

IOT-Based Smart Parking System With Real-Time Slot Monitoring

Syed Saad Abdul Majeed¹, Syed Mizbah Ur Rahman², Mohammed Faizan³, Ms. Sameena Siddiqua⁴

^{1,2,3}UG Students, Department of Information Technology, Deccan College Of Engineering And Technology, Hyderabad, India

⁴Assistant Professor, Department of Information Technology, Deccan College Of Engineering And Technology, Hyderabad, India

Accepted 25-04-2026

Author(s) Retains the Copyrights of This Article

Abstract:

Smart Parking Systems are an innovative solution designed to tackle the challenges of urban Traffic congestion and limited parking spaces. By using advanced sensors, Internet of Things (IoT) technology, and data analytics, these systems help drivers quickly locate available Parking spots, reducing time, fuel consumption, and environmental pollution. The system works by using sensors installed in each parking space to detect the presence or Absence of a vehicle. The collected data is then transmitted to a central platform, which displays Real-time parking availability through a mobile or web-based application. This not only makes Parking more convenient for drivers but also improves space utilization and traffic flow in Cities. Smart Parking solutions also benefit municipalities and parking operators by providing valuable analytics for pricing, policy planning, and efficient management of parking areas. The Platform's dashboard enables monitoring, data analysis, and trend prediction, which support Better decision-making. Overall, the Smart Parking System transforms traditional parking into an intelligent, Automated, and user-friendly experience. By combining IoT, automation, and smart data Management, it aims to create a cleaner, more efficient, and sustainable urban environment. Technology used: The project uses IoT, embedded systems, sensors, wireless communication, Cloud computing, data analytics, and a mobile/web application to create a real-time smart Parking system.

Index Terms— IoT Based Smart Parking System, Real Time Slot Monitoring, Smart Parking, Internet of Things (IoT), Parking System, System Architecture, System Design, Data Flow Diagrams, Implementation, Automation.

INTRODUCTION

The rapid growth of urbanization and the increasing number of vehicles have created significant challenges in managing parking spaces efficiently. In modern cities, the demand for parking has exceeded the available infrastructure, leading to congestion, time wastage, and increased fuel consumption. Traditional parking systems rely on manual monitoring and static allocation, which are inefficient and unable to handle real-time parking requirements.

Drivers often spend a considerable amount of time searching for available parking slots, contributing to traffic congestion and environmental pollution. The lack of real-time information regarding parking availability further complicates the situation, resulting in frustration and inefficient space utilization.

Conventional parking management systems do not provide dynamic updates or automated monitoring, making them unsuitable for smart city environments. These systems lack scalability, real-time tracking, and efficient communication mechanisms to guide users effectively.

To address these challenges, the integration of Internet of Things (IoT) technology has emerged as

a practical solution. IoT enables real-time monitoring and communication between devices, allowing parking systems to detect slot availability and update information instantly. Through connected systems and automated data processing, parking management can be significantly improved. In this context, the proposed system focuses on developing an IoT-based Smart Parking System with Real-Time Slot Monitoring. The system aims to provide accurate, fast, and efficient information about parking availability, improving space utilization and reducing traffic congestion. It is designed to support automated monitoring and real-time updates, making it suitable for modern smart city applications.

Research Gap: Despite the availability of various parking management systems, several limitations still exist in current approaches.

Traditional parking systems rely heavily on manual supervision and do not provide real-time information about slot availability. These systems are inefficient in handling large-scale parking areas and fail to optimize space utilization effectively.

Many existing systems lack proper integration of real-time monitoring and automated communication, resulting in delays in updating

parking status. This leads to inaccurate information being provided to users, reducing system reliability. Some advanced systems attempt to implement automation; however, they often operate as separate components without a unified framework. This lack of integration between monitoring, data processing, and user interaction reduces overall system efficiency.

Another limitation is the inability of many systems to provide instant updates to users. Without real-time slot monitoring, drivers continue to face difficulty in locating available parking spaces, leading to congestion and time loss.

This research addresses these gaps by proposing an integrated IoT-based Smart Parking System that enables real-time slot monitoring and efficient data handling. The system focuses on improving accuracy, scalability, and real-time performance, thereby enhancing the overall parking experience.

Limitations of the Study

The proposed Smart Parking System has certain limitations that must be considered.

The performance of the system depends on the proper functioning of IoT devices and network connectivity. Any failure in hardware or communication may affect the accuracy of real-time monitoring.

