System and method for resolving the parking issues using smart vehicle parking

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DECLARATION

We hereby declare that this submission is our own work and that, to the best of our knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

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CERTIFICATE

This is to certify that Project Report entitled " **System and method for resolving the parking issues using smart vehicle parking** " which is submitted by Ishita Srivastava, Kritika, Gurpreet Kaur in partial fulfillment of the requirement for the award of degree B. Tech. in Department of Computer Science of Dr. A.P.J. Abdul Kalam Technical University, Lucknow is a record of the candidates own work carried out by them under my supervision. The matter embodied in this report is original and has not been submitted for the award of any other degree.

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Last but not least, we acknowledge our friends for their contribution to the completion of the project.

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ABSTRACT

Traffic congestion, illegal parking, and safety problems have resulted from the imbalance between the increasing number of vehicles and the restricted number of parking spots in metropolitan areas. Conventional parking infrastructure is frequently ineffective, resulting in higher fuel use, wasted time, and financial losses. By offering an intelligent, Internet of Things-enabled parking solution that maximizes parking space use without necessitating extra infrastructure development, the initiative seeks to address these issues.

The project links up automobile owners looking for parking spots with owners of open spots who are prepared to lease their spots. To provide a flawless parking experience, the system combines Django (backend), Firebase (real-time data sync), and IoT sensors (parking space detection). Real-time parking availability updates are provided by ultrasonic and infrared sensors, cutting down on needless fuel use and cruise time.

ParkEzy encourages sustainable urban mobility through contactless purchases, automated booking, and geolocation-based slot discovery. By increasing transportation efficiency and lowering environmental impact, this project supports the Sustainable Development Goals (SDGs 11 and 12: Sustainable Cities, Responsible Consumption, and Industry & Innovation, respectively).

The implementation of the project is expected to reduce urban traffic congestion, enhance parking safety, and provide additional income opportunities for parking space owners, contributing to a smarter and more sustainable urban future.

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SDG MAPPING WITH JUSTIFICATION

SDG 9: Industry, Innovation, and Infrastructure

1. **IoT Integration for Smart Parking:** ParkEzy automates parking and increases efficiency by using ESP8266, IR sensors, and ultrasonic sensors.

2**. Real-Time Data Processing:** Firebase provides real-time parking status updates, which improve user and municipal planner decision-making.

SDG 11: Sustainable Cities and Communities

1.**Lessening Traffic Congestion:** The project makes the most of the current infrastructure by letting customers rent parking spots, which lessens needless traffic and movement.

2**. Improving Urban Mobility:** Sustainable urban planning is supported by efficient parking management, which guarantees a smooth transit flow.

3. **Reducing Accidents & Illegal Parking:** Well-organized parking lots reduce careless parking, which makes the roads safer and lowers the number of accidents.

SDG 12: Responsible Consumption and Production

1. **Optimizing Space Utilization:** This promotes the effective use of parking spots that are available, which lessens the demand for additional parking lots and conserves land.

2. **Reducing Fuel Consumption & Emissions:** By spending less time looking for parking, drivers reduce their carbon footprint and fuel waste.

3. **Promoting Community Participation:** This allows people to make money off of the locations they don't use, which encourages the use of shared resources.

CHAPTER 1
INTRODUCTION

1.1 Background

The rapid increase in the number of vehicles on the road has caused a significant imbalance between the demand for parking spaces and the actual supply, creating a variety of problems in urban areas. As cities grow and populations expand, the demand for parking has surged, but the infrastructure has not kept up with this rapid growth. This growing disparity is a major contributor to traffic congestion, unauthorized parking, and general disorder, particularly in high-traffic urban centers. Areas such as bustling marketplaces, popular tourist destinations, and densely populated city centers are particularly affected. The lack of well-planned and structured parking facilities leaves drivers with limited options. As a result, on-street parking becomes chaotic, leading to frequent traffic bottlenecks, delays, and frustration for drivers.

The issues stemming from this parking imbalance are multifaceted. Drivers often waste valuable time and fuel circling the block, searching for available parking spots, which leads to increased fuel consumption and unnecessary carbon emissions. These emissions contribute to the growing environmental challenges faced by urban areas, exacerbating air pollution and making cities less livable. The longer drivers spend searching for parking, the more congestion builds up, creating a vicious cycle of inefficiency. In many cases, drivers resort to unauthorized parking, further complicating traffic flow and increasing the likelihood of fines or legal penalties. Unauthorized parking can also lead to accidents, especially in areas where vehicles block lanes, entrances, or fire hydrants.

Car owners face a variety of challenges on a daily basis due to these inadequacies. In addition to the stress of navigating congested roads and parking violations, many drivers worry about the safety and security of their vehicles when parked in unsafe or unregulated areas. The absence of standardized parking slot dimensions and regulated parking zones only adds to the confusion, making it even harder for drivers to identify where and how they can legally park. The unpredictability of available parking, combined with the lack of clear guidance, creates an environment where drivers are unsure whether they will be able to find a spot, and if they do, whether it will be safe or legal.

To address these pressing urban challenges, ParkEzy proposes a smart and sustainable solution aimed at optimizing the use of currently underutilized parking spaces. Rather than relying on costly and time-consuming infrastructure development or the construction of new parking facilities, ParkEzy takes a more innovative approach by leveraging existing spaces more effectively. Through intelligent parking management systems, real-time slot availability tracking, and location-based recommendations, ParkEzy connects drivers with available parking spots in nearby areas that may not be readily visible or accessible to the general public. This includes

private parking lots, commercial premises, and other lesser-used locations that are often overlooked.

By utilizing these underutilized spaces, ParkEzy helps reduce the amount of time and fuel wasted on searching for parking. This not only alleviates traffic congestion but also contributes to a reduction in harmful emissions, making the urban environment cleaner and more sustainable. Additionally, ParkEzy's system streamlines parking by offering real-time updates on parking availability, so drivers can make informed decisions about where to park in advance. The integration of technology, coupled with a user-friendly interface, ensures that users can easily find parking options that suit their needs, whether they are looking for short-term or long-term parking.

Furthermore, ParkEzy's approach promotes more organized urban mobility by encouraging the sharing of underutilized spaces. Instead of building new parking structures, which can be costly and space-consuming, ParkEzy maximizes the use of existing resources, helping to optimize urban space without further contributing to urban sprawl. By promoting shared parking, the solution reduces the need for additional land development, helping to preserve green spaces and reduce urban heat island effects, further contributing to sustainability.

In conclusion, ParkEzy offers a practical, innovative, and scalable solution to one of the most persistent challenges faced by modern cities: parking management. By combining technology with sustainability, ParkEzy makes parking more accessible, efficient, and environmentally friendly, ultimately improving the quality of life for urban dwellers and visitors alike.

1.2 Introduction

The proposed project is an innovative **smart parking management system** specifically designed to address the growing issue of parking saturation in urban and high-density areas. With cities experiencing unprecedented growth in the number of vehicles, the demand for parking spaces has rapidly outpaced supply, leading to chronic congestion, illegal parking, and environmental strain. This project aims to provide a scalable and intelligent solution by **consolidating underutilized private, residential, and commercial spaces into a well-organized, structured parking network**.

The core idea of the platform is to transform idle parking spots—often found in housing societies, office complexes, malls, and privately-owned properties—into revenue-generating assets for landowners, while simultaneously offering vehicle owners a reliable, efficient way to discover, reserve, and navigate to available parking spaces in real-time. This **dual-sided platform** empowers both ends of the urban mobility spectrum: it provides convenience and assurance to drivers and offers monetization opportunities to property owners.

By **leveraging smart technologies**, the system integrates **IoT-based sensors** to monitor parking spot availability, **real-time data processing** to update parking inventories dynamically, and an **intelligent user interface** that provides seamless access via mobile or web applications. Users can search for parking by location, time, or availability, and receive navigation support and live updates. Integration with digital payment systems enables secure, cashless transactions.

To foster **user trust, security, and reliability**, the platform incorporates a **robust rating, review, and verification framework**. Landowners and parking spots go through a thorough verification process before being listed. After each use, both drivers and hosts can leave feedback, contributing to a transparent and accountable ecosystem. Additionally, safety features such as surveillance integration, emergency support, and real-time communication channels enhance the overall confidence of all stakeholders.

This smart parking solution is not just a tech-driven service; it aligns deeply with broader urban development and environmental goals. It directly supports the **Smart Cities Mission** by enhancing mobility infrastructure through digital innovation and contributes to several **United Nations Sustainable Development Goals (SDGs)**, including:

- **SDG 9 (Industry, Innovation, and Infrastructure)**: Promotes innovation and infrastructure optimization without new construction.
- **SDG 11 (Sustainable Cities and Communities)**: Enhances urban planning and reduces traffic congestion and emissions.
- **SDG 12 (Responsible Consumption and Production)**: Helps in participation of people and earn money out of it by consuming vacant spaces.

Unlike conventional parking projects that require significant investments in construction and land acquisition, this system emphasizes **resource optimization**, utilizing what already exists but remains underused. This approach not only saves public and private resources but also fosters a collaborative, circular economy where multiple stakeholders benefit.

In summary, this smart parking management system presents a sustainable, efficient, and inclusive solution to urban parking woes. By intelligently connecting unused spaces with drivers in need, it offers a practical model for modern, livable cities—balancing convenience, economics, and environmental stewardship.

1.3 Project Category

1. Smart Parking & Urban Mobility: This initiative uses technology to maximize parking space use.

2. IoT & Automation: For real-time parking monitoring, ESP8266, IR sensors, and ultrasonic sensors are used.

3. Web development: Django was used to create an effective parking space booking and administration system.

4. Sustainable Solution: Without requiring additional infrastructure, it lowers pollution, fuel waste, and traffic congestion. SDGs 9 (Innovation), 11 (Sustainable Cities), and 12 (Responsible Consumption) are all supported by the Smart City Initiative.

1.4 Objectives

1. Maximize Parking Space Utilization: To lessen parking shortages, make use of underutilized private and commercial spaces.

2. Reduce Traffic Congestion: Smoother traffic flow results from fewer cars looking for spots and parking on the street.

3. Improve Security & Reliability: To make parking safer, put in place a system of reviews, ratings, and verification.

4. Offer Real-Time Parking Solutions: Utilize a web-based platform to help users locate, reserve, and oversee parking spaces.

5. Use IoT for Smart Parking: For precise space automation and monitoring, use infrared and ultrasonic sensors.

6. Encourage Sustainable Urban Mobility: By reducing needless car travel, you may cut down on pollution and fuel waste.

7. Provide Extra Revenue Streams: Let landowners make money off of their empty parking spots.

8. Encourage Smart Cities and SDG Objectives: Comply with **SDGs 9 (Innovation), 11 (Sustainable Cities), and 12 (Responsible Consumption).**

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

India, as the second most populated country globally, grapples with accommodating over 40 million vehicles amid urbanization and economic growth. This surge in vehicle ownership, even during economic downturns, has led to severe parking issues across all urban areas. Parking problems manifest in two forms: off-street parking, common in shopping malls and large offices, and on-street parking, dictated by market forces, often leading to congestion. Overlooking parking in urban policy frameworks results in issues such as poor transport quality, land misuse, and environmental costs. To address these challenges, expanding parking spaces, enhancing accessibility, and optimizing existing infrastructure are essential. Additionally, incentivizing public transportation use, implementing variable parking pricing, and strategically pricing parking in commercial areas can effectively manage demand.

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2.2 Review

The issue of parking scarcity in India has become a significant urban challenge, exacerbated by the rapid pace of urbanization, population growth, and the increasing number of vehicles on the road. This multifaceted problem has placed tremendous pressure on existing parking infrastructure, causing not only inconvenience to drivers but also contributing to broader issues such as traffic congestion, environmental degradation, and economic inefficiencies. The research conducted on this issue sheds light on the complexity of the parking problem in Indian cities and provides insights into various solutions, with a strong emphasis on the role of technology, policy frameworks, and innovative planning strategies to address this growing concern.

India's urban landscape has been rapidly transforming over the past few decades, driven by unprecedented population growth and a surge in vehicular ownership. The rising number of vehicles, coupled with the limited availability of parking spaces, has led to a situation where the demand for parking far exceeds the supply. This imbalance has serious implications for urban mobility and has made the efficient management of parking spaces a pressing issue for urban planners and municipal authorities. According to research by Manjaly and Joseph, the annual economic losses due to parking-related issues are staggering, with these losses estimated to account for 1.56% of India's Gross Domestic Product (GDP). This figure underscores the urgency of addressing the problem, as parking inefficiencies not only inconvenience citizens but also have significant economic consequences.

In response to this crisis, innovative technologies have been explored to optimize the utilization of existing parking infrastructure. One of the most promising solutions to this problem is the adoption of smart parking systems. These systems use sensors, data analytics, and real-time monitoring to identify available parking spaces and guide drivers to them. By allocating parking spaces more efficiently, smart parking systems help reduce traffic congestion, fuel consumption, and the time spent searching for parking. Manjaly and Joseph’s research highlights how these systems can improve convenience for users while also contributing to the reduction of traffic

bottlenecks. Additionally, these systems can assist in maximizing the use of underutilized parking facilities, thereby making better use of existing infrastructure without the need for costly new parking structures.

Another key innovation discussed in various studies is the role of mobile applications in parking management. Research by Parmar et al. shows that mobile apps have emerged as valuable tools for improving the parking experience. These apps enable users to locate nearby parking facilities, reserve spots in advance, and receive navigation guidance to ensure a smooth and efficient parking process. In several case studies, the effectiveness of such applications has been demonstrated, showing how they can reduce the time spent searching for parking and increase the utilization of existing parking spaces. These apps also allow for dynamic pricing, giving users the option to choose parking spots based on real-time availability and price, further optimizing parking efficiency.

However, technological solutions alone are not enough to address the parking crisis. Aligning policy frameworks with urban planning objectives is crucial to creating sustainable parking solutions. As advocated by Peñalosa, municipal authorities play a key role in formulating regulations and guidelines that govern parking supply, pricing, and enforcement. Effective policy measures such as parking supply mandates for new developments, dynamic pricing schemes, and stricter enforcement of parking violations can help optimize parking resources. In addition to these measures, integrated transportation planning is vital. Urban planners need to prioritize sustainable modes of mobility, such as public transit, walking, and cycling, to reduce the overall demand for private vehicle parking. By focusing on alternative modes of transport, cities can reduce the dependency on private vehicles and ease the pressure on parking infrastructure.

The issue of parking also extends to road freight transport, which is often overlooked in discussions about urban parking. The lack of designated parking spaces for freight vehicles contributes to the congestion and disorganization of urban roads. Lizbetin and Bartuska's research highlights this issue, pointing out that the absence of dedicated freight parking spaces creates inefficiencies in goods movement and increases the overall demand for urban parking. To address this, it is essential to promote alternative transportation options for freight, such as the use of off-peak hours for deliveries, and to develop parking solutions that accommodate both passenger and freight vehicles.

Surveys and empirical studies on parking provide valuable insights into public perceptions and behavior regarding parking. Research conducted by Ahmed on car parking problems in urban areas emphasizes the importance of understanding user preferences and travel patterns when designing parking interventions. By studying how people use parking spaces and their decision-making processes, policymakers can develop tailored solutions that better meet the needs of different user groups. For example, parking strategies may need to be customized for residential,

commercial, or mixed-use areas, taking into account the specific parking demand in each type of location.

Environmental sustainability is another critical dimension of parking management, as urban parking is closely linked to environmental challenges such as air pollution and climate change. Various studies have proposed measures to make parking infrastructure more sustainable, including the development of green parking facilities that use permeable materials to reduce the urban heat island effect and promote water drainage. Additionally, the installation of electric vehicle (EV) charging stations in parking areas is an important step toward supporting the transition to cleaner vehicles. By integrating sustainability into parking management, cities can mitigate the environmental impact of transportation while promoting the adoption of eco-friendly vehicles.

Finally, public-private partnerships (PPPs) are increasingly seen as a viable model for financing and implementing parking infrastructure projects. Ahmedi's research advocates for the involvement of both government agencies and private developers in the development of parking facilities. These collaborative models enable the pooling of resources, expertise, and technology to scale up parking solutions more effectively. In addition to this, community engagement and stakeholder participation are critical in ensuring that parking policies and infrastructure projects meet the needs of local residents and businesses. By involving communities in the decision-making process, cities can foster greater buy-in and create parking solutions that are both efficient and equitable.

