is not suitable for managing linear parking or large parking lots. This will have a detrimental effect on both the system's dependability and communication performance.

Nguyen, D. B., et.al [5] As the Internet of Vehicles (IoV) develops, a growing number of sensors and cars are likely to connect to the network constantly, which could provide a network bandwidth issue. This makes the development of appropriate lightweight protocols for use in IoT environments important. Among the most developed options for this is MQTT. MQTT, as opposed to HTTP, can reduce energy usage and communication delays in the automotive environment by removing pointless communications through the use of a publish/subscribe architecture for polling information. The concept intends to be applied to crowdsourced-based smart applications, including smart parking in urban areas or smart trip planners.

Zhang, M., et.al [6] An enormous amount of unorganized information will be produced as the Internet of Things develops quickly. These are rapidly expanding data sets. The data exhibit complexity and polymorphism, with no discernible pattern or association among them. However, the demands of society's rapid development are beyond the capabilities of conventional data gathering, analysis, storage, and processing technology. An enormous amount of unorganized information will be produced as the Internet of Things develops quickly. These are rapidly expanding data sets. The data exhibit complexity and polymorphism, with no discernible pattern or association among them. However, the demands of society's rapid development are beyond the capabilities of conventional data gathering, analysis, preservation, and processing technology.

Taiwo, O., et.al [7] The improvement of energy leadership, home safety, environmental control, and other features of smart automated homes has been the focus of several research studies and published works of literature. In the realm of IoT, machine-learning techniques have also been used for analysis, prediction, and categorization. This section includes articles on the Internet of Things that are related to artificial intelligence in intelligent systems and smart home management. The instructions required for home control are provided by a base station. Additionally, a smartphone app with a graphical representation of sensor readings was created to interface with the cloud computer, the base station, and the satellite station for comprehensive home control.

Balfaqih, M., et.al [8] only driver preferences and demand are taken into account by the current systems. The criteria used to make the selection must minimize traffic, maximize parking usage, and ultimately increase revenue. On the other hand, parking lots often use a fixed hourly fee for temporary parking and a fixed membership charge for long-term parking. This pricing model does not generate a lot of income. Periodically, the fixed rate is determined using the historical occupancy rate. Such an approach results in less-than-ideal pricing since it ignores parking availability and need. Thus, to address the aforementioned problems, this study describes the planning and creation of a multi-layer IoT-based smart parking system. Various parking plans are taken into account by the system, such as a long-term driving plan and a short-term driving plan with or without advance registration.

Atiqur, R. et.al [9] Finding a parking spot during rush hour in cities is a challenge. For this reason, I've suggested an online method for booking parking spaces. These companies allow you to reserve parking spaces in advance, just like you would when booking an online train ticket. Parking spots can be reserved by users through a laptop or mobile application. The booking procedure was detailed by the algorithm above. Users receive information about parking availability from the information server; if any spots are available, the operator can book the desired time slot, settle any outstanding fees, and verify the booking slots. If an employee does not find the empty spaces then after a period he/she might request again for unoccupied slots.

Mouhcine, E., et.al [10] To govern and manage the traffic channeling system and create some ideal routes for vehicles and direct them towards the available parking, additional approaches have been developed to address the issues with traffic jams. These solutions involve the use of big data, cloud computing, and internet connectivity of vehicles. This article presents a revolutionary method for scheduling cars to arrive at their destinations—including parking spots—in the shortest amount of time. The sophisticated travel guidance system offered by the proposed system assists drivers in urban areas and steers them away from routes that experience heavy traffic.

3. METHODS AND MATERIALS

3.1 An Innovative Parking Services Business Model

This work-in-progress aims to extend parking systems' cloud architecture to accommodate new options presented by third parties referred to as parking service providers, or PSPs. It is motivated by the need to increase parking inventories and the possibilities of novel business models for parking services. PSP is a recently established company that offers services to individual parking lot owners or middlemen who list their lot in the cloud-based parking space directory. When drivers ask for parking spots, this information is sent to them, and the transaction is then completed directly between the parking service provider and the requester.

