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INTEGRATION OF THE INTERNET OF THINGS INTO AN INTELLIGENT PARKING SYSTEM

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Abstract
The integration of technology into human existence is evident in the progression of the Internet of Things (IoT). This research addresses the critical challenge of parking congestion, offering a thorough examination of a smart parking system application that seamlessly integrates IoT technology. Emphasizing practical implementation, a study conducted in a bustling shopping mall illustrates the effectiveness of the system. Employing tools like Light Dependent Resistor (LDR) sensors, Automatic Number Plate Recognition (ANPR) cameras, and Liquid-Crystal Display (LCD) lights, the system furnishes real-time information accessible via a user-friendly mobile application. The innovative incorporation of a Quick Response (QR) Code for vehicle identification enhances user convenience. Beyond the immediate advantages of locating available parking spaces and facilitating secure payments, the system contributes to economic optimization, decreased traffic congestion, and environmental sustainability. The research underscores the transformative potential of technology in reshaping parking management, offering a valuable template for future initiatives in various contexts.

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Key Words
internet of things, smart parking, mobile application.

Introduction

Over time, technology evolves at a rapid pace, enhancing the quality and efficiency of human life. The utilization of the Internet of Things (IoT) is one of the key technologies that contributes to the improvement of human life. The Internet of Things (IoT) relies on intelligent sensors and middleware to establish connections between clients and terminal devices. This technology enables the dissemination of intriguing information to the public concerning diverse elements present in our surrounding environment. The existence of IoT allows devices to function autonomously, overseeing and directing a system by responding to real-time events within the system (Fraifer & Fernström, 2016). With the advancement of the Internet of Things, one example of its application in everyday life is smart parking system.

The number of people using cars as their personal or family vehicles has been increasing (Faheem et al., 2013). The growing use of cars has led to traffic congestion in various places, including parking areas. This occurs because the available parking spaces often do not match the number of vehicles entering the parking area (Bibi et al., 2017). Urban residents in major cities, including Semarang, commonly favor shopping malls as a preferred destination. Going to shopping malls has become ingrained in their lifestyle, and it's not unexpected considering the wide array of offerings available. To enhance the comfort of visitors, mall management ensures the provision of various facilities, including ample parking spaces.

In Semarang, the usage of vehicles, particularly cars, is on the rise each year. Statistical data reveals that the car population increased by 21.9% from 2020 to 2021,

reaching a total of 281,971 cars in Semarang by 2021 (Statistics of Jawa Tengah Province, 2022). Surveys indicate that approximately half of these vehicles are expected to occupy parking spaces in malls. The rapid growth in the number of cars has led to significant issues, particularly in parking management. Although common solutions like implementing valet services have been attempted, they are often deemed expensive and unpopular among car users. Consequently, valet parking spaces are seldom utilized.

The increase in the number of visitors results in a higher volume of vehicles entering and exiting the parking area. The surge in the number of vehicles and the location of the shopping center pose a problem for traffic, particularly congestion, especially during peak access times to the parking lot. The congestion is caused by numerous vehicle users being unable to find parking spaces, coupled with a lack of information regarding available parking spaces and their locations. The irregular layout and condition of the parking spaces also lead to a reduction in parking spaces for vehicles, causing a mismatch in capacity. The disorganized positioning of vehicles results in time losses for users searching for parking, and vehicles have to queue, contributing to congestion at the exterior entrances of the parking area and causing discomfort for users (Kumar Gandhi & Kameswara Rao, 2016)

Mufaqih et al. (2020) discuss the implementation of a smart parking system to optimize parking slots and improve the parking process for customers. It allows real-time monitoring and analysis of parking data, which can be used for decision-making. Not only that, this system can also be accessed through a single network and platform, which influences the efficiency of electricity usage. Satpalkar et al. (2016) explain a system that allows drivers to find and reserve parking spots using QR codes. The main objective of this system is to help drivers easily find vacant parking spaces and reduce traffic. The proposed system eliminates the drawbacks of existing systems, such as the use of RFID, by using an Android application to reserve parking slots based on driver's needs.