In conclusion, the parking problem in India is a complex and pressing issue that requires a multifaceted approach. Through the integration of technology, effective policy frameworks, sustainable urban planning, and innovative financing models, it is possible to alleviate the parking crisis and improve urban mobility. The research reviewed in this paper provides valuable insights into the challenges and solutions that can help create more efficient, sustainable, and user-friendly parking systems in Indian cities.

2.3 Summary

In summary, parking challenges in highly populated Indian cities present a multifaceted problem that requires a comprehensive and integrated solution. These challenges are not only limited to the saturation of parking spaces but also extend to the lack of regulation in parking tariffs, environmental concerns, and the inefficiencies of existing infrastructure. As the number of vehicles continues to rise, the pressure on urban parking resources intensifies, leading to traffic congestion, longer travel times, unauthorized parking, and increasing environmental degradation

due to higher emissions. Given these growing problems, it is clear that parking management must be a top priority for policymakers, urban planners, and city authorities across India.

The shortage of parking spaces in urban areas is particularly acute in densely populated regions, commercial zones, and tourist destinations. As Indian cities continue to urbanize at an unprecedented rate, the demand for parking outstrips the available supply. This imbalance often results in chaotic, unorganized, and unsafe parking practices. Drivers are frequently forced to park illegally, blocking streets, footpaths, or fire hydrants, which further exacerbates traffic bottlenecks. Additionally, the absence of standardized parking dimensions and regulated zones makes it even more difficult for drivers to find appropriate and legal places to park. As a result, both the drivers and pedestrians suffer from the lack of structured parking solutions.

Another significant issue is the lack of regulation in parking tariffs. The absence of consistent pricing mechanisms has led to an inefficient allocation of parking resources. For instance, in some areas, parking fees are either too low to encourage turnover, or too high, deterring drivers from using available spaces. This lack of pricing regulation leads to underutilization of parking spaces in some areas, while other areas remain overcrowded. A solution to this problem would involve dynamic pricing mechanisms, where parking fees fluctuate based on demand and supply, ensuring more efficient use of parking spaces while also generating revenue for city maintenance.

Environmental concerns related to parking management are also at the forefront. As more vehicles flood the roads, emissions and fuel consumption skyrocket. The time wasted by drivers in search of parking spaces contributes directly to increased fuel consumption and carbon emissions, further deteriorating air quality. To mitigate these environmental impacts, cities must explore sustainable alternatives such as creating green parking facilities that incorporate eco-friendly materials, as well as encouraging the use of electric vehicles (EVs) by installing charging stations in parking areas. Additionally, better integration of public transit, cycling, and walking into urban mobility plans would reduce the overall demand for parking and contribute to more sustainable cities.

Innovative solutions to parking management have been explored through various technological advancements and policy strategies. Research conducted by Manjaly and Joseph emphasizes the importance of adopting smart parking systems that use sensors, data analytics, and mobile applications to guide drivers to available spaces in real-time. These smart systems not only improve convenience for drivers but also reduce traffic congestion and carbon emissions. Mobile apps, as highlighted by Parmar et al., offer drivers the ability to locate parking spaces, reserve them in advance, and even pay for parking digitally. These technologies enhance the parking experience, reducing the time spent looking for spots, and can significantly improve the utilization of available parking spaces.

Moreover, the role of urban planning and policy regulation is vital in addressing the parking problem. As noted by Peñalosa, aligning parking strategies with broader urban planning goals is crucial. Municipalities must introduce policies that promote sustainable transportation, such as prioritizing public transit, cycling, and walking over private vehicle use. This shift in urban design can drastically reduce the overall parking demand. Furthermore, city authorities should implement parking supply mandates for new developments, ensuring that adequate parking infrastructure is included in new residential, commercial, and mixed-use projects. In addition, authorities should also consider dynamic pricing models that adjust parking fees based on demand and time of day, encouraging more efficient use of parking resources.

The lack of parking for freight transport, as discussed by Lizbetin and Bartuska, is another key challenge. Often overlooked in discussions about urban parking, the need for designated freight parking spaces is critical to improving urban mobility and reducing congestion. Policies that promote off-peak delivery hours and dedicated parking areas for freight vehicles can help streamline the flow of goods and reduce pressure on city streets.

Public engagement is also a vital element in addressing parking problems. Understanding user preferences, behaviors, and travel patterns is essential for designing tailored parking solutions. Research by Ahmed on the car parking problem in urban areas emphasizes the importance of incorporating public opinion into the planning process. By conducting surveys and gathering data on how people use parking spaces, urban planners can design more effective interventions that meet the needs of both residents and businesses.

Finally, public-private partnerships (PPPs) play an essential role in financing and implementing parking infrastructure. As noted by Ahmedi, these partnerships can pool resources, expertise, and technology to scale up parking solutions. Governments, private developers, and technology providers can collaborate to build and manage parking systems that are both efficient and sustainable. Community engagement, through stakeholder participation and public consultations, ensures that parking projects meet local needs and gain broader acceptance.

In conclusion, the parking crisis in Indian cities is a complex issue that requires a multifaceted approach. By integrating insights from various studies—such as those by Manjaly and Joseph, Parmar et al., Peñalosa, Lizbetin and Bartuska, and Ahmed—India can develop a roadmap to address these challenges. By implementing smart technologies, effective policies, and sustainable urban planning strategies, Indian cities can reduce traffic congestion, minimize environmental impact, and enhance the overall quality of urban life. Only through comprehensive and coordinated efforts can India’s urban areas become more accessible, efficient, and livable for everyone.

2.4 Conclusion

In conclusion, the proposed invention addresses the pressing issues associated ever-expanding number of vehicles and the limited availability of parking spaces. areas grapple with the challenges of congestion and insufficient parking facilit innovation aims to streamline the process by aggregating vacant areas under a platform dedicated to parking solutions, The current imbalance between the increasing number of vehicles and the stagnant park infrastructure results in chaotic situations during peak hours, causing roadblocks a inconvenience. Our approach involves consolidating individual entities' vacant spac under a common label or umbrella, making them easily accessible for ing. This no only resolves the problem of saturated parking spaces but also aligns with the vision of Smart City initiatives and Sustainable Development goals. Moreover, landowners have the opportunity to generate additional revenue by participating in this shared parking system.

Urban mobility and traffic management are increasingly challenged by the constraints of limited land availability and the rapidly rising demand for parking spaces in metropolitan areas. As urban populations grow and vehicle ownership continues to surge, the strain on existing parking infrastructure becomes ever more apparent. Traditional responses—such as constructing multi-level parking facilities or expanding roadside parking—are not only capital-intensive but also unsustainable, as they demand additional land resources and contribute to urban sprawl and environmental degradation.

This study explores a **novel, technology-driven approach** to solving these pressing issues by developing a **comprehensive smart parking platform** that aggregates and optimizes underutilized private and open spaces. By **bringing together disparate parking resources—such as unused residential lots, commercial property spaces, institutional grounds, and vacant areas—under a unified digital platform**, this solution offers a **scalable, cost-effective, and environmentally sustainable alternative** to traditional parking infrastructure development.
The core of this system lies in its use of **Internet of Things (IoT) technology**, which enables **real-time monitoring and communication of parking space availability**. By embedding IoT sensors in parking locations, the system continuously tracks occupancy status, transmitting live data to the platform's cloud-based servers. This information is then relayed to users via a **mobile application or web portal**, allowing drivers to efficiently locate and reserve available parking spaces without the need for extended cruising—commonly known as "parking lot sailing." This not only minimizes driver frustration but also significantly **reduces fuel consumption, traffic congestion, and air pollution**, contributing to improved urban air quality and reduced greenhouse gas emissions.

An integral feature of the platform is its **transparent rating and review mechanism**, which facilitates **trust and accountability** between the two primary user groups: parking space owners and vehicle drivers. Every transaction—whether it involves booking a space, leaving a vehicle, or managing a parking area—is subject to a dual-feedback process. Verified user profiles, identity checks, and performance histories ensure a safe and reliable ecosystem where users can make informed decisions based on peer reviews and performance metrics.

From the perspective of **property and real estate owners**, the platform provides a **new revenue stream** by allowing them to monetize idle or sporadically-used parking spaces without significant investment. Spaces that might otherwise remain vacant for most of the day—such as office parking lots after hours or residential driveways during working hours—can now be made available to commuters, shoppers, tourists, and event-goers. This **asset-light model** not only maximizes spatial efficiency but also contributes to a more **dynamic and participatory urban economy**.

CHAPTER 3
PROPOSED SYSTEM

3.1 Proposed System

The **ParkEzy** project proposes an innovative parking management system that leverages cutting-edge IoT technology and a user-friendly web platform to address the growing urban parking challenges. With rapid urbanization and increasing vehicle ownership, parking has become a critical issue in densely populated cities. The system is designed to optimize the utilization of underused parking spaces, ensuring an efficient and seamless experience for both vehicle owners and space providers. ParkEzy aims to bridge the gap between demand and supply, making parking more accessible and reducing the inefficiencies that plague traditional parking solutions.

At the heart of ParkEzy is its intelligent parking monitoring system, which uses a combination of **ultrasonic sensors** and **infrared (IR) sensors** to monitor real-time occupancy in parking spaces. These sensors are strategically installed in designated parking areas and continuously gather data on whether a space is occupied or available. The collected data is transmitted wirelessly to a central database via the **ESP8266 microcontroller**, which ensures real-time updates on parking availability.

This data is then made accessible through a web-based application, developed using the **Django** framework, which allows users to easily access and interact with the system. The platform enables vehicle owners to **search for, reserve, and pay for parking spaces** in real-time. Users can locate available spots in their vicinity, reserve a space ahead of time, and complete payment seamlessly through the platform. This process minimizes the time spent searching for parking, alleviating traffic congestion and reducing fuel wastage.

To further enhance the user experience, ParkEzy includes a **robust rating and review system**. This feature allows vehicle owners to provide feedback on the quality and safety of the parking spaces they use, based on previous experiences. The ratings help maintain a high standard of service and increase the reliability of the platform. Additionally, the system enables **landowners** to monetize their unused parking areas, offering them an opportunity to generate extra income by renting out their spaces to nearby drivers.

By streamlining parking management, ParkEzy addresses the twin challenges of reducing urban traffic congestion and promoting more sustainable urban mobility. The system aligns with the goals of **smart cities** and **sustainable development**, contributing to a cleaner, more organized urban environment while improving the overall quality of life for city residents.

3.2 Unique Features

1. Real-Time Parking Monitoring

The core of the **ParkEzy** system is its **real-time parking monitoring**, which leverages **Internet of Things (IoT)** technologies to deliver up-to-the-minute data about parking space availability. Parking has always been a challenge in urban areas, leading to increased traffic congestion, wasted fuel, and frustration for drivers. **ParkEzy** addresses this by installing **ultrasonic** and **infrared (IR) sensors** in parking spaces. These sensors are integrated into the parking infrastructure and continuously monitor the occupancy of each parking spot.

Ultrasonic sensors work by emitting sound waves and measuring the time it takes for the sound to bounce back after hitting an object. This helps determine the exact distance to the nearest object, such as a vehicle, allowing the system to detect whether the parking spot is occupied. On the other hand, **IR sensors** function by detecting objects using infrared light. They can determine whether a vehicle is present in the parking space by measuring changes in light reflection.

The data collected by these sensors is sent in real-time to a **centralized cloud database**, where it is processed and made available to the user through the **ParkEzy** web application. Users can access this data from their smartphones, tablets, or computers, providing them with up-to-date information about available parking spaces in their vicinity. This significantly reduces the time drivers spend searching for parking spots, leading to lower traffic congestion in busy areas, reduced emissions from idling vehicles, and a better overall user experience.

Furthermore, the ability to locate and **reserve parking spots in real time** ensures that users are never left guessing about parking availability, making the entire parking process more convenient. It also contributes to the efficient utilization of existing parking resources without the need for new infrastructure investments.

2. User Rating and Review System

Building trust and ensuring the safety of users are critical components of any shared economy platform, and **ParkEzy** addresses this need with a robust **user rating and review system**. This feature allows users to leave detailed feedback about their parking experiences, both positive and negative. For instance, after reserving a parking space, users can rate the space based on various criteria such as location, security, ease of access, and overall satisfaction.

The **rating and review system** serves multiple purposes:

- **Accountability:** Space providers are held accountable for the quality of their parking spaces. If a parking spot consistently receives poor reviews, the platform can flag the issue and take appropriate action, such as removing the listing or requiring improvements.

- **Community Trust:** New users can rely on reviews from past users to make informed decisions about where to park, enhancing the overall trust within the community.
- **Quality Assurance:** Space providers who consistently receive positive reviews are rewarded with higher visibility, incentivizing them to maintain high standards of service.
- **Transparency:** It provides transparency to both space providers and users, ensuring that the platform operates in a fair and equitable manner.

Moreover, these reviews can help users identify the **best parking spots** based on other users' experiences, encouraging a more positive user journey. This feature, in turn, ensures the platform fosters a community where accountability and trust are paramount, creating an environment where users feel safe and valued.

3. Seamless Integration of Payment Solutions

A smooth and secure payment process is essential for the success of any online platform, and **ParkEzy** integrates **multiple payment solutions** to meet user preferences. The platform supports digital wallets, credit/debit card payments, and mobile payment options, offering a seamless experience for users when booking parking spots.

The primary goal of integrating various payment options is to ensure that the **booking process is as convenient as possible**. Users can choose the payment method that best suits them—whether they prefer the speed of a mobile wallet, the familiarity of credit/debit cards, or any other method available. This flexibility promotes a **cashless transaction environment**, aligning with the growing trend of digital payments and reducing the reliance on physical cash.

The **payment gateway** used in **ParkEzy** is **secure**, employing encryption technologies to protect users' financial data. Additionally, the platform supports **automatic payment processing**, ensuring that users are charged promptly for their bookings, and they receive instant confirmation of their reservations.

By streamlining the payment process and providing users with flexible options, **ParkEzy** ensures that users can complete transactions without hassle, making the overall experience much more efficient. This seamless integration also allows for **refunds** and **cancellations** to be processed easily, providing a safety net for users in case their plans change.

4. User-Friendly Interface

The **ParkEzy** platform is designed with a **clean, intuitive user interface** (UI) that makes navigating the application easy for users of all technological backgrounds. Whether users are tech-savvy or less familiar with digital platforms, the web application is structured in a way that allows everyone to interact with it effortlessly.

The main components of the **ParkEzy** UI include:

- **Search functionality:** Users can search for parking spots by location, price range, availability, and other filters. This search functionality is designed to be quick and responsive, providing users with relevant results in real-time.
- **Reservation system:** The booking flow is straightforward, with a clear **step-by-step process** that guides users from selecting a parking spot to completing their payment.
- **Account management:** Users can easily manage their profiles, view past reservations, and track their booking history. This ensures that users have full control over their parking activity and can access relevant details anytime.

The **dark theme UI** further enhances the user experience by providing a visually appealing interface that reduces eye strain, particularly in low-light environments. The user-friendly design prioritizes accessibility, ensuring that even those who are not tech-savvy can comfortably use the platform.

By focusing on a simple yet elegant UI, **ParkEzy** ensures that users can quickly find parking spots, make reservations, and manage their accounts without confusion, contributing to a positive overall experience.

5. Sustainable Urban Mobility

ParkEzy supports the development of **sustainable urban mobility** by improving the **efficiency of existing parking spaces**. Traditional parking management systems often require significant infrastructure investments, such as building new parking garages or expanding parking lots. However, **ParkEzy** takes a different approach by leveraging underutilized parking spaces, whether in private properties, commercial buildings, or even residential areas.

This optimization of parking spaces contributes to several **environmental benefits**:

- **Reduced traffic congestion:** By providing real-time information about available parking, users spend less time circling the area searching for spots, which reduces overall traffic congestion.
- **Lower emissions:** Fewer cars on the road searching for parking means less fuel consumption, leading to a reduction in carbon emissions and a cleaner urban environment.
- **Efficient use of resources:** Instead of building new parking infrastructure, **ParkEzy** ensures that existing parking spaces are used to their full potential, making the most out of limited urban space.

