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Smart Parking Monitoring System Based on The Internet of Things Using Arduino and NodeMCU

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***Abstract*—** Internet of Things (IoT) and smart city ecosystem, smart parking is an innovative solution that is relevant in developing a better future city. Along with the growth in the number of vehicles, parking spaces are available in public places such as development centers, airports, stations, and others whose capacity is increasingly limited. This research is to design an application and tool with the aim of arranging parking space reservations so that it is easy for drivers to get a spot. This design includes hardware and an Internet of Things connection with the designed application. This system connects IR Sensor to Arduino and NodeMCU wifi module. The NodeMCU chip consists of a SOC (system on a chip) with integrated TCP/IP protocol that allows Arduino to access the network. The cloud acts as a database to store all data related to parking areas and users who have access to the system. This component is placed in the parking area. The design results found that if there is a parked vehicle 2 LEDs will light up green, if obstructions or vehicles are not found, set to only 1 LED lit and a message is sent to the smartphone app informing them of unavailable parking. While the ultrasonic proximity sensor does not detect anything within 50 cm, on the app a white LED indicates that a parking space is available. A parking system that can provide parking location recommendations for checking sequences by a microcontroller program.

***Keywords*—**IoT, Smart parking, ESP8266, Arduino Uno, Blynk.

I. INTRODUCTION

The parking system has an important value today. The market is in dire need of a system that can regulate traffic in and out of a vehicle in the parking area. The availability of parking spaces is influenced by many things, including population growth and economic activity in the transportation sector, which is getting bigger every year. The presence of several parking users for both two- and four-wheeled vehicles in a region, even if there isn't enough room for everyone's cars to park (Putri, Dewa Ayu Putu Adhiya Garini, Putu Alit Suthanaya, 2017).

An adequate parking system is needed to keep up with the growth in the number of motorized vehicles, which is increasing every year. The current parking system is considered inefficient, resulting in congestion, air pollution, and increased fuel use. An effective smart parking system for finding available parking spaces is needed to overcome this problem (Muhammad, 2015).

Modern society is rapidly evolving as a result of scientific and technological advancements that make it possible to produce a wide range of intelligent tools, systems, and tools. Home appliances, robotics, intelligent vehicles, intelligent transportation systems, automation, intelligent sensor networks, communication systems, and various other gadgets are examples of these intelligent equipment, devices, and systems. This technology makes life more convenient, adaptable, and comfortable for people. Modern technology and its capabilities have an impact on many facets of human life, either completely or partially (Fahim et al., 2021).

To deliver the finest service swiftly and safely, it is necessary for elements like cars, roads, and users to be connected and assessed. This is the ecosystem for smart cities (Gohar et al., 2018). One reason for moving towards a smart city ecosystem is to use the potential of existing technology and infrastructure to provide the best utility to users and increase productivity. With the help of IoT applications, mobility and transportation are considered key factors that have an impact on maintaining our surrounding environment, especially for those using intelligent transportation systems (Bibri, 2018). The Internet of Things (IoT) has dramatically altered human behavior patterns over the past several years by offering a variety of facilities and convenience alternatives to improve daily living. IoT connects electronic devices in the digital world that have a sensor network and an internet connection (Qian et al., 2018; Sinha et al., 2017). Research related to the IoT field has found an exponential increase in IoT devices. By the end of 2020, there will be more than 25 billion IoT-based devices online (Sinha et al., 2017). IoT enables more efficient integration, interaction, and communication with digital electronic devices, sensors, and actuators that provide the services needed to achieve specific goals (Lee, 2019; Sha et al., 2020). IoT security employs numerous security controls, serving as a framework for other technical advancements (Ejaz et al., 2017). The Blynk application is a platform used to control Arduino, ESP8266, Raspberry Pi, and other modules via the internet. This server service has a mobile user environment for both Android and iOS that supports a variety of hardware that can be used for Internet of Things projects (Rismawati & Vidyaningtyas, 2020). Microcontrollers could maintain function while waiting for interrupts so that many of the microcontrollers used to be applied to certain applications (Laksono & Budiarso, 2023). NodeMCU ESP8266 offers convenience for developing internet-based devices because it is equipped with a wireless communication module (Wi-Fi). When more than one NodeMCU ESP8266 device with sensors works together, NodeMCU can be categorized as a Wireless Sensor Network (Arsyistawa et al., 2017; Syamsiar et al., 2016).