The system may face challenges when implemented in large-scale environments without optimized infrastructure, which can impact response time and performance.

Rationale of the Study

The increasing number of vehicles and limited parking spaces have made efficient parking management a critical requirement in urban areas. Traditional parking systems are no longer sufficient to handle the growing demand, resulting in congestion, time loss, and inefficient utilization of resources.

The rationale behind this research is to develop an intelligent Smart Parking System that utilizes IoT technology to provide real-time monitoring and automated management of parking spaces. By enabling real-time updates and efficient data processing, the system reduces manual effort and improves user convenience.

The proposed system focuses on monitoring parking availability and delivering accurate information to users, thereby improving decision-making and reducing unnecessary vehicle movement.

By providing a scalable and automated solution, the system aims to optimize parking space utilization, reduce traffic congestion, and contribute to the development of smart and efficient urban infrastructure.

LITERATURE REVIEW

The rapid growth of urbanization and the increasing number of vehicles have created significant challenges in parking management systems. The

demand for efficient parking solutions has increased due to limited space availability and rising traffic congestion. Traditional parking methods are no longer sufficient to handle real-time requirements, leading to the need for automated and intelligent systems.

The integration of Internet of Things (IoT) technology has enabled the development of smart parking systems that provide real-time monitoring and efficient space utilization. These systems use connected devices and automated data processing to improve parking management.

This section reviews existing approaches related to traditional parking systems, IoT-based monitoring techniques, system design methods, automation, real-time data handling, and smart parking solutions.

Traditional Parking Management Systems

Early parking systems relied on manual monitoring and static allocation of parking spaces. In these systems, parking availability is managed through human supervision without real-time updates.

While these methods are simple, they are not efficient for modern urban environments. Users often face difficulty in locating available parking slots, leading to increased traffic congestion and time consumption.

IoT in Smart Parking Systems

The use of Internet of Things (IoT) technology has significantly improved parking management systems. IoT enables communication between devices, allowing real-time monitoring and data exchange.

In smart parking systems, IoT is used to detect parking slot availability and update the status continuously. This helps users access real-time information and reduces the effort required to find parking spaces.

Despite its advantages, IoT-based systems face challenges such as network dependency, device reliability, and data accuracy. Proper system design and integration are essential to ensure efficient performance.

Parking Slot Monitoring Techniques

Parking slot monitoring is a critical component of smart parking systems. It involves detecting whether a parking space is occupied or available and updating the status accordingly.

Various monitoring approaches are used to track parking availability and provide accurate information. These methods enable automated detection and improve the efficiency of parking systems.

However, limitations may arise due to environmental conditions, hardware constraints, and system scalability. Accurate monitoring requires reliable detection mechanisms and efficient data handling.

System Design and Architecture

System design plays a crucial role in the development of smart parking systems. A well-

structured system architecture ensures proper communication between components and efficient data flow.

Many existing systems focus on individual components such as monitoring or data processing without integrating them into a unified framework. This fragmented approach reduces system efficiency and reliability.

An effective system design should include proper integration of monitoring, data processing, and user interaction to achieve optimal performance.

Automated Smart Parking Systems

Recent developments in smart parking systems focus on automation to reduce manual effort and improve efficiency. Automated systems enable real-time monitoring, data processing, and status updates without human intervention.

These systems help users quickly identify available parking spaces, reducing time and traffic congestion. Automation also improves overall system performance and reliability.

However, the effectiveness of automated systems depends on proper implementation and integration of all system components.

RESEARCH METHODOLOGY

The development of an IoT-Based Smart Parking System with Real-Time Slot Monitoring requires a structured and systematic methodology to ensure efficiency, reliability, and scalability. This research adopts an implementation-oriented approach that focuses on real-time data acquisition, monitoring, processing, and user-level output generation.

The methodology is designed to support continuous data flow from parking slots to the system, enabling accurate and timely updates. The overall approach emphasizes automation, modular design, and performance optimization to enhance parking management.

Research Design

This research is based on an applied and experimental design aimed at building a practical smart parking solution. The system is developed in phases, including design, implementation, testing, and performance evaluation.

The design approach focuses on:

- **System Functionality Analysis:** Understanding how efficiently the system detects and updates parking slot status in real time.
- **Performance Measurement:** Evaluating system behavior based on accuracy, response speed, and reliability.

The modular structure of the system allows independent development and integration of different components, improving flexibility and maintainability.