To realize this goal, a detailed examination of the parking operations depicted in Figure 3.1 is conducted to assess the potential for automation. Devices that are installed on or integrated into cars are utilized as communication links to communicate with parking infrastructures and cloud services [11]. The examination of parking-related issues and needs highlights the need for a modular research approach that looks at the state of the art for each component of the solution build-up and is covered in more detail below.

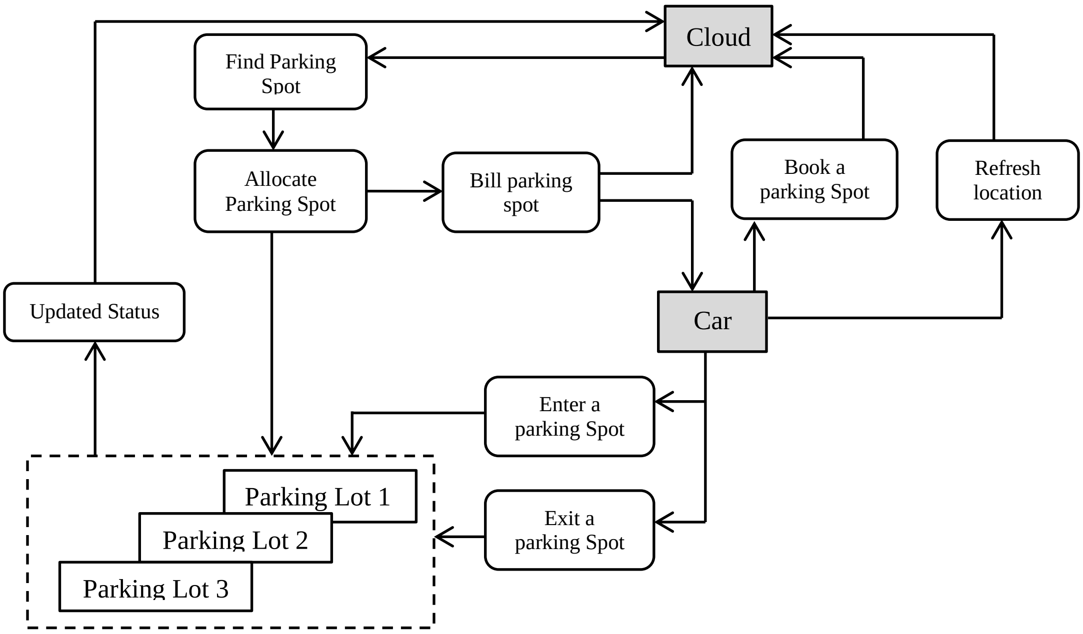

Figure 3.1. Parking-related activities

3.2 IoT Intermediary

Figure 3.2 shows the architecture that underpins the development of the PSP company model. This architecture makes use of a middleware layer to provide many sensing technologies for enabling various connectivity to parking spaces. As demonstrated, this allows the required middleware's features to provide cloud architecture for parking services. By offering a management layer that keeps an eye on the provisioning of parking offerings, the cloud makes it easier to approach parking in a service-oriented manner.

