JOURNAL OF NORTHEASTERN UNIVERSITY

Volume 25 Issue 01, 2022 ISSN: 1005-3026 https://dbdxxb.cn/ Original Research Paper

# ANALYSIS OF IOT BASED SMART PARKING MODELS- A SURVEY

**[1]Gurpreet Singh, [2]Amandeep Kaur, [3]Hardeep Singh, [4]Varinder Jit Singh Chandi**

gurpreetsinghgndu@gmail.com,Aman.cheema.2k12@gmail.com,hardeep.cet@gndu.ac.in,vjsc5abi@gmail.com

[1,2,3] Department of Computer Engineering and Technology, Guru Nanak Dev University, Amritsar Punjab, India

[4] Department of Computer Science and Engineering, Guru Nanak Dev University Regional Campus, Sultanpur Lodhi, Kapurthala, Punjab, India

**Abstract**

Due to the growing number of vehicles in the cities, urban traffic congestion is becoming more common. Besides, finding places to park even in car parks is not easy for drivers who run in circles. Studies have shown that drivers looking for parking spaces contribute up to 30% to traffic congestion. In this context, it is necessary to predict the spaces available to drivers in parking lots where they want to park. So to handle this situation smart parking is the only solution. Smart parking means using smart devices like various types of sensors, Road Side Units, Parking Side Units, Internet, Cloud services, Smartphones, etc for the parking process. In this proposed review paper we analyzed several papers based on various smart parking techniques and also made a comparison between some of them based on various factors.

**Keywords:** Smart Parking, Internet of Things, Sensor, Cloud, Server.

## 1. Introduction

Smart Parking is a parking solution that can accommodate in-ground Smart Parking sensors, cameras, or counting sensors. These tools are normally embedded within parking points or placed next to them to recognize whether parking bays are vacant or occupied. This happens through real-time data collection. The data is then conveyed to a smart parking mobile application or website, which communicates the availability to its users. Some firms also offer additional in-app information, such as parking charges and locations. This provides you the possibility to examine every parking alternative accessible to you [24]. Jingyu et al. [1] proposed the optimal parking lot determination based on the Logic model. The empirical results show that the parking lot induction process based on the Logic model can recognize the assortment of the best parking lot. Consolidated with the optimal path selection, the driver is supervised to reach the optimal parking lot on the optimal path. Stephane et al. [2] devised a new system that combines the IoT and a predictive model based on ensemble techniques to optimize the forecast of the availability of parking locations in smart parking. Shahan et al. [3] suggested a new technique in which neural networks are used to predict the parking location that will be convenient for drivers to settle on a reasonable area for holding. Qamas et al. [4] exhibited a novel cloud-based smart vehicle parking system (SVPS) over universal VANETs that grants a unique algorithm that provides a suitable vacant parking space information along with booking and recommendation prospects to aid vehicles in an effective, real-time and