The project also aligns with the broader goals of **smart cities** and sustainable development, which focus on creating urban environments that are more livable, efficient, and environmentally

friendly. By promoting **smart parking solutions**, **ParkEzy** contributes to the overall reduction of the environmental footprint associated with urban mobility.

6. Integration with Smart City Initiatives

As cities worldwide move toward becoming **smart cities**, the integration of **ParkEzy** into smart city frameworks becomes increasingly important. The system is designed to provide valuable data that can be used by local governments and urban planners to improve **traffic management** and **urban infrastructure**.

For example, the real-time data generated by the **ParkEzy** platform can help authorities understand parking demand patterns, identify congested areas, and optimize traffic flow. This information can be used to adjust traffic signals, allocate parking resources more effectively, and plan for future infrastructure developments. By integrating **ParkEzy** with existing **smart city initiatives**, local governments can improve **urban mobility** and **resource allocation** over time, leading to more efficient and sustainable urban environments.

Furthermore, **ParkEzy**'s alignment with **smart city goals** allows for potential collaborations with other technological solutions, such as **smart traffic lights** or **public transportation networks**, creating a cohesive ecosystem for managing city resources.

7. Enhanced Security Features

Ensuring the safety of both users and their vehicles is a primary concern for any parking management system. **ParkEzy** addresses this by implementing several **security features** that enhance user confidence and ensure a safe parking experience.

- **User Verification:** The platform employs a strong user verification process, where users must authenticate their identity via email or phone number before accessing the parking features. This ensures that only legitimate users are using the platform.
- **GPS Tracking:** Once a parking spot is booked, users can track their parked vehicles via GPS, ensuring that they can easily locate their vehicle at any time. Additionally, space providers can also use GPS tracking to monitor the location of their parking spots.
- **Security Cameras and Alerts:** For parking spots hosted by businesses or private owners, the integration of security cameras and automated alerts further ensures that vehicles are protected from theft or damage while parked.

These security features contribute to building **trust** between users and space providers, fostering a safer, more secure environment for all parties involved.

8. Notifications

ParkEzy integrates a **notification system** that keeps users informed about critical updates related to their parking bookings. Users will receive notifications for:

- **Booking confirmations:** Once a parking space is reserved, users will receive an instant notification confirming the reservation.
- **Parking availability alerts:** Users will be notified when a parking spot becomes available, helping them plan their journey better.
- **Payment reminders:** Notifications remind users about pending payments, upcoming reservations, or expired payments, ensuring a smooth and hassle-free experience.

These timely notifications help keep users engaged with the platform and improve their overall experience by ensuring that they are always up to date.

9. Community Engagement and Support

Finally, **ParkEzy** fosters a sense of **community** by encouraging users to participate in forums and discussions. The platform creates an interactive space where users can:

- **Share tips:** Users can exchange advice on the best parking locations or share strategies for finding parking during peak hours.
- **Report issues:** The community can help identify any technical issues or problems with specific parking spaces, ensuring the platform remains efficient and user-friendly.
- **Engage with each other:** Forums and discussion boards create a space where users can ask questions, interact with fellow users, and build a supportive community.

This community-driven approach promotes **collaboration** and **engagement**, which enriches the overall experience and creates a space where everyone’s needs are considered and addressed.

CHAPTER 4
REQUIREMENT ANALYSIS AND SYSTEM SPECIFICATION

4.1 Feasibility Study (Technical, Economical, Operational)

The feasibility study evaluates the viability of the project based on technical, economic, and operational aspects to ensure its successful implementation and sustainability.

1. **Technical Feasibility :-** It leverages IoT, cloud computing, and web technologies to create an efficient parking management system.
    - Hardware Integration: The system uses ultrasonic sensors, IR sensors, and ESP8266 microcontrollers to detect real-time parking space availability.
    - Software & Database: The platform is built using Django (Python framework) and Firebase for real-time data updates.
    - Scalability: The system is designed to handle multiple users and transactions simultaneously, making it scalable for expanding into different cities.
    - Security & Reliability: User authentication, encrypted transactions, and a review system ensure data security and reliability.

2. **Economical Feasibility:-**The project is economically viable due to its low implementation cost and revenue-generating model.
    - Initial Investment: The primary costs involve sensor deployment, cloud hosting, and web platform development, which are affordable compared to traditional parking infrastructure expansion.
    - Revenue Model:
        - Parking Space Owners earn revenue by renting out underutilized parking spaces.
        - Users pay a nominal fee for booking parking spots, generating income for the platform.
        - Premium Features (such as reserved slots, extended time, and special parking areas) provide additional revenue streams.
    - Return on Investment (ROI): The system has high revenue potential, making it self-sustainable in the long run.
        - Since the project optimizes existing parking spaces, it eliminates the need for costly infrastructure expansion, making it an economically feasible solution.

3. **Operational Feasibilty:-** Operational feasibility assesses the ease of implementation, management, and user adoption of the system.
    - User-Friendly Platform: The web-based system provides an intuitive interface for users to book and manage parking reservations easily.
    - Minimal Training Requirement: Vehicle owners and space providers require minimal training, as the system is designed to be simple and automated.
    - Automated Monitoring & Alerts: The system automatically updates parking availability and sends notifications to users, reducing manual intervention.
    - Security & Trust Mechanism: The rating and review system ensures reliability, encouraging more users to adopt the platform.
    - Collaboration with Local Authorities: The project can be integrated with smart city initiatives and municipal partnerships for better implementation and legal compliance

4.2 Software Requirement Specification

This section defines the technical and functional requirements necessary to implement the system.

4.2.1 Data Requirement:

1. VehicleOwner (Users Seeking Parking)

These are users searching for parking spaces.

Attributes:

- **User ID (Primary Key)** – Unique identifier for each user
- **Name** – Full name of the vehicle owner
- **Contact Details** – Phone number and/or email
- **Vehicle Details** – Type (sedan, SUV, electric vehicle, etc.)
- **Preferences** – Covered parking, EV charging, proximity filters, etc.

2. SlotOwner (Users Renting Out Parking Spaces)

These are users providing parking spaces.

Attributes:

- **Slot Owner ID (Primary Key)** – Unique identifier for each owner
- **Name** – Full name of the slot owner
- **Space ID –** Unique identifier for each parking slot
- **Location** – Address or latitude/longitude for geolocation mapping

- **Availability Schedule** – Time slots when the space is free
- **Rental Price** – Hourly or fixed rental charges
- **Payment Details** – Bank or UPI details for receiving payments

3. Booking (Relationship Between VehicleOwner & SlotOwner)

Represents an agreement between a VehicleOwner and a SlotOwner.

Attributes:

- **Booking ID (Primary Key) –** Unique identifier for each booking
- **VehicleOwner ID (Foreign Key)** – Links to the user booking the space
- **SlotOwner ID (Foreign Key)** – Links to the owner of the space
- **Space ID (Foreign Key)** – Links to the specific parking slot
- **Booking Date & Time** – Date and time of booking
- **Duration –** Start and end times of the booking
- **Payment Status –** Pending or Paid
- **Transaction ID –** Unique identifier for payment processing

4. Payment (Transaction Data for Bookings)

Stores details of payments made by users.

Attributes:

- **Transaction ID (Primary Key) –** Unique identifier for each payment
- **Booking ID (Foreign Key)** – Links payment to a specific booking
- **User ID (Foreign Key)** – Links payment to a specific user
- **Amount** – Total amount paid for the parking slot
- **Payment Method** – Credit/Debit card, UPI, Wallet, etc.
- **Payment Status** – Successful, Failed, or Pending
- **Timestamp** – Date and time of transaction

5. Geolocation & Navigation Data

Used to display available parking slots on a map and navigate.

Attributes:

- **Space ID (Foreign Key**) – Links to a parking space
- **Latitude & Longitude** – Stores precise GPS coordinates

4.2.2 Functional Requirement:

1. User Authentication and Registration:- Users should be able to create accounts, log in, and manage their profiles. Implement secure authentication mechanisms (e.g., OAuth, JWT).

2. Parking Spot Search and Navigation:- Users can search for available parking spots based on location, time, and other filters. Integration with maps (Google Maps, OpenStreetMap) for navigation to the selected spot.

3. Real-Time Availability:- Updates Display real-time availability status for each parking spot. Update availability dynamically as spots are booked or become free.

4. Booking and Payment:- Users can book parking spots in advance. Implement secure payment gateways for booking and payment processing.

5. Notifications:- Send notifications to users for booking confirmation, reminders, and updates. Notify users of any changes in availability or booking status.

6. Rating and Reviews:- Allow users to rate and review parking spots. Aggregate ratings to help users make informed decisions.

7. Admin Dashboard:- Admins can manage parking spaces, view bookings, and handle disputes. Monitor system health and performance.

8. IoT Integration:- If using IoT sensors, integrate them to detect spot availability. Update availability status automatically based on sensor data.

9. Security and Privacy:- Encrypt user data and ensure secure communication. Implement role-based access control (user, admin).

4.2.3 Performance Requirement:

1. Real-time Parking Availability Updates

- The system must process and update parking slot availability within milliseconds using ESP8266, IR sensors, and Firebase.
- Minimal latency in fetching and displaying data on the web interface.

2. Scalability

- The system should handle multiple users searching for parking spaces simultaneously without performance degradation.
- PostgreSQL must efficiently manage large volumes of parking and transaction data.

3. **Optimized Database Queries**
   - Efficient use of indexes and caching mechanisms to reduce query response time.
   - Avoid redundant data fetches with proper ORM (Django ORM) optimizations.

4. **Low Power Consumption for IoT Devices**
   - ESP8266 should be optimized to operate with minimal power consumption while maintaining reliable Wi-Fi communication

4.2.4 Maintainability Requirement:

1. **Modular Code Structure**
   - Follow MVC architecture in Django to separate business logic, data management, and UI components.

2. **Extensibility**
   - The system should allow future enhancements like dynamic pricing, AI-based parking predictions, and mobile app integration.

3. **Automated Testing**
   - Implement unit testing using Django's built-in test framework to ensure smooth functionality with each update.

4. **Code Documentation**
   - Clear documentation for API endpoints, database models, and IoT communication protocols to ease future modifications.

4.2.5 Security Requirement:-

1. **User Authentication & Authorization**
   - OAuth or JWT authentication for secure login.
   - Role-based access control (RBAC) for vehicle owners and space providers.

2. **Data Encryption**
   - Encrypt sensitive user data (passwords, transactions) using AES or SHA-256 hashing.

3. **IoT Device Security**
   - Secure ESP8266 MQTT communication to prevent man-in-the-middle attacks.
   - Ensure firmware updates are authenticated to prevent unauthorized modifications.

4. **SQL Injection & XSS Prevention**
    - Use Django's built-in CSRF protection and parameterized queries to prevent attacks.

4.3 SDLC Model Used: Agile Model

Architecture

- Frontend: HTML, CSS, JavaScript (with Dark Mode UI).
- Backend: Django (Python) with Django REST Framework.
- Database: PostgreSQL (structured parking data).

IoT Layer:

- ESP8266 (Wi-Fi module) + IR & Ultrasonic Sensors for detecting parked cars.
- MQTT Protocol for transmitting real-time sensor data to Firebase.

Workflow

- User searches for an available parking slot → Query sent to the server.
- IoT sensors detect parking occupancy → Data sent to Firebase → Updated in PostgreSQL.

