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Original Article

An Improved IOT Smart Parking System

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Abstract *- An improved smart parking system was designed and implemented using Internet of Things (IoT) Technology. The study deployed a wi-fi module to inquire about available parking space, register a prospective vehicle owner for reservation and obtain a confirmed or cancelled reservation via the mobile app. A unique feature of the parking slot is the presence of sensors that can activate an alarm in the event of an emergency incident. The parking system implementation involved a three-slot prototype whose status can be accessed remotely through the web application. The system operates in automatic mode depending on the online space availability or reservations made by the user. On parking a car in the allotted slot, an infrared sensor in that position detects its presence by changing the state of the output signal from LOW to HIGH. On booking, a "notify me" button is activated, and the web application sends a confirmation email stating the available space's status. A subscription test was carried out to verify if a user can subscribe for the notification in an event where there is no space available at that particular point in time. A space Status Test was conducted to ascertain whether the status of the parking spaces changes in real-time. The Reservation Test was also carried out to ensure users make reservations to confirm the availability of parking spaces before arrival. The improved IoT parking system has intelligent parking functionality with real-time responses, stability and practical utility compared to traditional parking systems.*

Keywords *- Infrared sensors, Internet of things, Smart parking, Wi-fi module.*

1. Introduction

The Internet of Things (IoT) is essential for connecting devices/machines to the network and then accessing them from any location. The need for humans to stay current with evolving technologies cannot be overemphasized. Moreover, typically, individuals have trouble finding parking spaces for their cars in cities. [1] developed a Smart Parking System (SPS) that allows users to locate the closest parking spot and displays the number of parking spaces that are currently available there. Additionally, it primarily focuses on minimizing the amount of time needed to locate parking spaces and also minimizes needless transit through densely populated parking spaces. As a result, it lowers fuel usage and atmospheric carbon footprints.

The implementation of a smart parking mechanism, which greatly lessens difficulty in conventional parking systems, was examined by [2]. By placing a sensor node on each parking space, the system can keep an eye on its condition. As a result, the sensor determines the parking space's status and notifies the controller of the central node server. The Node MCU gathers data from every sensor node and uploads it to the server, where users may use the internet from any location to verify the status of their parking. Devices, objects and machines can be connected to the internet and be recognized by other devices with IoT Technology [17]. It is accompanied by features like data sharing, remote control, machines, sensors, and electronics, constantly connected to local networks via embedded sensors [3]. IoT offers the chance to resolve issues, and enhance, simplify, and automate many different processes that take place every day. IoT technology has been adopted in numerous industries, including manufacturing, healthcare, and agriculture [4]–[6]. Additionally, smart parking and home monitoring employ it [7], [8]. Parking data can be captured, tracked, and analyzed through the installation of IoT to serve as the basis for decision-making [3]

2. Statement of the Problems

Due to the increase in population density and the need for individuals to live a comfortable life, secured parking spots are in relatively high demand. The drivers' parking experience is being negatively impacted by the rising number of vehicles on the road. In the conventional system, Drivers suffer significant losses in terms of money, productivity, and time spent looking for parking spaces in heavily populated locations. They are faced with numerous other limitations that tend to impede proper traffic flow and management systems. Thus, the reason for this research is to consider an improved approach to handling traffic issues and forestalling their negative impact.

3. Review of Related Works

The idea of smart cities has become very popular. The IoT module deployed on-site as part of the proposed work is utilized to track and signal the availability of parking spaces. With the aid of sensors [9] and [27], smart parking solutions can be utilized to find open parking spaces. This decreases the consumption of fossil fuels while also saving customers time. Technologies of all kinds are being employed to solve parking issues in public areas.

