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Method And Advantages Of Integrating Parking Infrastructure With The "Oson Parking Bot System"

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Abstract:

This article discusses ways to improve the efficiency of parking lot operations and enhance driver convenience in using parking facilities. It examines existing challenges in increasing the effectiveness of parking infrastructure and proposes recommendations and measures to address these issues.

Furthermore, the article explores the capabilities of the "Oson Parking Bot" system to facilitate easy access for drivers, and presents the system architecture and layer components for integrating the bot with parking infrastructure. The integration enables real-time transmission of available parking space data to drivers via IR sensors, and is implemented using a program developed in the Python programming language.

Keywords: Oson Parking Bot, integration, parking infrastructure, Arduino, API, Park & Ride, server, database, user interface, layer components

1. Introduction

Parking facilities constitute a vital component of transport infrastructure in modern urban environments. Enhancing the efficiency of parking systems involves a systematic approach aimed at optimizing the use of existing parking spaces, regulating traffic flow, and improving convenience for users.

Currently, parking-related issues have become some of the most pressing challenges worldwide. These problems significantly affect transportation demand and contribute to increasing levels of motorization. As a result, traffic congestion has emerged as a widespread concern in urban areas.

In response, growing attention is being directed toward the development of smart technologies that can identify available parking spots, guide vehicles efficiently, process payments, and enable advance reservations. Equipping parking lots with telematics systems and designing parking facilities that align with the needs of transport users are now key priorities in modern urban planning [1].

The "Oson Parking Bot" system is designed to reduce the time and resource costs incurred by drivers when searching for available parking spaces [2]. Using the "Oson Parking Bot" system, drivers can access real-time data on parking lot locations, availability, and pricing. Additionally, the system allows users to reserve parking spaces in advance and make electronic payments [3].

Research findings indicate that in highly urbanized cities, an average of 30–35% of daily road congestion is caused by drivers searching for parking spaces[4].

Furthermore, according to studies, in central urban areas, between 8% and 74% (on average 34%) of vehicles on the road are actively searching for parking. Private vehicles spend more than 80% of a 24-hour period parked near the driver's home, about 16% parked in other locations, and only 4% in actual use.

In the United Kingdom, 70% of the working population commutes by private vehicle, resulting in regular congestion during peak hours. Moreover, 29% of drivers prefer to return home if they cannot find parking. It is also problematic that 45% to 50% of parked vehicles are improperly parked in violation of regulations [5].

Researchers are conducting scientific studies aimed at improving parking systems by introducing smart parking solutions and equipping them with modern technologies to make their use more convenient, thereby reducing time and energy wasted searching for parking. In particular, current research focuses on optimizing parking design and implementing intelligent systems to reduce road congestion, minimize environmental pollution, prevent unnecessary fuel consumption and time loss, and improve the psycho-physiological well-being of drivers[6]. These objectives are considered priority and highly relevant.

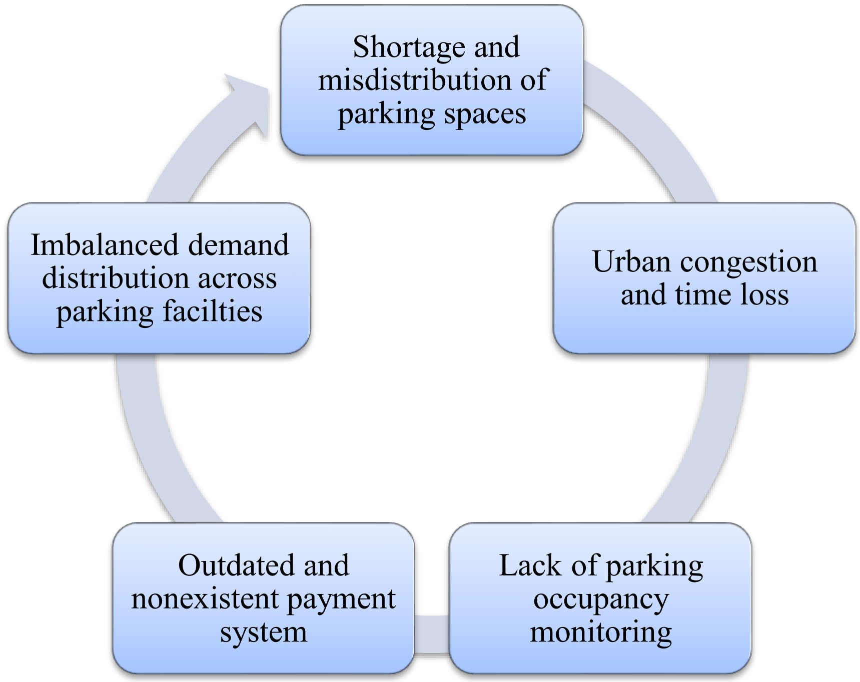
The quality of parking service is evaluated based on the following criteria:

1. Occupancy rate – the ratio of occupied to available parking spaces.
2. Waiting and searching time – the amount of time a driver spends finding a parking space.
3. Location convenience – proximity to main streets and key attractions.
4. Price – fairness of the price and its affordability for users.
5. Security – presence of cameras, lighting, and security systems.
6. Cleanliness and hygiene – cleanliness and compliance with sanitation standards.
7. Technological features – availability of a mobile app, QR codes, IoT technologies.
8. Number and types of spaces – availability of spaces for disabled persons and standard spaces.
9. User satisfaction.

2. Materials and Methods

Enhancing technological capabilities also helps to effectively organize the evaluation of other criteria[7]. The analysis of **Figure 1.** existing issues in organizing efficient parking operations is as follows:

Figure 1. Challenges in the Efficient Organization of Parking Systems Methods.



After analyzing the existing issues, the following recommendations and measures have been developed to improve the efficiency of parking system operations:

1. *Implementation of Smart Parking Systems.*

Automating the management of parking facilities can enhance convenience, reduce occupancy pressure, and save both time and resources[8].

2. *Development of an Optimization Method for Parking Allocation and Selection.*

Balancing demand across multiple parking locations allows for a more equitable and efficient use of available parking spaces within a given area.

3. *Regulation of On-Street Parking.*

Introducing time restrictions and implementing dynamic pricing for curbside parking can mitigate improper parking behavior, reduce congestion, and minimize the negative impact on traffic flow.

4. *Introduction of a Park-and-Ride System.*

Encouraging seamless transitions from parking areas to public transport helps reduce vehicle load in city centers, lowers parking demand, improves environmental outcomes, and mitigates congestion[9].

5. *Establishment of Green Parking Facilities.*

Equipping parking lots with solar panels and EV (electric vehicle) charging stations plays a critical role in environmental protection and supports sustainable urban development.

6. *Data-Driven Management and Forecasting.*

Utilizing real-time statistical data for monitoring and forecasting enables more precise, evidence-based decision-making and facilitates targeted management strategies.

7. *Strategic Placement of Parking Facilities.*

Selecting optimal locations for new parking lots reduces both travel distance and time, improving accessibility and overall system efficiency[10].

In Figure 2. the proposals outlined above for the development and optimization of parking systems play a vital role in enhancing the overall effectiveness of urban infrastructure. When implemented in a phased and systematic manner, these measures contribute not only to the improvement of traffic flow but also to greater environmental and economic efficiency.

