

# IoT and Cloud based Parking Allotment System

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## ABSTRACT

Efficient parking management remains a critical challenge in urban environments, contributing to traffic congestion, excessive fuel consumption, and environmental degradation. Conventional parking systems are limited by the absence of real-time tracking, often leading to underutilized spaces and increased road traffic. This paper introduces ParkEz, a novel IoT and cloud-based parking allotment system that leverages ultrasonic sensors and cloud infrastructure to deliver live parking availability updates and automate slot reservations. The system detects vehicle presence using IoT-enabled ultrasonic sensors and reflects slot status on a user-friendly web platform. Data is centrally stored and managed using MongoDB Atlas, enabling robust synchronization, remote access, and scalable deployment. Cloud integration also supports enhanced data security and sets the foundation for future predictive analytics capabilities. The system's performance is assessed through metrics of detection accuracy and operational efficiency in dynamic parking scenarios. Results confirm ParkEz's ability to reduce waiting times, maximize space utilization, and improve overall user satisfaction. The proposed solution represents a scalable, intelligent framework suitable for smart city applications, contributing to improved urban mobility and environmental sustainability. This work adds to the expanding body of research on IoT-driven smart parking and showcases the transformative potential of cloud-integrated systems in modern urban infrastructure.

## Keywords

Automated Parking System, Cloud Computing, IoT, MongoDB Atlas, Parking Slot Detection, Real-time Parking, Smart City, Smart Parking, Ultrasonic Sensors.

## 1. INTRODUCTION

As urban populations continue to grow and vehicle density increases, cities around the world are facing growing pressure to modernize their traffic and parking systems. Among the many challenges, the efficient management of parking infrastructure stands out as a persistent concern. In congested metropolitan regions, the shortage of readily available parking often leads drivers to circulate through streets in search of vacant spaces, resulting in unnecessary traffic buildup, greater fuel consumption, and elevated emissions. Estimates suggest

that this activity contributes to as much as 30% of urban traffic congestion [1][4].

Traditional parking mechanisms, which typically involve manual oversight or static allocation of parking slots, have proven inadequate for today's dynamic urban environments. These conventional approaches often fail to provide live occupancy status or reservation capabilities, which can lead to inefficient space usage, longer idle times, and unauthorized parking [3][6]. Moreover, their rigid infrastructure lacks adaptability, making it difficult to scale or upgrade to meet evolving smart city requirements.

Recent technological advancements have opened new avenues for intelligent mobility solutions. The integration of the Internet of Things (IoT) with cloud-based platforms has introduced a powerful framework for building adaptive, real-time systems. IoT enables seamless connectivity between physical sensors, computing devices, and digital interfaces, allowing continuous monitoring and communication of on-ground conditions [2][3]. Simultaneously, cloud services support centralized data storage, cross-platform accessibility, and scalable system management, making them ideal for city-wide applications [9][10][11].

Various smart parking implementations have emerged to address these issues. For instance, Pham et al. [1] developed a system utilizing ultrasonic sensors and cloud connectivity to track and update slot availability in real time. In another approach, Kotb et al. [4] introduced dynamic pricing mechanisms to improve slot distribution and increase system efficiency. Other recent innovations have incorporated fog computing [9], reinforcement learning algorithms for vehicle maneuvering [5], and blockchain-based identity verification for secure parking access [14].

Despite these advances, many current systems suffer from practical limitations such as high deployment costs, technical complexity, or dependence on smartphone applications—factors that hinder widespread adoption in varied socioeconomic and infrastructural contexts.

To bridge these gaps, this study presents ParkEz—an end-to-end smart parking solution that leverages IoT and cloud computing to enable real-time monitoring, intelligent slot allocation, and automated user interaction. The system employs ultrasonic sensors at individual parking spots for

vehicle

detection, while a Raspberry Pi microcontroller handles local processing and communication. Collected data is synchronized via MongoDB Atlas, enabling users to access live slot availability and make reservations through a responsive web portal. Additionally, a SIMCom-enabled payment module is incorporated to ensure accessibility even in areas with limited internet coverage or low smartphone penetration.

The primary goals of this research are: (1) to design and build a functional prototype that can operate in real-world conditions; (2) to analyze its performance in terms of detection accuracy, system responsiveness, and user interaction; and (3) to evaluate its scalability and potential for integration into broader smart mobility frameworks. Experimental findings indicate that ParkEz effectively minimizes search time, improves parking utilization, and enhances the overall experience for users.

