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## Towards Future Mobility: Smart Parking System Based on Internet of Things with Wearable Computing Technology on Campus

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### Abstract

Technological advances in the digital era opened the door to innovation in various fields, including urban mobility. This article described the concept and implementation of an Internet of Things (IoT)-based smart parking system integrated with wearable computing technology in a campus environment. The main objective of this research was to develop a smart parking system integrated with wearable computing technology. The methodology used involved designing an integrated parking system, mapping parking areas, and developing a mobile application. Facilitating users' capacity to locate available parking spaces and providing them with real-time information regarding such availability were the primary goals of the proposed system, providing notifications to users when their parking time was running out and facilitating parking payments directly via their smartphone or smartwatch. Integration between smart parking applications and smartphones or smartwatches allowed users to access parking services more quickly and efficiently, improving their overall parking experience. This article described the system architecture and algorithms used, as well as testing and evaluating system performance. The unique aspect of this Smart Parking System research was the integration of wearable computing technology and the Internet of Things (IoT) concept to create a smart parking solution that was comfortable and efficient in the campus environment. The limitations of the discussion in this research were limited to Internet of Things (IoT) technology, sensors, and mobile applications. Through the implementation of this system, it was hoped that it could positively contribute to increasing mobility and efficient use of parking spaces in the campus environment, as well as opening up opportunities for developing similar applications on a wider scale in the future.

**Keywords** *Smart Parking System, Internet of Things, Real-time Information, Smartphone, Campus environment*

### INTRODUCTION

In an era of ever-developing technology, urban mobility is one aspect that continues to experience significant changes ([Machdum & Ardhiyanto, 2020](#)). Parking problems, as one of the main challenges of urban mobility, have attracted the attention of researchers and practitioners to find effective and innovative solutions. Smart parking has emerged as a central concept to address this issue and improve the parking experience for users through the integration of IoT and wearable computing.

Population growth in large cities has increased the number of motorized vehicles and limited parking spaces available. This phenomenon causes traffic jams that are often caused by cars looking for a parking space. On the other hand, technological developments have opened up opportunities to create smarter solutions for managing parking, utilizing IoT and wearable computing concepts ([Permana & Silvanie, 2021](#)).

The main objective of this research is to develop a smart parking system that is integrated with wearable computing technology, especially smartwatches, to improve the user experience in finding, using and paying for parking spaces. Some specific objectives to be achieved through this

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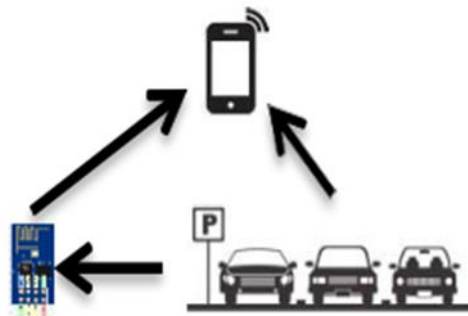


research include streamlining the process of finding parking, providing parking time notifications, and facilitating parking payments.

## LITERATURE REVIEW

### Smart Parking

Smart parking, also known as smart parking, is a concept that uses information and communications technology (ICT) to improve the efficiency, availability and management of parking spaces (Firmansyah et al., 2023). In an era where urbanization and the number of motorized vehicles continue to increase, smart parking is an important solution to overcome challenges in urban mobility.



**Figure 1.** Smart Parking System

One of the key components of smart parking is the use of sensors and IoT devices to collect data about parking space availability. Sensors installed in parking areas can detect whether a parking space is in use or empty. This information is then sent via the IoT network to the parking management platform.

The mobile application is the primary interface between the user and the smart parking system (Putra, 2020). Through this application, users can view real-time information about parking space availability, reserve parking spaces, pay for parking online, and receive notifications about their parking status. This application can also provide users with directions to reach available parking spaces.

### Internet of Things (IoT)

The term "Internet of Things" (IoT) describes a system in which everyday items linked to the web are able to exchange data and communicate with one another without the need for direct human or computer intervention (Putra & Hayat, 2021). Various parts of our lives, including smart homes, industries, and cities, have been profoundly affected by this idea, which has emerged as a major trend in the evolution of contemporary information and communications technology (ICT). In this explanation, we shall examine the concept, components, advantages, disadvantages, and potential future advancements of the Internet of Things.