In [10], by employing artifacts, an IoT-based smart parking system prototype was achieved to reduce traffic congestion and make it easier to find a parking space. [11] and [25] supported IoT using resource-constrained stationary and mobile nodes. These nodes can be positioned anywhere, and their mobility improves connectivity and network coverage. In a study by [12], the authors addressed the "difficult parking" issue that frequently interferes with people's daily travel. They developed and designed an urban parking path planning system using ArcGIS software, introducing 0–1 logical variables, (considering the shortest distance, the shortest travel time, or the minimum travel cost) route planning model of the parking lot by taking into account the traffic congestion delay index, which accurately reflects information about the current state of the roads. [26] investigated the state-of-the-art networking communication technologies for the IoT, placing particular emphasis on encapsulation and routing protocols and the relationship between the IoT network protocols and new IoT applications. In [14] and [21], an RFID tag was deployed for identifying vehicles, detecting open slots using IR sensors and calculating payment based on the length of parking time using a real-time clock. [15] and [19] Considered IoT for smart city applications, while [16] introduced machine learning in smart transportation systems using IoT. In [20], a pay-as-you-go (PAYG) approach was used to reduce traffic congestion in areas with no direct relationship between the rise in vehicles and the available infrastructure to contend with it. In [22], embedded systems and sensor networks were employed to achieve an efficient parking system with an automatic payment procedure. The mobile application has also been used for smart accessing of a parking Lodge, but this time it was achieved on a mini-computer platform [23,28].

4. Methodology

The implementation of the work requires a prototype of three parking slots accessed remotely through the web application via wi-fi connectivity to access the browser to see available spaces to decide on the reservation. Figure 1 shows the conceptual framework. The parking system operates in either automatic or manual mode, depending on space availability and reservations made by the user. On parking, a car in the designated area, the infrared sensor in that position will detect an occupant's presence by changing the state of its output signal from LOW to HIGH. This signal is applied to an input pin of the Atmega328P microcontroller to enable it to send a message to the Esp8266 microcontroller, which further sends it to the MQTT broker in the cloud. The message received by the MQTT is, in turn, published to all the clients' applications to indicate that the particular space is occupied. The same process occurs when a car is driven out of a parking space. However, the message received by the client app will indicate that the space is free. When users visit the mobile application to make a reservation, they press the reservation button and follow the subsequent reservation steps to the end. Upon successful reservation, the application publishes a message to the esp8266 through the MQTT broker. The message is finally sent to Atmega328P to update the status of the spaces reserved by users by turning on their respective blue LEDs. LCDs are also updated in the area to indicate the number of reserved spaces.

4.1. Software Implementation

The Arduino IDE software was installed on a computer. It can be seen in figure 1 below

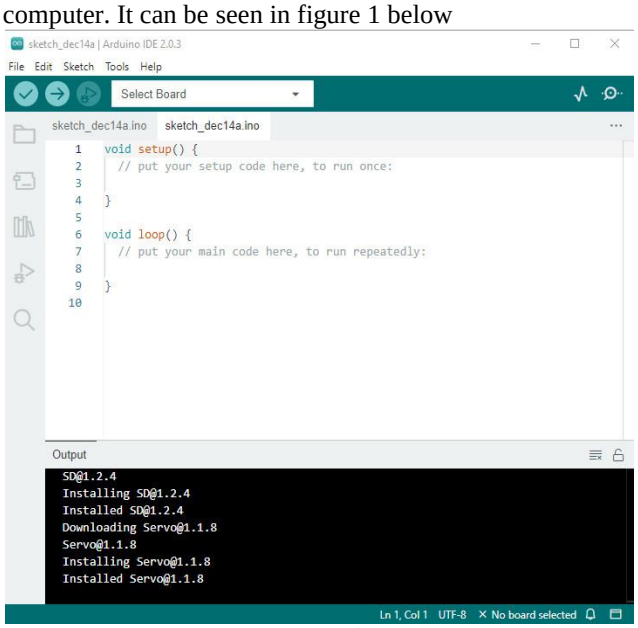

Fig. 1 Installing the Software Package

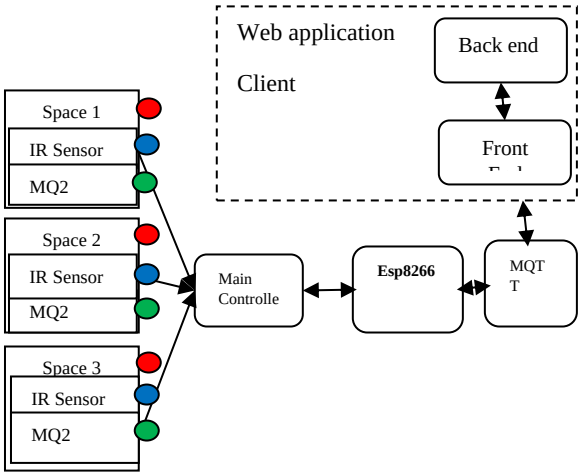

Fig. 2 The block diagram of the complete smart parking mall

4.2. Booking Process

Booking of parking space starts with visiting the web application via its url (https://car-parking-system-belloshehu.vercel.app/spaces) on a mobile device or computer. The entire process is itemized as follows:

- Visit the web application via its url (https://car-parking-system-belloshehu.vercel.app/spaces) using a computer or mobile device.