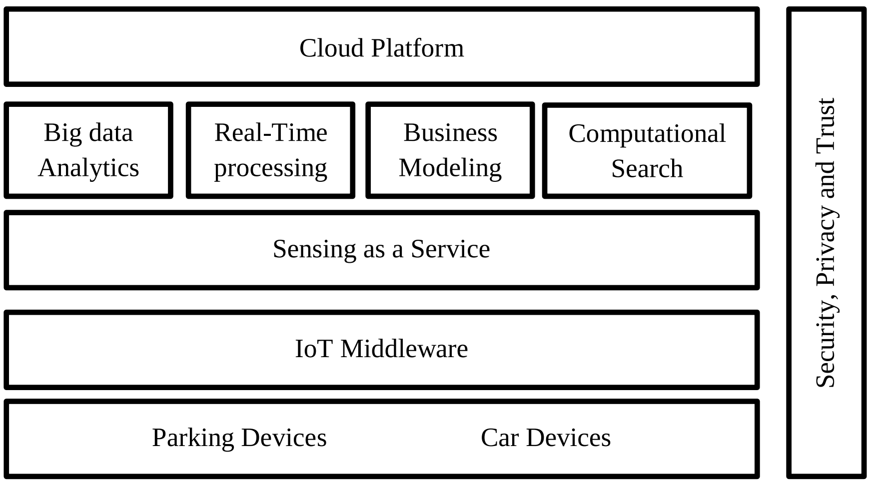

Figure 3.2 Building blocks of architecture

A platform for combining different services, such as sensing services that abstract the metadata connected to sensing devices, is offered by the cloud's infrastructure. The creation of standard dictionaries of metadata about sensors is suggested by an appropriate specification [12]. To enable applications to make decisions about parking services, ontology and inference rules are developed by this methodology. A parking-service registration and a knowledge base for value-added services can be integrated with the help of the perceiving as service architecture.

3.3 Possible ways to choose vehicle type

The user of our proposed system can check parking spot availability and choose the type of car in accordance with that.

Should the user be required to visit a large shopping center? Before viewing the parking area status of a certain mall, visitors must first log in to the internet page and search for that mall. If a parking spot is available, the user can gladly reserve it. The user can view the two-wheeler parking area otherwise. The user has the choice to use public transportation if the two-wheeler parking spot is also occupied.

After checking the parking situation, the user can make an informed decision about the kind of car that will work best for him.

3.3.1 Advantages of Putting in Place an Online Parking System

- Spending time hunting for parking is not necessary.
- decrease in the amount of time and gas that drivers spend looking for parking
- Fewer lines because cars will be directed to parking spots.
- Appropriate car selection based on parking space accessibility.
- Parking facilities benefit from increased income and profitability as a result of online registration.
-

3.4 System for Local Parking Management

This module is installed on the local parking administration server that is accessible from every parking lot. It is in charge of keeping an eye on the entire parking lot. To keep track of whether a parking lot is empty, reserved, or occupied, it keeps an entry for each one. The following is a list of the different tasks this system has completed.

- It processes the image obtained from PLMS using the automatic number plate recognition (ALPR) algorithm in an attempt to extract the number plate number of the parked car. The number plate number (LPN) can be manually entered into the system by the site officer using the GSM module connected to the LPMS if ALPR is unable to extract the LPN. If the car is parked or positioned wrongly, ALPR will not function effectively; in this scenario, the site officer will receive an SMS requesting manual LPN registration [13]. When a licence plate is hidden from view in an image, it is easy to identify inappropriate parking of the car. If manual LPN entry is unsuccessful, the LPMS will send incorrect parking indications to the PLMS, causing the warning sound to indicate improper driving.
- However, if the number plate number of a parked car is successfully retrieved, the record for that parking lot is updated to reflect the vehicle's details and alter its state from empty to occupy. The duration of a vehicle's occupation of the parking area is received by the car from PLMS when it leaves. After that, LPMS determines the parking fees for that car and, if payment is required, provides the driver with an SMS with a payment alternative.
- If the parking area is not full, it first chooses an empty parking lot and then sends the reservation command to the relevant PLMS once it receives a reservation demand for a parking lot from the central parking administration server. If the PLMS confirms the reservation, the associated parking lot's record is updated to reflect the reserved status and the vehicle's information. Following that, as shown by the workflow, the LPMS notifies the CPMS of the quantity of vacant parking lots and the reservation confirmation message. When a parking lot is filled, LPMS alerts CPMS to the fact that there are no open spots in that part of the parking complex.

3.4.1 System for Central Parking Management

To make CPMS accessible on the Internet, it is installed on a central parking management server, a top-tier server with a global IP. As a result, communication via the Internet is possible. It keeps track of the free parking spaces inside each parking facility by keeping a record for each parked facility.

Thus, via the parking availability GUI that runs on the driver's handheld device, it may provide information on parking facilities that are available around the city as well as the quantity of free parking lots. It forwards reservation requests to the relevant LPMS connected with that parking facility area when it receives them from the driver of a vehicle inside that specific facility area. CPMS are able to transmit the reservation confirmation and payment choices to the client application when LPMS has made a parking lot reservation and sent it.

