International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 11 | Nov 2023 www.irjet.net p-ISSN: 2395-0072

Smart Parking with Multi layered Security

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Abstract - *This paper introduces a pioneering project, "Smart Parking System with Multi-Layered Security," focusing on modernizing urban parking through a mobile application that integrates Internet of Things (IoT) and Cloud Services. The project's primary goal is to enhance both efficiency and security by implementing two-factor authentication (2FA). Unlike traditional parking methods relying on physical tickets, our system employs a two-factor authentication process. The first layer involves a user's username and password, ensuring initial access control. The second layer employs biometric authentication, specifically fingerprint recognition via the mobile app. This dual-factor approach significantly elevates security by requiring both knowledge (password) and possession (fingerprint). Practical applications include streamlined parking in crowded public spaces and enhanced security in office and residential areas. Users can confidently park, knowing that unauthorized access is restricted, and the system optimizes parking space utilization. Compared to conventional systems, our 2FA-enabled smart parking system eliminates physical tickets, reducing paper wastage, and offers heightened security, fostering trust in the facility. This paper explores the innovative integration of IoT and 2FA in smart parking, presenting a comprehensive solution to challenges faced by traditional parking methods in the digital age.*

Key Words: Smart Parking, Security, IoT, Authentication, Efficiency

1.INTRODUCTION

Our project, titled "Smart Parking System with Multi-Layered Security", addresses a highly relevant and practical issue in today's urban environment. The aim is to develop a mobile application to allocate parking spaces while incorporating multi-factor security, which enhances both convenience and security for users. Although this application will be the final outcome of the project, but the entirety of the project will cover the fields of Internet of Things, Cloud Services and so on. Traditional parking methods often lead to frustration and valuable time being wasted, especially in busy urban areas or crowded locations like malls. Implementing a smart parking system offers several advantages. With a smart parking system, users can swiftly locate and reserve parking spaces through the app, saving time and minimizing traffic congestion along with helping customers in securing their vehicles. Multi-Layered Authentication (MLA) has gained significant importance in today's digital landscape due to the growing prevalence of cyberattacks and data breaches. It goes beyond the traditional username-password authentication model, requiring users to provide multiple forms of verification before gaining access to an account or system. Incorporating multi-factor authentication into your smart parking app aligns with the need for robust security in today's digital age.

The objective of this project is to design and implement a robust and secure smart parking system that integrates two-factor authentication (2FA) to enhance the security and efficiency of parking facilities. The system aims to revolutionize the way users interact with parking spaces, ensuring both ease of use and heightened security measures. Traditional parking systems rely on physical tickets or passes, often leading to issues such as lost tickets, unauthorized access, and inefficient space utilization. The proposed smart parking system addresses these concerns by introducing a two-factor authentication process. The first layer of authentication involves the user's username and password, providing initial access control. The second layer employs biometric authentication, specifically fingerprint recognition via the mobile app. This dual-factor approach significantly elevates security by requiring both something the user knows (password) and something the user possesses (fingerprint).

The practical applications of this system are far-reaching. In crowded public spaces like malls, users can confidently park their vehicles, knowing that unauthorized access is restricted. In office and residential areas, the system ensures that only authorized individuals can access designated parking slots, reducing the likelihood of theft or vandalism. Additionally, the system aids in optimizing parking space utilization, as users can seamlessly locate and navigate to available spots using the app. Compared to the conventional parking systems, the 2FA-enabled smart parking system offers numerous advantages. It eliminates the need for physical tickets, reducing paper wastage and contributing to environmental sustainability. The enhanced security measures prevent instances of vehicle theft and unauthorized access, bolstering users' trust in the parking facility. Moreover, the system's real-time alert mechanism notifies security personnel immediately if a vehicle is moved without completing the 2FA process, enabling swift response to potential security breaches.

2. LITERATURE REVIEW

The authors propose a smart parking system with multi-layered security, integrating IoT and Cloud Services [1]. The system employs two-factor authentication (2FA) to enhance security, requiring both knowledge (password) and possession (fingerprint) for access [1] . This paper introduces an IoT-driven E-Parking System, utilizing Parking Meters (PM) integrated with ultrasonic sensors and Zigbee technology [2]. The proposed system aims to provide quick and automated solutions for finding suitable parking spaces and detecting improper parking in real-time [2].

