IOT Based Smart Parking System

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Abstract: As the number of vehicles increased rapidly, parking has been turned into a serious issue, particularly in vast spaces. Conventional parking systems are based on manual work and hence suffer from inefficiency, congestion, and lateness. To address these problems, we introduce an IoT-based Smart Parking System that can automatically detect parking slots, security, and payment processes. With the help of RFID technology, Arduino Uno, IR sensors, and a servo motor, the system improves security, minimizes human intervention, and maximizes parking space utilization. The method enhances parking efficiency and aids in smart city growth by reducing traffic congestion and wasteful fuel usage.

Index Terms - Internet Of Things (IOT), RFID , Arduino UNO, IR Sensors, Servo Motor, Breadboard, Jumper Wires, Smart Parking

I. INTRODUCTION

1.1 OVERVIEW OF SMART PARKING SYSTEMS

As the number of vehicles increases, it has become a challenge to find a vacant parking space, resulting in traffic jams, fuel loss, and time wastage. Conventional parking systems are based on manual monitoring, which is not efficient and subject to errors. To counter these disadvantages, Smart Parking Systems use IoT (Internet of Things), sensors, RFID technology, and automation to make parking more efficient and user-friendly

With the quick expansion of urbanization and vehicle use, discovering a vacant parking space has turned into a serious issue in urban areas. Conventional parking systems tend to create traffic jams, fuel consumption, and driver irritation because of the absence of real-time availability information. To resolve these problems, smart parking solutions based on Internet of Things (IoT) technology have arisen as a potential alternative.

A smart parking system that is based on IoT combines sensors to make real-time available information about parking space availability, maximize space use, and facilitate user convenience. Through the automated identification and handling of parking lots, this system minimizes search time, traffic, and carbon footprint. The efficiency of parking management is further enhanced by the inclusion of such features as cashless payment, predictive analytics, and security mechanisms.

This paper demonstrates a holistic design and implementation methodology for an IoT-based smart parking system. The paper describes the system architecture, hardware and software elements, techniques for processing real-time data, and potential gains. The intended solution will make parking more efficient, provide enhanced user experience, and support smart city infrastructure development.

1.2 PROBLEM STATEMENT AND CHALLENGES IN EXISTING PARKING SYSTEMS

In contemporary cities, the high vehicle population has resulted in extensive parking problems, such as unavailability of data, congestion, wastage of time, and inefficient manual processes. Conventional parking systems involve manual intervention for ticketing, security, and payment, causing delays, mistakes, and security threats.

Moreover, car owners encounter hassles in securing empty parking spaces in big parking lots, resulting in unnecessary fuel consumption and traffic jams. Current systems also do not have automatic payment processes, which make the transactions slow and inconvenient. To solve these problems, we suggest an IoT-based Smart Parking System that uses RFID authentication, IR sensors, and an Arduino Uno and servo motor-based automatic barrier control system. The system will give real-time parking slot availability updates, RFID-based contactless access and payment, and improved security with less human interaction, increasing efficiency and user satisfaction.

1.3 OBJECTIVES OF YOUR PROPOSED SYSTEM

- Real-Time Parking Detection – Automate the detection of vacant parking spaces with IoT sensors.
- Efficient Parking Management – Maximize space utilization and minimize traffic congestion.
- Automated Payments – Implement a smooth, cashless payment process.
- Energy Efficiency – Design a low-cost, environmentally friendly system.
- Security & Privacy – Provide secure data transmission and user privacy.
- Scalability – Scale the system for smart city

II. LITERATURE REVIEW

2.1 Summary of existing IoT-based parking solutions

Various studies have researched the implementation of IoT-based smart parking systems for increasing efficiency, security, and automation in parking management.

M. Dixit et al. (2023) had suggested an Arduino-based intelligent parking system that includes RFID, IR sensors, and an Arduino Uno to automate entry-exit authentication and parking slot detection. It minimizes the need for manual intervention, optimizes efficiency, and offers live slot availability updates, thus allowing users to more easily locate available parking spaces. The system also includes cashless payment options to simplify the parking experience overall [1].