## **2. LITERATURE REVIEW**

Recent research has increasingly focused on leveraging IoT, cloud computing, and intelligent algorithms to create more efficient and scalable smart parking systems. Pham et al. [1] introduced a cloud-integrated framework that employs IoT sensors for monitoring slot occupancy and automating allocation. Their system, which features real-time vehicle detection along with a user-friendly web interface, demonstrates how cloud platforms can improve both accessibility and scalability in parking services. Building on this work, the same research group later incorporated fog computing into their design [2], underscoring the benefits of reduced latency and more responsive real-time decision-making for slot assignment. The role of IoT in enhancing urban mobility is further underscored by Alam et al. [3], whose comprehensive survey highlights how IoT-based parking models contribute to real-time tracking, congestion reduction, and overall traffic flow improvement. In a related study, Kotb et al. [4] developed iParker—a system that applies dynamic pricing and adaptive resource allocation—to illustrate the impact of demand-based pricing on space utilization and system profitability. Advancements in artificial intelligence have also enriched the development of automated parking solutions. Zhang et al. [5] employed reinforcement learning algorithms to create an effective motion planning strategy that minimizes manual control, while Ma et al. [6] utilized machine vision for recognizing parking situations, thereby facilitating autonomous vehicle guidance and reducing congestion through visual processing. Connectivity frameworks and communication protocols are equally crucial for modern parking systems. Pous et al. [7] explored the application of LoRaWAN in urban environments and showed that its long-range and low-power characteristics make it a promising option for scalable, city-wide deployments. In contrast, security challenges within parking infrastructure were addressed by Rajyalakshmi et al. [8], who demonstrated an IoT-enabled facial recognition system designed to restrict unauthorized access and enhance vehicle identification. Recent studies have also highlighted the importance of decentralizing data processing. Research by Tang et al. [9] and Awaisi et al. [10] emphasizes that edge or fog computing can alleviate the burden on centralized cloud platforms by reducing latency and optimizing bandwidth usage. Expanding on this concept,

Celaya-Echarri et al. [11] proposed a decentralized fog-based architecture to sustain robust performance in distributed smart parking environments. Optimization techniques remain a key area of focus. Wang et al. [12] applied an enhanced ant colony algorithm to optimize vehicle path planning within parking facilities, thereby improving traffic flow during entry and exit operations. Moreover, Canli et al. [13] showcased how deep learning can be leveraged in a mobile application to provide predictive analytics and real-time parking updates, ultimately enhancing user experience. Security and data integrity have received considerable attention as well. Turki et al. [14] devised a secure framework using blockchain technology and Physical Unclonable Functions (PUFs) to ensure robust user authentication and prevent fraud. In addition, Lin et al. [15] extended the discussion by examining the broader application of IoT in smart tourism, illustrating the versatile potential of such technologies in various service-oriented domains. In summary, the diverse approaches detailed in these studies not only demonstrate the evolving nature of smart parking solutions but also reveal the pressing need for integrated, cost-effective, and accessible systems. This analysis provides a strong foundation and clear motivation for the development of our proposed ParkEz framework.

## **3. METHODOLOGY**

The methodology behind ParkEz involves the integration of IoT-based hardware components, cloud infrastructure, and a web-based user interface to develop a functional smart parking solution. The system is designed to address real-time vehicle detection, automated gate control, online slot reservation, and seamless payment handling.

The core of the system is powered by a Raspberry Pi 3 Model B+, which processes inputs from multiple sensors and actuators installed throughout the parking structure. Ultrasonic sensors placed in individual parking slots detect vehicle presence or absence, while infrared (IR) sensors located at the entry and exit points monitor the arrival and departure of vehicles. These inputs are processed by the Raspberry Pi to update parking slot status.