Data Flow Diagram:-

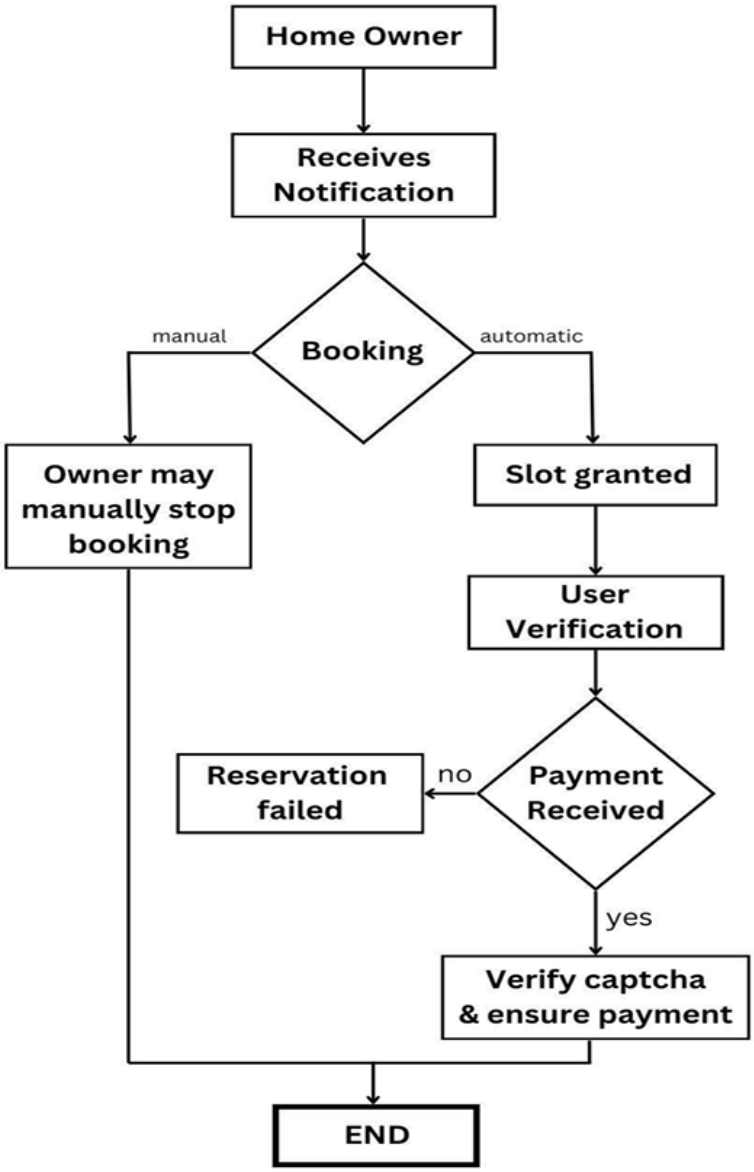


Fig 4.1: SlotOwner data flow

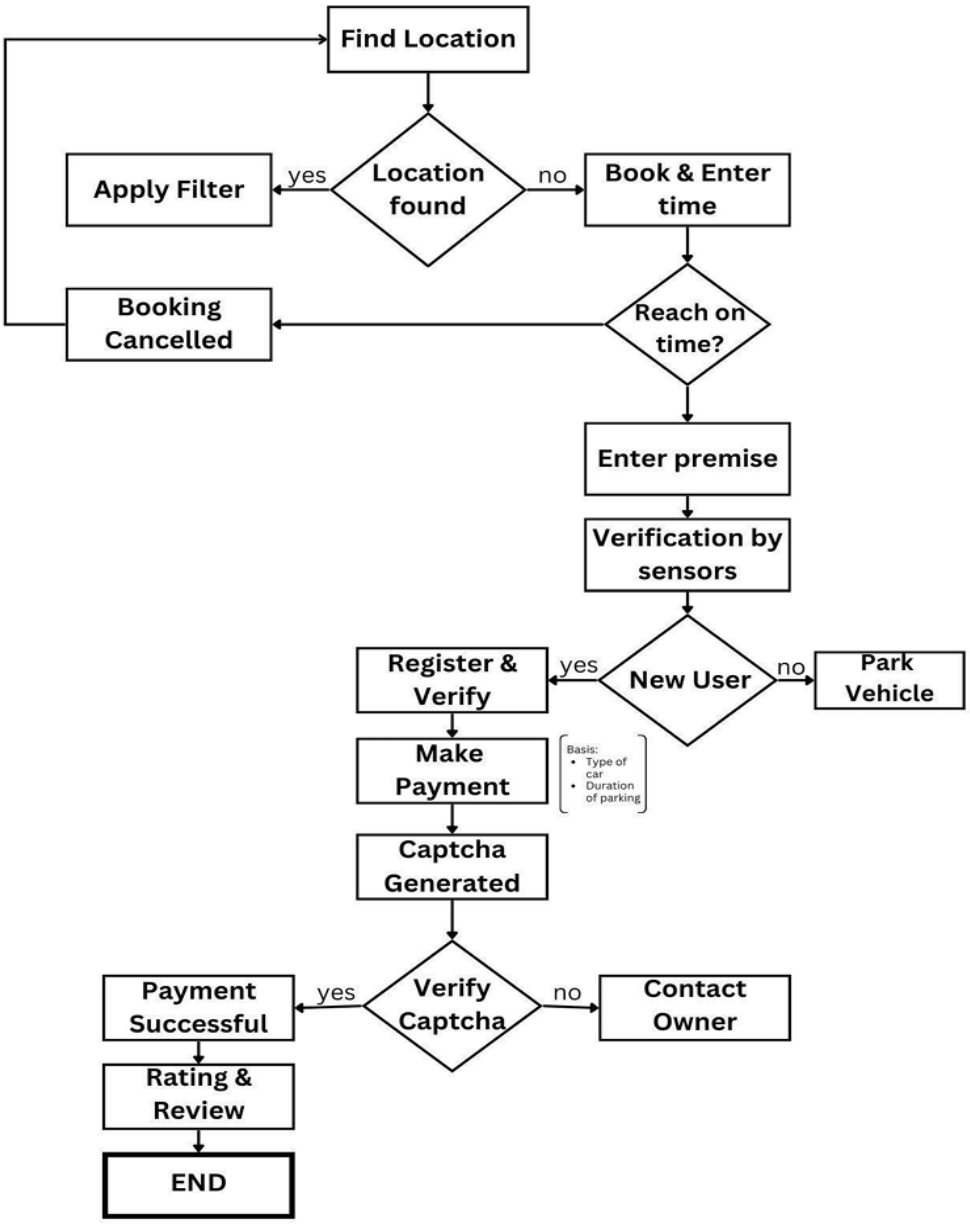
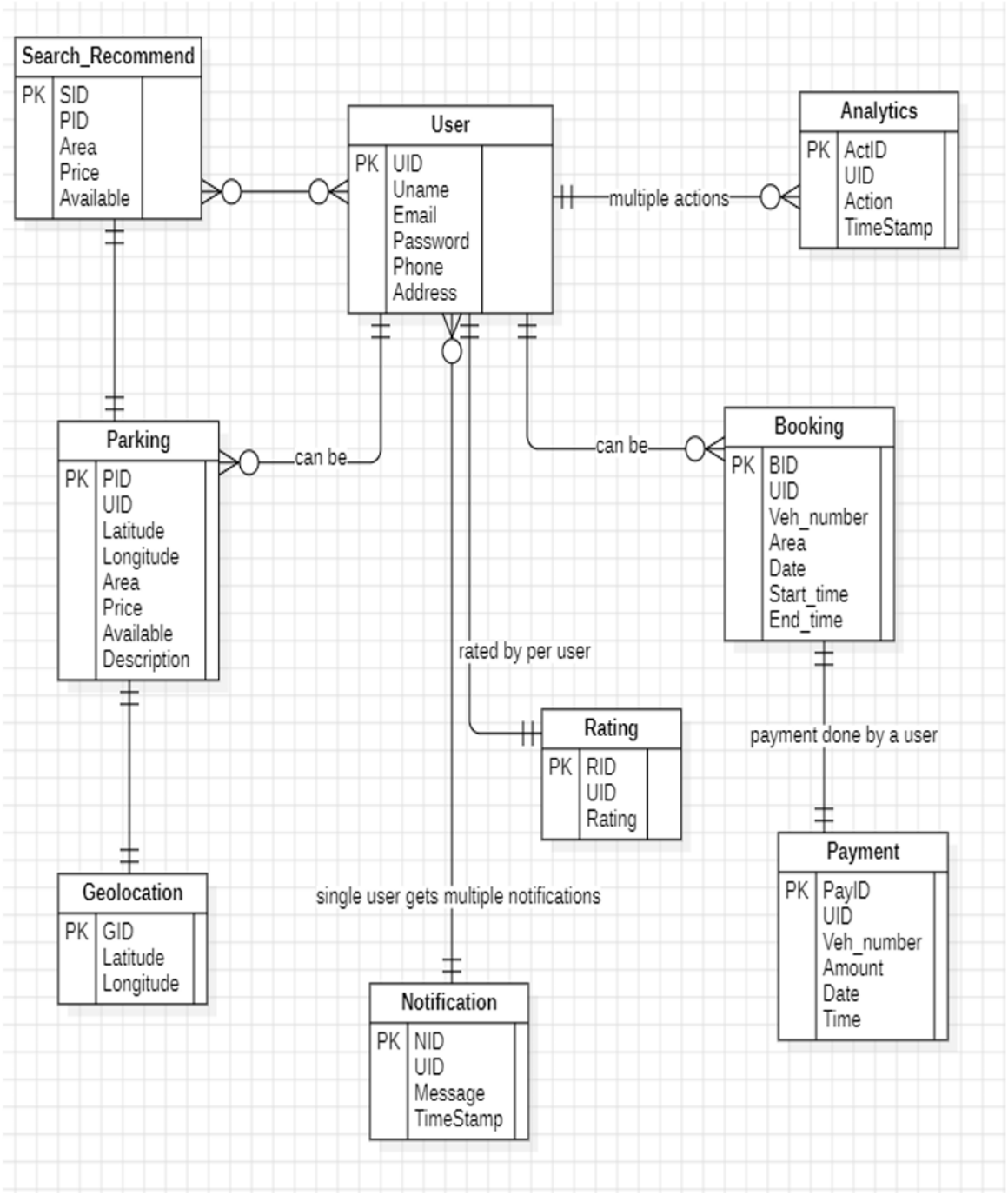


Fig 4.2: VehicleOwner data flow

4.4 Database Design:-



CHAPTER 5
IMPLEMENTATION

5.1 Tools and Technologies Used in ParkEzy Project

The project utilizes a combination of modern tools and technologies to ensure efficient parking management, real-time availability updates, and secure transactions. The key technologies used in this project are categorized as follows:

1. Backend Technologies

- **Django REST Framework for API Endpoints**
  The backend of the ParkEzy project relies heavily on the Django REST Framework (DRF) for building RESTful APIs that handle communication between the client (frontend) and the server. Django REST Framework is built on top of the Django framework, providing a powerful toolkit for creating API endpoints that handle various requests such as data retrieval, data submission, and updates in a structured and secure manner.
  The primary role of DRF in ParkEzy is to enable smooth communication between the user interface (UI) and the backend database. For instance, when a user reserves a parking spot, the frontend (React) makes an API request to the Django backend via DRF. The backend responds with a confirmation and updates the parking spot's availability in the database.

  Key Features of DRF:
  - Serialization: The framework uses serializers to convert complex data types (such as querysets and model instances) into native Python data types, which can then be rendered into JSON or XML.
  - ViewSets and Routers: DRF simplifies URL routing and view creation, making it easier to define endpoints and handle the requests in an organized manner.
  - Authentication & Permissions: It offers built-in features for managing different levels of access, ensuring only authorized users can access specific endpoints.

- **PostgreSQL Database for Data Persistence**
  PostgreSQL is a robust, open-source relational database management system (RDBMS) that serves as the primary database for ParkEzy. It is known for its reliability, scalability,

and support for advanced data types, making it an ideal choice for handling structured data in applications like parking management systems.

In ParkEzy, PostgreSQL is used to store crucial data, including:

- User information: Such as login credentials, personal details, and payment history.
- Parking spot details: Including availability status, reservation times, location, and pricing.
- Reviews and ratings: Provided by users for specific parking spots.
- Transaction records: Capturing payment history and reservation details.
- The relational nature of PostgreSQL allows for the efficient handling of complex queries, ensuring that the data retrieval processes (e.g., fetching available parking spots in real-time) are fast and optimized.

- **JWT for Authentication**

  JSON Web Tokens (JWT) is used in ParkEzy for user authentication and session management. JWT is a compact, URL-safe token format that ensures secure transmission of user information between the frontend and backend. When a user logs in, a JWT is generated and sent to the client, where it is stored (typically in local storage or cookies). For each subsequent request, this token is sent to the server, where it is verified to authenticate the user.

  The use of JWT in ParkEzy enhances the system's security by ensuring that only authorized users can access certain features, such as making a reservation or viewing payment history. It also reduces the load on the server by avoiding the need for session storage on the backend, allowing for a stateless authentication process.

- **Django Channels for Real-Time Updates (IoT Integration)**

  Django Channels extends Django's capabilities to handle real-time communication protocols, such as WebSockets. In the context of ParkEzy, Django Channels is crucial for real-time updates about parking spot availability. For example, when a parking spot is vacated or occupied, the frontend needs to be updated in real-time without requiring the user to refresh the page.

  The integration of Django Channels with IoT devices (e.g., ultrasonic sensors) enables seamless communication between the sensors and the user interface. As the sensors detect the status of parking spots, the backend can push updates to the frontend in real-time, ensuring users are always provided with the most accurate parking availability information.

2. Frontend Technologies

- **React.js with Hooks for State Management**
  The frontend of ParkEzy is developed using React.js, a JavaScript library widely used for building user interfaces. React allows developers to build efficient and dynamic web applications by breaking the UI into reusable components, making it highly scalable and easy to maintain. React's declarative approach ensures that the UI always stays in sync with the underlying data.

  The React Hooks feature, introduced in React 16.8, plays a critical role in ParkEzy's state management. Hooks such as useState, useEffect, and useContext help manage and update the application's state without needing to rely on classes or complex state management libraries like Redux.

  For example, when a user reserves a parking spot, the application's state is updated to reflect the changes in availability. React hooks ensure that the UI updates instantly when this state changes, providing a seamless user experience.

- **React Router for Navigation**
  React Router is used in ParkEzy to manage client-side navigation. It enables the creation of a single-page application (SPA), where the page does not reload when navigating between different sections. Instead, React Router dynamically updates the content, improving speed and performance.

  In ParkEzy, React Router handles navigation between various views, such as the parking spot map, user profile, payment page, and reviews section. React Router ensures smooth transitions and a better overall user experience by providing quick access to different parts of the application.

- **Axios for API Requests**
  Axios is a popular JavaScript library used for making HTTP requests from the frontend to the backend. It simplifies the process of sending data (e.g., parking reservations, user information) and receiving responses from the API endpoints built using Django REST Framework.
  In ParkEzy, Axios is used to interact with the backend API for tasks like:
  - Fetching available parking slots.
  - Sending user information for authentication.
  - Submitting reservation requests and payments.
  - Retrieving parking history and user reviews.

The integration of Axios ensures that ParkEzy can efficiently communicate with the backend in a streamlined manner.

- **Dark Theme UI Matching the Provided Mockups**
  The ParkEzy platform features a modern dark theme UI, which is designed to reduce eye strain and provide a more pleasant user experience, especially for users who access the platform during the evening or night. The UI design is carefully crafted to match the provided mockups, ensuring consistency in aesthetics and functionality.

  By adhering to a dark theme, the platform offers an elegant and sleek interface that enhances usability while also improving accessibility. The dark theme is implemented using CSS variables and is easily customizable for users who prefer a lighter theme.

3. IoT Technologies (For Smart Parking)

- **ESP8266 (Wi-Fi Microcontroller)**
  The ESP8266 is a low-cost Wi-Fi microcontroller used in ParkEzy to connect the IoT sensors with the cloud. It acts as the bridge between the physical world (sensors) and the digital world (backend server). The ESP8266 module collects data from the ultrasonic and IR sensors and transmits it to the cloud storage (such as Firebase), allowing the system to track the real-time status of parking slots.

  The ESP8266's Wi-Fi capabilities ensure that the data can be sent to the central server quickly and efficiently, ensuring that users can get real-time updates about parking space availability.

- **Ultrasonic Sensors**
  Ultrasonic sensors play a pivotal role in detecting the presence of vehicles in parking spaces. These sensors emit sound waves and measure the time it takes for the sound to bounce back after hitting an object. By calculating the distance to the object, the sensor can determine whether a parking spot is occupied or vacant.

  In ParkEzy, ultrasonic sensors are installed in parking slots to provide real-time data to the backend. When a vehicle occupies a space, the sensor detects the presence and communicates this information to the backend, which in turn updates the availability status on the frontend for the user.

- **IR Sensors**
  Infrared (IR) sensors are used in ParkEzy for object detection, helping to verify whether a parking spot is occupied or not. These sensors work by emitting infrared light and measuring how much light is reflected back, indicating the presence of a vehicle.

  IR sensors complement ultrasonic sensors by providing additional data to ensure the system accurately tracks parking spot occupancy.

4. Payment & Authentication Technologies

- **Django-PayPal for Payment Integration**
  To facilitate secure online payments for parking reservations, ParkEzy integrates Django-PayPal. This integration allows users to make payments for parking bookings using PayPal, one of the most trusted and widely used online payment platforms.

  By leveraging Django-PayPal, ParkEzy ensures that payments are processed securely and that users' financial data remains protected.

- **JWT for Authentication**
  As mentioned earlier, JSON Web Tokens (JWT) is used in ParkEzy to authenticate users and manage their sessions. JWT ensures that only authorized users can access certain features, like making reservations or viewing payment history.

5. Development & Collaboration Tools

- **Git & GitHub**
  Git is used for version control, tracking changes made to the project over time. It allows multiple developers to work on the same project concurrently, with the ability to merge their changes and manage different versions of the application.

  GitHub serves as the platform for hosting the project’s code and collaborating with other developers. It allows for easy code sharing, bug tracking, and version

CHAPTER 6
TESTING AND MAINTENANCE

6.1 Testing Techniques and Test Cases Used

6.1.1. Introduction

1. Test Strategies

- **Functional Testing:**
  - Ensures that each feature of the application works according to the requirements.
  - Includes login, booking, payment, notifications, and review features.

- **Integration Testing:**
  - Verifies the interactions between different modules, such as the connection between booking and payment systems or user notifications.
  - Includes complex workflows like booking creation, payment processing, and notification delivery.

- **Boundary Value Analysis:**
  - Tests the application at the boundaries of input ranges to uncover edge case issues.

- **Equivalence Partitioning:**
  - Groups input data into valid and invalid equivalence classes for efficient testing.

- **Usability Testing:**
  - Validates that the user interface (UI) is intuitive and provides a smooth user experience.

2. Test Process

- **Requirement Analysis:**
  - Understand project requirements from functional specifications and user stories.
  - Define acceptance criteria for each feature.

- **Test Planning:**
  - Develop a test plan outlining objectives, scope, resources, timelines, and deliverables.
  - Identify tools and techniques for testing (e.g., Selenium, Postman).

- **Test Design:**
  - Create test cases for individual modules, integration workflows, and edge cases.
  - Include boundary value and equivalence test scenarios.

- **Test Environment Setup:**
  - Configure a test environment that mirrors production conditions.
  - Integrate the database, APIs, and cloud services for end-to-end testing.

- **Test Execution**
  - Execute test cases manually and through automation tools.

- **Test Closure:**
  - Summarize testing activities, including the number of test cases executed, passed, failed, and blocked.
  - Prepare a final test report with recommendations for improvement.

3. Workflow

- **Development Phase:**
  - Unit testing while developing.

- **QA Testing Phase:**
  - Execute planned functional and integration tests.

4. **Methodologies Used**

- **Agile Methodology:**
  - Testing is integrated into the development cycle, allowing continuous feedback and iterative improvements.
  - Testing activities are planned for each sprint, ensuring timely validation of features.

- **Automation Testing:**
  - Automation tools like Selenium and JUnit are used for repetitive tasks such as regression and performance testing.

- **Black-Box Testing:**
  - Focuses on testing the application's functionality without knowledge of its internal code structure.

- **Risk-Based Testing:**
  - Prioritizes testing areas critical to user experience and business functionality, such as payments and booking modules.

- **Exploratory Testing:**
  - Testers explore the application to identify unexpected behavior and usability issues.

5. **Key Tools and Technologies**

- **Testing Tools:** Selenium, Postman (for API testing).
- **Security Tools:** Burp Suite.