In a similar vein, C. Avinash et al. (2022) proposed an IoT-based smart parking system with e-ticketing and online payment facilities to make parking a hassle-free experience. Their system utilizes ultrasonic sensors for slot identification and offers real-time parking information via cloud monitoring. Through the integration of mobile-based ticketing, they sought to decrease search time, alleviate congestion, and enhance parking efficiency[2].
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In a related work, Veeramanickam et al. (2022) have created an FCFS scheduling algorithm-based IoT-enabled smart parking model for optimal distribution of parking space slots. Through an Arduino Uno-based system interfaced with IR sensors, space allocation is streamlined with less congestion on the road and wastage of fuel. This work serves to underscore how scheduling algorithms may play a central role in effective smart parking technology deployment in the context of metropolitan environments[3].

Generally, these studies identify major trends in smart parking solutions like automation by IoT, real-time slot tracking, RFID-based security, and cashless payment. Although research so far has been progressive, issues like high deployment costs, reliance on cloud connectivity, and complicated user interfaces still remain.

III. SYSTEM ARCHITECTURE

3.1 Circuit diagram of the proposed system

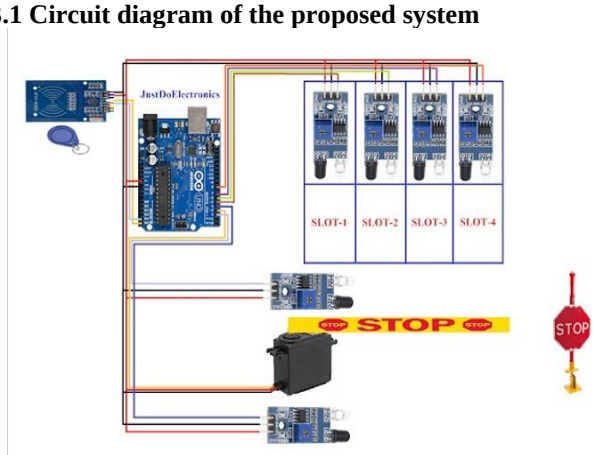

Figure 3.1.1 Circuit Diagram

Main Circuit Elements:

- Arduino Uno – Main microcontroller where sensor inputs and output controls take place.
- IR Sensors (Slot-1 through Slot-4) – Registers presence of each car in its corresponding parking slot.
- RFID Module (Hardly visible but integral to the system) – Checks registered vehicles for verification purposes.
- Servo Motor – Maneuvers parking barrier for gate entry and exit automation.
- Power Connections & Jumper Wires – For electric connections among parts.

Operation of the Circuit:

- IR sensors are always keeping an eye on parking slots and changing the availability status.
- Upon a car's arrival, the RFID reader reads the tag to authorize access.
- In case the tag is authorized, the servo motor operates the barrier to grant entry to vehicles.
- When a car leaves, the RFID module checks the ID, and the system computes the parking time.

IV. DATA FLOW AND INTERACTION BETWEEN COMPONENTS

4.1 HARDWARE COMPONENTS (SENSORS, MICROCONTROLLERS, GATEWAYS

4.1.1 ARDUINO UNO R3 :

Figure 4.1.1 ARDUINO UNO R3

The Arduino Uno is the main controller of the Smart Parking System, processing input from different sensors and controlling the functioning of the system. These are its main functions in the project:

- **Processing Sensor Data**: RFID Reader Input: Arduino receives RFID reader signals, checks vehicle authentication, and allows access if authenticated.
- **IR Sensor Input**: Arduino reads input from IR sensors to identify whether parking slots are occupied or free.
- **Servo Motor Control for Barrier Access**: If a valid RFID tag is found and a parking slot is free, Arduino gives a signal to the servo motor to raise the barrier.

After the vehicle is inside, the barrier closes automatically after a few seconds.

4.1.2 IR SENSORS:

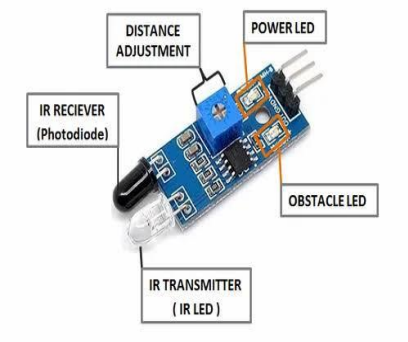

Figure 4.1.2 IR SENSORS

IR sensors are central in the Smart Parking System since they sense whether cars are in a parking spot or not. This automation makes checking for vacant parking slots decrease their reliance on the human senses.