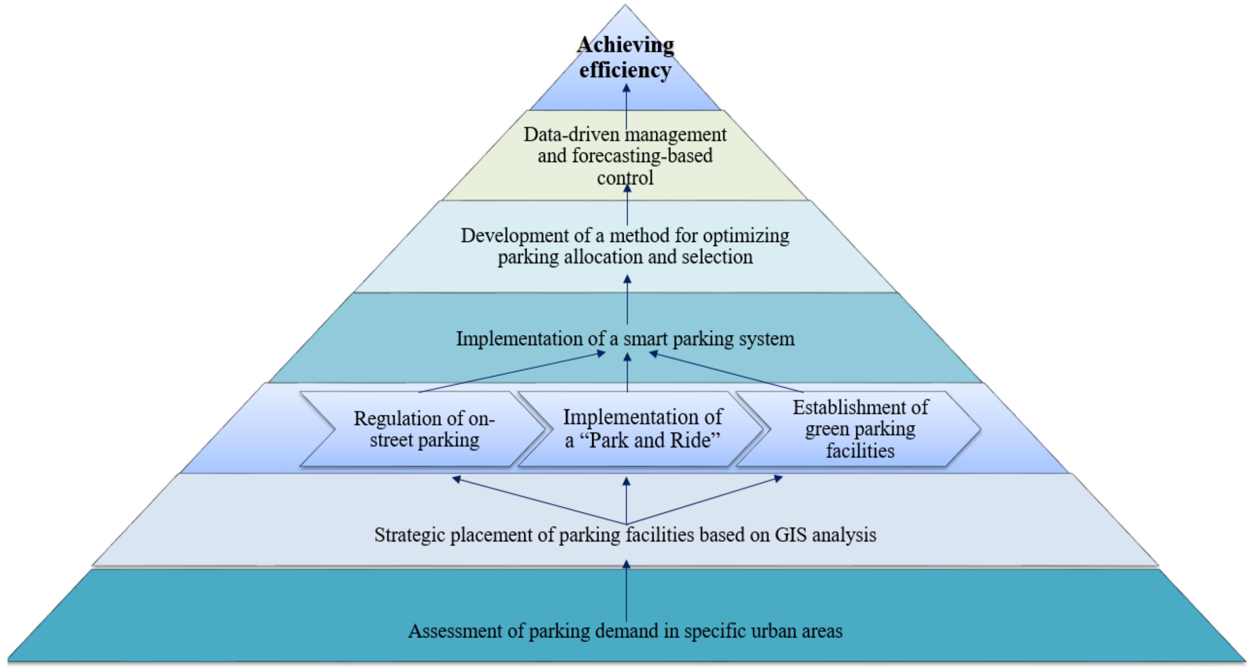


Figure 2. Stages Toward Achieving Parking System Efficiency

A step-by-step implementation strategy allows for the gradual integration of smart technologies, sustainable practices, and data-driven management into the parking ecosystem. This integrated approach supports the broader goals of smart city development by reducing congestion, lowering emissions, and optimizing resource utilization.

3. Results and Discussion

To implement this system effectively in practice, parking facilities must be equipped with the necessary infrastructure [11].

In order to deploy a smart parking system, the parking facility must be equipped with the following components:

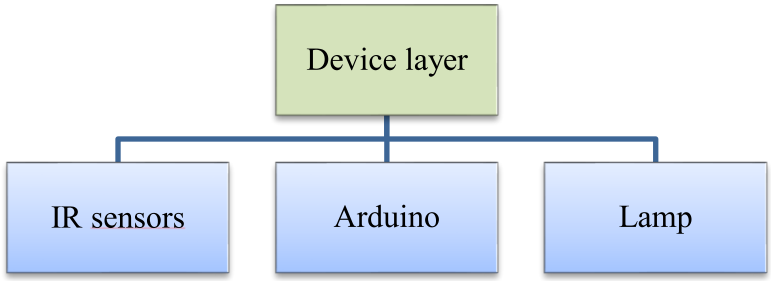
1. Sensors to detect vacant spaces and transmit data to the server
2. A monitor located at the entrance to display real-time information on available and occupied spaces
3. Central server
4. Telegram bot server
5. Arduino microcontroller
6. Database system

The "Oson Parking" system is structured into the following functional layers:

- Device Layer – physical hardware components, including sensors and controllers
- Service Layer – logic that processes and manages parking data
- Communication Layer – facilitates data exchange between components and servers
- Application Layer – software that processes requests and interacts with services
- User Interface – the interface through which users (drivers) interact with the system

This layered **Figure 3.** architecture ensures scalability, modularity, and ease of maintenance, while supporting real-time communication and automation[12].

Figure 3. Components Included in the Device Layer



- IR Sensors serve to detect and transmit information about available and occupied parking spaces within the parking facility.