**Submitted**: 08/03/2022 **Accepted**: 30/03/2022

explicit manner. Yacine et al. [5] investigated a research agenda that points at uplifting the parking space management from a completely physical profession to a business that reconstructs parking into a computational service. Sahil et al. [6] compared various smart parking systems that are being executed. Fadi et al. [7] prepared a survey of the current situation of smart parking methods including classification of the parking system, significant vehicle apprehension technologies, and communication module. Burak et al. [8] offered a hierarchical approach based on the binary search tree (BST) for parking monitoring systems that help users to arrive at a free parking spot easily. Sandeep et al. [9] advanced a scheme that employs machine learning-based approaches to predict possession of parking lots, which in turn is used to deduce occupancy driven prices for coming vehicles. Diya et al. [10] adopted a genetic algorithm strategy to address the concern of scheduling the vehicle to the parking bay. Yanfeng et al. [11] prescribed a new "smart parking" system for an urban environment. This system assigns and holds an optimal parking space for a driver based on the user's requirements that coupled proximity to destination and parking cost, while also assuring that the overall parking capacity is efficiently employed. Jiri Hanzla [12] considered two basic ways of guiding drivers to car parks in towns and urban areas i.e, static guidance (“offline”) and dynamic guidance (“online”). Mamta et al. [13] granted a complete analysis of crucial aspects for composing a smart parking system such as sensor selection and optimal position for sensor deployment for correct detection. Kun et al. [14] designed a phone-based system to trace a driver's trajectory to identify when they are about to embark on their parking spot. Jean et al. [15] conferred SmartPark, a system for real-time parking information that reclines the requirement for concentrated infrastructure, relying instead on the smartphone's sensors and the ubiquitous Wi-Fi and cellular infrastructure. Tullio et al. [16] deliberated the conceptual structure of IPA (Intelligent Parking Assistant) which aims at overcoming current parking supervision solutions and thereby becoming a leading standard for the so-called "smart cities". Ali et al. [17] acquainted a decentralized car parking procedure for vast car park areas based on cooperation among vehicles through vehicle-to-vehicle communication, called Cooperative Car Parking (CoPark). Pedro et al. [18] investigated the use of parking lots to solar-charged electric vehicles. Guangmei et al. [19] developed a Compact robotic automated parking (CRAP) system with greater storage utilization and accelerated response to store and manage cars. This system has double storage rings, instead of one storage ring in early compact automated parking (CAP) system for storing cars in each tier. Gwo Jiun Horng [20] planned an innovative exploring space occupancy indicator (SOI) system that uses taxis, public vehicles (PVs), and on-street parked vehicles to sense parking spaces and forwards sensed information to nearby Road Side Unit (RSU) hotspots. Sharaf et al. [21] prepared a survey and distributed it to 500 participants as a portion of a project, to identify the scale of the parking problem in Abu Dhabi and developed an intelligent mobile application for updating the indoor parking management system. Iuon et al. [22] assumed a new real-time parking service in vehicular cloud computing. Ching et al. [23] submitted iParking, a real-time parking space monitoring, and guiding system. The paper emphasizes roadside parking.

## 2. Proposed Work

With the rapid development of the economy, people's living standards continue to improve, which has exacerbated the rise in urban motor vehicles. The jump in the number of cars has promoted people's travel and raised economic growth. However, with the constant increase in the number of motor vehicles the dilemma of difficult parking is becoming more and more critical [1]. So to tackle this problem smart parking presents an efficient way to park individual vehicles without or very little human interaction. At present smart city is the burning issue in India. Smart parking plays a major role in making smart cities.

Jingyu et al. [1] practiced adaptive genetic algorithms to induce drivers and simulate them. With the aid of this algorithm optimal path and the shortest time for the motorist to arrive each parking lot from the current location is obtained. The wavelet neural network model is suggested and used a swarm optimization algorithm to optimize it.

Stephane et al. [2] created a parking availability prediction model in smart cities which notifies the driver whether parking space is available or not. This paradigm helps in the contraction of pollution levels as well as to control traffic congestion in smart cities. This model consists of five basic components such as:

i) Sensor
ii) Gateway hardware
iii) Server/Cloud
iv) Mobile application

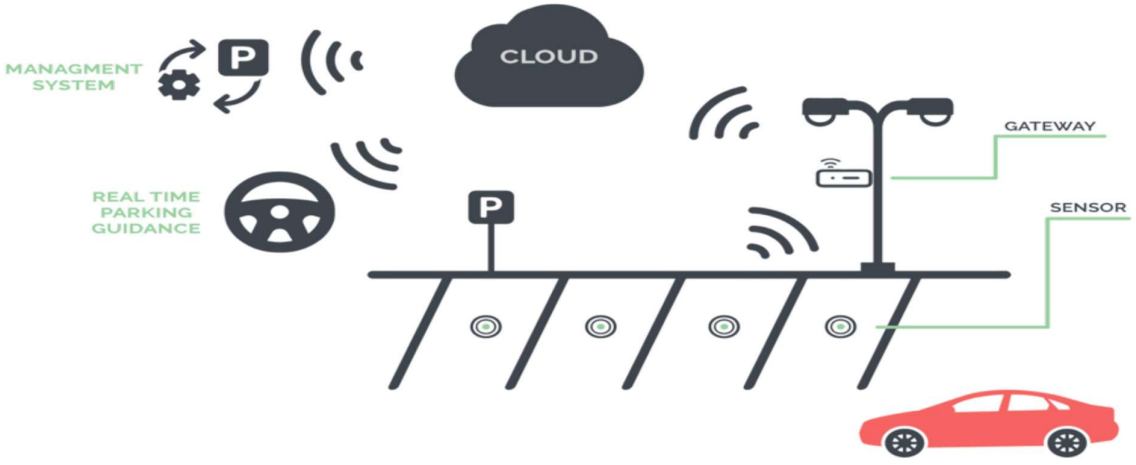


Fig. 1. Smart parking system. [2]

Shahan et al. [3] also advanced a parking forecast framework that tells the users regarding free and occupied space using Deep Extreme Learning Machine (DELM). It has been witnessed that the proposed DELM has the highest precision rate of 91.25%.

Qamas et al. [4] developed a smart vehicle parking system (SVPS) that grants a unique algorithm that provides authentic information about vacant parking spaces along with booking and recommendation options. Besides these numerous factors such as drive time, distance to

the prescribed parking facility, parking fee, walking distance from the parking facility to the destination, and traffic congestion, are deliberated in the recommended SVPS algorithm.

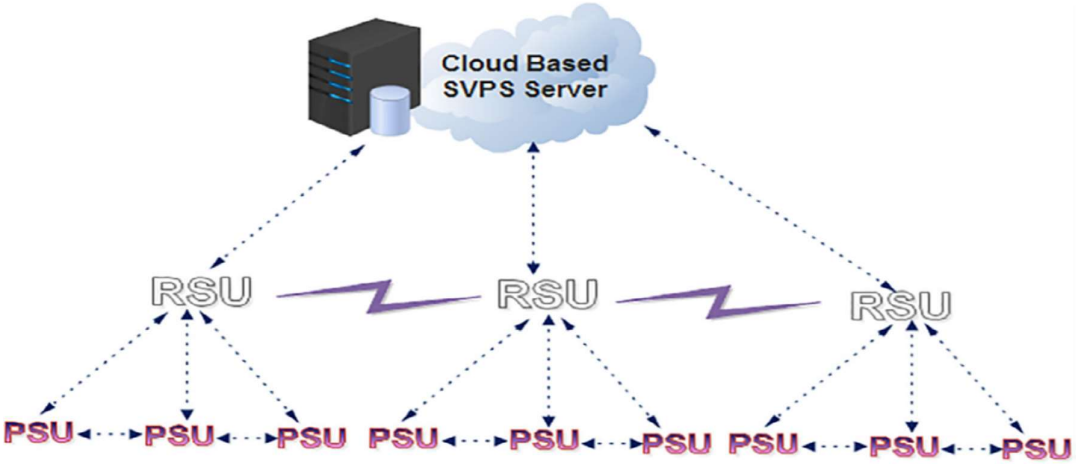


Fig. 2. Communication Paradigm for SVPS. [4]

Yacine et al. [5] presented a unique idea of the conversion of private land properties into smart parking to relieve stress on public agencies.

Sahil et al. [6] composed reviews of various smart parking methods and also compared different components used in various research papers. These components are compared based on their varying parameters.

Fadi et al. [7] also presented a survey on smart parking in IoT enabled cities and make an overview of the enabling technologies and sensors which have been usually used in the literature. It mainly underlines the significance of data reliability, security, privacy, and other critical design factors in smart parking.

Burak et al. [8] developed a Binary Search Tree(BST) algorithm based on a hierarchical approach for a parking monitoring system that assists users to reach an unoccupied parking spot easily. There are mainly two levels of BST algorithm. At first level algorithm checks for the nearest car park whereas at second level algorithm concentrates on the car park that is the nearest and checks the nearest parking spot in that car park.