Based on the existing issues, this research discusses the concept of designing a smart parking system application that utilizes Internet of Things (IoT) technology. This technology can create a system capable of monitoring objects automatically. The smart parking system is designed for the effective management of parking lots and entry/exit access, directing drivers to the right parking locations. The design of the smart parking system aims to provide a parking solution for Mall in Semarang. The designed system is expected to guide and direct drivers to parking locations, utilizing sensors that provide guidance through specific monitors to display real-time information. In the designed system, information about available parking spaces with their nearest locations and payment details is conveyed through the user's mobile application. Furthermore, when a driver leaves a used parking space, the system will update information about the parking space for other users. This parking system aims to help users save time and alleviate congestion at the entrances to shopping centers. The purpose of designing this application is to facilitate users in finding parking spaces by obtaining information from the system provided by the parking provider or Mall management in Semarang.

Methodology

Design System

Broadly, the system is designed to utilize Automatic Number Plate Recognition (ANPR) cameras employing optical character recognition techniques to read vehicle license plates (Dhiraj Yeshwant et al., 2014). The data is then transmitted through Arduino to process information and control the performance of connected components in the circuit as input processors from sensors, subsequently sending serial data via a wireless data transceiver (Pradana, 2016). If the vehicle license plate value is valid, it can be manually processed by clicking a button to obtain a parking ticket, whereby the Liquid Crystal Display (LCD) will show information about available and nearest parking spaces. Subsequently, the data for storing parking slots will be updated in the database using a servo with a closed feedback system where the position of the vehicle is communicated back to the control circuit within the servo motor (Purbo Wiseso et al., 2022), like the flow chart that can be seen in Figure 1.

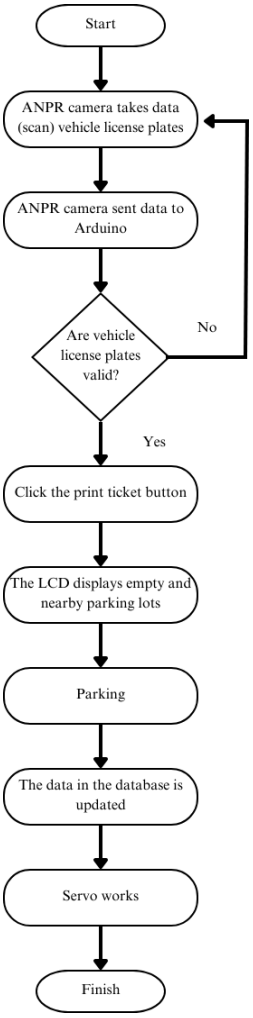

Figure 1. Flowchart System

Designing Applications for Users

Referring to Figure 2, users are required to have an account before parking. It is important to note that scanning the QR code is necessary to identify available and nearby parking spaces. If the parking lot is full, users will be directed to the homepage, which displays information about vacant parking spaces. Subsequently, users can initiate the parking process, complete the payment, resulting in the automatic opening of the gate.

