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.

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.

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.

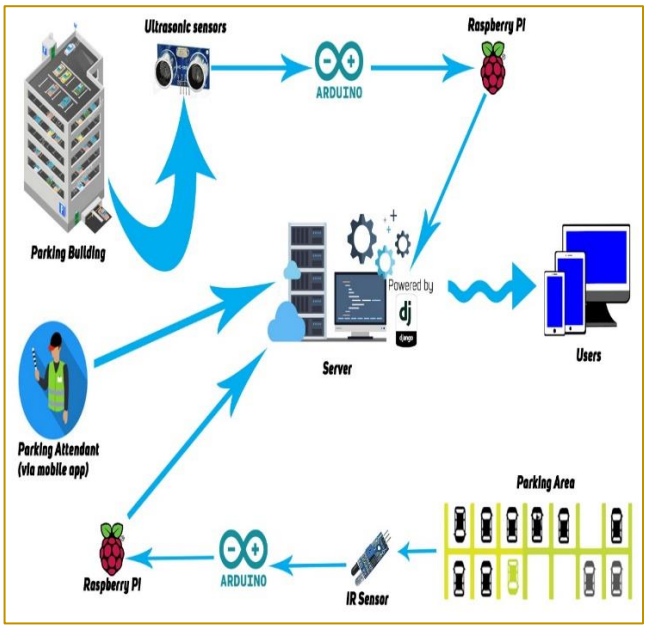

Fig.1. IoT-based smart parking system [21]

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.

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.

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.

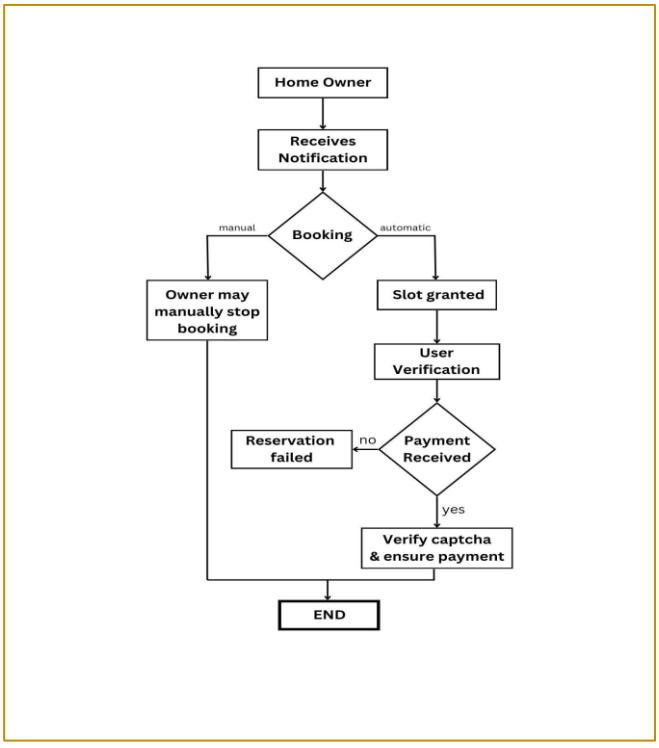

Fig.2. Area owner’s data flow diagram

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.

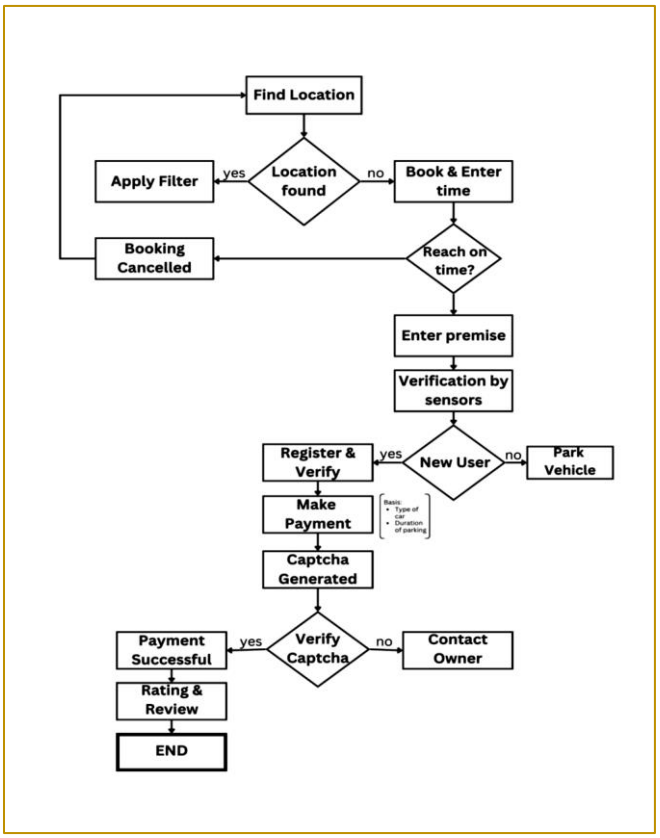

Fig.3. Vehicle owner's data flow diagram

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.
- 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]:

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

$\phi 1$ and $\phi 2$ stand for the latitudes; $\Delta\phi$ is the difference between the latitudes and $\Delta\lambda$ 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.

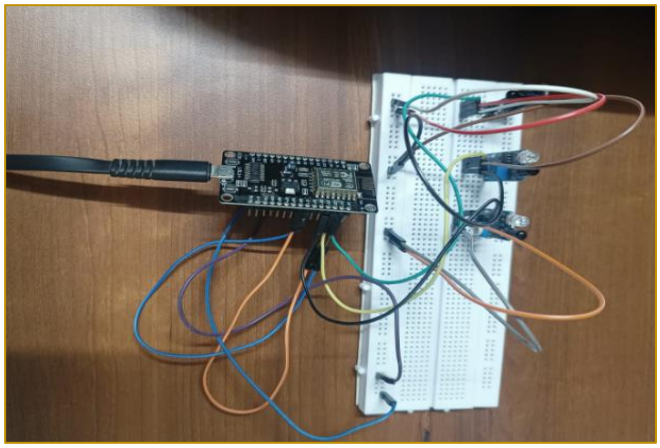

Fig.4. Sensors implementation

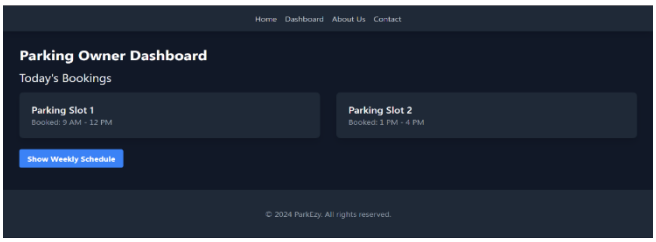

Fig.5. Available Parking slots showing on our website

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.
- **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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