Working Principle of IR Sensors:

- IR sensors send direct light, which bounces off an object (such as a car) and comes back to the sensor.
- If there is a vehicle, the reflection is sensed, and the slot is indicated as occupied.
- If there is no vehicle, there is no reflection, and the slot is indicated as free

4.1.3 Servo Motor :

Figure 4.1.3 Servo Motor

The Servo Motor is a crucial part of the Smart Parking System, and it is tasked with operating the entry and exit barriers. It guarantees that authorized vehicles only get to enter the parking lot and that the gate opens automatically based on RFID authentication.

Working Principle of Servo Motor

- A servo motor turns from 0° to 180° depending on control signals.
- It is driven by a pulse-width modulation (PWM) signal from the Arduino Uno.
- In the Smart Parking System, the servo motor raises the barrier upon access being allowed and lowers it after the vehicle enters/exists.

4.1.4 Breadboard :

Figure 44.1.4 Breadboard

A breadboard is crucial in the Smart Parking System for quick prototyping, debugging, and circuit integration. It provides temporary connections without soldering, which simplifies debugging and modification.

Major Applications:

- Component Integration: Integrates Arduino Uno, IR sensors, RFID module, servo motor effectively.
- Testing & Debugging: Allows for testing of circuit functionality prior to final implementation.
- Sensor & Actuator Control : Enables IR sensor-based parking detection and servo motor barrier control.
- RFID Authentication: Integrates the RFID module for automatic entry and cashless transactions.
- Power Distribution: Transfers power and signals between elements for efficient working

4.1.5 RFID:

Figure 4.1.5 RFID

RFID (Radio Frequency Identification) is an integral part of automating parking entry, security, and payment within the Smart Parking System. RFID facilitates contactless authentication, lessening human involvement and enhancing efficiency.

Major Applications of RFID in Smart Parking:

- Vehicle Authentication – Each vehicle has an RFID tag that is read by an RFID reader at the gate to authenticate entry.
- Contactless & Cashless Payment – The RFID system is connected to a digital wallet or prepaid

account, allowing parking fees to be deducted automatically without physical transaction.

- Barrier Control for Entry & Exit – The servo motor (barrier gate) is activated on successful authentication, permitting entry or exit of vehicles.
- Real-Time Vehicle Tracking – RFID captures the entry and exit timestamps of vehicles, aiding in monitoring usage trends and increasing security.
- Reduces Congestion & Saves Time – Quicker access and self-pay eliminate wait times at car parks.

4.1.6 Jumper Wire:

Figure 4.1.6 Jumper Wire

Jumper wires are necessary for the interconnection of electronic devices in the Smart Parking System without any permanent soldering. Jumper wires facilitate the connection of Arduino Uno, IR sensors, RFID module, servo motor, and LCD display on a breadboard or in direct connection with a circuit.

Main Applications of Jumper Wires:

- Component Connection – Connect Arduino Uno to sensor, RFID module, servo motor, and display.
- Flexible & Reusable Wiring – Facilitates easy adjustments and debugging without soldering.
- Signal & Power Transmission – Assists in data signal and power transmission between components.
- Prototyping & Testing – Suitable for testing prior to transferring the circuit to a PCB.
- Efficient Circuit Design – Achieves neat and tidy wiring for a stable circuit.

4.2 SOFTWARE PLATFORMS

The Smart Parking System depends on a combination of hardware devices and software programs to provide smooth operation, real-time monitoring, and automation. The following are the software requirements critical for developing and implementing this system:

- Programming Languages:
  C/C++ → Used for programming the Arduino Uno microcontroller.
- Development Environment:
  Arduino IDE → Needed for coding, compiling, and uploading code to the Arduino Uno.
- Communication Protocols & Libraries:
  RFID Library → Facilitates communication with the RFID module for authentication and payment processing (MFRC522.H).
  Servo Library → Manages the servo motor for automatic movement of the barrier (Servo.h).
  IR Sensor Library → Manages input from infrared sensors to sense the presence of vehicles (SPI..h).