3.4.2 Information on Parking Availability and Reservation Interface

The client application that has been installed on the driver's handheld device is this one. The driver can use this client GUI to reserve a parking space online in the appropriate parking facility area and to find out where parking facilities are available around the city. Should the reservation be successful, the driver will be requested to pay according to the length of the reservation. The client application receives the image of the parking facility area with the reserved parking place once payment has been received.

3.4.3 Parking Lot Surveillance System

The Arduino MEGA 2560 microcontroller is used to implement this software module. Based on timing disparities between the sent and received signals by the ultrasonic sensor node, which generates sound waves every 60 milliseconds, it may determine whether a vehicle is present in the parking lot or not. When a vehicle is found in the parking area three times in a row, it is established that a vehicle is using that parking lot. If the car is parked incorrectly, the number plate number will not be extracted from the picture by the LPMS, which will cause the alarm to ring to alert the driver of the error.

4. IMPLEMENTATION AND EXPERIMENTAL RESULTS

This dissertation will address the issue raised in the article "Smart Parking System" regarding the high cost. Since there will be fewer sensors, the Raspberry Pi and LCD won't be necessary because the system only uses an IR sensor connected to a NodeMCU for Wi-Fi connectivity and a direct Internet connection to a private cloud. An easy-to-use app that is free to download and install on all Android devices will display the availability of empty parking on the phone.

The research paper "Smart Parking System" observes that, although their system is less expensive and uses fewer sensors, it is also a waste of time because it takes time for people to wait to enter the entrance and parking lot. However, if you look up the parking on your phone, you can find it with ease [14]. The programmer is specific to this location and is easily constructed because, as we know, it is more complicated and simpler than looking up a page and scheduling parking.

The purpose of integrating private cloud computing into this system is to create a safe, incorporated parking information system where business owners, staff, and pupils can quickly locate parking spaces and avoid having to wait for an extended period. By using their login credentials, they may access the system, which eliminates delays for individuals within the company and boosts worker productivity.

4.1 Performance Metrics:

In terms of money, walking distance, searching time, or all three, smart parking should be less expensive from the perspective of the parker. However, from the perspective of parking executives, smart parking ought to yield the most revenue and maximise resource utilisation. Thus, we establish the primary performance metrics listed below.

I. First Simulation Results: Even Arrival Rate

Our system's concepts are validated by the findings presented in Table 4.1. According to parking managers, compared to non-directed and guided systems, respectively, the overall average utilisation rises by 21%, translating into gains in income of 16% and 14%. Because dynamic and static reservations were included, even if the utilisation by parking (represented by UP) is greater in other systems than SP has the highest overall utilization.

Table 4.1 Metrics of performance with various dynamic-static resource ratios

NG:G	10:80	20:60	40:40	60:20	80:20
Cost	1.35	1.34	1.35	1.33	1.33
Revenue	1.40	1.53	1.66	1.56	1.53
Utilization	1.45	1.46	1.48	1.49	1.47

