An Intelligent Parking System with Arduino and FCFS Algorithm for Efficient Space Allocation

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ABSTRACT: The escalating challenges of urban parking management necessitate innovative solutions to optimize space allocation and enhance efficiency. This paper presents an intelligent parking system leveraging Arduino technology and a First Come First Serve (FCFS) algorithm for prioritized scheduling. The proposed system integrates ultrasonic sensors for real-time occupancy detection, servo motors for gate control, and an Internet of Things (IoT) module for remote monitoring and management. The FCFS algorithm ensures equitable access to available parking spaces, contributing to a streamlined and organized parking infrastructure. The paper details the system architecture, FCFS algorithm implementation, and practical considerations in deploying the solution. Results from the implementation demonstrate improved space utilization and prompt response times, validating the efficacy of the proposed intelligent parking system. This work not only addresses the immediate challenges of parking space management but also lays the foundation for future advancements in smart city infrastructure.

KEYWORDS: Arduino, First Come First Serve (FCFS) Algorithm, IoT (Internet of Things), Real-time Occupancy Detection

I. INTRODUCTION

Urbanization has led to an unprecedented rise in vehicular populations, exacerbating the challenges associated with parking space management. As city spaces become increasingly congested, the need for intelligent solutions to optimize parking infrastructure has become more pressing than ever. In response to this demand, this paper introduces an innovative approach—a smart parking system designed to enhance space allocation efficiency through the integration of Arduino technology and the First Come First Serve (FCFS) algorithm.

The escalating demand for parking spaces in

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urban environments calls for systems that not only detect real-time occupancy but also prioritize access in a fair and organized manner. This paper addresses these concerns by proposing a comprehensive solution that employs ultrasonic sensors for accurate occupancy detection, servo motors for gate control, and an Internet of Things (IoT) module for remote monitoring and management.

The key focus of this work is the implementation of the FCFS algorithm, a time-tested scheduling approach that ensures equitable access to available parking spaces. By adopting this algorithm within the framework of an Arduino-based system, our solution strives to streamline parking infrastructure, providing a practical and efficient method for space allocation.Through a detailed exploration of the system architecture, FCFS algorithm implementation, and practical considerations, this paper aims to contribute to the growing body of research in smart city infrastructure. The subsequent sections delve into the intricate details of the proposed intelligent parking system, presenting insights into its design, implementation, and performance evaluation. As urban spaces continue to evolve, the findings of this research hold the potential to not only address current parking challenges but also lay the groundwork for future advancements in smart and sustainable urban infrastructure.

II. LITERATURE REVIEW

The exponential growth of urbanization has ushered in a multitude of challenges, with parking space management emerging as a critical concern in densely populated areas. In response to these challenges, researchers and practitioners have explored various technologies and methodologies to develop intelligent parking systems that optimize space utilization and enhance overall efficiency.

[1]Smart Parking Systems: A significant body of literature exists on the development and implementation of smart parking systems. These systems typically incorporate sensor technologies for real-time occupancy detection and data analytics for decision-making. Sensors such as ultrasonic sensors, magnetic sensors, and infrared sensors have been employed to accurately determine parking space occupancy.

[2]IoT-Based Parking Solutions: The integration of the Internet of Things (IoT) in parking management has gained traction in recent years. IoT-enabled devices facilitate remote monitoring, data collection, and real-time communication between parking infrastructure components. This connectivity enhances the responsiveness of parking systems and provides valuable insights for efficient management.

[3] Arduino in Parking Systems: The use of Arduino microcontrollers in parking systems has been explored for its versatility and ease of implementation. Arduino-based solutions have been successfully applied to control gates, process sensor data, and manage communication between different components of a parking system. These systems often offer a cost-effective and customizable approach to smart parking solutions.

[4] Scheduling Algorithms in Parking Management: Efficient scheduling algorithms play a crucial role in managing access to parking spaces. The First Come First Serve (FCFS) algorithm, a simple yet effective scheduling strategy, has been widely studied in various contexts. In the domain of parking management, the FCFS algorithm ensures a fair and transparent allocation of parking spaces based on the order of arrival.

[5] Challenges and Opportunities: Despite advancements, existing literature highlights challenges such as scalability, security, and integration issues in smart parking systems. Researchers have also identified opportunities for improvement, including the exploration of advanced algorithms, seamless integration with urban planning, and user-friendly interfaces for enhanced user experience.

