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Smart Parking System

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Abstract - As urbanization progresses, the surge in vehicle numbers has amplified the need for efficient parking management in cities. Traditional parking methods frequently lead to traffic congestion, poor space usage, and user dissatisfaction. This study introduces a smart parking solution that operates independently of Internet of Things (IoT) technology, instead leveraging software-based strategies with minimal hardware dependency.

***Key Words*:** Traffic Congestion,Urban Mobility,Space Optimization,Real-Time Availability.

INTRODUCTION

With the growth of urban areas, the increasing number of vehicles has made efficient parking management a significant challenge. Conventional parking systems, often reliant on manual methods, struggle to meet this demand, leading to traffic congestion, wasted fuel, and frustration for drivers looking for available spaces. While smart parking systems have been developed to address these issues, many of them depend on Internet of Things (IoT) technology, which can be complex, costly, and challenging to implement at scale.

This project presents a smart parking solution that avoids IoT technology, using software-driven methods and limited hardware instead. By utilizing computer vision and camera-based monitoring, the system detects vehicle occupancy in real-time, accurately updating available parking spaces without the need for individual IoT sensors. This design makes the system adaptable and cost-effective, suitable for various parking setups, from smaller lots to large urban facilities.

Key features of the system include real-time tracking of parking availability, optimized space allocation, and a user-friendly interface accessible via web and mobile platforms. A centralized database stores and updates occupancy data, providing accurate, up-to-the-minute information as vehicles enter and leave the parking area. Additionally, the system incorporates predictive algorithms to anticipate high-demand periods, ensuring efficient space management and smoother traffic flow.

By reducing hardware reliance, this smart parking solution provides a practical, affordable answer to common parking challenges, helping to ease urban traffic congestion, save fuel, and enhance the driver experience—all without the need for a complex IoT infrastructure.

LITERATURE SURVEY

The development of smart parking systems has become a focal point in research as cities seek solutions for traffic congestion and parking space inefficiencies. Traditional parking systems, which typically rely on manual processes, have been found inadequate for managing high vehicle volumes, particularly in urban settings. Studies by Zuylen and Taale (2010) report that approximately 30% of urban traffic congestion stems from vehicles circling in search of parking spaces. This highlights the need for automated and optimized parking solutions to address these challenges.

IoT-based parking systems, which utilize sensors to monitor parking availability in real-time, are well-explored in the literature. Research by Choudhury et al. (2016) shows that IoT sensors, such as infrared and ultrasonic devices, can provide reliable occupancy data that drivers can access via mobile apps. However, these systems require significant investment in infrastructure and ongoing maintenance, making them costly and complex, especially for large-scale applications. These limitations have prompted interest in alternative, non-IoT-based approaches that can offer similar benefits with fewer resource demands.

Camera-based and computer vision approaches are emerging as effective non-IoT alternatives for tracking parking occupancy. Studies by Li et al. (2018) demonstrate that camera systems, paired with image processing algorithms, can monitor multiple parking spaces with just one camera, reducing hardware costs. Recent advances in machine learning have further enhanced the accuracy of vehicle detection, even under challenging conditions, making these systems more adaptable and efficient.

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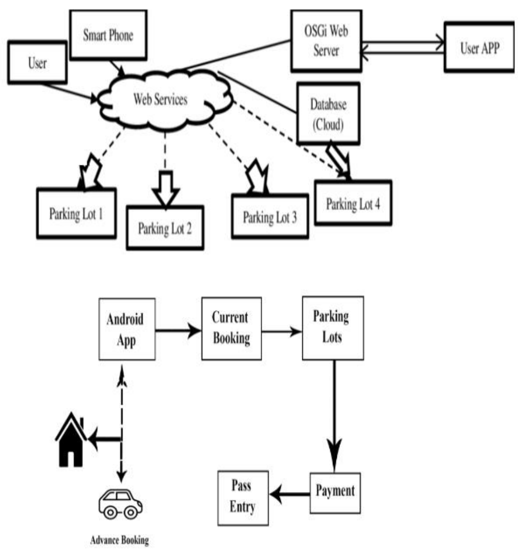
In addition, predictive algorithms are increasingly being integrated into smart parking systems to help manage demand and anticipate peak usage periods. Lin and Nie (2017) explored the application of machine learning models for forecasting parking demand using historical data and external factors such as weather and events. These algorithms optimize space allocation and improve system efficiency, a feature that can significantly benefit non-IoT smart parking solutions by helping them dynamically manage parking spaces.

Centralized databases are also crucial for managing real-time parking data, enabling quick data retrieval and easy integration with user interfaces. Studies by Lee et al. (2019) emphasize the role of centralized systems in providing consistent, updated information on parking occupancy, which is critical for accurate availability tracking. Such databases are especially beneficial for non-IoT parking solutions as they allow real-time data management without the need for extensive sensor networks.

Finally, user experience is a critical component of successful smart parking systems. Roumboutsos and Kapros (2008) suggest that a simple, intuitive interface enhances user satisfaction by allowing drivers to find parking spaces quickly. For non-IoT systems, providing a streamlined web or mobile interface can ensure that drivers have easy access to parking information in real-time, enhancing the overall user experience.