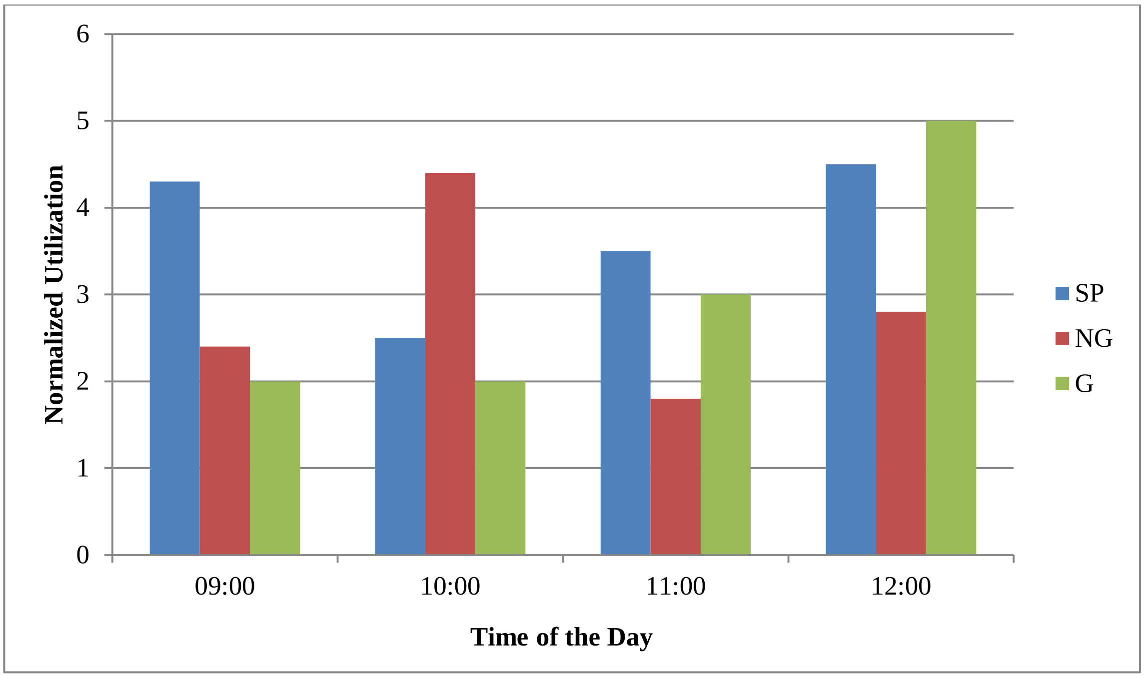

Figure 4.1 Performance measures based on arrival rate variation

Figure 4.1, where we ran several simulations with varying arrival rates—from high in the morning and evening to low in the afternoon—better illustrates the benefits of Parker. The outcomes of the second simulation match those of the first in terms of optimising the use of parking assets, raising earnings, and lowering parkers' expenses.

However, from the perspective of the parkers, SP has shown to provide the lowest total cost when compared to G and NG. For example, the overall cost is 20% and 38% lower in congested traffic compared to NG and G, respectively. Despite the fact that using SP costs more financially than other systems because of reservations, overall parker happiness is higher when using SP. The findings for heavy traffic clearly demonstrate this, with SP searches taking around 35 minutes less than NG and 21 minutes less than G. In heavy traffic, "multiple cars chasing the same spot" is the primary cause of the rise in seeking time in G. They hunt blindly for open places, which accounts for the sharp rise in searching times in NG.

Because there is no wandering time, SP also has the lowest cost. In busy traffic compared to normal traffic, the wandering ratio of parkers in NG rises by around 30%, while in G, it climbs by approximately 18%.