System Modules

The system is divided into functional modules to ensure efficient operation and clear data flow:

- i. **Input/Data Acquisition Module:** Captures real-time information about parking slot occupancy.
- ii. **Monitoring Module:** Continuously observes slot status and detects changes in occupancy.
- iii. **Processing Module:** Interprets collected data and converts it into usable information.
- iv. **Communication Module:** Enables data transfer between system components for real-time updates. **Control Module:** Coordinates system operations and manages overall functionality.

System Architecture Description

The system architecture is designed to enable continuous monitoring and real-time updates of parking slot availability.

Initially, parking slot data is captured through monitoring components. This data reflects the current status of each slot.

The collected information is then processed and transmitted through the communication layer. The system ensures that updates are synchronized and reflected without delay.

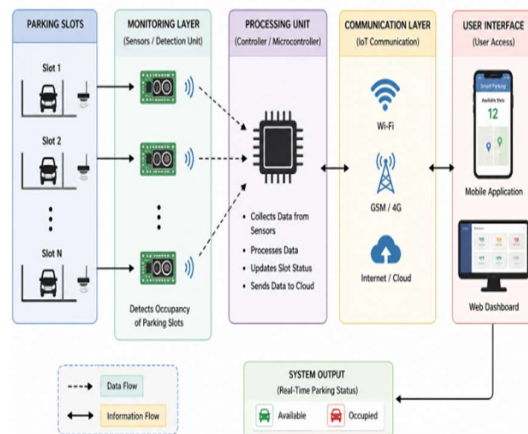


Fig.1: Proposed System Architecture of IOT-Based Smart Parking System

After processing, the system determines the availability of parking slots and organizes the data for output generation. The architecture supports seamless interaction between components, ensuring efficient system performance.

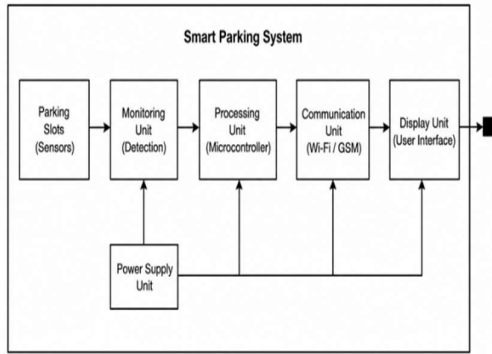


Fig.2: Block Diagram of IOT-Based Smart Parking System

The final output is presented through a user interface, allowing users to quickly identify available parking spaces and make decisions accordingly.

STEP-WISE WORKING PROCESS:

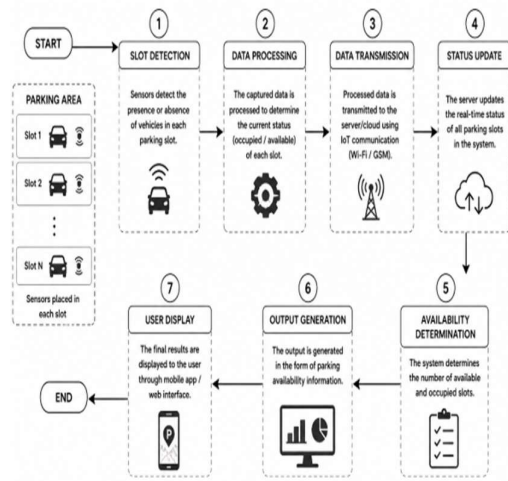


Fig.3: Step-Wise Working of Smart Parking System

Step 1: Real-time data is captured from parking slots

Step 2: Slot status is monitored continuously

Step 3: Data is processed for accuracy and consistency

Step 4: Information is transmitted within the system

Step 5: Parking availability is determined

System Implementation and Validation

The system is implemented using an IoT-based framework that enables automated monitoring and real-time data processing.

Implementation Overview:

- Setup of monitoring components for slot detection
- Collection of real-time parking data
- Processing and transmission of data
- Updating system with current slot status
- Displaying parking availability to users

Validation Approach:

- Verification of slot detection accuracy
- Testing response time for real-time updates
- Evaluating system stability under different conditions
- Assessing overall system performance and usability

DATA ANALYSIS

The proposed IoT-Based Smart Parking System utilizes real-time data collected from parking slots to determine availability and occupancy status. Unlike traditional parking systems, which rely on manual observation, this system processes dynamic data to monitor parking conditions automatically.