- Create an account or log in if an account is already created

- Click the reservation button to start the reservation/booking process.
- Enter the duration of the reservation in hours and minutes and the vehicle plate number
- Check out the reservation by going to the confirmation page
- Confirm the reservation if entered values are correct. Otherwise, go back to the previous page to make the necessary corrections.
- Check the email inbox for reservation/booking email confirmation
- The client can drive to their reserved space anytime as long as their reservation time is not expired.
- On arrival at the parking space, the gate is opened automatically for the motorist to enter and park the vehicle.
- The gate does not open automatically when all spaces are occupied or reserved. Hence, the motorist's identity is verified before the gate is manually opened to ensure that only people who have booked are allowed.

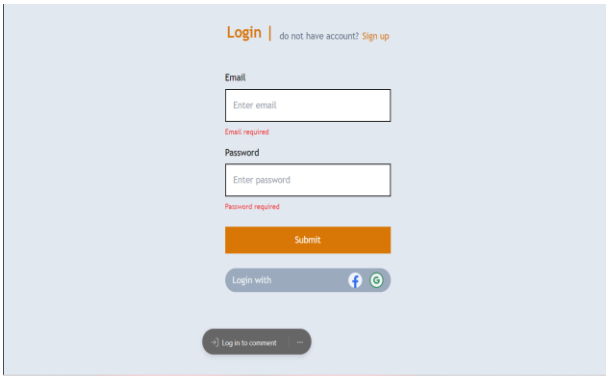

Fig. 3 Login page of smart parking web application

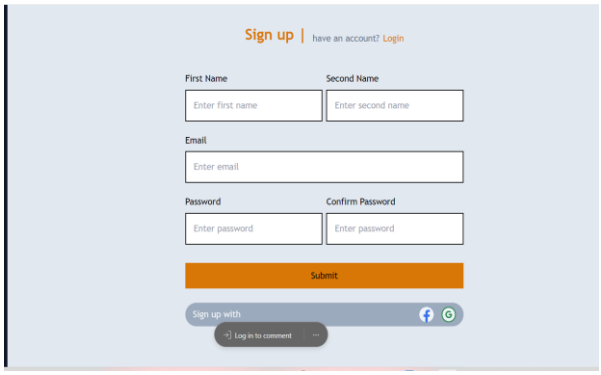

Fig. 4 Registration page of smart parking web app

4.3. Construction of Smart Parking System

After selecting components, modules and design of circuits, the construction, which involves PCB preparation, soldering components on PCB, connecting sensors and actuators to their respective interfaces, fabrication casing and the wooden compartment, was implemented.