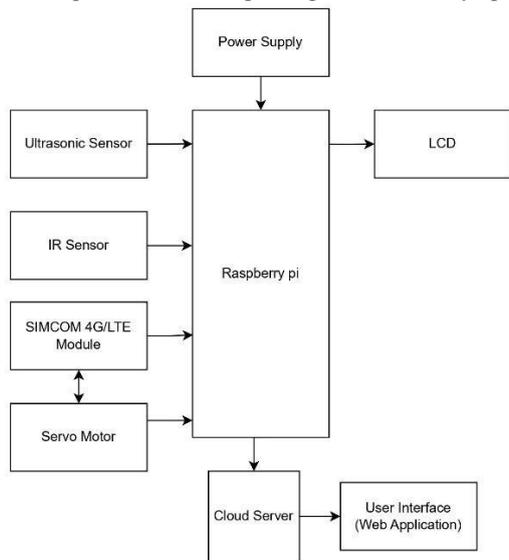
To provide users with real-time access to parking information, the system synchronizes data with MongoDB Atlas, a cloud-hosted NoSQL database. This ensures scalability and allows the system to be monitored or accessed remotely through a web interface. The website allows users to view slot availability, book reservations in advance, and confirm entry. A GSM module is incorporated into the system for SMS-based payment and communication, especially in regions with limited internet access.

The development process involved hardware integration, cloud synchronization setup, server-side and client-side programming, and extensive testing in a prototype environment. The entire system workflow is explained with the help of a block diagram, a logical flowchart, a list of components, and a detailed step-by-step description of the system's operation.

### **3.1 Block Diagram**

The block diagram of the IoT and Cloud-based Parking Allotment System (ParkEz) represents the system's architecture, highlighting its core components and their interactions. The system primarily consists of input sensors, a

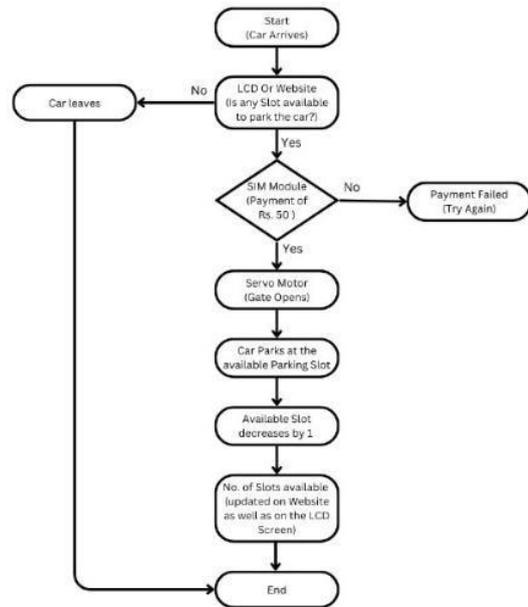
control unit (Raspberry Pi & Cloud Server), and output devices to provide real-time parking slot availability updates.



**Fig 1: Block Diagram of IoT & Cloud based Parking Allotment System (ParkEz)**

The smart parking system operates using a reliable power supply that energizes all connected components, including the Raspberry Pi, sensors, GSM module, LCD, and servo motors. The input section consists of various sensors and modules that collaboratively detect vehicle presence and manage parking operations—ultrasonic sensors identify vehicle presence in individual slots, IR sensors track vehicle entry and exit at the gate, and a SIM module handles communication for payment verification. Upon successful vehicle detection and payment confirmation, a servo motor controls the gate's opening and closing. Acting as the control unit, the Raspberry Pi processes sensor data and updates parking slot availability in real-time while communicating with a cloud server integrated with MongoDB Atlas for efficient data storage and retrieval. Output components include an LCD display that shows live slot availability within the lot, and a user-friendly web application that provides remote access to parking availability, booking status, and reservation options for enhanced user convenience.

### 3.2 Flowchart



**Fig 2: Flowchart of IoT & Cloud based Parking Allotment System (ParkEz)**

The flowchart in Figure 2 illustrates the sequence of operations involved in the ParkEz smart parking system. The process initiates when a car arrives at the entry gate. The system first checks for slot availability using data from ultrasonic sensors and displays the result on both the LCD screen and the web interface. If no slots are available, the system halts the process and prevents the car from entering. If a slot is available, the user is prompted to make a minimum payment of ₹50 via the GSM-based payment module. Upon successful payment, the servo motor is triggered to open the entry gate, allowing the vehicle to proceed. The car is then guided to an available slot, where the occupancy is detected by an ultrasonic sensor. Once parked, the system decrements the count of available slots and updates the real-time status on both the LCD screen and the website. Upon exiting, the car's departure is detected by IR sensors, and the system resets the slot status and closes the exit gate.

This flowchart highlights the system's emphasis on automation, real-time data synchronization, and user interaction minimization.

### 3.3 Component Information (Hardware & Software Used)

The ParkEz smart parking solution is a blend of integrated hardware and software components, each contributing to efficient automation, access control, user communication, and real-time monitoring. Here's a detailed overview of the components involved and their respective functions:

Raspberry Pi 3 Model B+ acts as the primary control unit, orchestrating sensor input, processing data, and managing system operations.