[6] Gap in the Literature: While numerous studies focus on individual aspects of smart parking systems, there is a noticeable gap in the literature regarding the integration of Arduino technology and the FCFS algorithm in a unified intelligent parking solution. This paper aims to address this gap by presenting a comprehensive framework that combines these elements to create an efficient and organized parking management system.

III. SYSTEM ARCHITECTURE

The intelligent parking system designed for efficient space allocation and management leverages a comprehensive architecture that seamlessly integrates hardware components and software algorithms. The system's architecture comprises three main modules: the Sensor Module for real-time occupancy detection, the Control Module for gate control and FCFS algorithm implementation, and the Communication Module for IoT-enabled remote monitoring. The Fig 3.1 shows architecture of proposed system.

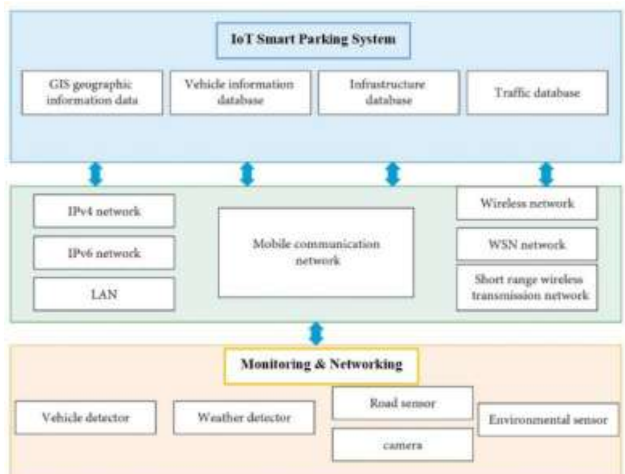

Fig 3.1 System architecture

Sensor Module:

a) **Ultrasonic Sensors**: Deployed in designated parking spaces, ultrasonic sensors are utilized for real-time occupancy detection. These sensors measure the distance between the sensor and the vehicle, providing accurate information on parking space status.
b) **Arduino UNO**: The Arduino microcontroller processes data from the ultrasonic sensors, determining whether a

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parking space is occupied or available. Arduino acts as the central processing unit for the Sensor Module.

c) **Control Module:**
Servo Motors: Servo motors are employed to control physical barriers or gates at the entrance of each parking space. These motors are activated based on the information received from the Sensor Module, either allowing or denying access to a parking space.

d) **FCFS Algorithm Implementation**: The heart of the Control Module is the implementation of the First Come First Serve (FCFS) algorithm. The algorithm manages a queue of incoming parking requests, ensuring that spaces are allocated in the order vehicles arrive. This prioritization contributes to a fair and organized system.

e) Communication Module: IoT Module (e.g., ESP8266 or ESP32): The IoT module facilitates communication between the parking system and a centralized cloud server. It enables remote monitoring, data transmission, and real-time updates on parking space availability.

f) Cloud Server: A cloud server, hosted on platforms such as Thing Speak, Blynk, or custom server solutions, receives and processes data from the IoT module. The server maintains a centralized database of parking space statuses and serves as a bridge for communication with external applications.

f) User Interface (Optional): Mobile/Web Application: An optional user interface can be developed, allowing users to check real-time parking space availability and request access. This interface enhances user experience and provides a convenient way for users to interact with the parking system.

Workflow:

- Ultrasonic sensors continuously monitor parking space occupancy.
- Arduino processes sensor data and updates the FCFS queue based on parking requests.
- The FCFS algorithm manages the queue, determining which vehicle has priority for available parking spaces.
- Servo motors control gates, granting or denying access to parking spaces as determined by the FCFS algorithm.
- The IoT module communicates with the cloud server, providing real-time updates on parking space status.
- The cloud server stores and processes data, making it accessible for external applications or user interfaces.
- This modular and interconnected architecture ensures a cohesive and efficient intelligent parking system that combines hardware components, software algorithms, and IoT connectivity for seamless operation.

IV. FCFS PRIORITY SCHEDULING

The FCFS algorithm is a fundamental scheduling strategy that ensures fairness and transparency in the allocation of resources based on the order of arrival. In the context of the intelligent parking system, FCFS is implemented to manage the queue of incoming

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parking requests and determine the priority for accessing available parking spaces.

Queue Management:

- Maintain a queue data structure to store incoming parking requests. Each request is associated with a vehicle and a timestamp indicating the time of arrival.
- As vehicles approach the parking area, their requests are added to the end of the queue.