Fig. 5 Space page of smart parking web application

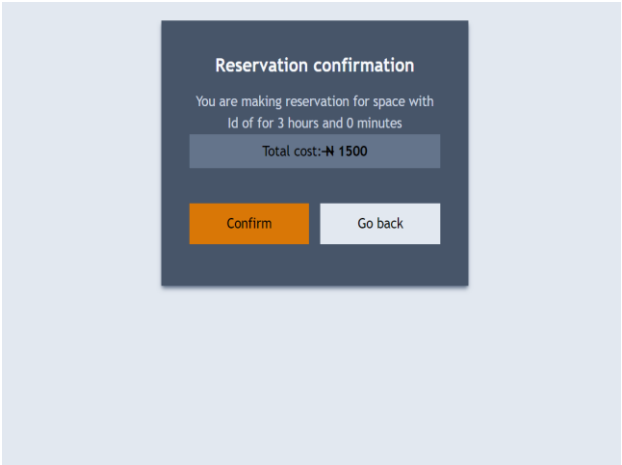

Fig. 6 Reservation confirmation page of smart parking web application

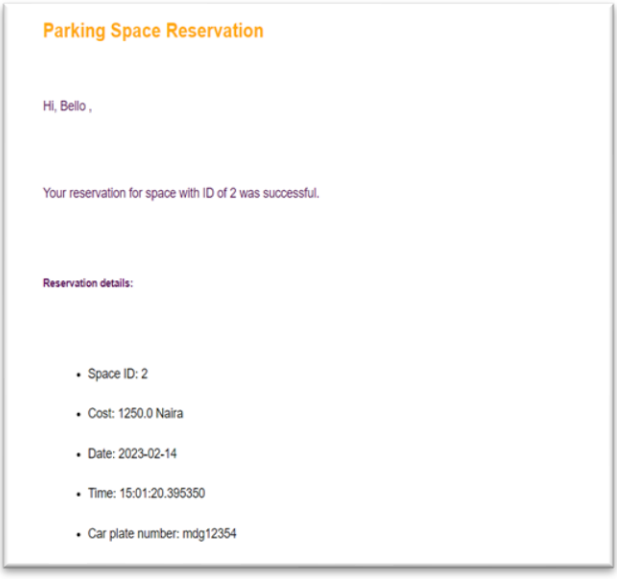

Fig. 7 Confirmation email for the booking

The completed parking lot is shown in figure 8 below.

Fig. 8 Completed Parking Lot

5. Results

The following tests were conducted to verify the functionality of the work in accordance with the requirement and stipulated objectives:

5.1. Reservation/booking Test

The essence of this test is to verify if a user can subscribe for the notification in a situation where there is no space available at that point in time. In this test, all instances of the space were either not created or occupied. So, a User would click the "notify me" button and a confirmation email is sent automatically by the web application.

If, for some reason, the user feels the need to cancel a subscription, the cancel button on the subscription page is activated, and then an email will be sent to confirm their cancellation success. Three different users conducted this test; Mr. Farooq Ado, Mr. Aminu Aliyu and Bello Shehu. The response of Bello Shehu is presented below.

Fig. 9 Reservation Cancellation Test Results

5.2. Space Status Test

The space status test was conducted to ascertain whether the status of the parking spaces changes in real-time. To achieve that, three items were used to represent/model cars, each removed and placed back to observe if the system indicates the change of their respective status in real-time. The test result is shown in figures 10 and 11 with LEDs to also respond to the changing status.

Fig. 10 Occupied Parking Spaces

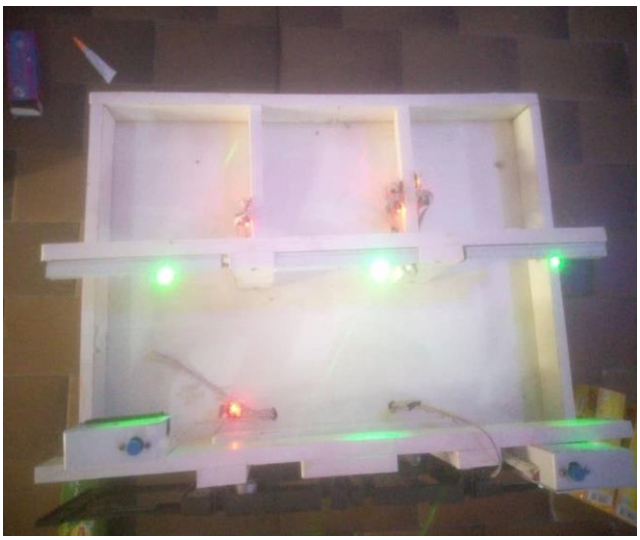

Fig. 11 Free Parking Spaces with Green LED

5.3. Reservation Test

One of the unique features of this parking system is that it allows users to make a reservation about parking for space availability before arrival. A reservation test was conducted to ensure this feature functions to satisfy its users.

The same users conducted this test; Mr. Farooq Ado, Mr. Aminu Aliyu and Bello Shehu. They both visited the site and made a reservation for a space, respectively. The process required them to specify the duration of their stay and their respective cars' plate numbers. After submitting the reservation, a confirmation email was sent stating the ID of the space, time and date of their reservation, as shown below.