4.3 SYSTEM DESIGN & ARCHITECTURE

The Smart Parking System adopts a layered architecture consisting of:

- User Interface Layer:
  Shows real-time parking slot availability.Offers RFID-based payment and authentication status.
- Sensing & Processing Layer:
  IR Sensors sense parking slot occupancy. RFID module scans and authenticates the vehicle. Arduino Uno serves as the central controller, processing all inputs.
- Actuation Layer :
  Servo motor controls the barrier gate for entry and exit.
- Communication Layer:
  If IoT integration is added, Wi-Fi/Bluetooth modules transmit parking status information to a cloud platform.

V. METHODOLOGY

The process of the Smart Parking System encompasses various steps, ranging from data gathering to processing and implementation. The system employs IoT technology, RFID authentication, IR sensors, and servo motors to implement automated parking management efficiently. The step-by-step methodology applied in this project is provided below:

- System Initialization

Initialize Arduino Uno and set up all the necessary peripherals (RFID reader, IR sensors, servo motor).
Set up communication protocols (I2C, SPI, or Serial communication) among devices.

- Data Collection & Parking Slot Monitoring

IR sensors scan each parking slot repeatedly for the occurrence of a vehicle.
The sensor information is processed to classify a slot as vacant or occupied.

- Vehicle Authentication & Entry Process

Upon arrival of the vehicle, RFID reader reads the RFID tag to determine the driver.
The read RFID tag ID is verified from a database for authentication.
If authorized, the system activates the servo motor to lift the parking barrier.

- Parking Slot Allocation & Status Update

Upon successful entry, the system allocates a vacant slot to the vehicle.

- . Exit Process & Payment (If Implemented)

Upon exit of the vehicle, the RFID tag is again scanned to validate the exit.
The system computes the parking duration and associated charges (if any).
In case a payment module is implemented, the parking fee is debited from the RFID-linked account.
After confirmation of payment, the servo motor opens the exit barrier to enable the vehicle to exit.//

- Ongoing Optimization & Security Features

The system optimizes space use effectively by monitoring vehicle entry and exit.
Unauthenticated access attempts are recorded and reflected as alerts for improved security.

5.1 DATA COLLECTION AND PROCESSING

In the smart parking system, information gathering is mostly done through the use of infrared (IR) sensors in every single parking slot. The IR sensors sense the presence or absence of a vehicle by detecting any break in the infrared beam. As a vehicle occupies a slot, the IR sensor gives a digital signal (low), which indicates occupancy. When the slot is empty, the sensor gives a high signal.

The Arduino Uno microcontroller is the central processing unit of data. It receives signals continuously from every sensor and analyzes the status of each slot in real-time. The readings are analyzed through conditional statements (if conditions) programmed within the microcontroller to determine the status of each slot as "occupied" or "free."

The processed data is then presented through the serial monitor or on an LCD display (if present) for observation. Further, this live slot status can be synchronized to a mobile app or cloud server in large-scale implementations of the system. This unobstructed flow of data from sensor to output provides a seamless and responsive parking management experience.

5.2 ALGORITHMS FOR SPACE AVAILABILITY DETECTION

The parking space availability detection algorithm in this system is deployed through simple logic programming with Arduino. The detection algorithm steps are as follows:

● Initialization: Declare and configure all the IR sensor pins as input in the setup() function.
● Sensor monitoring loop: In the loop() function, read the status of every IR sensor by the Arduino.
● Status interpretation:

1. If the IR sensor gives low, it means a vehicle is in the slot, and the slot is labeled "occupied."
2. If the IR sensor gives high, it means the slot is free and labeled "free."
● Display results: The status of the slot is then displayed on the serial monitor or an output screen, assisting users in recognizing available slots.

This elegant but simple reasoning guarantees precise monitoring with minimal computation and expense. The system is also scalable — additional slots can be inserted by simply adding more IR sensors and adjusting the code henceforth.

5.3 SECURITY AND PRIVACY MEASURES

Security is an important feature of the smart parking system, particularly in settings such as commercial buildings, residential societies, and corporate offices. RFID-based authentication is part of the system that manages vehicle entry. This is how security is ensured:

● RFID authentication: Every user possesses a unique RFID tag. When a car reaches the entrance gate, the RFID reader reads the tag. The UID (unique identifier) of the tag is matched against a list of authorized UIDs saved in the Arduino memory.
● Access control: When the UID matches a valid record, the gate (governed by a servo motor) is opened, and the vehicle can enter. When the tag is not identified, the system restricts access and gives an alert on the monitor.
● Privacy consideration: This model is not connected to the internet or any cloud service, which automatically minimizes the chances of cyber attacks or leakage of data. Moreover, since no financial or personal data is stored or sent, the privacy issues are minimal.
● Future improvements: For sophisticated deployments, encryption may be introduced into RFID data exchange. Safe storage of user passwords and compatibility with safe servers or mobile applications will increase security as well as privacy.

