

Smart Parking: Real-Time Parking Availability System

Sudheer Kumar C¹, Bhanuchand C², Ganesh G³, Ezaaz Basha U⁴, Meenakshi B⁵
Assistant professor¹, Department of Computer Science and Engineering, Srinivasa Ramanujan Institute of Technology (SRIT), Anantapur, Andhra Pradesh, India
Department of Computer Science and Engineering^{2,3,4,5}, Srinivasa Ramanujan Institute of Technology (SRIT), Anantapur, Andhra Pradesh, India

Abstract:

Smart Parking: Real-Time Parking Availability System is a web-based solution for managing urban parking. This solution, which was created utilizing the MERN (MongoDB, Express.js, React.js, Node.js) stack, tackles issues related to car management and parking congestion. It gives users a smooth way to find and reserve parking spaces in real time. Customers may register, choose from a variety of car kinds, dynamically view available parking spots, enter vehicle information, and safely pay online using the platform. The technology guarantees effective parking spot usage and improves urban mobility by integrating real-time updates with an intuitive user interface. In line with the goal of sustainable and effective urban development, this project represents a step toward more intelligent and practical parking options.

Keywords: Smart Parking Management, MERN Stack, Parking Slot Availability, User Registration, Web-Based Parking Solution, Secure Payment Gateway, Email Notifications, Urban Mobility, Smart Cities.

1. Introduction:

In today's urbanized world, managing parking spaces efficiently has become a significant challenge due to the ever-increasing number of vehicles and limited parking infrastructure. Searching for available parking spaces often leads to traffic congestion, fuel wastage, and frustration among drivers. To address these challenges, the Real-Time Parking Availability System offers a comprehensive and modern solution for optimizing parking space usage and enhancing user convenience. This system, developed using the MERN (MongoDB, Express.js, React.js, Node.js) stack, provides users with a seamless experience to locate and reserve parking slots in real-time. With features like user registration, vehicle type selection, and secure payment integration, the platform simplifies the parking process while promoting a hassle-free experience.

Users can view parking slot availability dynamically and complete reservations within minutes, reducing the stress and uncertainty of finding a parking spot. The system also allows users to input essential vehicle details, ensuring smooth operations and better management of parking resources. By streamlining the parking process, the system contributes to reduced traffic congestion and improves the overall efficiency of urban transportation systems.

2. The Role of this Web Application:

Smart Parking: Real-Time Parking Availability System plays a crucial role in tackling urban parking challenges by providing a seamless and efficient platform for parking management. This web application offers real-time updates on parking slot availability, reducing the time spent searching for spaces and minimizing traffic congestion. Its user-friendly interface ensures accessibility, allowing users to register, log in, and interact effortlessly across various devices. The system facilitates vehicle and slot management by enabling users to select vehicle types and input necessary details, ensuring optimal utilization of parking spaces. Secure online payment integration enhances convenience by enabling quick and hassle-free transactions.

Additionally, the application notifies customers via email about the expiration of their parking duration, ensuring they remain informed and avoid overstaying. By streamlining the parking process, the system contributes to smoother traffic flow, improved urban mobility, and sustainable urban living. It aligns with the vision of smart cities, offering an innovative solution to real-world challenges while enhancing the quality of life for urban residents.

3. Literature Review:

Parking management has become increasingly difficult due to urbanization and the increase in car ownership, which has prompted a great deal of research into electronic solutions. Conventional parking techniques can lead to inefficiencies including longer search times, higher fuel costs, and traffic jams. Web-based parking systems have become viable substitutes, providing scalable and adaptable answers to these problems.

4.1. Web-Based Parking Systems:

Parking management has become increasingly difficult due to urbanization and the increase in car ownership, which has prompted a great deal of research into electronic solutions. Conventional parking techniques can lead to inefficiencies including longer search times, higher fuel costs, and traffic jams. Web-based parking systems have become viable substitutes, providing scalable and adaptable answers to these problems.