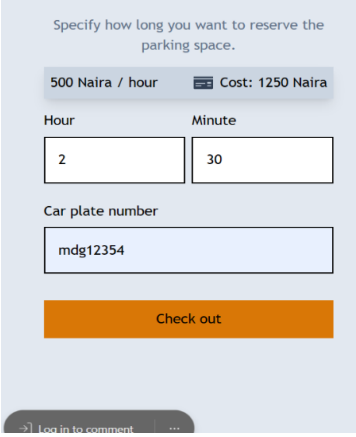

Fig. 12 Online Reservation Form

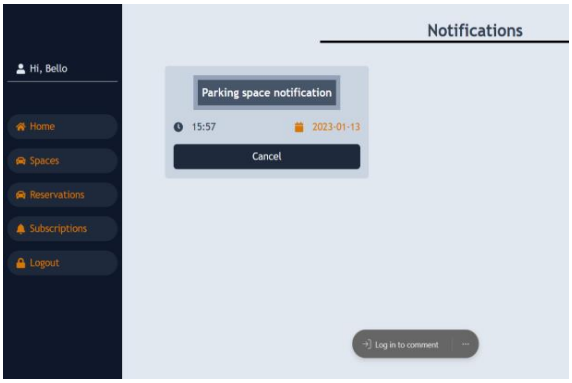

Fig. 13 Reservation template with "Cancel" Button

Conversely, users are allowed to cancel their reservation if the need arises. This action is accompanied by a confirmation email sent to users to confirm their cancellation.

Table 1. Test Results

Spaces	Status	Status	Status	Mode of operation
Space 1	Free	Free	Free	Automatic
Space 2	Occupied	Occupied	Occupied	Manual
Space 3	Reserved	Reserved	Reserved	Manual

5.4. Mode of Operation Test

This test was conducted to test the automatic and manual operational modes of this system. With the three boxes in their respective positions (within the range of the Infrared proximity sensors), the system entered manual mode to ensure another car did not enter since their any space available. Only operators can open or close both gates when necessary. The boxes were removed one after the other to observe the change in the operation mode. The result of the test is shown in the table below:

6. Conclusion

An IoT-based smart parking system was actualized in this work. This device was designed to indicate available and occupied slots to minimize traffic disorder, congestion, the greenhouse effect and unauthorized parking. It indicates the state of the parking slot on devices installed with the mobile application. Reservations are made on the device and can be confirmed or cancelled via electronic mail. Manual entry into the parking premises is also possible, but the gate opens only when there is available space. Compared with traditional parking systems, the smart parking system is, in a real sense, intelligent, with convenience, high stability and practical utility.

References

[1] Suvarna Nandyal, Sabiya Sultana, and Sadaf Anjum, "Smart Car Parking System using Arduino UNO," *International Journal of Computer Applications*, vol. 169, no. 1, pp. 13–18, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[2] Harkiran Kaur, and Jyoteesh Malhotra, "A Review of Smart Parking System based on Internet of Things," *International Journal of Intelligent Systems and Applications in Engineering (IJISAE)*, vol. 6, no. 4, pp. 248–250, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[3] Abhirup Khanna, and Rishi Anand "IoT based Smart Parking System," *International Conference on Internet of Things and Applications(IOTA)*, pp. 266–270, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[4] Lin Li, "Application of the Internet of Thing in Green Agricultural Products Supply Chain Management," *Fourth International Conference on Intelligent Computation Technology and Automation*, vol. 1, pp. 1022–1025, 2011. [CrossRef] [Google Scholar] [Publisher Link]

[5] Geng Yang et al., "A Health-IoT platform based on the Integration of Intelligent Packaging, Unobtrusive Bio-Sensor, and Intelligent Medicine Box," *IEEE Transactions on Industrial Informatics*, vol. 10, no. 4, pp. 2180–2191, 2014. [CrossRef] [Google Scholar] [Publisher Link]

[6] T. Qu et al., "IoT-based Real-Time Production Logistics Synchronization System under Smart Cloud Manufacturing," *The International Journal of Advanced Manufacturing Technology*, vol. 84, pp. 147–164, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[7] Shopan Dey, Ayon Roy, and Sandip Das, "Home Automation using Internet of Thing," "*7th Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON)*, pp. 1-6, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[8] Chokshi N Vishwa, "A Survey: Smart Parking System using Internet of Things (IoT)," *International Journal of Advance Engineering and Research Development*, vol. 4, no. 4 847-849, 2017. [Google Scholar] [Publisher Link]

[9] Ifeoma B. Asianuba, and Nzete Emeke Anderson, "Wireless Sensor Network for Car Space Display Unit," *World Journal of Innovative Research*, vol. 6, no. 3, pp. 6–10, 2019. [Publisher Link]

