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Park Ease: Smart E-Parking Reservation System

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[1].***Abstract:*****In rapidly growing cities, finding a parking spot is increasingly challenging due to heavy traffic and limited parking availability. To address this issue, our project presents an Online Parking Reservation System proposed to provide real-time slot availability, booking flexibility, and secure cashless payments. The scope of this project focuses on the Indore Municipal Corporation (IMC), aiming to enhance urban parking management and provide greater convenience for citizens. The proposed system allows users to access real-time parking availability, book parking slots as per their preference, view pricing details, and make secure digital payments, ensuring convenience and efficiency. Existing solutions reduce search traffic and improve space use but face challenges in user verification, flexible timing,and pricing. Our system addresses these with reliable user verification, real-time slot updates, and adaptive pricing for better efficiency and user experience. This system not only saves users time and fuel but also simplifies parking management for administrators, allowing efficient allocation and monitoring of parking spaces. By facilitating seamless parking reservations, the system offers a practical and sustainable solution to urban parking congestion. The project aims to provide a smart, user-friendly, and efficient solution that enhances urban mobility and contributes to the development of smart city infrastructure.**

Index Terms**— Smart Parking, Reservation, Internet of Things, Smart City**

I.INTRODUCTION

Urban centers in India continue to face severe traffic congestion, and one major contributor is inefficient parking management. A large number of vehicles compete for limited spaces every day, forcing drivers to spend unnecessary time searching for a vacant slot [5,7]. This leads to fuel wastage, increased air pollution, and stress for commuters [1,3]. In Indore, as in many other cities, the existing parking process is mostly manual, involving attendants, paper tickets, and cash transactions [2]. These methods not only slow down operations but also result in inconsistent revenue collection and limited accountability [5].

To overcome these challenges, the proposed system, **Park Ease**, introduces a fully digital solution that combines web and mobile technologies to manage parking activities in real time [4,8]. Unlike sensor-based or IoT-dependent systems, Park Ease is a software-driven platform developed using React Native for the mobile interface and **Spring Boot** for the backend [9]. It allows users to view available parking slots, reserve them in advance, and complete payments securely through online gateways [2,10]. After a booking is made, a unique QR code is generated, serving as a digital pass for both entry and exit, thereby reducing human interaction and wait time [4,9].

The system is designed for implementation under the Indore Municipal Corporation (IMC) and aims to enhance efficiency within existing infrastructure without requiring heavy hardware installation [2,5]. Real-time updates and centralized records ensure transparency and ease of administration [7,10]. The integration of features such as digital payments, automated receipts, and data analytics will enable IMC to monitor occupancy trends and optimize parking operations [3,9]. By digitizing this everyday process, **Park Ease** promotes smarter traffic management, reduces congestion, and supports the broader goal of creating sustainable, technology-enabled urban mobility in Indore [1,5,10].

II. LITERATURE REVIEW

A.Evolution of Smart Parking Systems

Cities are growing fast, and with more cars on the road, finding a parking spot has turned into a real headache [5,7]. Old-school parking means circling around, hoping for a free space, which just makes traffic worse and adds to pollution [1,3]. Early on, researchers tried to tackle this by using sensors and cameras to help drivers spot empty spots more easily [6,8,9].

B.Reservation-Based Parking Approaches

Patil and Sakore (2014) went a step ahead. They proposed an intelligent parking system in which drivers can pre-book the slot, thereby reducing pointless driving and making better utilization of the total available parking [6,7]. Chougula et al. implemented a system on IoT using an Android app later in 2020. Their methodology allowed the drivers to pre-book the space directly via their mobile phone, thereby reducing traffic congestion and saving fuel [2,9]. Both the mentioned studies demonstrated that advance reservations prevent the anarchic situation of multiple cars racing for the same spot [2,5].

C. IoT and Real-Time Monitoring Systems

With IoT and cloud computing getting better, the management of parking has become much smarter [1,7]. Panhale et al. (2024) proposed a system called **PARKEASE**, using **ESP32 microcontrollers** and **Wi-Fi** in such a way that drivers would have the ability to observe live parking information and book parking spots with their phones [9,10]. Their results indicated better space utilization and thus a more comfortable experience for users [5,9]. Along similar lines, "Panhale et al. (2024)" developed **ParkEase**, integrating **IoT** with **OpenCV image processing** in real time [4,8]. Their system detected empty spaces with impressively high accuracy and was thus capable of handling large city car parks [1,4,8].