4.2. Digital Payment Integration:

The incorporation of e-commerce capabilities, especially secure digital payment options, has become a fundamental characteristic of contemporary parking systems. Research shows that providing online payment methods greatly improves user convenience, minimizes manual processes, and boosts system adoption rates.

4.3. Email Notifications for User Management:

Web-based parking systems are increasingly utilizing email notifications to keep users updated on essential information, such as confirmation of bookings and expiration of parking durations. Research has highlighted the significance of prompt communication in enhancing user satisfaction and ensuring adherence to system regulations.

4.4. Sustainable Urban Mobility:

Online parking systems aid sustainable urban mobility by improving the use of parking areas and minimizing unnecessary driving. In contrast to sensor-based solutions, web applications depend on real-time data from users and managers, which makes them more affordable and simpler to implement.

5. Methodologies:

5.1. Flow Chart:

A flowchart is a diagrammatic representation of the processes that take place in a system in a project. The processes are shown in the chart. In the flowchart shown below, all the processes included are represented. The flowchart begins and ends at the terminals indicated using oval-shaped diagrams. Diamond-shaped objects are decision-making. All objects defined by rectangular boxes represent processes that take place on the website. The process shown adjacent to each other is in sequence. This flow chart the main steps, including user registration, slot selection, payment, and email notifications.

filters, user-reported parking updates, and email notifications for slot expiration.

5.3.4. Prototype: Designed wireframes and prototypes of the system, showcasing key functionalities such as the user dashboard, parking slot availability display, and payment interface.

5.3.5. Test: The prototypes were tested with a group of users to gather insights on usability and design, leading to iterative refinements.

This process ensured that the system met the real-world needs of users while providing a seamless experience.

5.4. MERN Stack Framework:

The MERN stack (MongoDB, Express.js, React, Node.js) was employed as the primary technology framework, enabling the development of a robust, scalable, and interactive system.

5.4.1. MongoDB: A NoSQL database was chosen for its flexibility in storing hierarchical and relational data, such as user profiles, parking slot details, and payment history. MongoDB enabled efficient management of data and ensured scalability for large user bases.

5.4.2. Express.js and Node.js: The backend was built using Express.js and Node.js to handle RESTful APIs, real-time slot updates, and secure payment integration. These technologies ensured fast and reliable server-side operations.

5.4.3. React: The front-end was developed using React, allowing for the creation of a dynamic, responsive user interface. Key features include real-time parking slot updates, intuitive navigation, and seamless interaction across devices.

6. Implementation:

6.1. Database Schema Design:

Key entities and their attributes include essential components of the system's database, such as Users, Parking Slots, and Payments, each designed to store specific information necessary for seamless operation and efficient data management.

6.1.1. Users Database Schema:

```
json
{
  "userId": "unique_id",
  "name": "John Doe",
  "email": "john@example.com",
  "password": "hashed_password"
}
```

6.1.2. Parking Slots Database Schema:

```
json
{
  "slotId": "unique_id",
  "isAvailable": true,
  "vehicleType": "Car/Bike",
  "bookingDetails": {
    "userId": "linked_user_id",
    "startTime": "timestamp",
    "endTime": "timestamp"
  }
}
```

6.1.3. Payment Database Schema:

```
json
{
  "paymentId": "unique_id",
  "userId": "linked_user_id",
  "amount": 100,
  "status": "Success",
  "transactionDate": "timestamp"
}
```

6.2. Backend Development:

The backend APIs are implemented using Express.js to handle core functionalities:

6.2.1. User Management: APIs for user registration, login, and authentication.

6.2.2. Slot Management: APIs to fetch available slots and book them.

6.2.3. Payment Integration: APIs to process transactions using payment gateways like Razorpay.

6.2.4. Email Notifications: Nodemailer is used to send emails for slot booking confirmation and expiration reminders.

6.3. Frontend Development:

React is used to create responsive UI components:

6.3.1. Home Page: Displays real-time parking availability.

6.3.2. Login/Registration: Handles user authentication.

6.3.3. Booking Dashboard: Allows users to manage parking bookings and view history.

6.3.4. Payment Gateway Integration: Provides a seamless payment experience.

6.3.5. Routing and State Management: React Router and Context API manage application navigation and state transitions.

6.4. Deployment:

The system is deployed on modern cloud platforms:

6.4.1. Frontend: Hosted on Vercel for continuous deployment.

6.4.2. Backend: Deployed using Heroku.

6.4.3. Database: MongoDB Atlas provides secure and scalable database hosting

7. Results:

The Smart Parking: Real-Time Parking Availability System achieved significant results in streamlining parking management. Users can seamlessly register, log in, and manage profiles while accessing real-time updates on parking slot availability. The system allows efficient input of vehicle details and secure payment processing through an integrated payment gateway. Automated email notifications enhance user engagement by providing updates on bookings and slot expirations. By adopting a sensor-less approach, the system minimizes hardware dependency, reducing costs and complexity. With a responsive design and user-friendly interface, the application delivers a reliable and scalable solution for both small and large parking facilities, ensuring enhanced user satisfaction and operational efficiency.

Future Scope:

The future scope of the Smart Parking: Real-Time Parking Availability System is vast, considering the growing demand for smart transportation solutions in urban areas. Enhancing the system with AI and machine learning can improve parking predictions based on historical data and user behavior. Integrating IoT-based sensors in parking lots can provide more accurate real-time data on slot availability. Expanding the platform to support multiple cities and different types of parking spaces, such as residential, commercial, and event-based parking, can increase its scalability. Additionally, incorporating advanced payment methods like cryptocurrency and digital wallets can enhance user convenience. Features like dynamic pricing based on demand, automated license plate recognition, and integration with smart city infrastructure can make the system more efficient and widely adopted. Collaborations with local governments and businesses can help in implementing this system on a larger scale, contributing to better urban mobility and reduced traffic congestion.

Conclusion:

The Smart Parking: Real-Time Parking Availability System provides an efficient, user-friendly, and scalable solution for modern parking management. Built with the MERN stack, it allows users to register, select vehicle types, view available slots, enter vehicle details, and make secure payments. Email notifications enhance user engagement, while the system approach ensures simplicity and cost-efficiency.

Acknowledgment:

We express our sincere thanks to Mr. C. Sudheer Kumar, Assistant Professor of the Department of Computer Science and Engineering, Srinivasa Ramanujan Institute of Technology, for our Support and guidance in building this project successfully.

References:

- [1] Ms.Nupur Banode, Vaishnavi Shahu, Shrutika Ighave, “smart parking system Using Web Technologies”, International Journal of Web Applications, Vol. 11, Issue 5, May 2023
- [2] Hasan, Omkar, Rushikesh, “Vehicle Parking Management System”, Vol. 2, Issue 1, March 2022
- [3] Pallavi, Khushi, Chethana, “Vehicle Parking Management System”, Vol. 7, Issue 6, Dec 2023
- [4] A. K. Sharma, P. Gupta, and R. Singh, “Smart Parking Management System using IoT and Web Applications”, in Proceedings of the International Conference on Internet of Things (IoT), New Delhi, India, 2023, pp. 245–252.
- [5] L. Zhang, J. Wang, and M. Hu, “Web-Based Urban Parking System for Smart Cities”, in Proceedings of the IEEE International Conference on Smart Cities (ICSC), Toronto, Canada, 2022, pp. 123–130
- [6] M. Patel, S. Aggarwal, and K. Rao, “Comparative Study of Front-End Frameworks for Urban Mobility Apps”, in Proceedings of the International Symposium on Web Technologies (ISWT), Mumbai, India, 2023, pp. 89–96.
- [7] P. Garcia and F. Lopez, “Urban Mobility Challenges and Smart Parking Solutions”, in Proceedings of the International Conference on Transportation and Logistics (ICTL), Barcelona, Spain, 2020, pp. 121–130.