6.1.2. Scope

1. In Scope

Functional Requirements to be Tested:

- **User Authentication and Management:**
  - User registration for vehicle owners and area providers.
  - Login/logout functionality with secure password hashing.

- **Area Providing Module:**

- Parking area registration with details (name, address, total spaces, price per hour, etc.).
- Editing, updating, and deleting parking area details.
- Real-time updates of available parking spaces.

- **Area Booking Module:**
  - Searching for parking areas based on geolocation and availability.
  - Booking functionality with start and end times.
  - Real-time updates to availability upon booking confirmation or cancellation.

- **Payment Processing:**
  - Integration with payment gateways for secure transactions.
  - Payment methods: credit/debit cards, UPI, net banking.
  - Payment status updates and refund mechanisms.

- **Notification System:**
  - Sending notifications for booking confirmations, cancellations, and payment updates.
  - Marking notifications as read/unread.

- **Reviews and Ratings:**
  - Users can provide ratings and reviews for parking areas.
  - Moderation and retrieval of reviews.

Non-Functional Requirements to be Tested:

- **Performance:**
  - Response time for booking searches and payment processing.
  - Scalability to handle high user traffic during peak hours.

- **Usability:**
  - Intuitive user interface for both vehicle owners and area providers.

- **Security:**
  - Data encryption for sensitive information (e.g., passwords, payment details).
  - Protection against vulnerabilities like SQL injection, XSS, and CSRF.
  - Secure API communication using HTTPS.

- **Compatibility:**
  - Cross-browser testing (e.g., Chrome, Firefox, Safari).
  - Testing on multiple devices (Android, iOS, desktops).

- **Reliability:**
  - Ensuring system stability under various scenarios (e.g., high traffic, unexpected inputs).
  - Database integrity with consistent updates to available spaces and user data.

- **Maintainability:**
  - Testing the modular structure for easy updates and fixes.
  - Validation of automated test cases to facilitate future regression testing.

6.1.3. Quality Objective

1. **Conformance to Functional and Non-Functional Requirements:** The application must be thoroughly validated to ensure it meets both functional and non-functional requirements. This includes core features such as user authentication, area booking, payment processing, and notification delivery. Functional requirements focus on ensuring that the system behaves as expected—whether it's accurately processing bookings, handling user login, or providing correct payment confirmations. Non-functional requirements address how well the system performs under different conditions, such as responsiveness, availability, and security. Both these sets of requirements must be rigorously tested to ensure the platform functions smoothly across various use cases and environments.

2. **Delivering Quality as Defined by Stakeholders:** The quality of the Application Under Test (AUT) must align with the standards and expectations outlined by stakeholders. This encompasses functionality, usability, performance, and security. Stakeholders may include the client, end-users, and internal teams, all of

whom have specific quality expectations. For instance, clients may prioritize speed, while end-users might value ease of navigation. A comprehensive testing approach ensures that the application not only functions correctly but is also optimized for a seamless, user-friendly experience. Performance benchmarks and security requirements should be validated to guarantee that the application meets the client's vision.

3. **Identifying and Resolving Bugs Before Deployment:** It's crucial to proactively identify and resolve defects or issues in the application during the testing phase. Thorough testing, including unit, integration, and system testing, should be conducted to uncover any bugs. Once identified, these bugs must be documented, categorized based on severity, and resolved promptly. This step is vital to ensuring that the application is stable and error-free when it goes live, minimizing the risk of disruption after deployment and providing a smooth user experience.

4. **User Satisfaction:** User satisfaction is paramount for the platform's success. The application must deliver an experience that is both intuitive and efficient for vehicle owners and area providers. This involves focusing on user interface design, ensuring ease of navigation, and optimizing workflows to reduce unnecessary complexity. Furthermore, the application's performance must be responsive, with quick load times and minimal downtime. Security features such as encrypted transactions should be integrated to guarantee that sensitive data is protected. Ultimately, meeting these expectations will ensure a positive user experience, leading to higher user retention and satisfaction.

5. **System Reliability and Scalability:** The platform must be able to support a growing user base without compromising performance. This requires rigorous testing to verify system reliability under varying loads and conditions, including peak usage periods. Load testing and stress testing should be performed to ensure that the platform can handle spikes in traffic or simultaneous user interactions. Scalability should also be a key consideration in both the application architecture and the infrastructure it runs on, enabling future growth and minimizing performance degradation as more users join the platform.

6. **Integration and Interoperability:** The application consists of multiple modules, such as user management, booking, payment, and notifications. These modules need to work together seamlessly to provide a unified experience. Integration

testing is essential to verify that these modules interact as expected. Additionally, the application must be tested across different devices, operating systems, browsers, and networks to ensure consistent functionality and performance. This guarantees that users can interact with the platform smoothly, regardless of their preferred environment.

7. **Data Integrity and Security:** User data, especially sensitive information like personal details and payment information, must be handled securely. The platform should implement industry-standard security measures to protect data both at rest and in transit. This includes encryption, secure authentication methods, and role-based access control. Rigorous security testing, such as penetration testing and vulnerability scanning, should be conducted to identify potential weaknesses and ensure data integrity. By safeguarding user data, the platform can build trust and ensure compliance with privacy regulations.

8. **Regulatory and Compliance Adherence:** The application must comply with all relevant legal, financial, and data protection regulations. This includes standards like GDPR (General Data Protection Regulation) for data privacy and PCI DSS (Payment Card Industry Data Security Standard) for handling financial transactions. Ensuring compliance not only mitigates legal risks but also builds trust with users and stakeholders. Regular audits and checks should be performed to verify that the platform adheres to the required standards.

9. **Minimizing Risk:** Testing should not only focus on functionality but also on identifying potential risks in performance, security, and user interactions. Risk management involves conducting comprehensive testing to detect vulnerabilities and performance bottlenecks before they affect users. By identifying and mitigating risks early, the platform can reduce the chances of major issues arising after deployment, ensuring a smooth user experience and business continuity.

10. **Readiness for Future Enhancements:** The platform should be designed with maintainability and scalability in mind. As new features or updates are introduced, the application's architecture should allow for easy integration and future-proofing. Modular code, clear documentation, and scalable infrastructure will help ensure that the platform can grow and adapt to evolving user needs and market demands. Testing for future enhancements should be planned to ensure the system can handle future updates without disrupting existing functionality.

6.1.4. Roles and Responsibilities

1. **QA Analyst (Quality Assurance Analyst)**
   - Role: Ensures the quality of the application through rigorous testing.
   - Responsibilities:
     - Create and execute test cases based on functional and non-functional requirements.
     - Perform various types of testing such as functional, regression, usability, and performance testing.
     - Log and track defects in the defect management tool.
     - Validate defect fixes and perform retesting.
     - Collaborate with developers to understand issues and resolve them efficiently.
     - Prepare test summary reports and share findings with the team.

2. **Developers**
   - Role: Build and maintain the application based on requirements and feedback.
   - Responsibilities:
     - Develop features and functionalities as outlined in the project specifications.
     - Fix bugs identified during testing.
     - Perform unit testing and code reviews to ensure code quality.
     - Collaborate with QA analysts to understand and resolve defects.
     - Optimize the application for performance, security, and scalability.
     - Provide technical documentation for the developed modules.

3. **UI/UX Designer**

   - Role: Designs the user interface and user experience to ensure a seamless user journey.
   - Responsibilities:
     - Create wireframes, mockups, and prototypes based on requirements.
     - Ensure the design aligns with the target audience's preferences.
     - Collaborate with developers to ensure the design is implemented correctly.
     - Conduct usability testing and make adjustments based on feedback.

- Maintain consistency in design elements throughout the application.

4. **Database Administrator (DBA)**
   - Role: Manages the database to ensure data integrity, security, and performance.
   - Responsibilities:
     - Design and implement the database schema.
     - Optimize database queries for performance.
     - Ensure data backup and recovery mechanisms are in place.
     - Monitor database health and resolve any issues.
     - Enforce security measures to protect sensitive data.

6.2. Test Methodology

6.2.1. Overview

Selected Methodology: Agile

Agile methodology was chosen for the project due to the following factors:

1. **Nature of the Project**
   - Dynamic Requirements: The requirements for the Project are expected to evolve based on user feedback, emerging trends, and stakeholder inputs. Agile allows for flexible adjustments during development.
   - Module-Based Approach: The project is divided into modules (e.g., User Management, Area Booking, Payments, Notifications), which can be developed and tested incrementally.

2. **Collaboration Needs**
   - Cross-Functional Teams: Agile promotes collaboration between developers, QA analysts, business analysts, and other stakeholders, which is essential for this multifaceted project

3. **Focus on Quality**
    - Continuous Testing: Agile integrates testing throughout the development lifecycle, ensuring that bugs are identified and addressed early.
    - User-Centric Development: By incorporating user feedback in every sprint, Agile ensures the application meets functional and non-functional requirements.

4. **Risk Mitigation**
    - Frequent Releases: Regular releases reduce the risk of delivering a product that doesn't meet expectations.
    - Early Issue Identification: With iterative development and testing, potential risks and issues are identified early, minimizing delays and cost overruns.

5. **Project Complexity**
    - Integration of Multiple Modules: Agile supports the seamless integration of complex, interdependent modules like geolocation, payment systems, and notifications.
    - High Scalability: Agile can accommodate the growing scope of features and functionalities as the project evolves.

6. **Comparison with Other Methodologies**
    - Waterfall: Waterfall is rigid and doesn't accommodate changes well. For a dynamic project like Project, this would lead to delays and increased costs.
    - Iterative: While iterative allows some flexibility, it lacks the collaboration and frequent feedback loops provided by Agile.
    - Extreme Programming (XP): XP's focus on engineering practices might not align with the broader business and client collaboration needs of the project.

6.2.2. Test Levels

1. **Unit Testing**
   - Purpose: To validate individual components or modules of the application in isolation.
   - Scope:
     - Ensure that methods, functions, and classes for modules like User Management, Area Booking, and Payment Processing work as intended.
     - Test critical functions such as user authentication, vehicle registration, and booking creation.
   - Responsible Team: Developers and QA
   - Tools Used: JUnit (for Java-based testing).
   - Example:
     - Verify that the validateUserCredentials () method correctly authenticates users.
     - Test if the calculateTotalCost () function calculates the booking cost accurately.

2. **Integration Testing**
   - Purpose: To test interactions between modules and ensure seamless data flow.
   - Scope:
     - Verify integrations between modules like:
       - User Management ↔ Area Booking.
       - Booking ↔ Payment.
       - Notifications ↔ Booking and Payments.
     - Ensure APIs and database queries are working correctly when modules communicate.
   - Responsible Team: QA
   - Tools Used: Postman (API Testing), Selenium (for end-to-end flows).
   - Example:
     - Check if a successful booking triggers a notification.
     - Test payment success updates the booking status to "Confirmed."

3. **Acceptance Testing**
   - Purpose: To validate the application meets client expectations and is ready for deployment.
   - Scope:
     - Conduct User Acceptance Testing (UAT) with client and end-users.

    - Validate real-world scenarios, such as a user booking a parking spot at a specific location using their registered vehicle.
- Responsible Team: QA and End-User Representatives.
- Tools Used: Manual Testing, or tools such as BrowserStack for cross- platform compatibility testing.
- Example:
    - Validate if the area owner can see booking and payment details for their parking areas.

4. **Regression Testing**
    - Purpose: To ensure new features or changes do not negatively affect existing functionality.
    - Scope:
        - Rerun test cases for critical modules (e.g., User Management, Payment Processing) after introducing new features or fixes.
    - Responsible Team: QA
    - Tools Used: Selenium (for automation).
    - Example:
        - Verify that adding a new payment method does not disrupt the booking workflow.

6.2.3. Test Completeness

1. **Test Coverage**
    - Requirement:
        - Achieve 100% coverage for all critical modules and workflows.
        - All functional and non-functional requirements should be covered by test cases.
        - Verify edge cases, boundary conditions, and real-world scenarios.
    - Verification:
        - Review test coverage reports to ensure every functionality and integration is tested

2. **Execution of Test Cases**
    - Requirement:
        - Execute all manual and automated test cases planned during test design.
        - Ensure that tests for major workflows, such as user registration, booking, payment, and notification, are successfully executed.

    - Verification:

- Review the execution status in the test management tool (e.g., Jira, TestRail).
- Confirm that test cases marked as critical and high priority are executed without errors.

3. **Bug Resolution**
   - Requirement:
     - All critical and high-priority bugs identified during testing are resolved.
     - Medium and low-priority bugs should either be resolved or deferred with client approval for future releases.
   - Verification:
     - No open critical bugs remain.
     - Medium and low-priority issues are documented and scheduled for subsequent releases if not fixed.

4. **Performance Benchmarks**
   - Requirement:
     - Meet all performance benchmarks, including response time, load capacity, and scalability.
     - Confirm that the application performs efficiently under peak load conditions.
   - Verification:
     - Review performance testing reports from tools like JMeter to ensure all benchmarks are met.

5. **Security Validation**
   - Requirement:
     - Address all identified vulnerabilities from penetration testing and security audits.
     - Ensure data encryption, secure payment processing, and proper access controls.
   - Verification:
     - Review security test results and confirm no critical vulnerabilities remain unaddressed.

6. **User Acceptance Testing (UAT)**
   - Requirement:
     - UAT feedback from the client and end-users is positive.
     - All reported issues during UAT are resolved or documented for future consideration.

- Verification:
    - Validate that UAT sign-off is obtained from stakeholders.

7. **Regression Testing**
    - Requirement:
        - Complete regression testing to ensure that new changes have not affected existing functionalities.
    - Verification:
        - Review the regression testing logs and confirm that no major issues were introduced during recent updates.

8. **Documentation Completion**
    - Requirement:
        - All test artifacts, including test cases, defect reports, and test execution reports, are documented and shared with stakeholders.
        - User manuals and training documents are updated based on the final application.
    - Verification:
        - Perform a final review of test documentation to ensure completeness and accuracy.