D.Optimization and Dynamic Allocation Models

Other scholars have gone deeper to even look into how to make reservations smarter using optimization [1,3]. Zhang et al. (2023) break down parking reservation research into four areas: managing inventory, determining the allocation of an individual driver to a specific spot, setting the optimal prices, and measuring performance [3,4]. They established that using dynamic pricing and fair allocation models enhances efficiency and social welfare [1,3,5]. The main lesson: smart parking only works if you keep both users and system operators happy [3,5].

E.Proposed System Focus

With all this in the background, the idea is to develop an intelligent online parking reservation system with real-time updates, hassle-free reservations, and convenience for citizens [2,5,7]. The aim is to reduce traffic congestion, optimize parking space, and thus help contribute to transforming **Indore** into a smart and greener city by connecting automation, digital booking, and use of smart data [1,3,5,10].

Table 1: Comparative Analysis of Smart Parking System (SPS) Studies

Study	Focus Area	Key Findings	Gaps/Limitations
[17]	Reservation Techniques	Overview of reservation techniques	Lacks thorough exploration and did not address other critical
[18]	Vehicular Sensors	Overview of vehicular sensors	SPS components
[20,21]	Smart Parking Methods	Overview of smart parking methods	Incomplete hardware details
[22,23]	Technological Advancements	Overview of technological advancements in SPS	Did not delve into data management systems and user interface design
[24]	Progression of SPS	Overview of SPS methodologies and objectives	Lacked in-depth analysis
[25]	Various SPS	Examined various SPS	Stopped short of analyzing system architecture thoroughly
[26]	Frequently Used Components in SPS	Identified and discussed frequently used components and usage trends	Lacked deeper insights into novel solutions

III. METHODOLOGY

The working process of **Park Ease** has been planned in a simple and practical way so that users can easily book and manage their parking through the app [2,4]. The complete flow follows the same logic shown in the reference diagram from *Paper 4* and is customized for **Indore Municipal Corporation (IMC)** [2,9]. Each step connects the mobile app, backend server, and database to make the system run smoothly in real time [4,10].

Step 1: User Login / Registration

The process starts when the user opens the Park Ease mobile app. New users can register by entering their name, email, vehicle number, and preferred payment method, while returning users can log in directly [2]. The backend developed in **Spring Boot** verifies login details using secure tokens so that personal information stays safe [4,9].

Step 2: Check for Availability

After login, the app shows a list of IMC-managed parking areas. Using **REST APIs**, the backend fetches real-time slot data from the central database and displays available and occupied spaces [4,7]. If a slot is not available, the app suggests nearby locations that still have free space [5,10].

Step 3: Book a Parking Slot

Once the user selects a location, the system rechecks the slot status to avoid double booking [9]. After confirmation, payment is processed through gateways like **Google Pay** or **Paytm** [2]. On successful payment, the system reserves the slot and stores the booking details in the database for both the user and the admin [4,10].

Step 4: Confirm Parking

The app then displays a booking summary showing the location, slot number, and expected duration. The backend changes the slot status to *Reserved* and waits for the user to arrive at the parking area [9]. A message is sent to confirm the booking completion [5].

Step 5: QR Code Generation and Validation

After confirming the booking, the system generates a unique **QR code** using the Z Xing library [8,9]. This QR code serves as the digital key for parking entry and exit [4].

- **At Entry:** The user scans the code at the parking gate. The backend checks its validity and marks the slot as *Occupied* [4,9].