The term "Internet of Things" describes a system in which various everyday items—including gadgets, cars, and sensors—are linked together and able to gather and share data over an internet connection. The idea is to build a "smart ecosystem" where gadgets work together to make different tasks easier by allowing people to remotely monitor, control, and automate physical objects over an internet connection.

### Components of the Internet of Things

A communication network is the backbone of the Internet of Things (IoT), allowing devices

to share data with IoT management platforms ([Hidayat et al., 2022](#)). Wireless networks like Wi-Fi, Bluetooth, or Zigbee, or cellular networks like 4G or 5G, can serve as this communication network.

**IoT Management Platform:** This is a software system that manages and analyzes data received from IoT devices and provides an interface for users to monitor and control devices. The platform can also provide additional services, such as device management, security, and data analysis ([Purwandari & Firmansyah, 2023](#)).

### **Wearable Computing Technology**

Wearable Computing technology refers to electronic devices worn on the user's body, designed to provide computing functions and access information in a directly accessible and convenient format ([Shi et al., 2020](#)). These devices generally have integrated computing capabilities, such as data processing, internet connection, and user interface interaction, which allow users to interact with the digital world more easily.

## **RESEARCH METHOD**

### **System Design**

First, we designed an IoT-based smart parking system integrated with wearable computing technology, especially smartwatches.

### **Data collection**

To map parking areas on campus, we conducted a field survey, which included identifying parking locations, parking capacity, and parking usage patterns.

### **Mobile Application Development**

Users will be able to see the availability of parking spots in real time, make online reservations, and pay for their parking via this app.

### **Integration with Wearable Computing Technology**

We use appropriate APIs and development platforms to connect parking applications with smartwatches so that users can access parking services through their smartwatch devices ([Silvanie et al., 2023](#)).

### **Data analysis**

We use statistical methods and other data analysis techniques to identify system strengths and weaknesses and gain valuable insights for further improvement and development ([Syah & Angellia, 2020](#)).

## **FINDINGS AND DISCUSSION**

### **Parking Sensors**

Each parking spot has a sensor that can detect when a car is in the area. The sensor will notify the system when a parking spot is in use, thus making that spot unavailable.

1. Installation of Parking Sensors

Every parking spot in the monitored area has parking sensors installed.

2. Vehicle Presence Detection

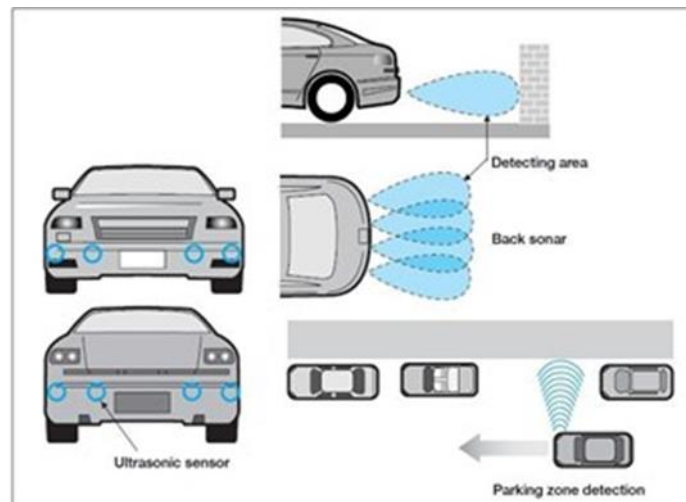
Parking sensors notify the parking management system of any changes in occupancy status whenever a vehicle moves into or out of a parking space.

3. Sending Information to the Parking Management System

After detecting the presence of a vehicle, the parking sensor will send information about the

status of the parking space (available or occupied) to the parking management system via a wireless connection, such as Wi-Fi or Bluetooth.