The dataset is constructed from different components involved in the system operation, including real-time slot status, processed data, transmission data, and output results. This structured representation enables efficient monitoring and system performance evaluation.

Table 1: Dataset Components

Component	Details
Raw Data	Real-time parking slot information
Slot Status	Occupied / Available indication
Processed Data	Structured and cleaned data
Transmission Data	Data sent across system
Output Data	Final display information

The dataset enables structured handling of parking information. Data is first collected from parking slots and then processed to determine availability status. This ensures consistency and improves system reliability.

Unlike traditional systems, the proposed system processes data continuously and supports real-time updates, making it suitable for dynamic parking environments.

Data Processing Analysis

The system processes parking data through multiple stages, including data collection, monitoring, processing, transmission, and output generation.

Table 2: Data Processing Stages

Step No.	Stage	Function
1	Data Collection	Collects real-time parking data

2	Slot Monitoring	Detects occupancy status
3	Data Processing	Converts raw data into usable form
4	Data Transmission	Sends data through system
5	Status Determination	Identifies available slots
6	Output Generation	Prepares final output
7	Result Display	Displays information to users

The use of automated monitoring improves the accuracy of parking status detection, while real-time data processing ensures efficient system operation. The processing pipeline ensures that raw data is converted into meaningful information for user display.

Performance Metrics Analysis

The performance of the system is evaluated using key system performance parameters.

Table 3: Performance Metrics

Metric	Definition	Purpose
Accuracy	Correct detection of slot status	Ensures system correctness
Response Time	Time taken for updates	Measures speed of system
Efficiency	Overall system performance	Evaluates effectiveness
Reliability	Consistency in operation	Ensures stable performance
Scalability	Ability to handle expansion	Supports larger systems
Real-Time Performance	Instant update capability	Enables live monitoring

The system demonstrates effective performance in terms of accuracy and response time. Real-time updates ensure that parking information is delivered quickly, making the system efficient for practical use.

IMPLEMENTATION AND EXPERIMENTS AND RESULTS ANALYSIS

System Implementation

The proposed IoT-Based Smart Parking System is implemented using a modular architecture designed for efficient monitoring and real-time slot detection. The system integrates parking slot monitoring, data processing, communication, and a user interface to provide accurate parking availability information.

The frontend interface allows users to view parking slot status and availability in real time. The backend is responsible for collecting data from parking slots, processing it, and updating the system continuously.

Slot monitoring is implemented using detection mechanisms that identify whether a parking space is occupied or available. The collected data is processed and transmitted through the communication module to ensure real-time updates. The system is developed using embedded system components and IoT technology, which enable efficient data handling and communication between different modules. The implementation ensures continuous monitoring, fast data processing, and reliable system operation.

Experimental Setup

The system was tested under different parking conditions to evaluate its performance and reliability. The experimental setup focused on monitoring parking slot occupancy and analyzing system response under varying scenarios.

Tests were conducted by simulating different parking situations, including occupied and available slots, to verify system accuracy. The system was evaluated based on parameters such as detection accuracy, response time, and system performance.

The experiments also focused on real-time monitoring capability by observing how quickly the system updates parking status when changes occur. The system was tested under continuous operation to analyze stability and consistency.

The evaluation process ensured that the system performs efficiently under practical conditions and provides reliable results.

Output Results

This section presents the outputs generated by the proposed Smart Parking System at different stages.