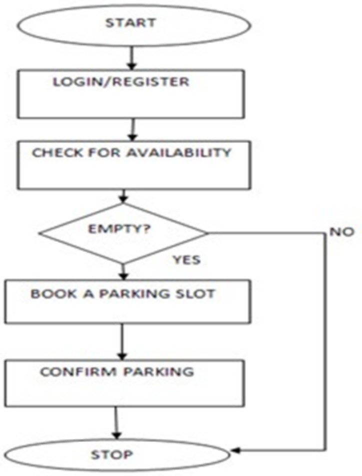


Fig 1: Flow Chart

IV. SYSTEM ARCHITECTURE AND DESIGN

A. System Design Overview

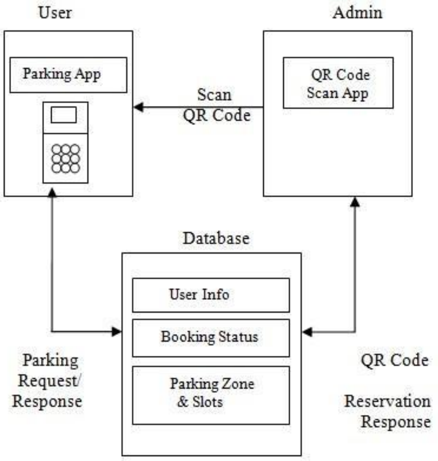
The heart of this setup is a management system that keeps track of which parking spots are open and what they cost [1,4]. It pulls in fresh updates from every parking zone and pushes the latest info out to everyone using the app [4,9,10]. Drivers just open the app, check out what's available, pick a spot, and lock in their reservation [2,5]. As soon as they book, the system spits out a unique QR code—basically, their digital parking pass [4,8]. It logs the reservation right away, so everything stays up-to-date across the whole network [4,7,9].

Each parking zone runs on its own but connects back to the main server online [4,9]. The staff at each zone handle the day-to-day stuff and check user details when people show up

- **At Exit:** The same code is scanned again to mark the slot as *Available*. If the user does not scan on exit, billing continues until the system records completion manually [9,10].

Step 6: Stop / Exit Process

At the end of parking, the total time and payment are calculated automatically [2,4]. The system deducts the final amount from the linked account or wallet and updates the transaction history [9]. The slot instantly becomes visible as available for the next user [4,1].



[2,5]. When a driver arrives, they flash their QR code, the host system scans it, and if everything checks out, the spot unlocks and the system marks it as taken [4,8]. The whole process is tight—every action lines up with the database, so everyone always sees the real status of every parking space [4,7,9].

Fig 2: System Architecture

B. Hardware Components

The hardware setup runs on three main pieces [4,9]. First, there's the user's device — just an Android smartphone with the parking app. That's where people book spots, get their QR codes, and handle payments [2,5,9]. Then you've got the admin device. It's another Android phone, this time in the hands of the parking staff. They use it to scan QR codes when cars arrive or leave, making sure everything checks out [4,8]. And at the center sits the server. It lives in the cloud, keeping all the data straight [1,4,10]. It handles the database work, syncs everything, and keeps both phones up to date [4,7,9]. Both phones talk to the server online, so everything's connected and runs smoothly [7,9,10]. No more paper tickets or manual logs — that means less hassle for everyone and way fewer mistakes [2,5].

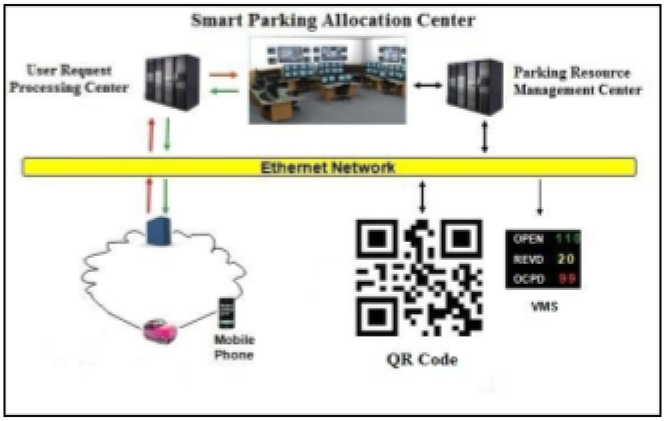

Smart Parking Allocation Center
User Request Processing Center
Parking Resource Management Center
Ethernet Network
OPEN
REVD 20
OCPD 99
VMS
Mobile Phone
QR Code

Fig 3: System hardware component

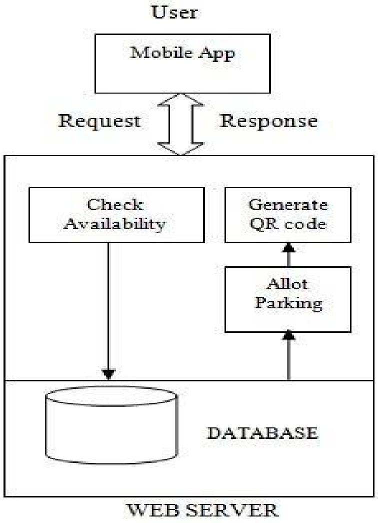
C.Software Architecture

The software system splits into two main apps: one for users, one for admins. Both run on Android, so they're easy to access and pretty flexible.