Sandeep et al. [9] advanced an on-street occupancy prediction scheme for the Seattle city which presents predicted occupancy of various parking lots to the parkers and hence, in getting optimal parking space. An occupancy driven machine learning-based on-street parking pricing system is developed which balances the interests of both, i.e., parking authority/owners and parkers. In-advance accepted or rejected parking request guides traveler/parker which in turn can reduce cruising time and hence, traffic congestion. The author also concluded that out of the four different types of machine learning models NN (Neural networks model), LIN (Linear model), DT (Decision tree model) and rF (Random forest model) the most suitable model is rF

in predicting occupancy and also it attain the highest accuracy, i.e., 99.01% among all applied models with an acceptable error rate of 5%.

Diya et al. [10] developed a trolley system and the genetic algorithm implementation to find the best parking slot, make the proposed system efficient in terms of space utilization and trolley efficiency. The genetic algorithm supports this system to optimize the searching process for the best region without much time wastage. The Autonomous trolley system reduces the waiting time of the customer in the queue. The client can leave their vehicle at the entrance and then the vehicle will travel up to parking space through trolley. The queuing theory is applied to derive the utilization, efficiency, and waiting for the time factor of the system.

Yanfeng et al. [11] recommended a smart parking system that includes the Driver Request Processing Center (DRPC) and a Smart Parking Allocation Center (SPAC). The DRPC gathers driver parking requests and real-time information (i.e., car location), keeps track of driver allocation status, and sends back the assignment results to drivers. Based on the driver requests and parking resource states, the SPAC makes assignment determinations and allocates and reserves parking points for drivers.

Jiri Hanzl [12] discussed two basic ways "online" and "offline" for supervising drivers to car parks and also decided smart technologies that are used for easier orientation of road users in multi-story car parks when exploring for free parking spaces. The benefit of the "offline" guidance system is its lifetime and easy maintenance without the necessity of its connection to a power source. On the other hand, the "online" guidance system also equips drivers with information about the current occupancy of car parks (number of free parking spaces) and probably the types of vehicles and the distance to the car park.

Mamta et al. [13] presented a comprehensive analysis of Light Dependable Resistor (LDR) sensor that operates on shadow detection principal and Infra-Red (IR) sensor which works on object detection. Both of these sensors are used in smart parking for recognizing the vehicle's presence in parking. It is concluded that the IR sensor delivers better than the LDR sensor in terms of its precision in detecting the vacant parking slots and vehicle detection in diverse environmental factors.

Kun et al. [14] designed a phone-based system to detect the driver's location so that parking controllers came to know when a customer about to vacate their parking spot. The authors focus on the efficiency and accuracy of using a phone to observe the driver's walking trajectory, applying a waist-mounted PDR system that can measure the driver's moving distance with high accuracy.

Jean et al. [15] stated SmartPark, a smartphone-based system that addresses the dual challenge facing the automatic on-street parking management. It can recognize unparking events with

accuracy reaching 100% and offers an approach for overcoming the barrier-to-entry issue, all with a negligible impact on battery life.

Tullio et al. [16] exhibited a novel smart parking system, called (Intelligent Parking Assistant) IPA, for the management of the off-street parking localities in consolidated cities. IPA puts the management of parking spots into a diverse perspective that goes ahead the simple engineering (or automation) of the parking system through the use of wireless networks and sensor communication.

Ali et al. [17] presented a new scheme called Cooperative Car Parking (CoPark). In CoPark, the task of finding car parking spaces inside a large car parking area is
achieved via smart agents in vehicles opportunistically cooperating to locate parking spaces as near as possible to the final destination with reduced searching time.

Pedro et al. [18] explored the use of parking lots to solar charge electric vehicles. Solar panels provide shade and generate electricity to charge parked electric vehicles. In a vehicle-to-grid approach, the vehicles may also feed the grid and support it with ancillary services. A benefit often mentioned while addressing solar parking lots is the shade provided by the solar panels' coverage to the vehicles. Shade considerably reduces the vehicle temperature during sunshine, guarding it against sun damage, such as paintwork damaged or cracked and warped interiors.