In big cities, smart parking systems are frequently deployed, even in malls. There are sensors that can detect the presence or absence of parked vehicles (Pradana, 2015). Drivers still must go around looking for available parking spaces. Implementing smart parking using IoT can have a significant impact on reducing delays and crowded conditions in parking areas. IoT sensors can be installed in parking spaces to detect the presence or absence of vehicles. This data can be collected in real-time and transmitted to a centralized system. Drivers can access this information through mobile apps or digital displays, enabling them to find vacant parking spots quickly, reducing the time spent searching for parking spaces.

This research is used to test the application of Internet of Thing technology that is connected to digital electronic devices and to determine the performance of smart parking systems with the Internet of Thing. This research is expected to provide benefits to the public and related agencies to provide information about the availability of parking lots. The information obtained can make it easier for the driver to order and manage parking spaces and can generate information on the performance of the Internet of Thing integrated smart parking system which information can be used as a reference for further research.

The implementation of IoT-enabled smart parking systems offers multifaceted benefits for urban environments. Not only does it alleviate traffic congestion by facilitating quick and efficient parking space location, but it also minimizes air pollution and fuel consumption by reducing unnecessary vehicle idling. The integration of IoT technology enhances the user experience through real-time information access, while optimizing parking space utilization and supporting informed urban planning decisions. Furthermore, these systems contribute to sustainable transportation choices, provide a foundation for future research and innovation, and foster public awareness and engagement in shaping dynamic and responsive urban transportation systems.

II. Literature Review

A. State of The Art

Big cities face huge problems in providing parking space for their citizens during the rush hour of the day. As a result, citizens spend countless hours searching for the perfect parking space or standing in line to find one. This, in turn, creates traffic jams. Considering the problem, many researchers have suggested different smart parking systems (SPS) approaches and technologies to reduce this problem. In their research, researchers filled the gap by providing insight into the suitability of SPS in various environmental conditions and its advantages (Fahim et al., 2021). The smart parking system architecture (SPS) consists of several layers based on their function (Bagula et al., 2015; Revathi & Dhulipala, 2012). First, the sensing layer, which is the framework of the smart parking system, and is responsible for detecting the presence or absence of vehicles in an area using different sensing technologies. This technology mostly consists of receivers, transmitters and anchors. The second, the network layer, is the communication segment of the system, which is responsible for exchanging messages between receivers/transmitters and anchors. Third, the middleware layer, which is the processing layer of SPS where a new algorithm is used to process real time data. This layer also acts as a data store, as well as a liaison between end users who request services from lower layers. Finally, the application layer, which is the top layer in the system, connects SPS with clients (end users) who request different services from cellular information panels and/or different stations. The smart city structure aims to combine data from various sources and destinations in a single point. In article (Kilic & Tuncer, 2017) provides a framework that can instantly communicate park information to visitors in various parts of the city. Parking information is stored in a database using cloud architecture via sensors at the entrance to the parking lot. Visitors can get parking information stored in a database with a mobile application. This smart parking system makes it possible to find a suitable parking space, to prevent loss of customer time and to reduce costs.

B. Internet of Thing

The Internet of Things, or what is often called IoT, is the concept of everyday objects that are connected to the internet and can identify other devices. The Internet of Things is divided into two parts: the Internet, which is a computer network system that is interconnected to serve users by using standard internet protocol packages (TCP/IP), and Things, which are objects or devices (Shidiq, 2018). The principle of IoT is that it is a medium that helps facilitate daily human activities (Adani, 2020). If this IoT technology is realized, it will facilitate daily human activities without having to operate tools or machines one by one. Tools or machines that have IoT technology will work by themselves.

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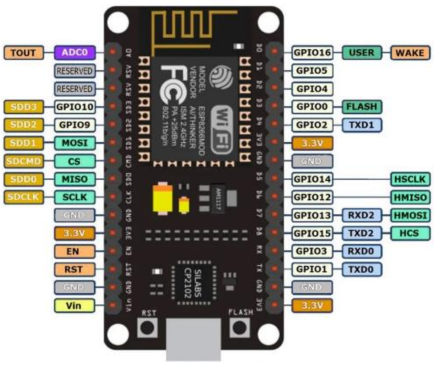
C. *Smart Parking*

Smart Parking as seen on Picture 1 is part of the internet that uses sensors that communicate remotely via the internet and share information using a communication protocol (Fahim et al., 2021). Smart Parking is a monitoring and security system for parking access. With Smart Parking, it will really help drivers find available parking spaces and maintain vehicle security. Smart parking is also one of the many technologies implemented in the smart city concept (Al-Turjman & Malekloo, 2019).