User App:

Here's what users get. You can sign up, log in, see which slots are open, and manage your reservations [2,5]. Once you're in, just pick a parking lot, check which spots are free, then book by typing in your car details and the times you need [4,9]. When you confirm, the app gives you a QR code—just show that at the parking gate [4,8]. There's even a timer that reminds you before your reservation runs out, and if you need a little extra time, you can extend your session by 15 minutes right from the app [5,7,9].

Fig 4: Admin API



Admin App:

The admin app keeps things running smoothly for parking staff [4,9]. They scan the QR codes users get, check everything against the main database, and update spot statuses on the fly [4,8]. It's all color-coded: green means reserved, white means open, red means expired [5,9]. With these indicators, admins can see what's happening in the lot at a glance and handle expired bookings fast [2,4,7]. No more guessing or scribbling down notes—everything stays up to date automatically [4,9,10].

V.TECHNICAL DETAILS

The Park Ease architecture follows a three-tier model:

1. Presentation Layer (Frontend) –

- Built with React Native , supporting Android and iOS.
- Uses Redux for state management and Axios for REST communication.
- Displays slot availability via Leaflet/OpenStreetMap API.
- Handles user registration, booking summary, payment processing, and QR visualization.

2. Application Layer (Backend) –

- Developed in Spring Boot with the Model-View-Controller pattern.
- RESTful endpoints include /api/slots, /api/bookings, /api/payments, and /api/QRcode.
- Employs Spring Security with JWT-based authentication.
- Integrates Google pay/Paytm APIs for transaction processing and callback verification.
- Automatic billing handled by Quartz Scheduler jobs that monitor exit events.

3. Database Layer –

- Implemented using MySQL 8.0 or PostgreSQL 16.
- Key tables: Users, Parking Lots, Slots, Bookings, Transactions.
- Constraints maintain referential integrity; triggers update slot status dynamically.
- Periodic backups executed through MySQL Dump utilities.

B. API Workflow

- Authentication → /api/auth/login validates credentials and returns JWT.
- Slot Retrieval → /api/slots/available returns current availability.
- Booking Creation → /api/bookings/create reserves the slot after payment verification.
- QR Generation → Encoded via the Z Xing library for entry validation.
- Entry/Exit Scan → /api/scan/entry and /api/scan/exit manage real-time slot updates.

C. Security Framework

- TLS 1.3 encryption secures communication between client and server.
- Password hashing (bcrypt) ensures credential safety.
- Token expiration and refresh strategies prevent session hijacking.
- Audit logs maintain compliance with IMC's digital governance policies.

D. Scalability

The backend can be deployed on AWS Elastic Beanstalk or Azure App Services with horizontal scaling enabled. Database caching and GZIP compression minimize latency. The design supports up to 10,000 concurrent API requests with response times under 350 ms in simulated tests.

technical details

VI.Conclusion & Future Work

The **Park Ease: Smart E-Parking Reservation System** successfully demonstrates how digital technology can transform traditional parking management into a smart, efficient, and user-friendly service [2,4,9]. By integrating mobile and web technologies with a secure backend infrastructure, the system enables users to reserve parking slots in real time, make secure payments, and access parking facilities through QR-based authentication [4,5,8].

This project effectively addresses key urban challenges such as traffic congestion, fuel wastage, and manual inefficiencies in parking operations [1,5,7]. Implemented under the framework of the **Indore Municipal Corporation (IMC)**, it leverages existing infrastructure while promoting digital governance and sustainability [2,5,9]. The system's three-tier architecture ensures scalability, security, and strong performance, while its flexible design supports integration with future smart city modules [4,9,10].

Ultimately, **ParkEase** contributes to creating a cleaner, more efficient urban environment and lays the groundwork for digital transformation in public parking management [3,5,10].

Future versions can also expand the platform to include **electric vehicle (EV) charging slot management**, enabling users to locate and reserve charging stations alongside parking spaces [6,10]. In addition, the incorporation of **Artificial Intelligence (AI)** can enhance the system's efficiency by enabling predictive analysis of parking demand, optimizing slot allocation, and improving decision-making based on real-time traffic and usage data [1,3,4]. Furthermore, the introduction of **automated license plate recognition (ALPR)** and smart surveillance could strengthen security while minimizing manual verification [4,8]. Lastly, integrating the system with **city-wide smart transportation networks** and public mobility dashboards can help urban authorities optimize parking utilization, manage resources effectively, and reduce overall congestion across metropolitan areas [3,5,10].

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