Ultrasonic Sensors (HC-SR04) are installed in individual parking spots to detect the presence or absence of vehicles.

IR Sensors are positioned at both the entrance and exit points to monitor vehicle movement and validate access events.

SG90 Servo Motors automate gate operations, enabling

them to open or close based on verified vehicle entries or exits.

LCD Display provides live updates on parking slot availability, helping drivers quickly identify vacant spots.

SIM Module (A7670C) is used for handling mobile payment processing and sending SMS confirmations once a transaction is completed.

Power Supply Unit ensures a consistent and reliable voltage supply to the Raspberry Pi and all other connected components.

Raspberry Pi OS, a Linux-based operating system, serves as the software backbone, running scripts that control the system's functionality.

Python is the core programming language used to interface with hardware devices and manage real-time operations effectively.

React.js powers the web application, allowing users to view parking slot availability and make online reservations.

MongoDB Atlas, a cloud-based database, stores dynamic parking data and records of completed transactions for efficient backend management.

### 3.4 Working of the System

#### 3.4.1 Car Arrives at Entry Gate (Step 1):

The IR sensor at the gate detects a vehicle. The Raspberry Pi checks slot availability by querying MongoDB. If slots are available, the system allows entry.

#### 3.4.2 Payment & Gate Control (Step 2):

If the system requires payment, the user makes a transaction via A7670C SIMCom. After successful payment, the Raspberry Pi activates the servo motor, opening the gate.

#### 3.4.3 Parking Slot Detection (Step 3):

Ultrasonic sensors continuously check for vehicle presence in slots. Data is updated in MongoDB, and the website displays the new parking status.

#### 3.4.4 Car Leaves the Slot (Step 4):

When a car exits a slot, the ultrasonic sensor detects it. The database updates the available slots on the website.

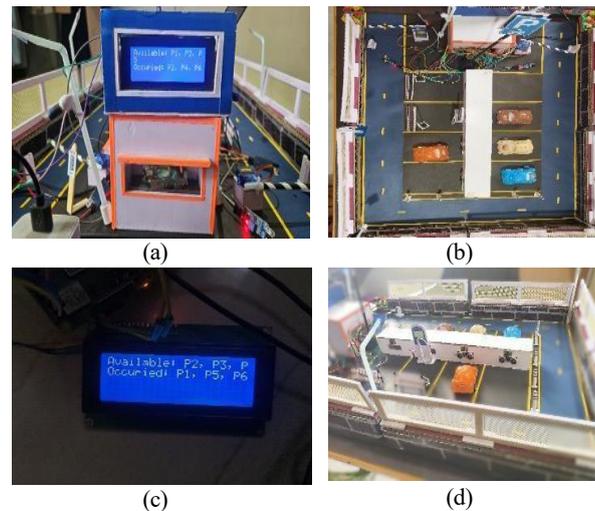
#### 3.4.5 Car Exits the Parking Lot (Step 5):

IR sensors at the exit detect the car. The Raspberry Pi triggers the servo motor to open the exit gate. The system logs the exit time and updates availability.

## 4. RESULTS

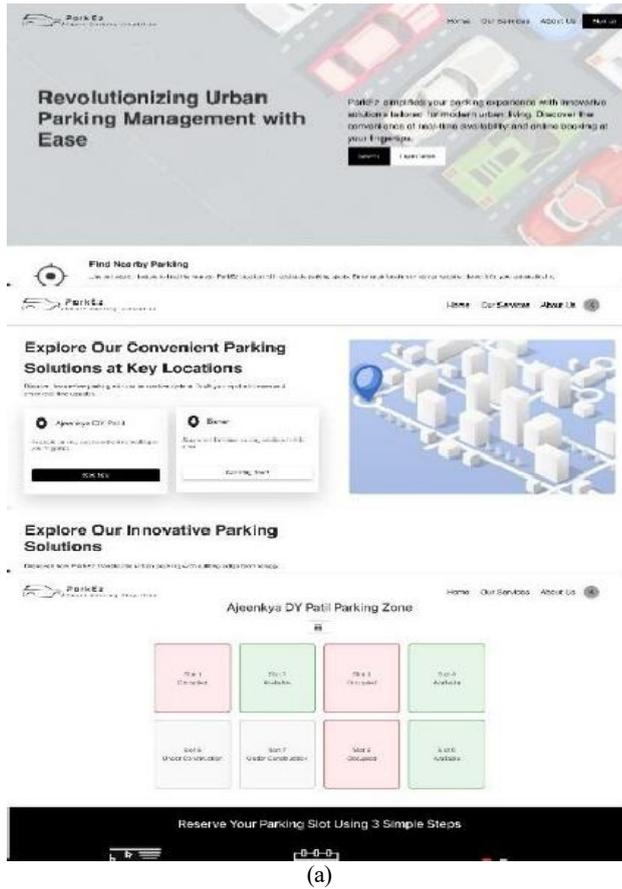
This section presents the practical implementation and testing outcomes of the ParkEz smart parking system. The prototype was deployed and evaluated under real-time conditions to assess its functionality, responsiveness, and reliability. The system successfully demonstrated real-time slot detection, automated gate control, cloud synchronization, and user interaction via the web interface and GSM module.