Picture. 1. Smart parking

D. *ESP8266 NodeMCU*

The ESP8266 NodeMCU firmware by Expressive is free and uses the SPIFFS file system for the on-module and flash-based ESP8266 Wi-Fi SOC (NodeMCU 2018). Uses the Arduino IDE software to be programmed and is capable to uploading data from numerous sensors to the Internet. The ESP8266 NodeMCU was chosen to connect to sensors and upload environmental data to the IoT platform through Wi-Fi due to its characteristically cheap cost. Using the HTTP protocol and an API key, NodeMCU can communicate with IoT systems and the cloud (Application Program Interface). Access to discreetly handle and watch over data is available to users. The ESP8266 NodeMCU pin layout is shown in Picture 2.



Picture. 2. Central unit: ESP8266

ESP8266 NodeMCU is a versatile and popular microcontroller development board that can be utilized in various Internet of Things (IoT) projects, including an automatic parking system. The ESP8266 NodeMCU is relatively inexpensive compared to other microcontrollers, making it an affordable choice for small-scale projects. NodeMCU allowing it to connect to the internet and communicate with other devices or services. This feature is beneficial for remote monitoring and control of the parking system. The compact size of the NodeMCU board makes it suitable for embedding within the parking system without taking up much space. The NodeMCU can be programmed using the Arduino IDE or other supported platforms, making it accessible to beginners and developers with little or no prior experience. NodeMCU provides several General Purpose Input/Output (GPIO) pins that can be used to interface with various sensors, actuators, and components required in the automatic parking system. using GPIO pins, NodeMCU can connect to proximity sensors (e.g., ultrasonic sensors) to detect the presence of vehicles and determine parking space availability. The onboard processor of the NodeMCU allows for real-time data processing, making it capable of handling tasks such as parking spot monitoring, occupancy status, and sending alerts. NodeMCU's Wi-Fi capability enables it to communicate with cloud services or platforms, allowing for data storage, analysis, and access from anywhere. NodeMCU offers flexibility and a wide range of libraries and community support. This enables developers to customize and enhance the automatic parking system according to their specific requirements. ESP8266 NodeMCU is designed for efficient power usage, making it suitable for IoT applications that need to be powered by batteries or solar panels. Based on a microcontroller with 8 bits and 32 kilobytes of flash memory (ATMEGA328; Atmel Corp., San Jose, CA, USA). The board features 6 analog input pins and 14 digital input/output pins. It contains a USB port that can be used as a data transfer port for computers. Arduino sketches for sensor control and data acquisition are available on the www.jaimegb.com web page. Specifications for the Arduino Uno (Aptisi, 2019).

E. *Arduino*

Arduino uno provides 20 I/O pins, consisting of 6 analog input pins and 14 digital input/output pins for analog 6 pins themselves which can function as digital outputs if additional output is needed besides the 14 pins already available. Arduino Uno specifications show on Table 1.

Table. 1. Arduino Uno specifications

Specification	Information
Microcontroller	ATmega328P
Voltage	5 Volts and 3.3 Volts
Input Voltage	7-12 Volts
Input Voltage	6-20 Volts
Digital I/O pins	14 (6 as pwm outputs)
PWN Pins	6
DC current per I/O Pin	20 mA
Current DC pin 3.3 V	50 mA

Specification	Information
Flash Memory	32 KB (Atmega328P), 0.5 KB used bootloader
SRAM	2KB
EEPROM	1KB
Clock Speed	16MHz
Length	68.6mm
widths	53.4mm
Weight	25 g

Source: (Aptisi, 2019)

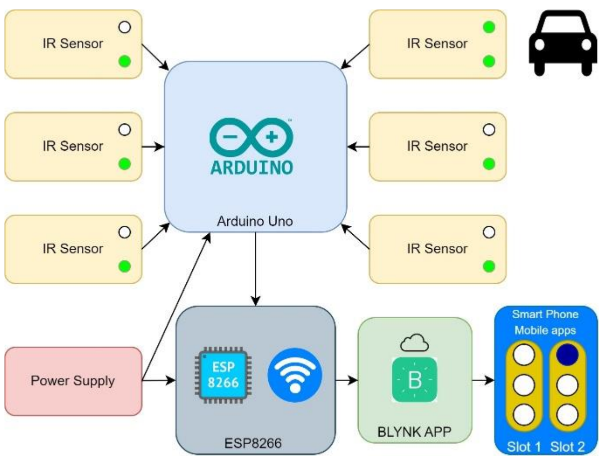
F. BLYNK

The BLYNK app is a mobile app supporting iOS and Android OS for the most popular IoT platforms to connect devices to the cloud, design apps to control them, and manage devices. In this project, BLYNK is used to display the status of the parking slots in the parking lot.