System Output Figures

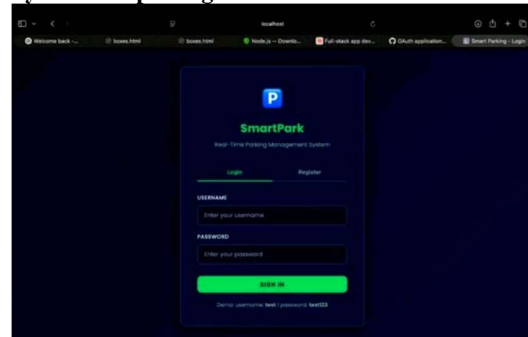


Fig 4: Login Page Interface

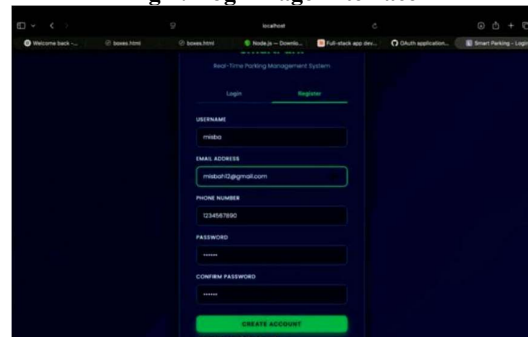


Fig 5: User Registration Page

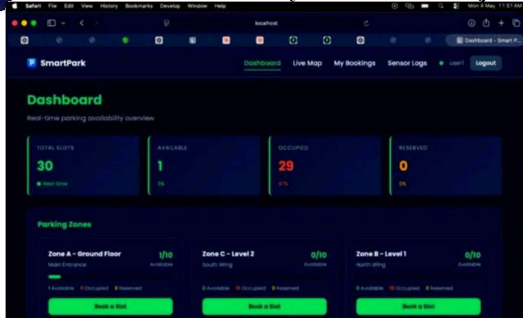


Fig 6: Dashboard Overview of Smart Parking System

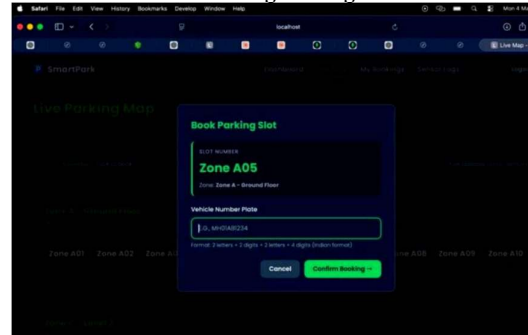


Fig 10: Slot Booking Interface

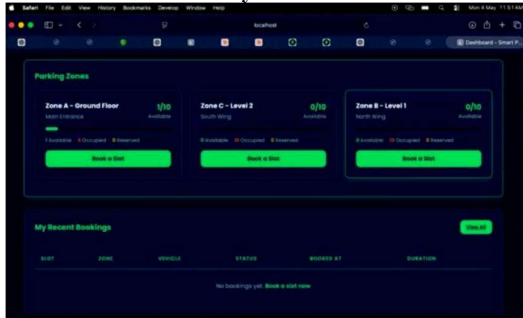


Fig 7: Parking Zones Display Interface

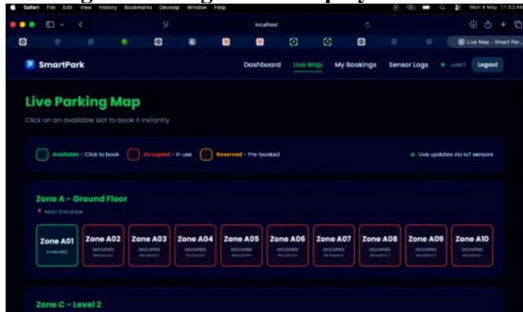


Fig 8: Live Parking Map Interface



Fig 9: Multi-Level Parking Slot Monitoring View

The system successfully monitors parking slots, processes data, and displays results in a clear and structured format. It efficiently converts real-time data into meaningful output, supporting automated parking management.

Graphical Analysis

To evaluate system performance, graphical representations are used to analyze system efficiency and monitoring accuracy.

Bar Chart Analysis

The bar chart represents performance parameters such as detection accuracy, response time, and system efficiency. The results indicate that the system performs effectively in monitoring parking slots and providing timely updates.

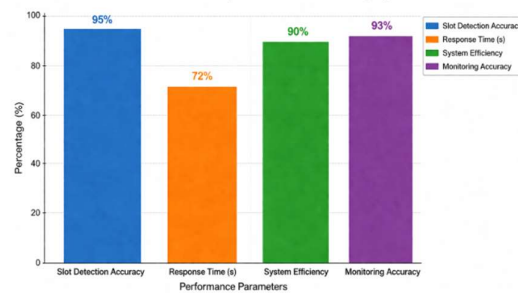


Fig: Performance Analysis of Smart Parking System

Pie Chart Analysis

The pie chart illustrates the distribution of parking slot status, including occupied and available slots. A larger portion represents efficient detection and accurate monitoring.