[10] E. Cassin Thangam et al., "Internet of Things (IoT) based Smart Parking Reservation System using Raspberry-pi," *International Journal of Applied Engineering Research*, vol. 13, no. 8, pp. 5759–5765, 2018. [Google Scholar] [Publisher Link]

[11] Sheetal Ghorpade, Marco Zennaro, and Bharat Chaudhari, "Survey of localization for Internet of Things Nodes: Approaches, Challenges and Open Issues," *Future Internet*, vol. 13, no. 8, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[12] Jianping Sun et al., "Design and Implementation of Urban Parking Path Planning System," *Advances in Social Science, Education and Humanities Research*, pp. 82–90, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[13] Oludolapo Olufajo, and Michael Mustapha, "A Scalable Smart Parking Management System with A Client Mobile Application," *SSRG International Journal of Computer Science and Engineering*, vol. 8, no. 5, pp. 1-11, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[14] S. S. Thorat et al., "IoT Based Smart Parking System Using RFID," *International Journal of Computer Engineering in Research Trends*, vol. 4, no. 1, pp. 9-12, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[15] Saber Talari et al., "A Review of Smart Cities Based on the Internet of Things Concept," *Energies*, vol. 10, no. 421, pp. 1-23, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[16] Ajay Kumar Dogra, and Jagdeep Kaur, "Moving towards Smart Transportation with Machine Learning and Internet of Things (IoT): A Review," *Journal of Smart Environments and Green Computing*, vol. 2, pp. 1-18, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[17] Abhay Deshmukh, and Radhika D. Joshi, "Understanding the Architecture of Internet of Things using a Case Study of Smart Parking," *Asian Journal of Convergence in Technology*, vol. 5, no. 1, 2019. [Google Scholar] [Publisher Link]

[18] Ganga Holi, and Rachna Rao, "An IoT Based Driver Assistance System to Detect and Notify the Presence of Potholes and Humps on Roads," *International Journal of Computer Trends and Technology*, vol. 67, no. 5, 146-150, 2019. [CrossRef] [Publisher Link]

[19] R. Subhash et al., "IoT Based Smart Parking System*," International Journal of Pure and Applied Mathematics*, vol. 119, no 14, pp. 367-375, 2018. [Publisher Link]

[20] A. Sant, L. Garg, P. Xuereb, and C. Chakraborty. A novel green IoT -based Pay-as -you-Go Smart Parking System, Computers, Materials and Continua, vol.67, no. 3, pp. 3523-3544, 2021.

[21] Pragati Kanchan, "Real Time Location Based Shared Smart Parking System," *6th International Conference on Energy and City of the Future*, vol. 170, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[22] Faiz Ibrahim Shaikh et al., "Smart Parking System Based on Embedded System and Sensor Network," *International Journal of Computer Applications*, vol. 140, no.12, pp. 45-51, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[23] Vladimir Sobeslav, and Josef Horalek, "A Smart Parking System Based on Mini PC Platform and Mobile Application for Parking Space Detection," *Mobile Information System*, vol. 2020, 2020. [CrossRef [Google Scholar] [Publisher Link]

[24] Rometdo Muzawi et al., "Pattern Lock and GPS-Based Motorcycle Security System," *International Journal of Engineering Trends and Technology*, vol. 70, no. 3, pp. 185-194, 2022. [CrossRef] [Publisher Link]

[25] Adil Hilmani, Abderrahim Maizate, and Larbi Hassouni, "Hierarchical Protocl Based on Recursive Cluster for Smart Parking Applications using Internet of Things," *Wireless Communication and Mobile Computing*, vol. 2020, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[26] Anna Triantafyllou, Panagiotis Sarigiannidis, and Thomas D. Lagkas, "Network Protocols, Schemes, and Mechanisms for Internet of Things (IoT): Features, Open Challenges, and Trends," *Wireless Communications and Mobile Computing*, vol. 2018, 2018, [CrossRef] [Google Scholar] [Publisher Link]

[27] Albert Domingo et al., "Public Open Sensor Data: Revolutionizing Smart Cities," *IEEE Technology and Society Magazine*, vol. 32, pp. 50–56, 2013. [CrossRef] [Google Scholar] [Publisher Link]

[28] Mohd Mustari Syafiq Ismai et al., "IoT Based Smart Parking System," *Journal of Physics; Conference series, 2nd International Conference on Advance & Scientific Innovation*, vol. 1424, 2019. [CrossRef] [Publisher Link]