III. Research Methods

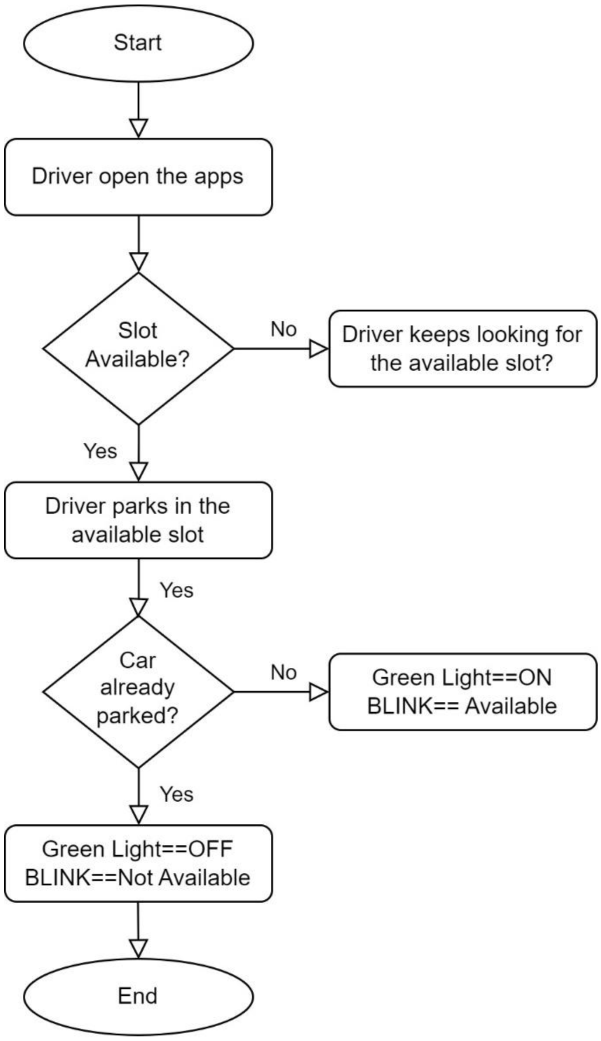
A. System Design

This part elaborated the approach to develop the proposed Smart Parking System. The smart parking system architecture is shown in Picture 3, illustrating the components used. The IR sensor is connected to the Arduino and the NodeMCU Wi-Fi module. The NodeMCU chip is a system on a chip that includes built-in TCP/IP protocols that let Arduino connect to wireless networks. The sensor and the NodeMCU are connected through Arduino. The cloud functions as a database to store all the information about the parking lot and the system's users. The NodeMCU is then used by the Arduino to transmit the data to the cloud. The mobile application serves as the user's interface for communicating with the Blynk Cloud system.



Picture. 3. System Architecture

The database, which houses user data, and data analysis make up the first and second components of the software system. This is how the system functions: The LED becomes blue while processing when space is occupied, which is determined by successive readings from the ultrasonic sensor and notifies the Blynk mobile app that there is a car nearby. The ultrasonic sensor will read a car approaching and send data to the Arduino, which is delivered to the NodeMCU, which transmits the information to the cloud where the database is hosted. The system will next perform an authentication check by comparing the received data to the database's data. The LED will change to a solid blue state if there is a match with the database. If there is not a constant reading of object within 30 cm, the system will set the LED to white, indicating that a parking space is available. The flowchart in Figure 4 shows the system flow for cars entering and exiting the parking lot. The running system begins with compiling a system flowchart. The system flowchart can be seen in Picture 4.



Picture. 4 Flowchart System

III. Result and Discussion

A. Prototype System

This project produces a working prototype of a smart parking system using nodeMCU and Arduino hardware, and proximity sensors to detect objects that are connected to the application shown in Picture 5.