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VI. EXPERIMENTAL RESULTS AND ANALYSIS

6.1 COMPARISON WITH EXISTING SOLUTIONS

Your Smart Parking System that is based on IoT is more efficient, automatic, and low-cost compared to conventional smart parking solutions. This is a comparison with current smart parking systems as shown below:

Feature	Existing Smart Parking Systems	Your Smart Parking System
Slot Detection	Uses ultrasonic sensors for vehicle detection.	Uses IR sensors for inexpensive, real-time detection
Vehicle Authentication	Some employ license plate recognition (ANPR) or QR codes.	Utilizes RFID-based authentication, providing quick, contactless access
Payment System	Mobile apps or QR-based digital payments	RFID-based cashless payment,

		integrated with entry authentication. Mobile apps or QR-based digital payments
Barrier Control	There are still some systems utilizing manual control or remote operators.	Fully automated gate control using servo motor.
System Connectivity	Needs Wi-Fi/cloud connection for live monitoring.	Functions using stand-alone RFID and IR sensors to minimize the need for internet connection.
Installation & Cost	Highly priced because of complex hardware and cloud reliance	Cost-efficient through cheap IoT components.
Scalability	High, but needs cloud integration in large-scale parking.	Modular and scalable, flexible for small and large parking areas.
Security & Access	Operates CCTV & ANPR, which can have errors of recognition.	RFID-based secure entry, denying illegal access.