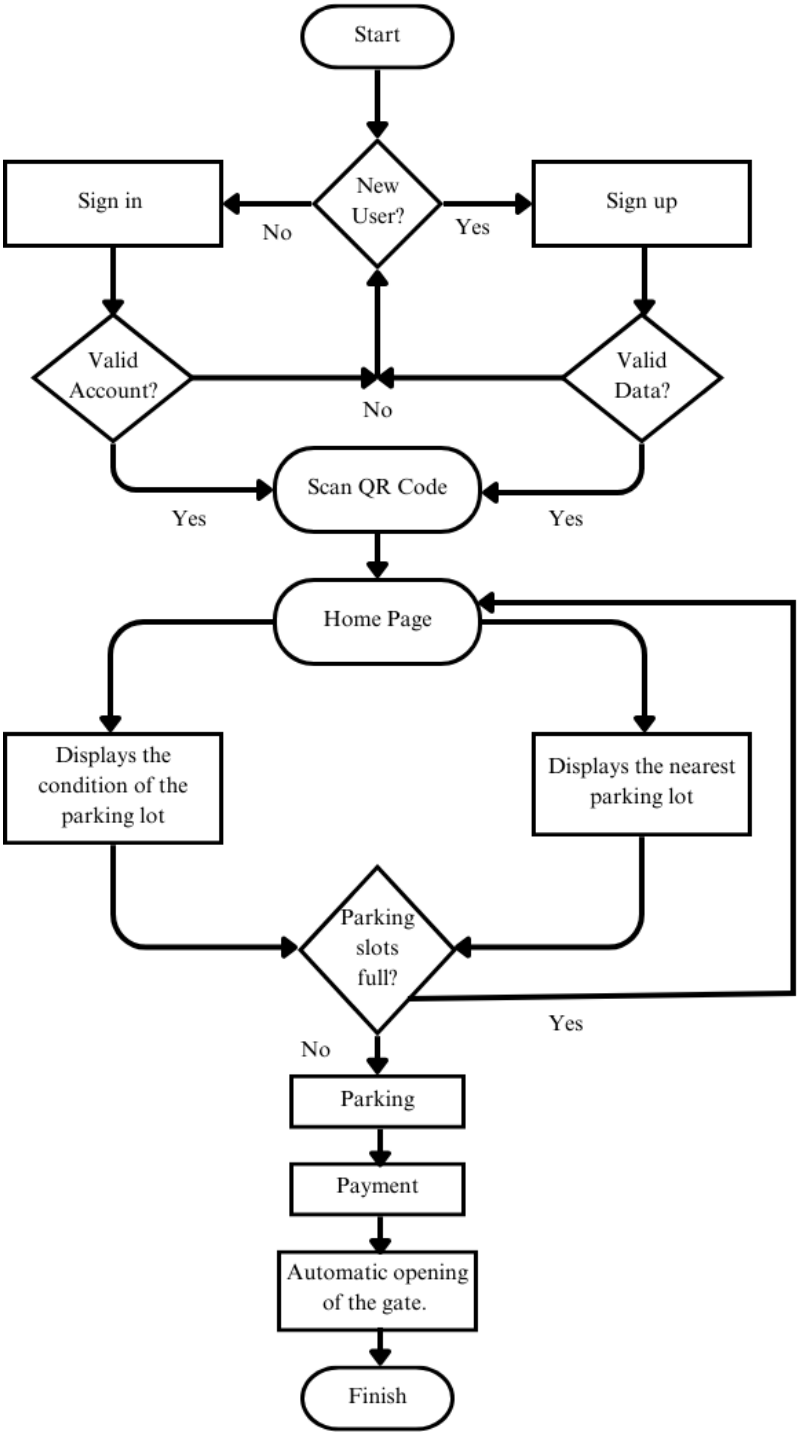

Figure 2. Flowchart System for Users

Result and Discussion

The smart parking system applied is a monitoring and controlling system for parking access. The smart parking system will assist drivers in finding available parking spaces, especially for car drivers, and ensure the security of parked vehicles. Additionally, the system also provides information about available and unavailable parking areas, as well as parking locations that will be directed using maps within the application. More specifically, this system will recommend the nearest vacant parking spaces to the driver. This result has an impact on increasing the utilization of parking spaces and time efficiency (Atiqur, 2021)

The smart parking system utilizes an application as a medium to convey parking information and facilitate parking fee payments. Before users can utilize it, they need to register an account, which will be used to verify user data and determine the amount to be paid. Similar to typical account registration, in Figure 3, users need to fill in several details such as name, email address, and password. After entering the data, users simply need to click the "Create New Account" button to complete the account creation. For a faster registration process, users can choose to proceed using their Gmail or Instagram accounts. The inputted data will be stored in the smart parking system database. Once the data is saved, users can proceed to log in to the application.

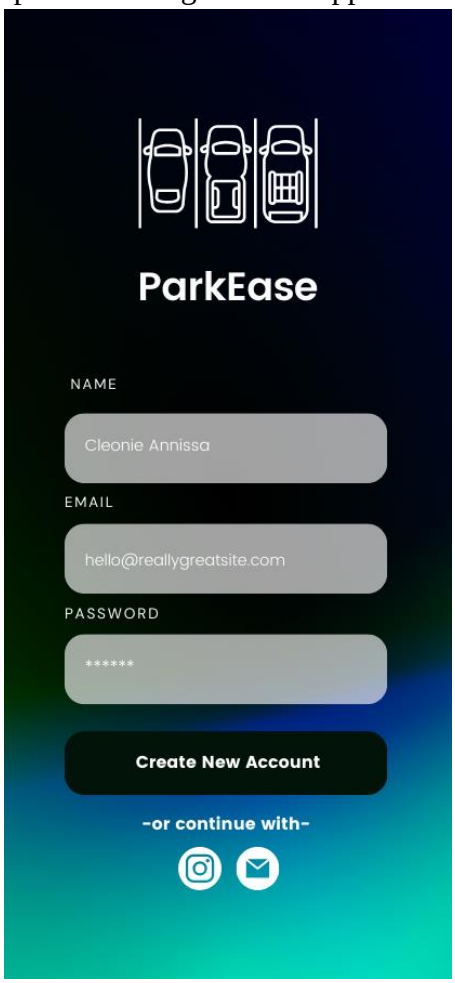

Figure 3. Registration Page

Users can access the system by going through the login process first. Figure 4 displays the login page. During the login process, users will be prompted to enter the username and password associated with the account they registered earlier. For informational purposes within the application, each parking space is equipped with a sensor, specifically a Light Dependent Resistor (LDR) sensor, as shown in Figure 5.