Guangmei et al. [19] revealed an idea of using compact robotic automated parking (CRAP) system which is an automated car storage system which moves using elevators with vertical automated guided vehicle (AGV) in the vertical direction and using rotating rings and tier-captive AGV in the horizontal direction. With very high storage density (with two-layer storage positions and no aisles), low cost, and less storage area due to the multiple tiers, the performance of a CRAP system can outperform traditional parking systems. Many material handling technologies have been newly developed for such systems, such as in the USA, China, Israel, and Germany, especially in urban areas where parking space is costly and inadequate. Based on the appearance of robots and robot-based technology, people begin to explore the application of smart cities.

Gwo Jiun Horng [20] designed a Space Occupancy Indicator (SOI) system for exploring parking space. This system uses public vehicles, taxis, and on-street parked vehicles to sense information about parking space, and then this sensed information will be conveyed to nearby Road Side Unit (RSU) hotspots. This transmitted data includes information about the availability of parking spaces and their location and direction. Consumers use a Cellular Automata (CA) model and a small world mechanism to receive information about on-street parking space and recommendation.
Sharaf et al. [21] surveyed parking problems in Abu Dhabi. Firstly, a survey was prepared and distributed to 500 participants to identify the scale of the parking problem in Abu Dhabi. Then,

a technical framework for developing an intelligent mobile application for improving the indoor parking management system in Abu Dhabi was developed. Conclusions indicate that the proposed mobile application will help in reducing the time consumed in searching for parking and will increase the efficiency of the parking system in Abu Dhabi.

Iuon et al. [22] admitted a real-time parking service in vehicular cloud computing. In this system when drivers send a parking service request to vehicular clouds, the vehicular cloud will compute the suitable parking lot for drivers. Besides this, it also combines proxy re-encryption into the scheme in protecting the service provider's benefit. The main qualities of this service are mutual authentication, user anonymity, data confidentiality, traceability, and revocability.

Ching et al. [23] submitted an iParking, a real-time parking space monitoring, and guiding system. This system identifies the availability of parking spaces through image analysis, where the images come from the event recorders installed in cars on the roads. Upon receipt of a parking request, the system seeks for the nearest parking space, and then directly navigates the requesting driver to the available parking space. The author expected that this system supports to improve safety and traffic on the roads.

**Analysis of some smart parking models**

| Reference | Year | Model/Analysis type | Application area | Devices/Sensors used |
|---|---|---|---|---|
| Stephane et al | 2020 | Improving parking availability prediction in smart cities with IoT & Ensemble-based model | Birmingham, England | Gateway hardware, Server/Cloud, Mobile application, Different sensors |
| Shahan et al | 2020 | Prediction of parking location by using artificial neural networks | _ | Does not specified |
| Qamas et al | 2018 | Cloud-based smart vehicle parking system | _ | Parking Side Unit, Road Side unit, On-Board Unit |
| Yacine et al | 2016 | Internet of Things approach | _ | Does not specified |

| | | | | |
|---|---|---|---|---|
| | | to cloud-based smart car parking | | |
| Burak et al | 2018 | Binary search tree-based hierarchical placement algorithm for IoT based smart parking applications | _ | Ultrasonic sensors |
| Diya et al | 2018 | Genetic algorithm approach to autonomous Smart Vehicle Parking System | _ | Ultra-sonic sensors, Autonomous trolley |
| Gwo Jiun Horng | 2019 | Innovative parking space searching space occupancy in dicator system | _ | Ultrasound sensing devices, Road Side Units |

Table.1. Comparison of different IoT based Smart parking models

## 3. Conclusion

Smart parking is the need of an hour. The population is rising at quite high speed so the problem of parking vehicles in urban areas also arises. Many recent studies show that in urban areas individuals waste approximately 15-30 minutes in searching for a parking space and this also contributes to added pollution level because during this time individuals waste a huge amount of fuel. So to tackle this problem the concept of smart parking arises. This paper includes an analysis of distinct smart parking techniques. Smart parking makes use of divergent types of automatic devices like sensors, Road Side Units, Parking Side Units, etc. At last, we also make a comparison between different papers based on diverse components.

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