BASIC SYSTEM ARCHITECTURE:



1. System Architecture Overview

For an **Android-based Smart Parking System** without using IoT, the architecture will focus on Android application development, a centralized backend for data processing, and manual or semi-automated systems for monitoring parking availability. Below is a detailed architecture for such a system:

Architecture of an Android-based Smart Parking System (without IoT)

1. **Android User Application:**
   a. **User Interface**: The mobile app allows users to interact with the parking system. Key features include:
      i. **Search Parking Spaces**: Users can check the availability of parking spots at nearby parking lots in real time.
      ii. **Reserve Parking**: Users can book a parking spot for a particular duration and receive a confirmation.
      iii. **Payment**: Users can make payments for parking through integrated payment systems (e.g., PayPal, Google Pay).
      iv. **Navigation**: After booking a spot, the app can provide directions to guide users to the parking location.
      v. **Notifications**: Send real-time updates such as booking confirmations, parking reminders, and alerts for time expiry.
2. **Admin Web Dashboard (Optional):**
   a. Admins can monitor the system's performance, track parking lot occupancy, and manage user data.
   b. Features include:
      i. **Parking Availability Management**: Admins can manually update parking status if needed (e.g., when a spot is occupied or vacated).
      ii. **Reports and Analytics**: Admins can generate reports on parking utilization, peak hours, and payments.
      iii. **System Management**: Admins can set pricing, update parking lot information, and manage user accounts.
3. **Backend Server (Web API):**
   a. **Web Server**: A backend server (e.g., built with Java, Spring Boot, or Node.js) hosts the system and communicates with both the Android app and database.
   b. **Database (MySQL/PostgreSQL)**: The central database stores parking information, user data, reservations, payments, and availability status. It contains tables for parking lots, spots, users, reservations, payment logs, and more.
   c. **Booking and Reservation Management**: The backend handles user bookings, tracks real-

time availability, and updates the database when spots are reserved or vacated.

d. **Payment Processing**: The backend integrates with third-party payment gateways (e.g., Stripe, PayPal) to handle transactions securely.

e. **Admin Dashboard**: An administrative interface to manage parking lot data, monitor activity, and generate reports.

4. **Parking Lot Management System:**
   a. **Manual Availability Update**: Staff at the parking lot can manually update the availability status of parking spots on the backend server. This could be done via a mobile app or a desktop web interface.
   b. **Visual Indicators**: Simple indicators (like signs, color-coded parking spots, or slot numbers) can help users identify available or occupied spots. These markers are updated based on the data input from the lot management system.
5. **Communication Between Components:**
   a. **RESTful API**: The communication between the Android app and backend is done through REST APIs. The app sends requests to the server (e.g., check availability, book a spot), and the server responds with the necessary data (availability, booking confirmation).
   b. **Notifications**: The backend uses services like **Firebase Cloud Messaging (FCM)** to send push notifications to users regarding booking updates, reminders, or parking time expirations.
6. **Flow of the System:**
7. **User Interaction (Android App):**
   a. The user opens the Android app and searches for parking spaces near their location.
   b. The app queries the backend server for parking availability in nearby parking lots.
   c. The backend server responds with available parking spaces.
   d. The user selects a spot, and the app sends a request to the server to reserve it.
   e. The server confirms the reservation, updates the database, and sends a confirmation to the user's app.
   f. The user proceeds to the parking lot and parks in the assigned spot.
8. **Parking Lot Management (Backend):**
   a. Staff can update the parking availability in real-time through the admin web dashboard or mobile app if a car leaves or enters.
   b. Parking availability updates are reflected immediately in the system and can be queried by the users.
9. **Payment:**
   a. Once the parking time expires, the user is notified to make a payment.
   b. The user makes the payment via an integrated payment gateway.
   c. The payment is processed by the backend, and the transaction is logged in the database.
10. **Admin Control (Admin Dashboard):**
    a. Admins can monitor real-time availability, track revenue, and manage parking spots (add/remove spots, set pricing).
    b. Admins can view the performance of the system and manage users if necessary.
11. **Components Breakdown:**
12. **Frontend (Android App)**:
    a. **Languages**: Java/Kotlin for Android development
    b. **UI**: XML for layouts, Java/Kotlin for app logic
    c. **Libraries**: Retrofit for API calls, Glide/Picasso for image loading, Firebase for push notifications
13. **Backend (Web API)**:
    a. **Languages**: Java with Spring Boot (or Node.js for a JavaScript stack)
    b. **Database**: MySQL/PostgreSQL
    c. **Payment Integration**: Stripe, PayPal API
    d. **Framework**: Spring Boot (for Java-based backend), Express.js (for Node.js-based backend)
14. **Admin Dashboard**:
    a. **Languages**: HTML, CSS, JavaScript (for the frontend)
    b. **Framework**: ReactJS or Angular for the frontend, and Spring Boot or Node.js for the backend.
15. **Technologies Used:**
16. **Android Development**: Java/Kotlin, Android Studio, Firebase
17. **Backend Server**: Java/Spring Boot or Node.js, MySQL/PostgreSQL
18. **Payment Gateway**: Stripe, PayPal
19. **Push Notifications**: Firebase Cloud Messaging (FCM)

CONCLUSION

The non-IoT Smart Parking System offers an efficient, cost-effective solution for managing parking spaces in urban and private settings. By utilizing cameras, data analytics, and predictive algorithms, the system enables real-time parking availability updates, reducing congestion and optimizing parking space utilization. It provides a user-friendly experience with functionalities like real-time space detection and predictive demand analysis. The system is scalable, affordable, and easier to implement compared to IoT-based alternatives, making it a suitable option for cities, commercial establishments, and residential areas.

The advantages of this system include cost savings, improved user convenience, and better resource management, while its limitations mainly stem from the reliance on visual data accuracy and potential system performance challenges. Despite these limitations, the system provides a robust foundation for improving parking management and optimizing parking space usage.

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