Table 6.1: Comparison with other systems

6.2 RESULTS

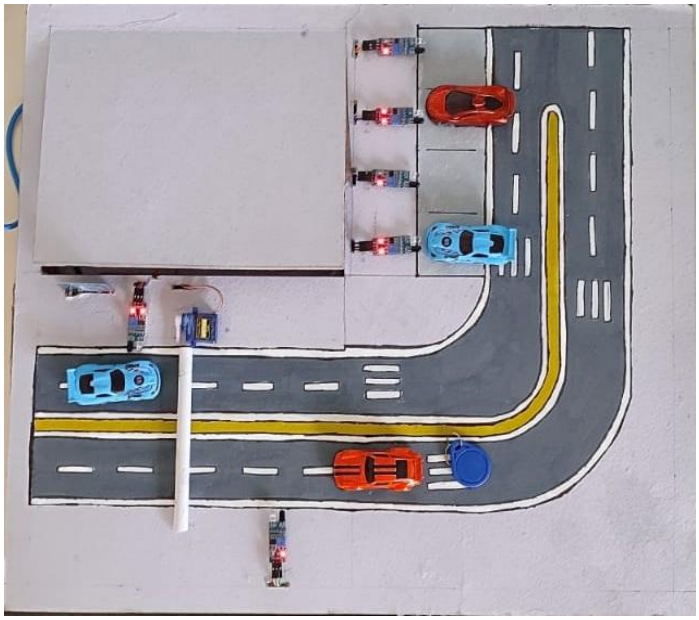

Figure 6.2.1 Smart parking system

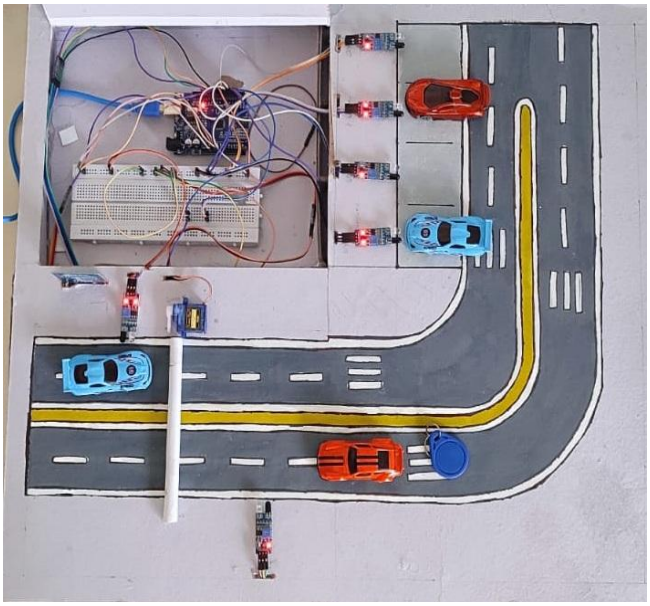

Figure 6.2.2 Smart parking system

VIII. CONCLUSION AND FUTURE SCOPE

The Smart Parking System is an innovative and effective solution for addressing the issues of urban parking management. Utilizing IoT technology, RFID authentication, and real-time slot detection, the system automates the process of parking, reduces human intervention, increases security, and maximizes space utilization. Automatic entry-exit systems based on servo motors and cashless RFID-based transactions ensure easier and more efficient parking. Further, this system also alleviates traffic congestion by directing drivers to vacant parking spaces, ultimately reducing fuel usage and environmental pollution. The cost-effectiveness, scalability, and real-time monitoring of the system make it an invaluable resource in the construction of smart cities. If implemented and integrated with mobile apps or cloud databases correctly, the Smart Parking System can considerably enhance parking efficiency, minimize operational expenses, and boost user satisfaction.Integration with Mobile Applications – A specific mobile app can be created to offer real-time parking availability information, reservation capabilities, and payment integration for an easy user experience..

REFERENCES

[1]. M. Dixit, A. Priya, G. Haldiya, A. Priya, and B. Kumar, "Smart Car Parking System using Arduino," in *2023 IEEE International Students' Conference on Electrical, Electronics and Computer Science (SCEECS), IEEE, Feb. 2023, pp. 1–6. doi:* 10.1109/SCEECS57921.2023.10063121.

[2]. C. Avinash, G. Rohit, C. Rajesh, A. Suresh, and S. Chinnadurai, "IOT Based Smart Parking System With E-Ticketing,"
in 2022 International Conference on Recent Trends in Microelectronics, Automation, Computing and Communications
Systems (ICMACC), IEEE, Dec. 2022, pp. 108–112. doi: 10.1109/ICMACC54824.2022.10093659.

[3]. Veeramanickam, M. R. M., et al. "IoT based smart parking model using Arduino UNO with FCFS priority scheduling." *Measurement: Sensors 24 (2022)*: 100524.

[4]. Mariappan, Dinesh Babu, Ankit Parihar, and Mayank Kumar. "Ardino based IoT smart parking system." 2021 3rd *International Conference on Advances in Computing, Communication Control and Networking* (ICAC3N). IEEE, 2021.

[5]. S. GokulKrishna, J. Harsheetha, S. Akshaya, and D. Jeyabharathi, "An IoT based Smart Outdoor Parking System," *in*
2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS), IEEE, Mar. 2021, pp. 1502–1506. doi: 10.1109/ICACCS51430.2021.9441766.

***[6]*.** Y. Agarwal, P. Ratnani, U. Shah, and P. Jain, "IoT based Smart Parking System," *in 2021 5th International Conference*
on Intelligent Computing and Control Systems (ICICCS), IEEE, May 2021, pp. 464–470. doi:
10.1109/ICICCS51141.2021.9432196.

[7]. D. Ashok, A. Tiwari, and V. Jirge, "Smart Parking System using IoT Technology," *International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE), IEEE*, Feb. 2020, pp. 1–7. doi: 10.1109/icETITE47903.2020.457.

[8]. Y. S. Parihar, "Internet of Things and Nodemcu A review of use of Nodemcu ESP8266 in IoT products," *International Journal for Research Trends and Innovatio*, vol. 6, no. 6, pp. 1085–1088, 2019.

[9]. Mudaliar, Shruthi, et al. "IoT based smart car parking system." *Int J Sci Adv Res Technol 5.1 (2019)*: 270-272

[10]. Khanna, Abhirup, and Rishi Anand. "IoT based smart parking system." *2016 international conference on internet of things and applications (IOTA). IEEE, 2016.*

[11]. Rahman, Saidur, and Poly Bhoumik. "IoT based smart parking system." *International Journal of Advances in Computer and Electronics Engineering 4.1 (2019): 11-16.*

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