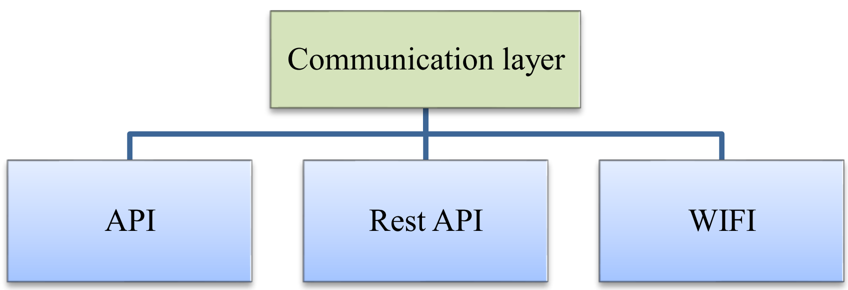
Analysis of Sensors Used in Smart Parking Systems

IR (Infrared Sensors) – these are devices used to detect vehicles in parking facilities through infrared radiation. Objects with a temperature of 5°C or higher emit infrared radiation[13]. IR sensors are divided into two types: active and passive IR sensors. Due to their sensitivity to weather conditions, it is not recommended to use these sensors in open-air parking lots. Additionally, the installation and operating costs of these sensors are relatively high[14].

- Lamps are used to visually indicate the status of each parking spot by displaying red and green colors.
- Arduino acts as an intermediary device that receives data from the sensors and transmits it to the central server.

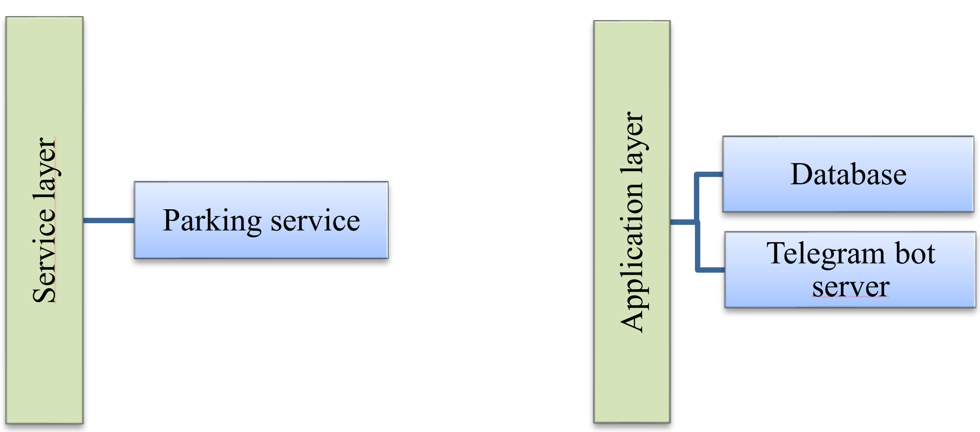
In **Figure 4.** The components of the communication layer enable seamless data transmission between devices and servers, ensuring real-time updates within the "Oson Parking Bot" system.

Figure 4. Components of the Communication Layer



The application layer components, which include the Telegram bot server and the database, are illustrated in **Figure 5.**

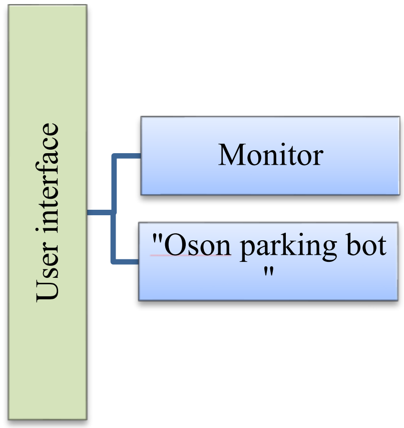
Figure 5. Components of the Service and Application Layers



The components of the service layer include the parking server and the Telegram bot server, which are responsible for receiving and transmitting data within the parking facilities, see Figure 5.

In **Figure 6.** The application layer manages the network and connects various software applications, ensuring seamless communication and coordination between system components.

Figure 6. User Interface



The user interfaces that provide information to users—i.e., drivers—include the monitor and the "Oson Parking Bot" application.

Through the monitor, drivers can receive real-time information about available and occupied parking spaces before entering the parking facility.

Figure 7. illustrates the schematic representation of the integration between the "Oson Parking Bot" and the parking facility, along with the system layers.

In the system, in order to balance demand across multiple parking facilities, parking data is transmitted in real time to a central database and the "Oson Parking Bot" system.