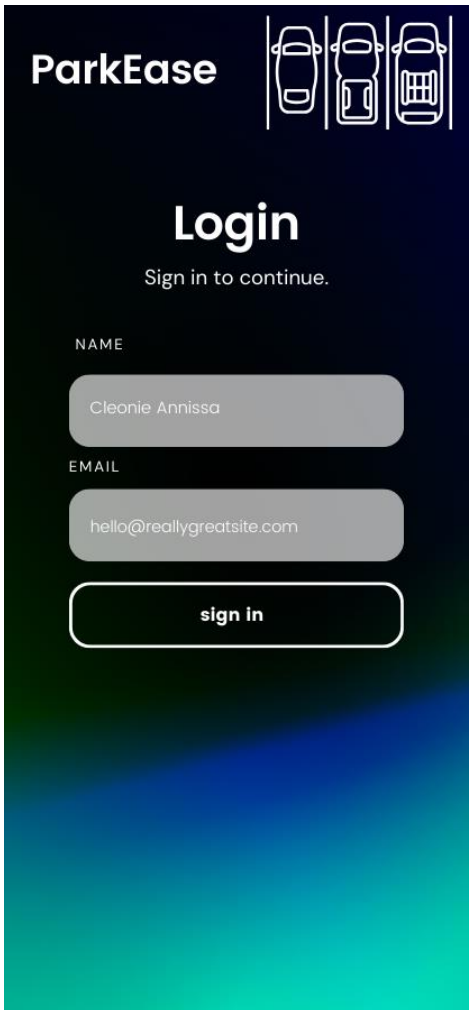

Figure 4. Login Page

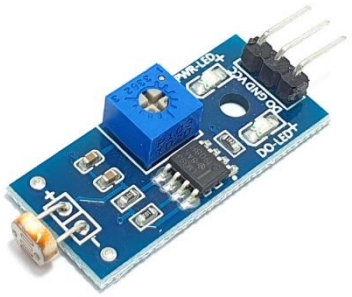

Figure 5. LDR (Light Dependent Resistor) Sensors

The LDR sensor operates in a manner similar to a typical variable resistor. When the LDR is exposed to a significant amount of light, its resistance value decreases. Conversely, if the LDR is in darkness or receives minimal light, its resistance value increases. When a parking space is occupied, the car obstructs the light reaching the LDR sensor, and a digital signal is then sent to the Arduino for processing. The data processed by the Arduino is used to update the database indicating available and occupied parking spaces. Consequently, the LCD connected to the computer and server displays the number of vacant parking spaces. The application also shows the count of available parking spaces based on the data in the database.

When a vehicle enters the parking area, the driver will encounter an automatic barrier with an ANPR camera capable of detecting and reading the vehicle's license plate. The data, in the form of the license plate, will be stored in the system. ANPR (Automatic Number Plate Recognition) is a technology that applies optical character recognition to images, enabling automatic reading of license plates from digital images. Its operation involves converting the digital image of the license plate into ASCII characters (American Standard Code for Information Interchange). Once the ASCII characters are successfully detected, the system automatically matches them with the data stored in the database.

The reading of the license plate of a vehicle may experience disruptions when lighting is insufficient. The ANPR camera processes the image of the detected license plate into input data, which is then transmitted to the computer, causing the parking barrier gate to open in this system. The opening process of the parking barrier gate involves the Arduino microcontroller. The communication that takes place on the Arduino is serial communication using Bluetooth as the communication medium. The purpose is to transmit sensor reading data to detect vehicles.

When a car enters, the user will receive a parking ticket containing the scanned license plate data and the start time of parking. Subsequently, the application will scan the QR code received by the user through the parking ticket machine. The data from the QR code and the user who scanned it will be stored in the database, allowing the system to obtain information about the user who parked the vehicle. After the data is saved, the application interface will switch to the parking space display page, as shown in Figure 6.