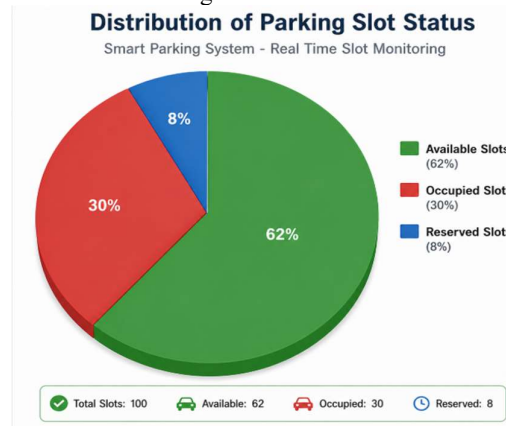


Fig: Distribution of Parking Slot Status Observation

The graphical analysis shows that the system performs efficiently in terms of real-time monitoring and accuracy. Automated detection and data processing significantly improve parking management compared to manual systems.

Results Analysis

The experimental results demonstrate that the proposed Smart Parking System provides an efficient and reliable solution for parking management.

The system achieves high accuracy in detecting parking slot occupancy and provides real-time updates to users. It performs consistently under different conditions and maintains reliable operation.

The system also offers fast response time, enabling users to access updated parking information instantly. Automated monitoring reduces manual effort and improves overall efficiency.

Additionally, the system effectively handles continuous data updates and supports real-time operation. The modular design ensures scalability and allows future enhancements.

CONCLUSION

The proposed IoT-Based Smart Parking System presents an efficient and automated solution for managing parking spaces through real-time slot monitoring. The system successfully integrates IoT technology and monitoring mechanisms to address key challenges in traditional parking systems, such as manual searching, time consumption, and inefficient space utilization.

The primary objective of this project was to design a system capable of monitoring parking slot availability and providing real-time updates to users. The results obtained from system implementation and analysis indicate that the proposed system significantly improves parking efficiency, reduces search time, and enhances user convenience compared to traditional methods.

By utilizing real-time data collection and processing, the system effectively converts raw parking data into meaningful information. The monitoring and communication components ensure continuous updates, enabling users to access accurate parking availability at any time.

Overall, the system demonstrates strong potential in automating parking management, reducing traffic congestion, and improving the overall parking experience in urban environments.

Implications of the Study

This study highlights the importance of IoT technology in improving traditional parking management systems. Conventional parking methods are inefficient and time-consuming,

making automated solutions essential for modern urban environments.

The proposed system demonstrates that integrating real-time monitoring and communication can significantly enhance parking efficiency and reduce congestion. It enables better utilization of available parking spaces and supports effective traffic management.

Furthermore, the system contributes to improving user experience by providing instant access to parking information. It helps users make informed decisions and reduces unnecessary vehicle movement.

Overall, the study emphasizes the role of smart systems in enhancing efficiency, convenience, and reliability in parking management.

Limitations

Despite its advantages, the proposed system has certain limitations:

• Dependency on System Components:

The performance of the system depends on the reliability of monitoring and communication components.

• Limited Coverage Area:

The current implementation is limited to specific parking areas and may require expansion for larger deployments.

• Infrastructure Requirements:

Installation of monitoring components requires proper infrastructure setup.

• Real-Time Constraints:

System performance may be affected under heavy usage or large-scale deployment without optimization.

• Limited Testing Environment:

Extensive real-world testing across different environments has not been fully conducted.

Future Work

The system can be further enhanced through the following improvements:

- Integration with Mobile Applications:** Develop mobile-based applications for easier user access and interaction.
- Expansion to Large-Scale Systems:** Extend the system to support multiple parking areas and smart city infrastructure.
- Advanced Monitoring Techniques:** Improve detection mechanisms for higher accuracy and reliability.
- Cloud-Based Data Management:** Implement cloud integration for better data storage and accessibility.
- Navigation Support:** Provide directions to available parking slots for user convenience.
- Enhanced User Interface:** Design more interactive and user-friendly interfaces for improved usability.

- g. **Reservation System Integration:**
Enable users to reserve parking slots in advance to reduce uncertainty and waiting time.
- h. **Automated Payment System:**
Integrate digital payment options for seamless parking fee transactions.
- i. **Energy-Efficient Operation:**
Optimize system components to reduce power consumption and improve sustainability.
- j. **Security and Access Control:**
Implement authentication and monitoring features to enhance system security.
- k. **Real-Time Notifications:**
Provide alerts and notifications to users regarding slot availability and status changes.
- l. **Data Analytics and Reporting:**
Analyze parking data to identify usage patterns and improve system planning.

REFERENCES

[1] A. Khanna and R. Anand, "IoT-Based Smart Parking System," *International Conference on Internet of Things and Applications*, 2019.