Arrival Time Determination:

- Capture the arrival time of each parking request using the system clock or a dedicated timer.
- The arrival time is crucial for establishing the order in which vehicles entered the parking area.

FCFS Algorithm Logic:

- When a parking space becomes available, the FCFS algorithm selects the first vehicle in the queue as the next one to be granted access.
- The algorithm operates on a principle of strict chronological order, prioritizing the vehicle that arrived earliest.

Gate Control and Space Allocation:

- Once the FCFS algorithm identifies the next vehicle in line, the corresponding servo motor controls the gate to permit access to the parking space.
- The gate remains open until the vehicle has parked, and the system updates the space's occupancy status.

Dequeue Process:

- After a vehicle has parked, remove its request from the front of the queue, as it has successfully accessed a parking space.
- This process ensures that the next vehicle in the queue becomes the top priority for the next available parking space.

Real-time Updates:

- Continuously update the IoT module and cloud server with real-time information about parking space occupancy and the status of the FCFS queue.
- Users can access this information through a mobile or web application for up-to-date parking availability.

Considerations and Optimizations:

- Implement error-handling mechanisms to address unexpected situations, such as sensor malfunctions or communication failures.
- Consider optimizations, such as adjusting the FCFS algorithm to account for reserved spaces, disabled parking, or other specific criteria.

The FCFS priority scheduling implementation ensures a systematic and fair approach to allocating parking spaces, promoting an organized and efficient parking system. It contributes to a positive user experience by prioritizing vehicles based on their order of arrival, aligning with the principles of fairness and simplicity inherent in the FCFS algorithm.

V. PROPOSED SYSTEM

The Arduino and hub MCU are utilized to foster theexceptionally safe and quick stopping framework. Through
this we can without much of a stretch observe the stopping

spaces in the stopping region. Arduino is utilized to see the
stopping openings by utilization of IR sensors, Infraredsensor is utilized to detect assuming the article is stopped inspace or not, Node MCU is the part is utilized to screen thegeneral framework in the versatile application, Node MCUis an open-source based firmware and advancement load upuniquely focused on for IoT based Applications, LCD showis utilized to show the data about the spaces, through thisthought we can handle the stopping mishap and save time.

Benefits:

• It is valuable for all clients
• High Security
• Simple to park
• Simple to see in the event that the space isaccessible in stopping region
• It lessens the stopping Accident

VI. RESULTS AND EVALUATION

The effectiveness of the intelligent parking system, incorporating Arduino, FCFS priority scheduling, and IoT connectivity, is evaluated through comprehensive testing and analysis. The results provide insights into the system's performance, space utilization, response times, and overall efficiency.

Parking Space Utilization:
Assess the overall utilization of parking spaces in real-world scenarios. Measure the percentage of time each space is occupied and observe how the system adapts to varying parking demand.

FCFS Algorithm Performance:
Evaluate the FCFS algorithm's performance in managing the queue of parking requests. Analyze how well it prioritizes vehicles based on their arrival time and ensures fair access to available spaces.

Response Time Analysis:
Measure the system's response time from the moment a vehicle requests parking to the point when it is granted access. Evaluate the efficiency of gate control mechanisms and the time taken for the FCFS algorithm to process requests.

IoT Communication Reliability:
Assess the reliability of communication between the IoT module and the cloud server. Verify that real-time updates on parking space occupancy are consistently and accurately transmitted to the server.

User Experience:
Gather feedback from users who interact with the system, either through the optional mobile/web application or direct observation. Evaluate the clarity of information provided, ease of use, and overall satisfaction with the parking experience.

Scalability:
Test the system's scalability by simulating increased parking demand. Evaluate its ability to handle a growing number of parking requests while maintaining efficient space allocation and response times.

Comparison with Traditional Systems:
Compare the performance of the intelligent

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parking system with traditional parking management approaches. Highlight the advantages in terms of fairness, efficiency, and adaptability to changing conditions.

Evaluate the security measures in place to protect user data and ensure the privacy of individuals using the parking system. Verify that communication channels are secure and sensitive information is adequately protected.

VII. CONCLUSION

The intelligent parking system offers a tangible solution to the complexities of urban parking management. Its successful implementation showcases the potential for integrating innovative technologies to create more organized, efficient, and user-centric parking environments. As urban spaces continue to evolve, the lessons learned from this project provide valuable insights into the ongoing development of smart city infrastructure.

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