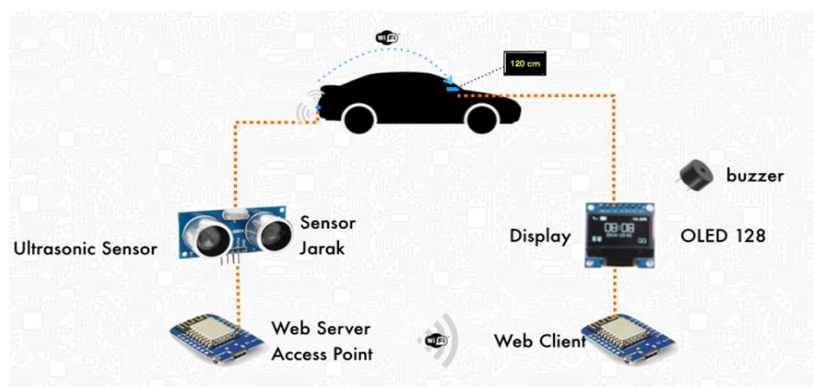
4. Updated Information on Parking Space Availability  
After receiving information from the parking sensors, the parking management system will update data about the availability of parking spaces in the appropriate database or data storage.
5. Access information on parking space availability via the smartphone application  
Users can access information about parking availability via their smartphone application. The application will display a parking area map with parking space availability indicators.



**Figure 2.** Parking Sensor Process

### Parking Sensor Connection

Parking sensors connect to the parking management system via a wireless network, such as Wi-Fi or Bluetooth. Information collected by parking sensors will be sent to the system in real time.



**Figure 3.** Wireless Portable Parking Sensor

1. Monitoring and Detecting Vehicle Presence by Parking Sensors  
Every parking spot in the monitored area has parking sensors installed. It is the job of this sensor to identify when a car is in the parking lot.
2. Sending Parking Sensor Data via Wireless Connection  
The parking sensor will wirelessly communicate with the parking management system to



- report the space's status after it detects a vehicle.
3. **Data Reception by the Parking Management System**  
The parking management system will receive data from parking sensors via a wireless connection.
  4. **Update information on parking space availability in the database**  
After receiving data from the parking sensors, the parking management system will update the parking space availability information in the appropriate database or data storage.
  5. **Access information on parking space availability via the smartphone application**  
Users can access the most up-to-date information on parking space availability through their smartphone app as soon as it is updated in the database.

### Parking Management System

The parking management system is the core of the intelligent parking system. It is a software platform that manages and analyzes data from parking sensors. This system also manages interactions between users and available parking spaces.



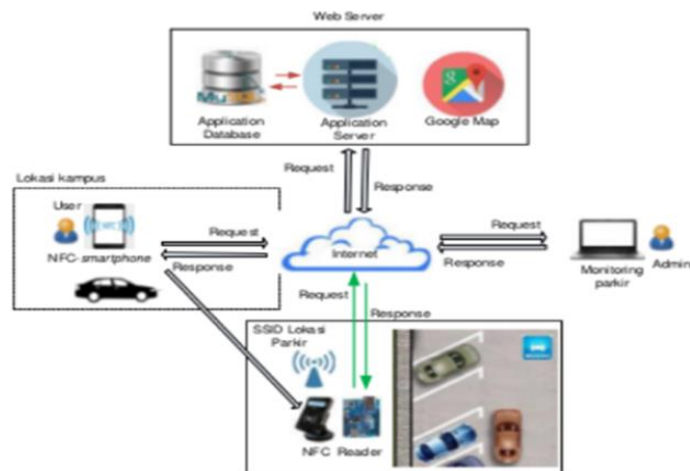
**Figure 4.** Smart Parking Management System

1. **Receiving Data from Parking Sensors**  
The parking management system receives data regarding the availability of parking spaces from the linked parking sensors.
2. **Data Processing and Updating**  
After receiving data from the parking sensors, the parking management system will process the data and update the parking space availability information in the appropriate database or data storage.
3. **Integration with Smartphone Applications**  
Once the parking space availability information is updated in the database, the parking management system will integrate this data with the user's smartphone application.
4. **Providing Information to Users**  
After integration with the smartphone application is complete, users can access information about parking space availability through the application.
5. **Providing Notifications and Notifications**  
Apart from displaying information about the availability of parking spaces, the parking

management system can also provide alerts and notifications to users via smartphone applications.