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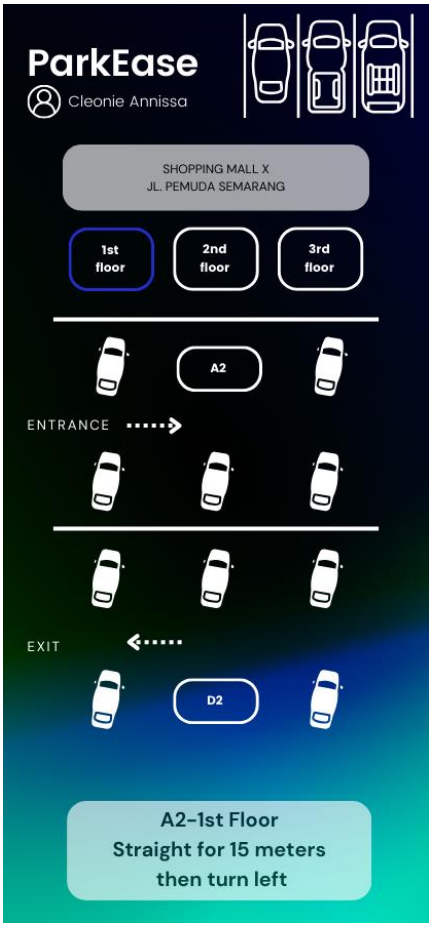

Figure 6. Parking Lot Availability Page

The detection results received by the sensor are then processed by the Arduino to send data on available and unavailable parking spaces. The availability of parking spaces is determined through the use of LDR sensors at the parking spots. Information about vacant parking spaces is processed using a sorting method based on proximity to the entrance. The sorted data results in a decision regarding the parking space closest to the entrance, which is then communicated to the user for entry to that parking spot.

After the system guides the user to the nearest parking space, the car will enter the vacant parking spot, obstructing the light directed to the LDR sensor. The obstruction of light to the LDR sensor will alter the resistance on the LDR sensor, and this change in resistance will be transmitted to the Arduino microcontroller. The data is then processed, resulting in a change in the color of the parking space indicator light from green to red. The significant change in resistance on the sensor will also update the count of available and occupied parking spaces in the database.

The system will then send a notification to the user through the application, corresponding to the time when the user scanned and the occurrence of a significant change in resistance in the vacant parking space. The notification interface displayed in the application can be seen in Figure 7. The sensor location data will be used to determine the user's parking location. With this feature, users who have finished their

visit to the mall in Semarang will find it easier to locate where their vehicle is parked. This also reduces the risk of visitors forgetting the location where their vehicle is parked.

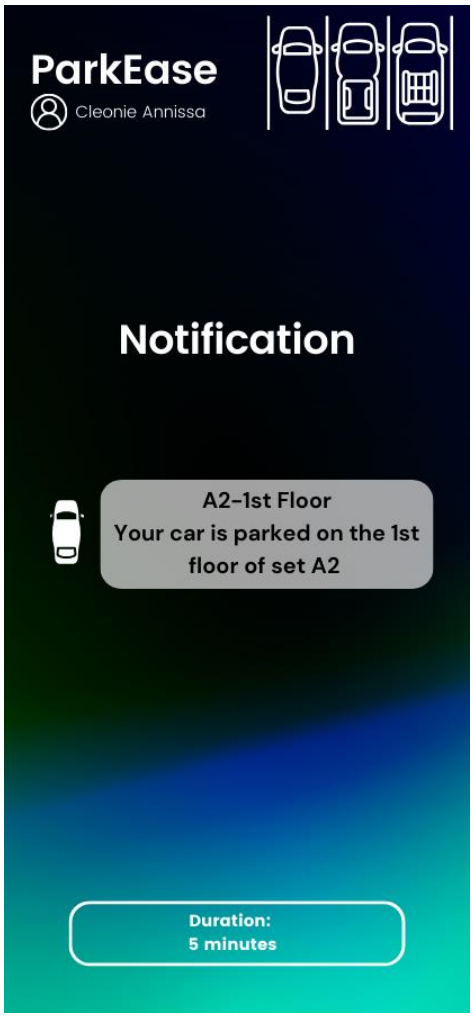

Figure 7. Notification of Vehicle Parking Location Page

If a user is about to exit the parking area, they will be directed to the payment menu. This condition aims to reduce the potential for congestion in the parking area (Biyik et al., 2021). For the payment method, a payment gateway is employed, utilizing e-money. The application will then calculate the detailed payment based on the parking duration multiplied by the hourly parking fee. The parking duration is determined by subtracting the entry time from the exit time. The payment process involves scanning the e-money at the ticket machine. The ticket machine identifies the card, and the e-money balance is deducted according to the parking fee and duration. Once the payment process is completed, the user can leave the parking area.