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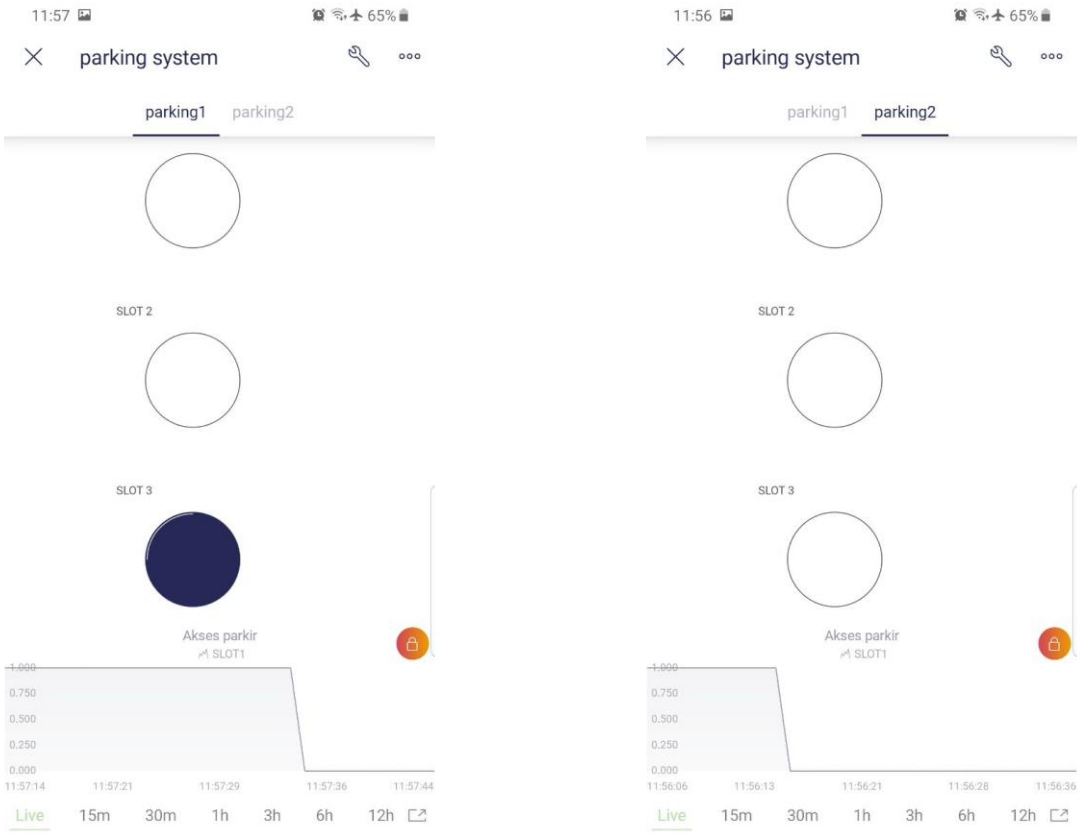
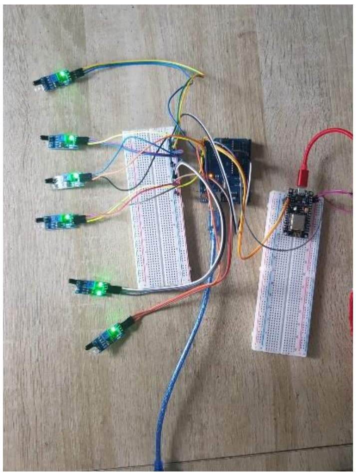


(a) (b)

Picture. 5. Smart Parking System Application Display, Parking Slot 1 (a), Parking Slot 2 (b)

The application has a number of views, as shown in Picture 6.



Picture. 6. Smart Parking System Prototype

The online dashboard menu's contents from the sensor detection findings are shown in the first display of the menu for parking spaces one and two in Picture 7 after that. It will be determined as filled or occupied if a car is recognized if the IR obstacle sensor is obstructed by a car based on the prototype in Picture 5, which is comparable to parking spots 1 and 2, each of which includes three sensors. As a signal or indication that the parking area is occupied by things, the LED will be turned on. The sensors in this system communicate with each other via a Wi-Fi connection (Arduino, ESP8266, and Blink Cloud). Sensor data is transmitted and coordinated with data in the application. Then, the application will show current parking lot information. Picture 6 illustrates how the application is synchronized with a real-time database in Blink, which functions as a cloud.