### Smartphone Application

The smartphone app is the main interface between the user and the smart parking system. Users can download these apps from the app store that is appropriate to their device platform (for example, App Store for iOS or Google Play Store for Android).



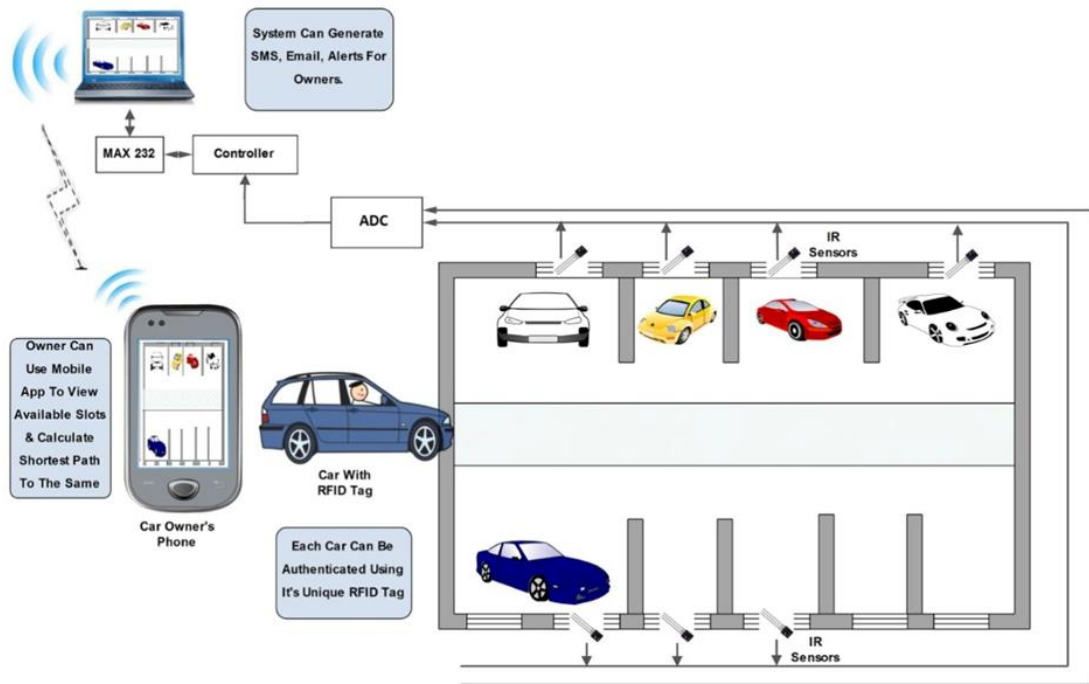
**Figure 5.** Parking System with Smartphone

1. Looking for a Parking Place  
Users can use a smartphone application to search for available parking spaces in a particular area.
2. Parking Space Reservation  
Users can also make parking reservations via the smartphone application.
3. Parking Payment  
After making a parking reservation, users can use the smartphone application to pay for parking online.
4. Receipt of Notifications and Notifications  
Smartphone applications can also provide notifications to users regarding parking.
5. User Interaction with the Parking System  
Through smartphone applications, users can interact with the smart parking system in various ways, such as searching for parking spaces, making reservations, paying for parking, and receiving notifications.

### Parking Spot Search

Users can use a smartphone application to search for available parking spaces in a particular area. The application will display a parking area map with indicators of parking space availability.