Figures 3 (a), (b), (c), and (d) showcase various views and working stages of the implemented ParkEz Parking System prototype.

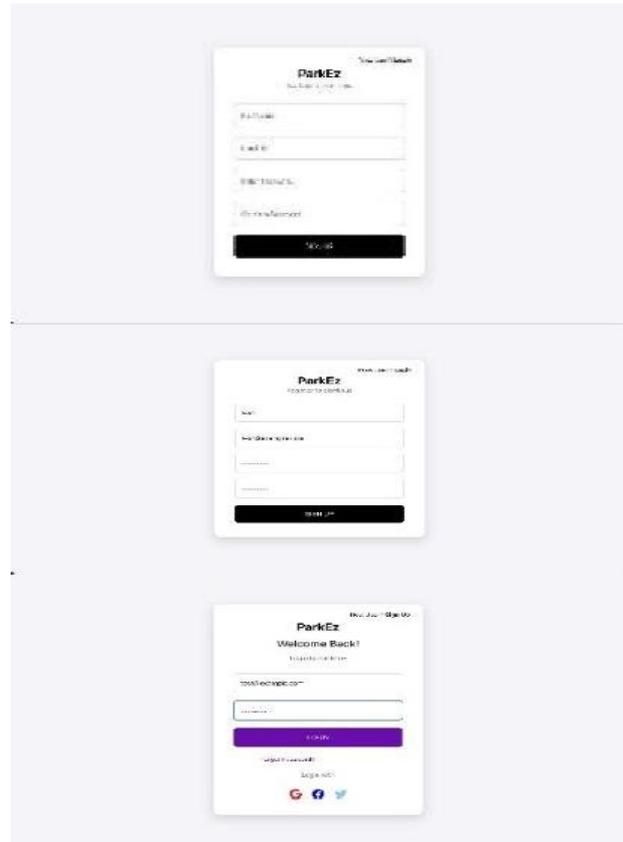


**Fig 3: (a) Front view of ParkEz Parking System (b) Top view of ParkEz Parking System (c) Displaying of Slot availability on LCD Screen (d) Side view of ParkEz Parking System**

Figures 4 (a) and (b) display the front-end interface of the ParkEz web application. Figure 4(a) shows the homepage and booking interface where users can view slot availability and reserve parking spaces. Figure 4(b) highlights the login and signup functionality that allows users to create an account or securely access the system.



(a)

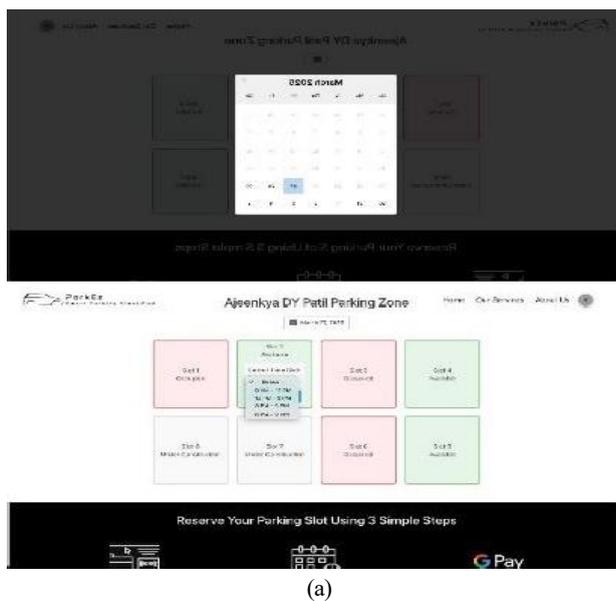


(b)