Figure 7. Integration Scheme Between "Oson Parking Bot" and the Parking Facility

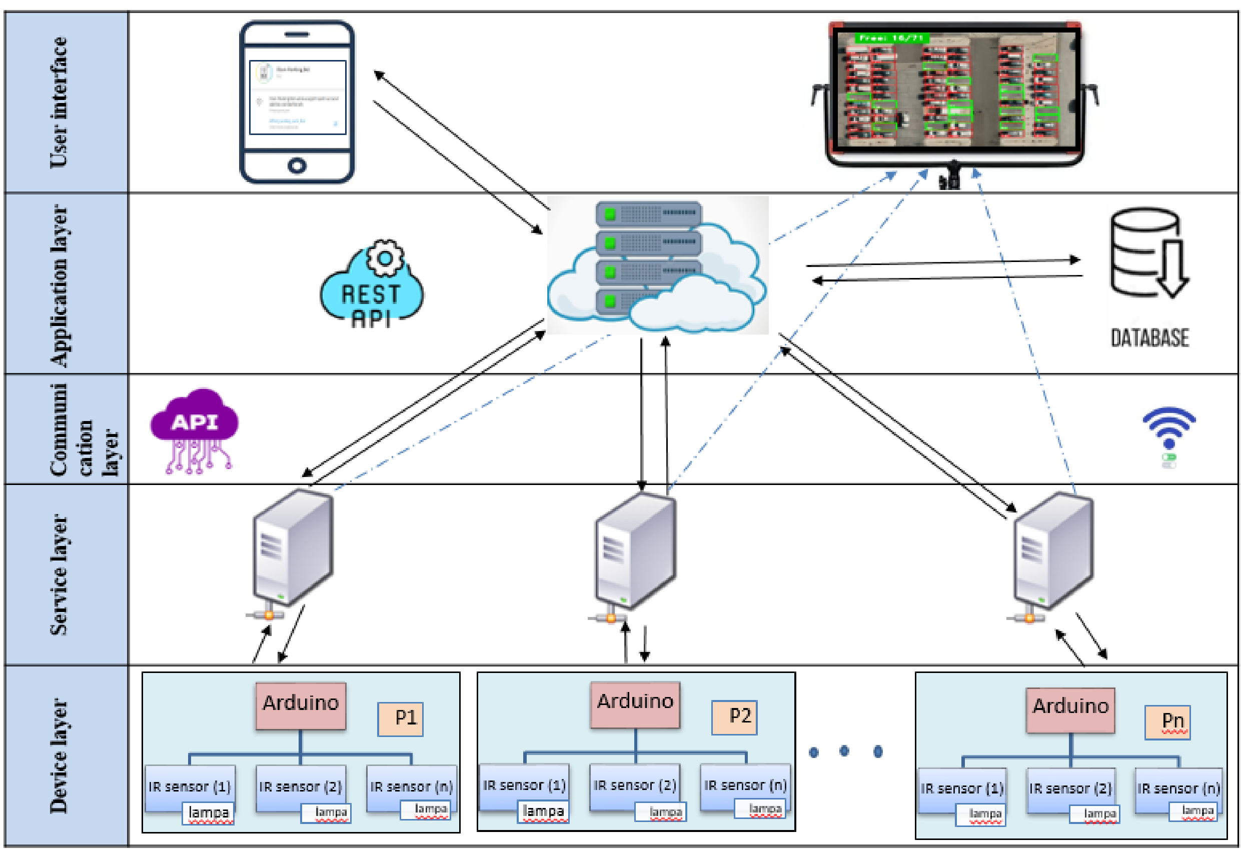


Figure 7. illustrates the parking infrastructure and the real-time transmission of data to the server, as well as the forwarding of this data to the "Oson Parking Bot" system and the central database[15]. In

addition, displaying available and occupied parking spaces in the mobile application and on monitors at the parking entrance further enhances the quality of parking services.

4. Conclusion.

Recommendations and measures aimed at improving the efficiency of parking facilities have been developed. Problems related to the effective organization of parking operations were studied, and systematic approaches were explored to maximize the efficient use of parking spaces, regulate traffic flow, and enhance convenience for users. Based on the schematic diagrams presented above, selecting the components of the parking infrastructure and implementing them in practice enables the integration with the "Oson Parking Bot" application, which assists drivers effectively. Through the proposed recommendations and measures, it is possible to smarten the parking system, improve parking efficiency, and enhance the quality of services provided to drivers.

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