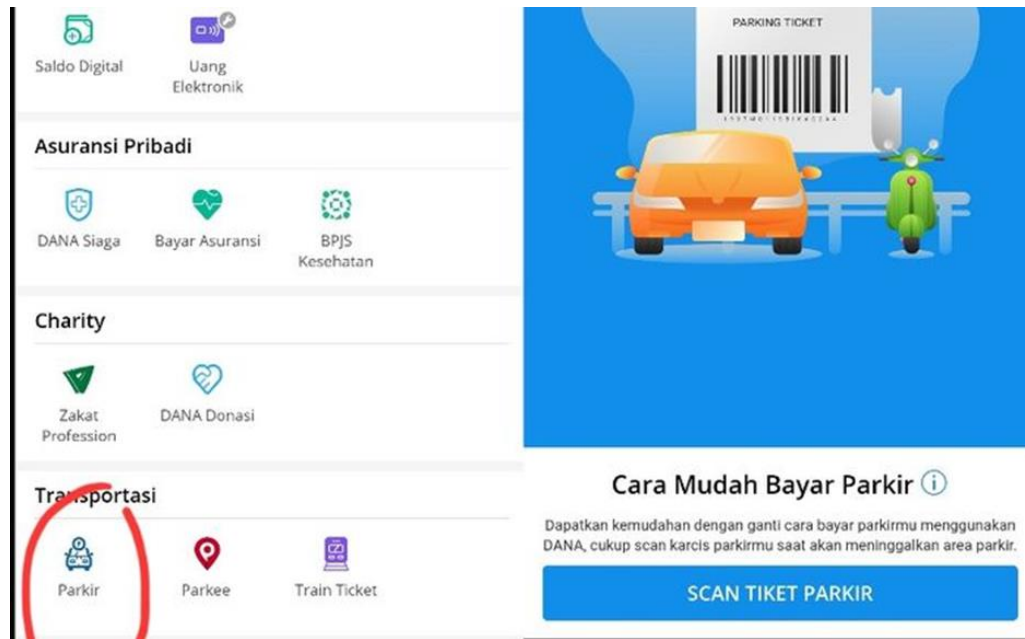


**Figure 6.** Displaying a Parking Area Map on a Smartphone

1. Access the Smartphone Application  
Users open a smartphone application that has been installed on their device.
2. Select the Parking Spot Search Option  
Users select the "Parking Space Search" option or a similar feature within the smartphone app.
3. Determine the location or parking area  
Users then specify the location or parking area where they want to find a parking space.
4. Displays information on parking space availability  
After determining the location or parking area, the smartphone application will display information about the availability of parking spaces in that area.
5. Choose a Parking Place  
Based on the displayed parking space availability information, users can select an available parking space that suits their preferences.

### Parking Payment

The smartphone app allows users to pay for parking online using various payment methods, such as credit cards or digital wallets. This allows users to make transactions easily and quickly.



**Figure 7.** Paying for Parking Online Using a Digital Wallet

1. Choice of Payment Method  
After users select a parking space and make a reservation via the smartphone application, they will be directed to make parking payments.
2. Enter Payment Details  
After selecting a payment method, users will be asked to enter the required payment details, such as credit card number or digital wallet account information.
3. Payment Verification  
After entering payment details, the application will verify the information provided by the user to ensure the validity of the transaction.
4. Confirm Payment  
After successful verification, the application will display payment confirmation to the user.
5. Payment  
After the user confirms the payment, the application will automatically process the transaction using the selected payment method.
6. Confirmation of Successful Payment  
After the payment is successfully processed, the application will display a successful payment confirmation to the user.

### **Smart Parking System as a Solution**

Smart parking systems are solutions that allow users to easily find, reserve and pay for parking spaces using their smartphones. This brings several significant benefits, not only to individual users but also to parking managers and society as a whole.

The parking management system is the core of an intelligent parking system. It is responsible for processing data from parking sensors, updating parking space availability information in the database, and data integration with the user's smartphone application. With an efficient parking management system, users can access information about parking space availability easily and quickly, as well as make parking reservations and payments conveniently

via their smartphone application.

Overall, smartphone-based smart parking systems bring several significant benefits. This not only reduces the time spent searching for available parking spaces but also reduces traffic congestion in parking areas, improves parking management efficiency, and provides a more convenient parking experience for users.

## CONCLUSIONS

Implementing a smart parking system offers several significant benefits. First, this system provides easy and fast access for users to find available parking spaces via their smartphone application. With parking availability information updated in real-time, users can save time and reduce the frustration associated with searching for a parking space.

Second, the smart parking system also brings efficiency in parking management. By using parking sensors and a connected parking management system, parking managers can accurately monitor parking space availability and optimize the use of available parking spaces. This can reduce traffic congestion in parking areas and improve the parking experience for users.

Apart from that, the smart parking system also allows users to make parking reservations and payments online via their smartphone application. This not only provides convenience for users, but also helps reduce the risk of losing or theft of physical parking tickets.

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