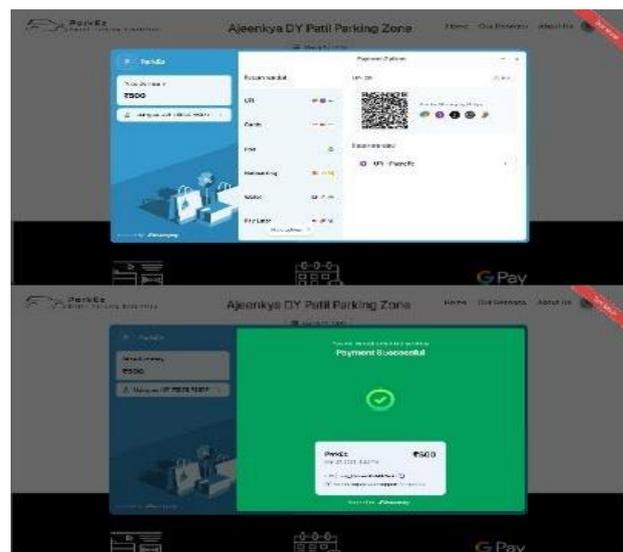
Fig 4: (a) ParkEz Website – Home and Bookings Page (b) ParkEz Website – Signup and Login Interface

Figures 5 (a) and (b) highlight the user interaction and payment flow of the ParkEz system. Figure 5(a) demonstrates

the step-by-step process of booking a parking slot through the web interface. Figure 5(b) shows a test payment transaction executed via the integrated Razorpay payment gateway, ensuring smooth and secure online transactions.



(a)



(b)

Fig. 5: (a) Slot Booking Process on the ParkEz Website (b) Test Payment Integration Using Razorpay Gateway

## 5. FUTURE SCOPE

While ParkEz effectively automates parking management, several enhancements can be explored to improve efficiency and user experience. One major advancement is the integration of AI for parking prediction, where machine learning algorithms can analyze historical data to predict peak parking demand and suggest optimal parking locations. This would help drivers plan their parking in advance and reduce congestion during busy hours.

Another key improvement is mobile application development, enabling users to book parking spaces in real-time through a dedicated Android/iOS app. This app could provide push notifications for slot availability updates, allowing users to make informed decisions without needing to visit the parking lot physically.

To further streamline parking access, a License Plate Recognition (LPR) system can be integrated using computer vision. This would allow automatic vehicle identification upon entry and exit, eliminating the need for manual ticketing or RFID-based access systems, thus improving security and reducing waiting time at parking gates.

Additionally, a cloud-based parking analytics dashboard can be introduced to assist parking management authorities in monitoring occupancy trends, revenue generation, and peak hour analysis. By leveraging cloud computing, real-time data insights can be gathered to enhance operational efficiency and decision-making.

For a broader impact, integration with smart traffic systems can be explored to optimize city-wide vehicle movement. By linking ParkEz with urban traffic management systems, real-time data can guide drivers to nearest available parking slots, reducing congestion and improving urban mobility.

Finally, multi-location expansion can be implemented to adapt ParkEz across multiple urban parking zones. A centralized database would enable cross-location reservations, allowing users to book parking spaces in different areas seamlessly. This would provide a scalable, interconnected parking solution suitable for smart cities and large metropolitan areas. By implementing these enhancements, ParkEz can further revolutionize urban parking management, making it more efficient, intelligent, and user-friendly.

## 6. CONCLUSION

ParkEz, powered by IoT and cloud technology, provides a highly intelligent, automatic solution to metropolitan parking problems. Utilizing technology components like IR and ultrasonic sensors, Raspberry Pi, and MongoDB Atlas, it provides end-to-end continuous, real-time monitoring of available parking slots in addition to user-friendly web management for easy user access and booking of slots. Automated control of entry, exit, and payment minimizes the necessity of manual oversight, serving to ease congestion, reduce fuel usage, and lower environmental pressures. The results of the implementation show ParkEz as an efficient and flexible solution for today's urban landscape, making it a welcome addition for smart city projects. This research contributes to the current body of knowledge in IoT-based parking systems and shows how cloud-enabled platforms can redefine urban infrastructure to enhance efficiency, mobility, and sustainability.

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