II. The Variant Arrival Rate from Models

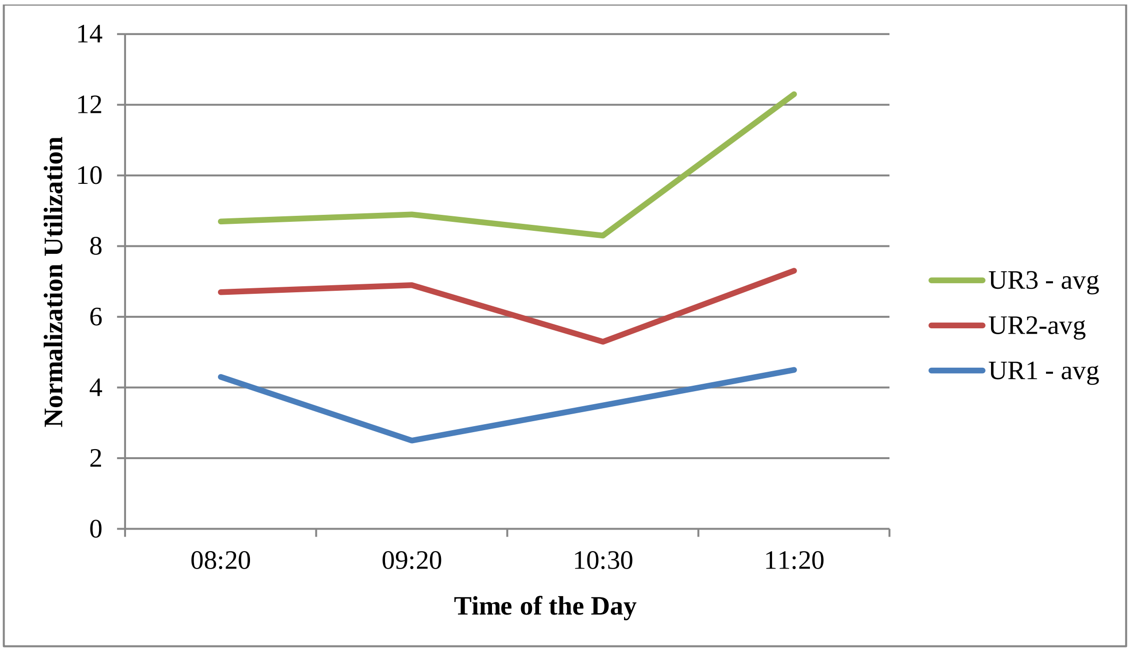

Figure 4.2 Comparison of utilization for both fixed and dynamic rates

This section uses the scheme in Table 1 to investigate the impact of dynamically altering resource pricing in accordance with real-time utilization measures. The results are shown in Figure 4.2. It is seen as assumed that we can regulate and restrict the use of resources by consistently altering their prices. Additionally, these adjustments lead to a fair distribution of resource utilization among parking spaces, which helps to lessen the overall traffic gridlock that parking causes. When utilizing fixed pricing, the average utilization of parking resource 1 is greater than that of other resources; however, when employing dynamic pricing, there is a considerable difference, resulting in about equal average utilization of the three parking sources.

But below are a few things to keep in mind: 1) SP has more revenue than one at 7 PM. This may typically occur when the parking resource is almost completely booked and additional reservation costs are applied. 2) When there is a low arrival rate, the overall cost of parking in SP is not lower than in G. This is so because, just like in SP, costs are minimised in G as well. Moreover, a low arrival rate reduces the likelihood of straying in G, which cuts down on the amount of time needed to seek. Increasing the reservation prices during periods of low arrival rate, however, can address this [15]. 3) The amount of time spent searching in SP remains rather constant throughout the day, indicating that our methodology prevents users from straying and reduces traffic congestion generally.

With the exception of one parameter that determines the ratio of resources allocated for dynamic reservations to those configured for static ones (DR: SR), the majority of the parameters utilized in the simulation are specified to be fluid and not fixed. The primary performance indicators under variable arrival rate with varying DR: SR. The table displays the best results for DR: SR=70:30.

The arrival rate for parkers is set at 70:30, which explains why, but the fluctuations are barely noticeable. This demonstrates the dynamic-static interface's high efficiency, which was previously addressed. Consequently, it makes sense to set the default to DR: SR = 50:50 since parkers' decisions to make dynamic or static bookings in real life won't always be the same.

5. Conclusion

A smart parking system that improves user efficiency by reducing search time and overall moving expenses to the selected parking spot has been suggested by this study. The study's most evident conclusion is that we suggested a smart parking system for cars that will guarantee a decrease in data transmission over the network and conserve energy at the mental level. The application layer on the side of things aims to save the user time, prevent traffic jams, locate open parking spots, and lower gas emissions from driving while looking for open spots.

This research also concludes that the suggested approach offers a very easy and effective solution to deal with parking traffic, which people encounter daily. It also saves time and money. In the future, the programmer can be improved even further to become more accurate. Additional functions can be added to the system with ease, such as the ability to reserve parking via a mobile application. According to extensive simulation results, the proposed system outperforms the non-guided parking system in terms of total revenue for managing parking by up to 18%, maximizes total utilization by up to 31%, and significantly reduces the total real cost for all parkers by up to 38%. Ultimately, we suggested a dynamic pricing plan, and through simulations, we discovered that when we integrated it with parker's model, it balanced the utilization of all parking resources and helped to reduce overall traffic congestion brought on by parking.

Additionally, we demonstrated the system's suggested methodology and pertinent techniques. Furthermore, ongoing work on the other problems and will be addressed in subsequent studies, based on the findings of this paper. Subsequent research endeavors will entail the extensive real-world application of the suggested methodology, together with system testing to verify outcomes. Creating a smartphone application to help users locate open parking spaces and navigate them will be the last phase in the process.

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