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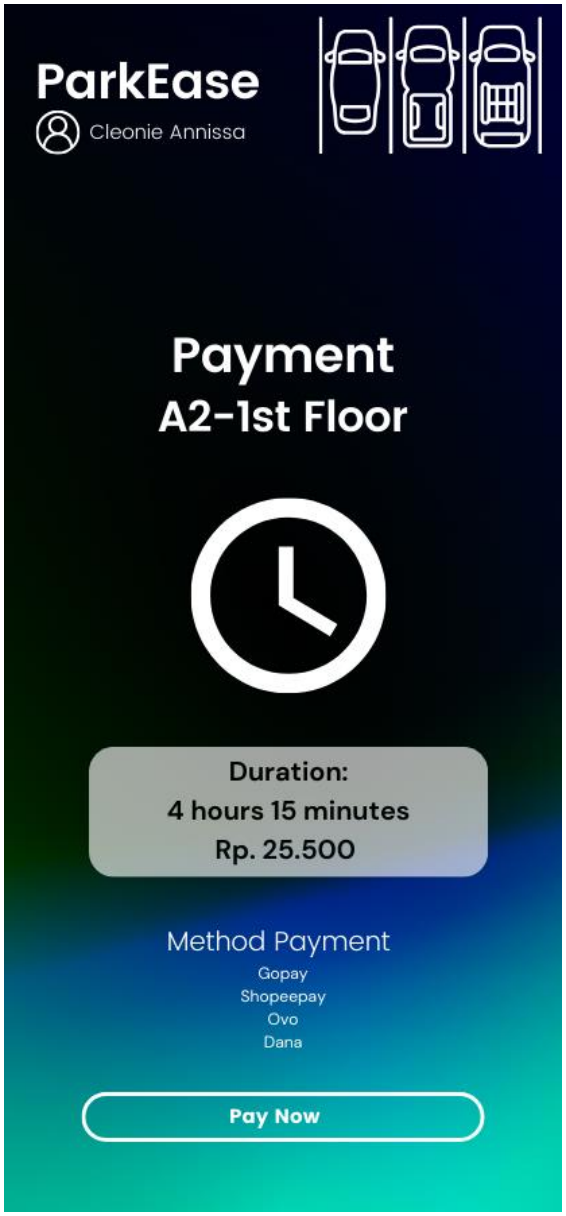

Figure 8. Parking Payment Page

The payment interface on the application can be seen as shown in Figure 8. The payment gateway will send a transaction success status, and if successful, the Arduino will change the indicator on the parking space back to green, indicating that the parking space is ready for use. With a command to the Arduino, the servo motor will then automatically open the barrier gate after the payment process is completed.

Smart parking systems offer several advantages in cost-benefit analysis and economic analysis. One of the main benefits of smart parking systems is that they can increase revenue for parking operators by reducing the number of people who do not park due to the difficulty of finding a parking spot (Mangiaracina et al., 2017). Smart parking systems can also help optimize parking space usage, improve the efficiency of parking operations, and reduce traffic congestion, ultimately saving time and money for

drivers. Additionally, smart parking systems can reduce carbon emissions from vehicles by decreasing the congestion and mobility of the vehicles in search of parking, contributing to environmental sustainability.

Conclusion

From this research, it can be concluded that the design of a smart parking system application implementing IoT is an appropriate solution to address the issue of vehicle congestion when entering parking areas. The smart parking system utilizes an IoT framework with ANPR cameras and LCDs that can easily provide information, which is then transferred to the controller, activating the system. The smart parking system not only facilitates the connectivity of the parking system but also enhances parking management with built-in features such as detailed information about available parking spaces, nearest locations, occupied parking spots, and easy payment methods. Furthermore, it ensures a secure level of operation, where every vehicle entering the system must be identified, utilizing parking tickets as the vehicle's identity. The authors recognize that parking has posed challenges in Semarang, extending beyond shopping malls to various other locations such as tourist attractions, traditional markets, restaurants, and more. In light of this, the author anticipates that this paper could offer valuable insights for addressing parking issues in diverse settings or serve as a foundation for future research studies.

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