6.2.4. Test cases:

Test Case ID	Scenario	Input	Expected Output
UA-001	Login with valid	Valid	Success: User logged in
	credentials	username/password	
UA-002	Login with invalid credentials	Invalid username/password	Error: "Invalid credentials"
UA-003	Login with empty fields	Empty username/password	Error: "Fields cannot be empty"
UA-004	Password length boundary (min)	Password = 6 characters	Success: Logged in

UA-005	Password length boundary (max)	Password = 20 characters	Success: Logged in
UA-006	Account lock after 5 failed attempts	5 invalid login attempts	Error: "Account locked for security reasons"

Table 6.2.4.1: User Authentication Module

Test Case ID	Scenario	Input	Expected Output
AM-001	Add new area with valid details	Valid area details	Success: Area added
AM-002	Add new area with missing fields	Missing address/total spaces	Error: "All fields are required"
AM-003	Update area details (price per hour)	Valid price	Success: Details updated
AM-004	Update area with invalid price	Negative price	Error: "Invalid price value"
AM-005	Delete area with active bookings	Area with bookings	Error: "Cannot delete area with active bookings"

Table 6.2.4.2: Area Management Module

Test Case ID	Scenario	Input	Expected Output
BM-001	Book a parking space (valid)	Valid user, area, vehicle	Success: Booking created
BM-002	Book a space with invalid area ID	Invalid area ID	Error: "Area not found"

BM-003	Book space when no slots are available	Area with 0 available slots	Error: "No slots available"
BM-004	Cancel a booking (valid)	Booking ID	Success: Booking canceled
BM-005	Cancel a booking (expired)	Booking with past end time	Error: "Cannot cancel expired booking"

Table 6.2.4.3: Booking Module

Test Case ID	Scenario	Input	Expected Output
PM-001	Process payment (valid)	Valid booking, amount	Success: Payment confirmed
PM-002	Process payment (failed gateway)	Valid details, gateway fails	Error: "Payment failed. Try again."
PM-003	Payment with partial amount	Amount < Total Cost	Error: "Insufficient payment amount"
PM-004	Payment refund on cancellation	Valid cancellation	Success: Amount refunded
PM-005	Payment using coupon (valid)	Valid coupon applied	Success: Discount applied, payment processed

Table 6.2.4.4: Payment Module

Test Case ID	Scenario	Input	Expected Output
NT-001	Send booking confirmation notification	Valid booking	Notification sent to user

NT-002	Send notification on failed payment	Payment fails	Notification sent with retry instructions
NT-003	Notify area owner on low rating	Area rating drops below 3	Notification sent to owner
NT-004	Notification status update (read)	User reads notification	Status updated to "Read"

Table 6.2.4.5: Notifications Module

Test Case ID	Scenario	Input	Expected Output
RR-001	Add review with valid details	Valid area, rating, review text	Success: Review added
RR-002	Add review without rating	Missing rating	Error: "Rating is required"
RR-003	Add review with invalid rating	Rating > 5 or < 1	Error: "Rating out of range"
RR-004	Duplicate review submission	User submits a second review	Error: "Review already submitted"

Table 6.2.4.6: Reviews and Ratings Module

Test Case ID	Scenario	Input	Expected Output
GL-001	Search parking near valid location	Latitude, Longitude	Success: List of parking areas returned
GL-002	Search parking with invalid location	Out-of-bounds coordinates	Error: "Location not supported"
GL-003	Calculate distance from user to area	Valid coordinates	Success: Distance calculated

Table 6.2.4.7: Geolocation Module

Equivalence Testing:

Test Case ID	Input Field	Equivalence Classes	Expected Result
EP-001	Username	Valid: [1–50 chars], Invalid: [0, >50]	Valid: Accept; Invalid: Reject
EP-002	Password	Valid: [8–20 chars], Invalid: [<8, >20]	Valid: Accept; Invalid: Reject

Table 6.2.4.8: User Authentication

Test Case ID	Input Field	Equivalence Classes	Expected Result
EP-003	Area Availability	Valid: Available slots > 0	Show available areas
EP-004		Invalid: Available slots = 0	Show "No slots available"

Table 6.2.4.9: Area Availability

Test Case ID	Input Field	Equivalence Classes	Expected Result
EP-005	Card Number	Valid: 16 digits	Valid: Accept; Invalid: Reject
EP-006	Amount	Valid: [1–5000 INR], Invalid: [<1, >5000]	Valid: Accept; Invalid: Reject

Table 6.2.4.10: Payment

Decision Table:

Condition	C1	C2	C3	C4	Outcome
Booking status is "Confirmed"	Yes	Yes	No	No	Notify user
Payment processed successfully	Yes	No	Yes	No	Update booking status to "Paid"
Area availability updated	Yes	Yes	Yes	No	Notify interested users
Expected Outcome	Notify	Deny	Update	Log Error	

Table 6.2.4.11: Decision Table for Complex Module Interactions

Condition	C1	C2	C3	C4	Action
Booking status is "Booked"	Yes	Yes	No	No	Process cancellation
Cancellation request within 1 hour	Yes	No	Yes	No	Refund full amount
Refund request outside 1 hour	No	Yes	No	Yes	Partial refund
Expected Outcome	Refund	No Refund	No Action	No Action	

Table 6.2.4.12: Booking Cancellation and Refund

Condition	C1	C2	C3	C4	Action
Total spaces > 0	Yes	Yes	No	No	Allow booking
Available spaces > 0	Yes	No	Yes	No	Allow booking
Booking cancelled	No	Yes	No	Yes	Increase available spaces
Expected Outcome	Allow	Deny	Deny	Update	

Table 6.2.4.13: Parking Availability Update

6.3. Resource & Environment Needs

6.3.1. Testing Tools

1. **Automation Tools**
   - Purpose: To automate repetitive test scenarios for regression, performance, and functional testing.
   - Tools:
     - Selenium: For functional and regression testing of the web application.
     - Appium: For testing mobile versions of the application.
     - Postman: For API testing and validation.
     - JMeter: For performance and load testing.

2. **Collaboration Tools**
   - Purpose: To facilitate communication and collaboration among team members.
   - Tools:
     - Slack: For team communication.
     - Confluence: For maintaining centralized documentation and knowledge sharing.

3. **Version Control Tool**
   - Purpose: To track changes to test scripts, automation code, and documentation.
   - Tool:
     - Git: For version control and collaboration.
     - GitHub/: For hosting repositories.

4. **Reporting Tools**
   - Purpose: To generate and share test execution and defect tracking reports.
   - Tools:
     - Excel/Google Sheets: For simple reporting needs.

6.3.2. Test Environment

11. **Hardware Requirements**
    - **Test Machines (Desktops/Laptops)**
      - Processor: Intel i5 or higher / AMD Ryzen 5 or higher
      - RAM: Minimum 8 GB (16 GB recommended for automation and performance testing)

- Storage: Minimum 256 GB SSD (512 GB SSD or higher recommended for faster performance)
- Screen Resolution: 1920x1080 (Full HD) or higher
- Network: Stable broadband connection with minimum 50 Mbps speed
- Graphics: Integrated graphics (dedicated GPU if load testing requires graphical simulations)

- **Mobile Devices**
  - Android: Devices running Android 8 (Oreo) or higher
  - Screen Sizes: A mix of devices covering small, medium, and large screen sizes for responsive testing

- **Servers (for Environment Hosting)**
  - CPU: 4-core or higher
  - RAM: 16 GB or higher
  - Disk Space: Minimum 1 TB (for database, logs, and backups)
  - Network: High-speed Ethernet connection for local servers

12. Software Requirements

- **Operating System**
  - Windows 8 and above (recommended: Windows 10 or 11)
  - macOS (for compatibility testing)
  - Linux distributions (for backend testing and server environment)

- **Office Suite**
  - Microsoft Office 2013 and above
  - Alternative: LibreOffice or Google Workspace

- **Email and Collaboration**
  - Microsoft Exchange for email management
  - Slack, Microsoft Teams, or Zoom for team collaboration

- **Browsers (for Cross-Browser Testing)**
  - Chrome: Latest version
  - Firefox: Latest version
  - Microsoft Edge: Latest version
  - Safari: Latest version (for macOS and iOS devices).

CHAPTER 7
CONCLUSION & FUTURE SCOPE

Conclusion:

Urban mobility and traffic management are increasingly challenged by the constraints of limited land availability and the rapidly rising demand for parking spaces in metropolitan areas. As urban populations grow and vehicle ownership continues to surge, the strain on existing parking infrastructure becomes ever more apparent. Traditional responses—such as constructing multi-level parking facilities or expanding roadside parking—are not only capital-intensive but also unsustainable, as they demand additional land resources and contribute to urban sprawl and environmental degradation.

This study explores a **novel, technology-driven approach** to solving these pressing issues by developing a **comprehensive smart parking platform** that aggregates and optimizes underutilized private and open spaces. By **bringing together disparate parking resources—such as unused residential lots, commercial property spaces, institutional grounds, and vacant areas—under a unified digital platform**, this solution offers a **scalable, cost-effective, and environmentally sustainable alternative** to traditional parking infrastructure development.
The core of this system lies in its use of **Internet of Things (IoT) technology**, which enables **real-time monitoring and communication of parking space availability**. By embedding IoT sensors in parking locations, the system continuously tracks occupancy status, transmitting live data to the platform's cloud-based servers. This information is then relayed to users via a **mobile application or web portal**, allowing drivers to efficiently locate and reserve available parking spaces without the need for extended cruising—commonly known as "parking lot sailing." This not only minimizes driver frustration but also significantly **reduces fuel consumption, traffic congestion, and air pollution**, contributing to improved urban air quality and reduced greenhouse gas emissions.

An integral feature of the platform is its **transparent rating and review mechanism**, which facilitates **trust and accountability** between the two primary user groups: parking space owners and vehicle drivers. Every transaction—whether it involves booking a space, leaving a vehicle, or managing a parking area—is subject to a dual-feedback process. Verified user profiles, identity checks, and performance histories ensure a safe and reliable ecosystem where users can make informed decisions based on peer reviews and performance metrics.

From the perspective of **property and real estate owners**, the platform provides a **new revenue stream** by allowing them to monetize idle or sporadically-used parking spaces without significant investment. Spaces that might otherwise remain vacant for most of the day—such as office parking lots after hours or residential driveways during working hours—can now be made available to commuters, shoppers, tourists, and event-goers. This **asset-light model** not only maximizes spatial efficiency but also contributes to a more **dynamic and participatory urban economy**.

In addition to its practical benefits, this solution aligns closely with the goals and visions of the **Smart Cities Mission** and the **United Nations Sustainable Development Goals (SDGs)**. Rather than promoting the expansion of concrete infrastructure, the approach advocates for **smart resource utilization, environmental sustainability, and enhanced urban livability**.

Specifically, it supports:

- **SDG 9: Industry, Innovation, and Infrastructure** by leveraging cutting-edge technology to improve urban infrastructure efficiency.

- **SDG 11: Sustainable Cities and Communities** by reducing urban congestion and enhancing public access to services.

- **SDG 13: Climate Action** through reduced vehicular emissions and more efficient fuel use.

In conclusion, this study emphasizes that **effectively managing existing vacant and underutilized spaces through smart technology** can serve as a **long-term, sustainable solution** to urban parking challenges. The implementation of such a platform not only benefits individual drivers by simplifying parking but also creates **financial incentives for property owners**, enhances overall traffic flow, and supports broader environmental and urban planning objectives. This model represents a forward-thinking, inclusive approach to urban development, where digital innovation and sustainability work hand in hand to address the mobility needs of today and tomorrow.

Future Scope:

- **Enhancing User Flow:** To enhance user flow, streamline the user interface by eliminating unnecessary steps and ensuring intuitive navigation. Clear call-to-action (CTA) buttons should be strategically placed for easy access, and visual cues like contrasting colors or animations can guide users through key actions. Incorporating progress indicators for multi-step processes, such as checkout or registration, will help

users understand where they are in the process. Personalizing the experience based on user data, such as pre-filled forms or tailored suggestions, can further ease navigation, while real-time error prevention and clear messaging ensures users avoid mistakes and can resolve issues quickly.

- **Dynamic Payment Flow:** A dynamic payment flow should offer users a variety of payment methods, from traditional credit cards to digital wallets and region-specific options like mobile payments. Localized payment solutions ensure the platform accommodates users' preferences based on their location. Real-time updates on payment status (successful, pending, or failed) with actionable next steps are crucial, and displaying clear security assurances about data protection builds trust and reduces concerns over payment safety.

- **Enhancing Geo-Location Search:** Improving geo-location search involves offering advanced filters that allow users to refine their search based on proximity, such as adjusting the radius to find relevant results within a certain distance. Real-time location updates, utilizing GPS or IP-based tracking, automatically adjust search results based on the user's current position. Integrating interactive maps lets users visualize search results and navigate routes more effectively. Personalized, location-based recommendations, such as nearby events or services, enhance the experience, while geofencing allows for targeted notifications when users enter specific areas, offering deals or updates related to their location.

- **Scalability and Expansion:** The platform's potential to reach entire cities, regions, and even nations is highly encouraging. As smart city technology becomes more widely used, it will be able to expand to new metropolitan regions and solve parking issues in urban areas across the globe.

- **Integration with Public Transport Systems:** To allow for integration with public transport systems, the platform might be expanded. This would allow users to find parking near bus stops, train stations, and metro hubs. This will lead to a decline in the use of private vehicles for urban commuting and an increase in the use of public transportation.

- **Data-Driven Insights**: It has the potential to develop into a platform that offers city planners and local governments insightful information on urban mobility thanks to its access to vast amounts of real-time data. This information could improve the design of the next infrastructure projects, ease traffic, and reduce congestion.

- **Partnerships with Commercial Establishments**: The number of parking spaces might be further increased by extending the platform's scope to include partnerships with commercial entities (such as shopping centres, hotels, and office buildings). This would provide consumers with more alternatives while assisting companies in making additional cash.

- **Sustainability and Green Initiatives**: It can be integrated with programs which are sustainable to support eco-friendly parking solutions such as designating spaces for electric cars (EVs) with charging stations and promoting carpooling.

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(57) Abstract :

The present invention provides system and method for resolving parking issues using smart vehicle parking that ensures efficiency by integrating Internet of Things (IoT) devices into the parking lots. These modules instantly update a web application with the availability of a place based on automatic determination. By doing this, traffic flow is improved overall and the amount of time spent looking for parking is decreased. Area owners have complete control over their properties and can handle reservations and cancel them as needed. Reviews and ratings are meant to ensure security and trust, allowing drivers and parking suppliers to assess one another prior to confirming a reservation. Verification and other similar processes strengthen security and ensure safe transactions. Figure 1

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RESEARCH PAPER PROOF

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1 message

Microsoft CMT <noreply@msr-cmt.org> Sun, 18 May, 2025 at 8:08 pm
To: ishita.2125cs1199@kiet.edu

Hello,

The following submission has been edited.

Track Name: Track 2: VLSI, Embedded Systems and Advanced Communication Networks

Paper ID: 149

Paper Title: System and method for resolving the parking issues using smart vehicle parking

Abstract:
Traffic congestion, illegal parking, and safety problems have resulted from the imbalance between the increasing number of vehicles and the restricted number of parking spots in metropolitan areas. Conventional parking infrastructure is frequently ineffective, resulting in higher fuel use, wasted time, and financial losses. By offering an intelligent, Internet of Things-enabled parking solution that maximizes parking space use without necessitating extra infrastructure development, the initiative seeks to address these issues. The project links up automobile owners looking for parking spots with owners of open spots who are prepared to lease their spots. To provide a flawless parking experience, the system combines Django (backend), Firebase (real-time data sync), and IoT sensors (parking space detection). Real-time parking availability updates are provided by ultrasonic and infrared sensors, cutting down on needless fuel use and cruise time.
ParkEzy encourages sustainable urban mobility through contactless purchases, automated booking, and geolocation-based slot discovery. By increasing transportation efficiency and lowering environmental impact, this project supports the Sustainable Development Goals (SDGs 11 and 12: Sustainable Cities, Responsible Consumption, and Industry & Innovation, respectively).
The implementation of the project is expected to reduce urban traffic congestion, enhance parking safety, and provide additional income opportunities for parking space owners, contributing to a smarter and more sustainable urban future.

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Thanks,
CMT team.

IoT-based Safe Parking System and Minimizing Roadblocks

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Abstract—There is a significant disparity between the number of cars and parking spots in metropolitan areas, particularly during rush hour, which results in traffic congestion, obstructions, and inconvenience. Our method addresses these problems by uniting vacant areas—owned by individuals or businesses—under a unified, well-designed platform. These spaces can be registered for public use, making the most of existing resources without the need for additional infrastructure. This will help to alleviate parking shortages and support the objectives of sustainable development and smart cities. To ensure efficiency, we integrate Internet of Things (IoT) devices into the parking lots. These modules instantly update a web application with the availability of a place based on automatic determination. By doing this, traffic flow is improved overall and the amount of time spent looking for parking is decreased. Area owners have complete control over their properties and can handle reservations and cancel them as needed. Reviews and ratings are meant to ensure security and trust, allowing drivers and parking suppliers to assess one another prior to confirming a reservation. Verification and other similar processes strengthen security and ensure safe transactions. Ultimately, our technology provides landowners with a sustainable and scalable solution to urban parking issues, as well as an opportunity to earn additional revenue.

Keywords—Parking Space Management, Smart City Solutions, IoT Parking Modules, Land Utilization, Real-Time Parking Availability, Traffic Congestion Solutions.

I. INTRODUCTION

Car ownership is increasing at a rapid rate, there is an imbalance in metropolitan areas between the number of cars and parking spots. This inequality leads to expanding urban problems of safe and lawful parking, as well as traffic jams and concerns about the safety of vehicle owners and pedestrians. In places with high population densities, such as marketplaces, commercial districts, and popular tourist destinations, parking problems are particularly problematic due to space constraints, which further complicate urban mobility and highlight the urgent need for creative solutions. A significant element contributing to this issue is the imbalance between parking availability and demand. On-street parking, which is frequently encroaching on private property and reducing the amount of space on the road available for cars, is the primary cause of traffic. In addition, cruising—the act of driving about in search of a parking space- has become popular among drivers. This leads to traffic congestion, air pollution, and inefficient fuel consumption. The problem is worse by the absence of a conventional system for parking slots, which results in an inefficient use of available space because many parking spots are either too tiny or too huge. Additionally, driving stress and general road safety are decreased by drivers' ongoing fear of fines (challans) for parking illegally.