[2] S. Ghosh, S. K. Das, and A. Roy, "Smart Parking Systems Using IoT: A Survey," *IEEE Access*, vol. 8, pp. 181654–181671, 2020.

[3] M. Amato, F. Carrara, F. Falchi, C. Gennaro, and G. Vairo, "Deep Learning for Smart Parking Systems," *IEEE Transactions on Intelligent Transportation Systems*, vol. 21, no. 10, pp. 1–12, 2020.

[4] A. Badii, M. Bellini, and P. Nesi, "Smart Parking in Smart Cities: A Comprehensive Review," *Future Internet*, vol. 12, no. 5, 2020.

[5] N. Grodi, D. Rawat, and F. Rios-Gutierrez, "Smart Parking: Parking Occupancy Monitoring and Visualization System," *IEEE Systems Journal*, vol. 15, no. 3, pp. 3457–3466, 2021.

[6] R. Keerthana and P. Manickam, "IoT-Based Smart Parking System with Real-Time Monitoring," *International Journal of Advanced Research in Computer Science*, 2021.

[7] S. S. Yau and S. K. S. Gupta, "Internet of Things for Smart Cities: Technologies and Applications," *IEEE Computer Society*, 2021.

[8] M. A. Hannan, M. M. Hoque, A. Mohamed, and A. Ayob, "Review of Smart Parking Systems Using IoT," *Sensors*, vol. 22, no. 2, 2022.

[9] J. Lin, W. Yu, N. Zhang, X. Yang, H. Zhang, and W. Zhao, "A Survey on Internet of Things: Architecture, Enabling Technologies, Security and Privacy," *IEEE Internet of Things Journal*, 2022.

[10] A. Sharma and S. Kumar, "Real-Time Smart Parking System Using IoT and Cloud Computing," *Journal of Ambient Intelligence and Humanized Computing*, 2022.

[11] K. S. H. Tehrani and A. Michael, "Wearable Internet of Things: Concepts, Applications and Challenges," *IEEE Access*, updated applications including smart infrastructure, 2022.

[12] P. Bagula, L. Castelli, and M. Zennaro, "On the Design of Smart Parking Systems Based on IoT," *IEEE Sensors Journal*, 2023.

[13] S. K. Datta, C. Bonnet, and N. Nikaein, "IoT Architecture for Smart Cities," *IEEE Communications Magazine*, updated applications in 2023.

[14] V. Rajendran, R. Karthikeyan, and S. Prasanna, "IoT-Based Smart Parking System with Mobile Application Support," *International Journal of Engineering Research & Technology*, 2023.

[15] A. Verma and P. Sood, "Smart Parking System Using IoT and Real-Time Data Monitoring," *International Journal of Computer Applications*, 2023.

[16] H. Gupta, V. Kumar, and R. Kumar, "Cloud-Based Smart Parking System with Real-Time Monitoring," *Journal of Cloud Computing*, 2023.

[17] M. Singh and P. Kumar, "IoT Enabled Smart Parking System for Urban Areas," *International Journal of Smart Technology and Learning*, 2024.

[18] R. Sharma and A. Jain, "Real-Time Parking Management System Using IoT," *IEEE International Conference on Smart Systems*, 2024.

[19] S. Mehta and D. Patel, "Design and Implementation of Smart Parking System Using Sensors and IoT," *International Journal of Innovative Technology*, 2024.

[20] P. N. Mahalle, N. R. Prasad, and R. Prasad, "Internet of Things: Key Applications and Protocols," *Wiley*, updated edition 2023.

[21] A. K. Sangaiah, G. Wang, and A. Liu, "Smart Cities: Applications, Technologies, and Challenges," *CRC Press*, updated 2022.

[22] M. Collotta, G. Pau, and V. M. Salerno, "IoT for Smart Cities: Real-Time Applications," *IEEE Internet of Things Magazine*, 2023.

[23] Y. Liu, X. Chen, and L. Wang, "Edge Computing for Smart Parking Systems," *IEEE Transactions on Network Science and Engineering*, 2023.

[24] T. Qiu, R. Qiao, and D. Wu, "Edge Computing in Industrial IoT: Architecture and Applications," *IEEE Communications Surveys & Tutorials*, 2022.

[25] Z. Ullah, F. Al-Turjman, and L. Mostarda, "Applications of Artificial Intelligence in Smart Parking Systems," *IEEE Access*, 2023.