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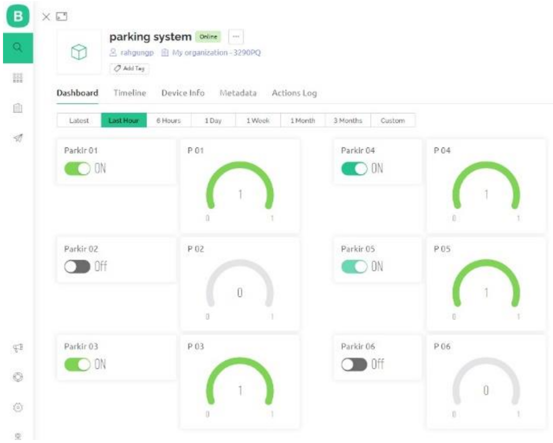
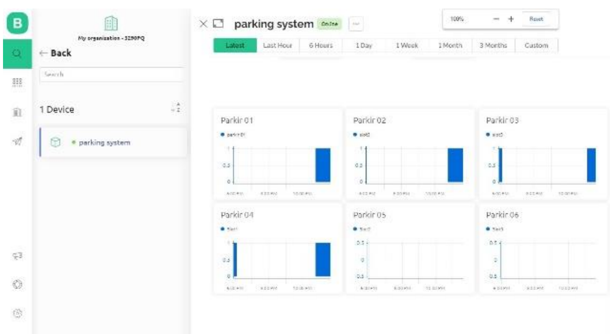


Picture. 6. Central unit: ESP8266

This is being done to test the idea of the Internet of Things (IoT), which is the situation in which anyone can access data at anytime, anywhere, simply using an internet connection.

B. *Hardware Testing*

In order to create a prototype module, we used an Arduino Uno and NodeMCU, an ultrasonic proximity sensor, and an online Blynk Cloud database. If a vehicle is detected within 50 cm of the ultrasonic proximity sensor, the sensor refers to the subsequent action. While data is being gathered and processed, the sensor's LED flashes green. The system transmits data that is received by the ultrasonic sensor; if it detects a parked car, two LEDs are set to turn green; if vehicle or obstacle is not detected, only one LED is set to turn on, and a message alerting the user to illegal parking is sent to the smartphone application. Available. Despite the ultrasonic proximity sensor not picking up anything within 50 cm, when a parking place is requested, a white LED turns on.



Picture. 7. Visualization of Vehicle Detection

To perform analysis and provide visual dashboards that depict various parking statuses, Blynk charts are utilized as cloud-based analysis and application tools. A graph shown in Picture 7 shows that parking space I is entirely occupied whereas parking space II is only partially occupied. This dashboard is simple to comprehend and can be accessed via a web interface and application to allow monitoring the state of numerous parking lots in real-time. The dashboard also shows a graph of the most recent sensor readings that the system used to determine the state of the parking.

C. *Software Implementation*

This system's firmware, ESP8266 Standalone, is an example file based on the Blynk IOT library in the Arduino IDE (Wan, Song, and Cao 2019). Using an Auth Token given by Blynk IOT, we connected the NodeMCU to the Blynk server after creating an SSID and password. A wireless network is established between Blynk IoT and the client (NodeMCU) after the firmware has been uploaded to the NodeMCU. As illustrated in Figure 7, we then design six control buttons and set the output pins that will be utilized to instruct the NodeMCU to perform certain actions. After the NodeMCU receives the control command, the relay module's channel status is changed from on to off or from off to on.

IV. CONCLUSIONS

The intelligent parking system has been successfully created in accordance with the objective, namely, to find out the condition of the parking lot via the internet that is connected to the application in real-time. The system provides information to users via the internet, which is connected to the application in real time, about the available parking spaces. This application can allow parking lot users to search for empty spaces in parking lots using Internet of Things (IoT)-based applications. After reviewing several implementations of various smart parking systems, we propose prototypes, build successful implementations of similar smart parking systems, and add an online database. The system is based on IoT, which takes the real-time value from the sensor and forwards it to the server, which then passes the data to the mobile application. The prototype was successful in identifying vacant parking spaces cost-effectively while increasing the accuracy and efficiency of monitoring, tracking, and smart city ecosystems. The development of this system is to collect real-time data after it is implemented in real parking lots, and with the help of the collected data, it can predict parking availability.

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