It is difficult to solve these parking issues without adding more infrastructure, particularly in big cities where there is a lack of available space. As an alternative to depending on pricey development projects to provide more parking spots, this attempts to offer a sustainable, scalable solution by making the most of already-existing resources. Our concept tackles parking overcrowding by integrating empty spaces, including idle commercial spaces and private properties, into a single parking platform. This approach not only addresses the present parking shortage but also advances the more general goals of smart city and sustainable development initiatives. It works as a middleman between car owners and parking space providers to deliver a safe, effective, and adaptable parking solution. Car owners may quickly find and reserve parking spots based on price, location, and availability by using an online platform.

Area	Fact	Source
Traffic Congestion	Urban areas face a **30% increase in congestion** due to vehicles searching for parking spaces.	International Parking Institute
Search Time	Drivers in India spend an average of **20 minutes searching for parking**.	Boston Consulting Group

Unused Spaces	Studies estimate that **20-30% of urban spaces remain unused**, even during peak hours.	Urban Land Institute
Economic Impact	Efficient parking solutions can save up to **₹1,500 crores annually** in wasted fuel and time costs.	McKinsey & Company
Industry Growth	The parking industry is expected to grow at a **CAGR of 9.6% from 2023 to 2028**.	Market Research Future
Vehicle Theft	**58% of urban vehicle thefts** occur in unregulated or unsafe parking spaces.	National Crime Records Bureau, India
IoT Effectiveness	IoT-based surveillance can reduce theft incidents by **40%**.	Frost & Sullivan
Space Utilization	Smart parking solutions powered by IoT can increase parking space utilization by **20-30%**.	Allied Market Research
Global Market Size	Global IoT in parking market size is projected to reach **$12 billion by 2025**.	Grand View Research
Environmental Impact	Idling vehicles searching for parking contributes to **10% of urban CO_2 emissions**.	Environmental Protection Agency, USA
Emission Reduction	Smart parking systems can reduce CO_2 emissions by up to **40%**.	Smart Cities Council
Internet Access	**95% of urban dwellers in India** have access to mobile internet, enabling digital parking solutions.	Telecom Regulatory Authority of India
Payment Gateway	Payment gateways like Razorpay handle **$50 billion in annual transactions**.	Razorpay Report, 2023
Smart Cities Mission	The **Smart Cities Mission** has allocated **₹6,000 crores** for smart urban infrastructure.	Ministry of Housing and Urban Affairs, India

Table 1: Impact on various areas listed

However, property owners can increase their income without making large investments by renting out the places they don't utilize. Parking spots will have Internet of Things (IoT) modules placed to give real-time availability updates, making it easy and quick for users to find and reserve spaces. In addition to lowering the need for cruising, the system's dynamic booking and availability tracking help enhance traffic flow and cut down on emissions from prolonged idling.

II. Literature Review

Due to rising vehicle ownership and urbanization, nearly 40 million vehicles are clogging India's urban centres, creating serious parking issues. Economic progress and population increase have made this problem worse. There are two types of parking issues: off-street parking, which is usually found in big businesses and retail centres, and on-street parking, which is more erratic and driven by the market and frequently causes traffic jams. The inability to incorporate parking regulations into urban planning has led to several problems, such as ineffective land use, poor transportation quality, and negative environmental effects. It is crucial to increase parking spaces, improve accessibility, and maximize current infrastructure to address these issues. The main answers are to promote public transit, use dynamic parking pricing, and apply smart pricing in commercial zones. The assessment of parking problems in India looks at the various aspects of the issue, which is fuelled by growing vehicle ownership and fast urbanization. This thorough research, which is based on several studies, emphasizes the necessity of addressing the parking space deficit and its effects on urban mobility. The number of vehicles and India's expanding population have put tremendous strain on the country's infrastructure. To maximize parking usage, creative solutions have been put forth, such as smart parking systems. Manjaly and Joseph [1] point out that problems with parking cost India's GDP 1.56% annually. Their suggested smart parking solutions provide effective space distribution, easing traffic and enhancing comfort. In a similar vein, parking management has found use in mobile applications. Parmar et al. [3] provide examples of how users can find and book parking spaces.

Paper reference no.	Year	Key finding	Research focus
25	2023	SCOPE model, utilizing AlexNet and YOLO-V3 as learning controllers, achieved high accuracy (99.87% and 99.89%, respectively) in identifying parking lot statuses, demonstrating its effectiveness for smart city ecosystems	Revolutionizing Urban Mobility: IoT-Enhanced Autonomous Parking Solutions with Transfer Learning for Smart Cities

24	2023	Arduino-based smart parking system offers a cost-effective and adaptable solution for managing parking demand, improving space availability and efficiency, with potential for scaling and enhancing smart city applications	IoT-Enabled Smart Parking: Enhancing Efficiency and Sustainability in Smart Cities
14	2023	Arduino-based smart parking system effectively enhances parking efficiency, reduces congestion and emissions, and supports sustainable urban development through affordable, scalable IoT integration	Research Paper on Smart Car Parking System
20	2022	IoT-enabled wireless sensor networks, simulated using CupCarbon IoT 5.0, effectively calculate the shortest distance between nodes through comparative analysis of routing techniques	Comparative Study of Shortest Distance Calculation Techniques in IoT-Based Wireless Sensor Networks
16	2021	Intelligent Transportation Systems (ITS), leveraging wireless networks, deep learning, and optimization algorithms, effectively reduce traffic congestion and improve travel time when tailored to location-specific needs	Intelligent Traffic Management : A Review of challenges, solutions and future perspectives
19	2021	AI and ML-driven traffic management systems optimize traffic flow, reduce congestion, and minimize manual intervention through advanced algorithms and smart technologies	A comprehensive review of intelligent traffic management using machine learning algorithms
23	2021	ILP and FIS-based parking management model can optimize campus parking assignments, reduce wandering time, and enhance satisfaction by considering user preferences and institutional priorities	Parking Demand vs Supply: An Optimization-Based Approach at a University Campus
1	2019	well-managed and accessible parking system is essential to alleviate parking shortages, reduce traffic congestion, enhance convenience, and provide social, environmental, and governmental benefits	Parking Problems in INDIA: Measuring the Momentary Loss
5	2017	modern technological solutions and improved urban planning are essential to address the imbalance between parking supply and demand, while also considering environmental impacts for more livable cities.	Car Parking Problem in Urban areas, causes and Solutions

Table 2: Literature review summary

Furthermore, Peñalosa [2] emphasizes how important it is to match parking regulations with urban planning. Parking

supply, price, and enforcement laws are largely established by municipal authorities. Policies such as zoning laws, parking requirement requirements for new construction, and dynamic pricing structures are useful tools for encouraging economical land use and lowering the ownership of excessive numbers of vehicles. As Lizbetin and Bartuska [4] have observed, the scarcity of parking spots for road freight transit is another major problem. Urban mobility plans that incorporate walking, bicycling, and public transportation can lessen reliance on private vehicles and thereby ease the demand for parking. It's also important to learn more about how the public views parking and behaves about it.

To effectively create solutions to solve parking issues, Ahmed [5] emphasizes the significance of comprehending travel patterns and preferences. Sustainable environmental practices are also a major component of parking management. Numerous studies highlight how crucial electric vehicle charging stations and green parking infrastructure are to minimizing parking's negative environmental effects. Furthermore, as Amira Elsonbaty and Mahmoud Shams have discussed, cloud computing and IoT have improved smart parking solutions [6]. Real-time tracking of available parking spaces is made possible by their Smart Parking Management System (SPMS), which makes use of Arduino, Internet of Things sensors, and mobile applications.

The parking availability is tracked by the system using infrared sensors. Data is sent to a server over Wi-Fi and accessed by users through a mobile app. This app offers an affordable, easy-to-use platform for finding open places, booking them, and getting updates. By utilizing IoT, SPMS streamlines parking administration and lowers fuel usage by cutting down on the amount of time spent looking for parking spots. Furthermore, Khanna and Anand's work [7] describes an Internet of Things (IoT)-based cloud-integrated parking system that uses sensors to keep an eye on every parking spot and notifies users via a mobile application of its real-time availability. This kind of solution eases traffic congestion and improves urban mobility by drastically cutting down on the amount of time wasted looking for parking spots.

PPPs, or public-private partnerships, are also essential for funding and constructing parking infrastructure. To mobilize resources and scale up parking solutions, Ahmed [5] promotes cooperative arrangements between public authorities, commercial developers, and technological companies. Building consensus on parking management solutions requires including stakeholders and the community in decision-making processes.

In summary, parking issues in India's densely populated cities are complex and need an all-encompassing solution. Novel approaches to parking management are required in light of problems like oversaturated parking spots, unregulated rates, and environmental issues. Effective legislation, public awareness initiatives, and technology developments should support these efforts. India can reduce traffic congestion, improve the quality of urban life, and lessen its environmental effects by taking a comprehensive approach to parking difficulties.

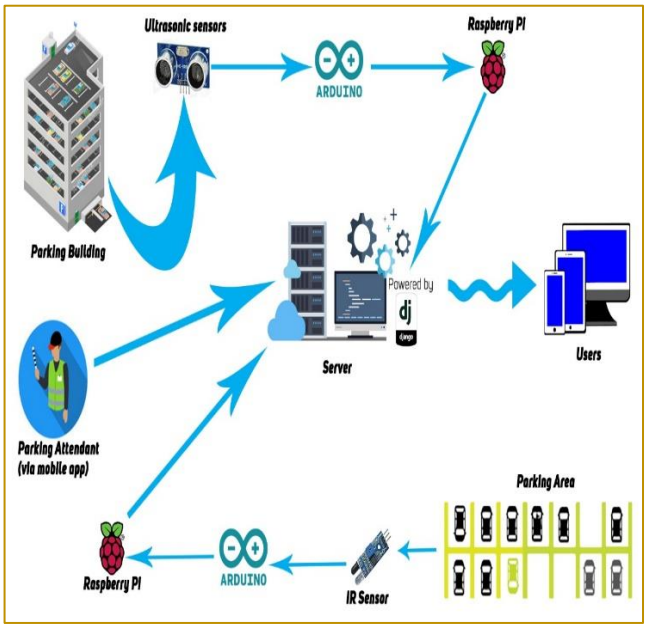

Fig.1. IoT-based smart parking system [21]

A. Existential Problem

- **Underutilization of Existing Parking Spaces:** To address the rising demand for parking, the majority of research and solutions centre on developing additional infrastructure. Optimizing the utilization of underutilized areas, such as garages, private plots, and other vacant assets, is noticeably lacking in attention. There aren't many alternatives that combine these areas into a centralized system that facilitates simple public parking access.
- **Lack of Real-Time Availability Data:** Users must drive about looking for parking spaces because many of the parking solutions on the market today do not offer real-time data on the availability of spots. This causes pollutants in addition to causing traffic congestion. Although smart parking has been the subject of various studies, little research has been done on how to integrate this technology in poor nations in a way that is both scalable and affordable.
- **Inadequate Focus on Sustainable Development:** Although there is a growing global concern about sustainable urban development, many parking systems just consider convenience and ignore the environmental impact of adding more infrastructure. The body of research on strategies that support sustainable development objectives by making the most of already-existing spaces and minimizing the need for new construction is lacking.
- **Limited Community Engagement Models:** The potential of community engagement is largely overlooked in current parking management research. There aren't many studies that address how private citizens or companies can add empty spots to a broader parking ecosystem, resulting in a win-win situation. There aren't many outlets that promote community involvement in resolving urban parking issues.

- **Lack of Flexible and Transparent Booking Systems:** Numerous parking systems now in use do not provide flexibility or customized booking alternatives depending on user preferences like cost, distance, or location. Furthermore, few studies have addressed the need for user-friendly platforms that provide safe payment methods and clear information on parking rates. Transparency in booking and pricing is still a big challenge.
- **Insufficient Safety and Trust Mechanisms:** Rarely does the literature now in publication address the safety worries of both car owners and space providers. Few studies have offered comprehensive procedures like a rating and review system, paired with verification processes to assure confidence and security in parking transactions. This is a serious imbalance, particularly in crowded places where people prioritize their safety.
- **Challenges with Scalability and Implementation in Developing Countries:** Although several smart parking solutions have been put into practice in affluent nations, there is still a lack of research on how scalable these solutions would be in highly crowded, resource-constrained cities. Studies that have been done in the past frequently undervalue the particular economic, social, and infrastructure problems that emerging nations face, which makes it difficult to apply or scale up beneficial solutions in these areas.

Region	Vacancy Rate	Vacant Units (millions)	Key Cities/Areas	Key Observations
Urban India (Overall)	11.1%	11.1 million	Across cities	Due to high investment properties and poor land-use planning.
Greater Noida (U.P.)	61%	Approx. 100,000 units	Greater Noida, surrounding NCR areas	Significant portion of housing stock remains unoccupied.
Mumbai (Maharashtra)	15%	Approx. 300,000 units	Mumbai Metropolitan Region	15% vacant housing, mostly in peripheral areas.
Vasai-Virar (Maharashtra)	50%	Approx. 70,000 units	Vasai-Virar	Large vacant properties due to overbuilt areas for investment.
Jammu & Kashmir	20%	Approx. 100,000 units	Srinagar, Jammu	High vacancy due to migration and demographic shifts.
Gujarat	18%	Approx. 250,000 units	Ahmedabad, Surat, Vadodara	Excess housing in rapidly developing industrial areas.

Table 3: Vacant and unused spaces in India [27] [28]

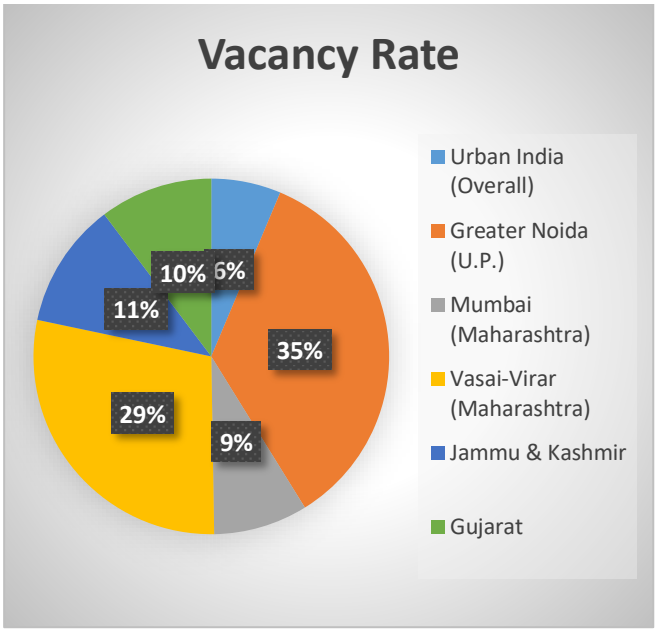

Fig.2. Vacant and unused spaces in India

III. PROPOSED SYSTEM

The goal of the proposed system is to simplify parking administration by combining open spots onto a single platform. This system uses a centralized web platform, IoT integration, and real-time data to enable safe, adaptable, and effective parking options for both car owners and area providers. The following is an overview of the system's main elements, including its functional modules and database structure.

A. Centralized Platform and User Management

- The web-based platform that acts as a middleman between area suppliers and car owners is the central component of the system. Users can register, search, and manage parking spaces, whether they are vehicle or area owners.
- Users Table: This table stores essential information about users, including vehicle owners and area owners.

It records user credentials and contact details, ensuring user verification and profile management.

- Vehicles Table: For vehicle owners, this table stores information about their registered vehicles, linking them to their respective user accounts for efficient vehicle management.

B. Parking Space Registration and Management

- Parking space owners can register their spaces on the platform, and car owners can then book those spaces. Through IoT modules placed in the parking lots, the system enables real-time updates on parking availability.
- Areas Table: This table stores parking area details, including location (latitude and longitude), pricing, total and available spaces. It links parking areas to area owners and ensures real-time availability updates.
- IoT Integration: IoT modules will be installed in parking areas to detect the presence of vehicles, allowing for real-time monitoring of parking space availability. This data will be automatically updated on the web platform.

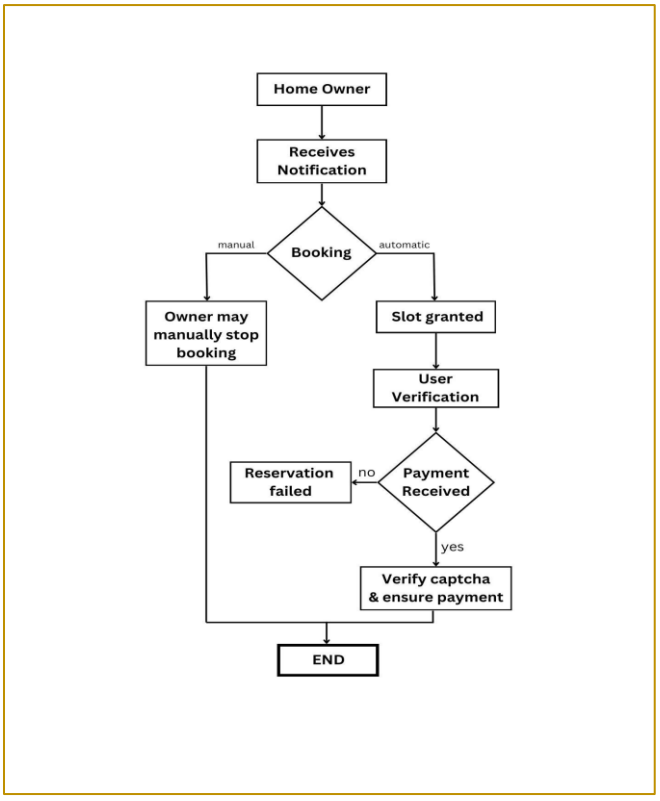

Fig.3. Area owner's data flow diagram

C. Secure Payment Processing

- A payment gateway is integrated into the system to handle transactions. Both area owners and users can monitor their earnings and securely make payments for their reservations.
- Payments Table: This table records payment transactions linked to bookings, ensuring secure and transparent financial operations. Payment methods and transaction statuses (e.g., completed or pending) are also recorded.
- Payment Integration: The system follows industry-standard payment protocols to safeguard transactions and ensure data security for both vehicle owners and area providers.

D. Notification and Alerts System

- The platform's integrated notification system makes sure users are informed of any updates, payment status, and booking confirmations.
- Notifications Table: This table stores notifications sent to users, ensuring they receive timely updates about bookings, payments, and platform changes. Notifications are linked to user profiles, ensuring personalised communication.

E. Real-Time Parking Booking and Management

- Using the platform, vehicle owners may look for, pick, and reserve parking spots. Users can customize their options using the booking module according to criteria like availability, cost, and proximity.

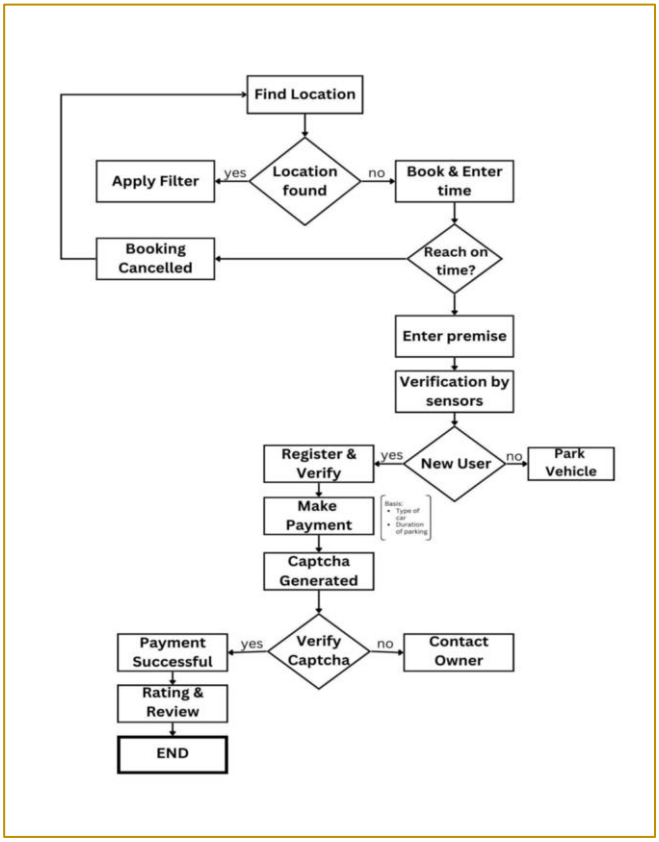

Fig.4. Vehicle owner's data flow diagram

- Bookings Table: This table records parking bookings, linking vehicle owners, their vehicles, and the selected parking area. It tracks booking details, including start and end times, costs, and status (booked, completed, or cancelled).
- Dynamic Space Management: Upon a confirmed booking, the system automatically updates the

available spaces in the Areas Table, ensuring that real-time data is reflected on the platform.

F. Review and Rating System

- The platform lets customers rank and write reviews about their parking experiences, which improves trust and safety. The quality of services for both car owners and local suppliers is enhanced by these comments.

IV. IMPLEMENTATION

We used an Arduino, an ESP8266, and a MQTT-based system to develop an Internet of Things solution that uses location coordinates to calculate the distance between two sites. Latitude and longitude (GPS coordinates) had to be obtained from two different sites for the setup to work. The distance between these coordinates was computed in the code using the Haversine formula [22]:

$$d = 2r \arcsin\left(\sqrt{\sin^2\left(\frac{\phi_2 - \phi_1}{2}\right) + \cos(\phi_1)\cos(\phi_2)\sin^2\left(\frac{\lambda_2 - \lambda_1}{2}\right)}\right) \quad (1)$$

ϕ1 and ϕ2 stand for the latitudes; Δϕ is the difference between the latitudes and Δλ is the difference between the longitudes. The symbol r signifies the Earth's radius or around 6371 km. We set up the Arduino to record GPS data, compute distance using the Haversine method, and display the result. The system was outfitted with an ESP8266 for wireless connectivity, enabling the instantaneous transmission of the calculated distance to an MQTT broker. This made it possible to track and monitor distances between two places remotely using the Internet of Things platform.

Algorithm:

```
// Java program for the haversine formula
public class HaversineFormula {
        static double haversine (double lat1,
double lon1, double lat2, double lon2) {
// distance between latitudes and longitudes
        double disLat = Math.toRadians(lat2 - lat1);
        double disLon = Math.toRadians(lon2 - lon1);
// convert to radians
        lat1 = Math.toRadians(lat1);
        lat2 = Math.toRadians(lat2);
// apply formulae
        double n = Math.pow(Math.sin(disLat / 2), 2) +
Math.pow(Math.sin(disLon / 2), 2) * Math.cos(lat1) *
Math.cos(lat2);
        double rad = 6371;
        double m = 2 * Math.asin(Math.sqrt(n));
        return rad * m;
    }
    // Driver Code
    public static void main(String[] args){
        double lat1 = 28.741023;
        double lon1 = 77.500771;
        double lat2 = 28.828984;
        double lon2 = 77.577019;
        System.out.println (haversine(lat1, lon1, lat2, lon2)
    + " K.M.");
    }
}
```

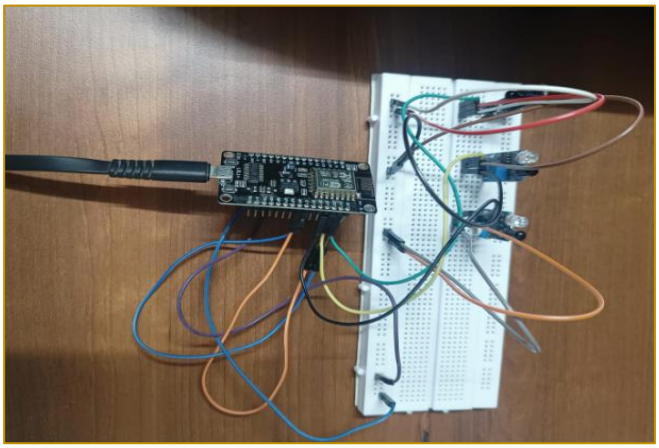

Fig.5. IoT implementation

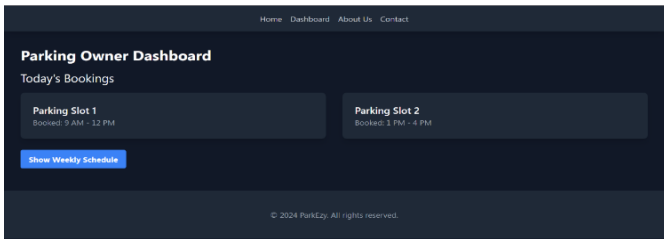

Fig.6. Available Parking slots showing on our website

Proof of the formula [26]:

$$\text{hav}(\theta) = \text{hav}(\Delta\varphi) + \cos(\varphi_1)\cos(\varphi_2)\,\text{hav}(\Delta\lambda) \quad (2)$$

by transforming the points given by their latitude and longitude into cartesian coordinates, then taking their dot product. Consider two points p1, p2 on the unit sphere, given by their latitude φ and longitude λ :

$$\mathbf{p_2} = (\lambda_2, \varphi_2)$$
$$\mathbf{p_1} = (\lambda_1, \varphi_1) \quad (3)$$

These representations are very similar to spherical coordinates; however, latitude is measured as angle from the equator and not the north pole. These points have the following representations in cartesian coordinates:

$$\mathbf{p_2} = (\cos(\lambda_2)\cos(\varphi_2),\ \sin(\lambda_2)\cos(\varphi_2),\ \sin(\varphi_2))$$
$$\mathbf{p_1} = (\cos(\lambda_1)\cos(\varphi_1),\ \sin(\lambda_1)\cos(\varphi_1),\ \sin(\varphi_1)) \quad (4)$$

From here we could directly attempt to calculate the dot product and proceed, however the formulas become significantly simpler when we consider the following fact: the distance between the two points will not change if we rotate the sphere along the z-axis. This will in effect add a constant to λ1, λ2. Note that similar considerations do not apply to transforming the latitudes - adding a constant to the latitudes may change the distance between the points. By choosing our constant to be -λ1, and setting λ`=λ, our new points become:

$$\mathbf{p}'_2 = (\cos(\lambda')\cos(\varphi_2),\ \sin(\lambda')\cos(\varphi_2),\ \sin(\varphi_2))$$
$$\mathbf{p}'_1 = (\cos(0)\cos(\varphi_1),\ \sin(0)\cos(\varphi_1),\ \sin(\varphi_1))$$
$$= (\cos(\varphi_1),\ 0,\ \sin(\varphi_1)) \quad (5)$$

With θ denoting the angle between p1 and p2, we now have that:

$$\cos(\theta) = \langle \mathbf{p}_1, \mathbf{p}_2 \rangle = \langle \mathbf{p}'_1, \mathbf{p}'_2 \rangle = \cos(\lambda')\cos(\varphi_1)\cos(\varphi_2) + \sin(\varphi_1)\sin(\varphi_2)$$
$$= \sin(\varphi_2)\sin(\varphi_1) + \cos(\varphi_2)\cos(\varphi_1) - \cos(\varphi_2)\cos(\varphi_1) + \cos(\lambda')\cos(\varphi_2)\cos(\varphi_1)$$
$$= \cos(\Delta\varphi) + \cos(\varphi_2)\cos(\varphi_1)(-1 + \cos(\lambda')) \Rightarrow$$
$$\operatorname{hav}(\theta) = \operatorname{hav}(\Delta\varphi) + \cos(\varphi_2)\cos(\varphi_1)\operatorname{hav}(\lambda') \quad (6)$$

This proof has been cited from Wikipedia [26] and used in this project.

Below are the tables with calculated distances:

Area	Latitude	Longitude
SRM NCR	28.741023	77.500771
Modinagar Temple	28.828984	77.577019
Meerut City Station	28.976200	77.703700
Ghaziabad Junction	28.669156	77.453758
Hindon Airport	28.665617	77.432001
India Gate, Delhi	28.612894	77.229446
Taj Mahal, Agra	27.175144	78.042142
Jaipur Railway Station	26.919650	75.787819

Table 4: Areas with Corresponding Latitude and Longitude

From	To	Distance (km)
SRM NCR	Modinagar Temple	12.6
SRM NCR	Meerut City Station	35.0
Ghaziabad Junction	Hindon Airport	3.0
India Gate, Delhi	Taj Mahal, Agra	194.2
Taj Mahal, Agra	Jaipur Railway Station	233.7

Table 5: Calculated distances for parking using the Haversine formula

A. Technology used

- **Hardware:** consists of IoT sensors, placed in parking slots to identify availability status and provide data in real-time using Wi-Fi networks to a central server. Then it transmits data to a cloud like AWS. Gateway devices are also needed for connecting different modules. Additionally, networking hardware such as modems and routers are needed for connectivity. To engage with platform and parking slots, users must have smartphones or computers with proper internet connectivity.

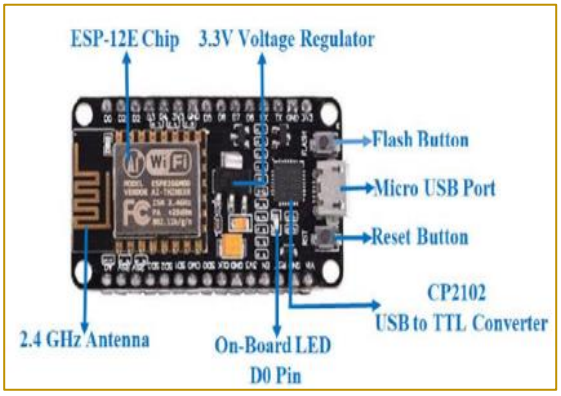

Fig.7. Node MCU ESP8266 development board [6]

Fig.8. Arduino UNO board [6]

- **Software:** comprises of web-based platform with Django for backend and React framework for frontend. IoT sensor is needed for real-time data processing, which is controllable using MQTT protocols. AWS is needed for hosting, storage and scaling of the system. Bookings, parking slot availability and user data are managed using PostgreSQL and MySQL. SSL encryption provides secure transactions and data integrity.

B. Future Scope:

- **Scalability and Expansion**: The platform's potential to reach entire cities, regions, and even nations is highly encouraging. As smart city technology becomes more widely used, it will be able to expand

to new metropolitan regions and solve parking issues in urban areas across the globe.

- **Integration with Public Transport Systems**: To allow for integration with public transport systems, the platform might be expanded. This would allow users to find parking near bus stops, train stations, and metro hubs. This will lead to a decline in the use of private vehicles for urban commuting and an increase in the use of public transportation.
- **Data-Driven Insights**: It has the potential to develop into a platform that offers city planners and local governments insightful information on urban mobility thanks to its access to vast amounts of real-time data. This information could improve the design of the next infrastructure projects, ease traffic, and reduce congestion.
- **Partnerships with Commercial Establishments**: The number of parking spaces might be further increased by extending the platform's scope to include partnerships with commercial entities (such as shopping centres, hotels, and office buildings). This would provide consumers with more alternatives while assisting companies in making additional cash.
- **Sustainability and Green Initiatives**: It can be integrated with programs which are sustainable to support eco-friendly parking solutions such as designating spaces for electric cars (EVs) with charging stations and promoting carpooling. This also aligns with global goals aimed at reducing traffic while providing more sustainable urban ecosystems.

V. Conclusion

Urban mobility and traffic management are facing major issues due to the limited amount of land available and the growing demand for parking places in urban areas. This study has investigated a novel approach using a platform that maximizes unused parking spots. Bring open spaces and other private areas under one roof to create a scalable and sustainable alternative to parking infrastructure development. Our method exploits space efficiency by employing Internet of Things technology to provide real-time information on parking availability while reducing air pollution and traffic congestion caused by parking lot sailing. Because the platform's rating and review system ensures security in every transaction, trust is developed between owners of parking spaces and drivers of automobiles. Real estate owners have other direct financial opportunities. The goals of initiatives for smart cities and sustainable development encourage efficient use of existing resources rather than advocating for a large quantity of new buildings. By reducing traffic, the study suggests that managing vacant and unused spaces may be a long-term solution to parking problems and this will benefit both area owners and vehicle owners.

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