The focus of this paper is on proposing an IoT-based Parking Garage Information System (PGIS) that utilizes Wireless Sensor Networks (WSN) and RFID for efficient parking management [3]. The system employs ARM7/LPC2148 controllers, Zigbee modules, and reflection sensors for parking space detection [3]. This paper presents a smart parking service based on Wireless Sensor Networks (WSN), allowing drivers to efficiently locate available parking spaces [4]. Low-cost wireless sensor network modules are deployed in each parking slot, providing real-time parking availability information to users through a mobile application [4]. The authors propose an automatic smart parking system using IoT, aiming to assist users in locating nearby parking areas and reducing the time spent searching for parking spaces [5]. The system utilizes a cloud-based IoT architecture, Raspberry Pi microcontrollers, and Pi cameras for real-time parking information [5].

This paper introduces an innovative algorithm enhancing cloud-based smart parking using IoT technology [6]. The system optimizes parking cost based on distance and available spots, utilizing Wireless Sensor Networks (WSN) and RFID for monitoring car parks [6].

This smart parking system offers real-time online parking space information and alleviates time-consuming searches [7]. The system, driven by IoT, utilizes Arduino as the central control, ultrasonic sensors for car detection, and an Ethernet shield for internet connectivity [7].

The paper introduces an IoT-driven smart parking system designed for managing large parking lots effectively [8]. The system offers real-time information on available slots via a mobile app, employing cloud-based IoT technology and Arduino for hardware components [8].

This paper proposes a framework utilizing deep long short-term memory networks and IoT for parking space prediction [9]. The system analyzes cloud-stored data with deep learning for real-time parking availability, focusing on sensor-based architecture [9].

The authors introduce a smart parking system based on resource allocation and reservations, addressing urban settings [10]. The system employs timedriven mixed-integer linear programming (MILP) for optimal allocation and simulations show improvements in search time and parking costs [10].

This paper introduces an algorithmic approach to parking planning, treating it as a linear assignment problem [11]. The proposed algorithm focuses on effective problem resolution using a Greedy approach [11]. This paper introduces a smart parking system allowing users to reserve slots via an Android app [12]. The system aids vehicle owners in locating parking spaces and encompasses both software and hardware platforms [12]. The paper introduces a smart car parking system, addressing parking space availability and traffic congestion [13]. The system locally processes data and applies filtering and fusion techniques, sending transformed data to the cloud for evaluation using machine learning algorithms [13]. The paper introduces an IoT-enabled smart parking system utilizing ultrasonic sensors, Arduino Uno, and a cloud server [14]. The system is accessible through an Android app, allowing users to monitor and reserve parking slots using unique OTPs for allocation [14]. This paper introduces an Android-controlled Automated Car Parking System, minimizing human intervention and enhancing efficiency [15]. The system automates parking and unparking, reducing search time for available spaces [15]. This paper introduces an IoT-based Smart Parking system with mobile integration [16]. The system offers features for reserving, authenticating users, finding nearest spots, and managing accounts [16].

This paper introduces a COVID-19 based solution focusing on sanitization and access control through a smart door [17]. The smart door incorporates sensors such as ultrasonic and temperature sensors for access control [17].

This paper presents a low-cost smart home device focusing on home security and automation [18]. The device utilizes cost-effective microcontrollers like Arduino boards and related modules for implementation [18].

This paper introduces a system for automating the garage door based on the owner's presence using PIR sensors [19]. The system detects movement and sends signals to a microcontroller, automating the garage door opening and closing [19].

This paper presents an independent security system for garage door access using Radio Frequency Identification (RFID) [20]. The system identifies users through RFID tags and allows access based on the tag's ID [20].

3. GAP ANALYSIS

A gap analysis of the literature survey reveals several trends and areas where further research could be explored. While the surveyed papers collectively address the integration of IoT and various technologies into smart parking systems, there are notable gaps and opportunities for future

investigations. Firstly, while many papers propose sophisticated technological solutions, few explicitly address the challenges related to user adoption and acceptance of these smart parking systems. Future research could delve into user behavior, preferences, and the impact of these technologies on user experience. Additionally, there is a need for more comprehensive studies on the scalability and adaptability of these systems to different urban environments, considering factors such as infrastructure requirements and technology dependencies. Moreover, security and privacy concerns, especially regarding the utilization of cloud services, are briefly mentioned in some papers but warrant in-depth exploration. Lastly, the surveyed literature primarily focuses on individual components of smart parking systems; future research could explore holistic approaches that consider the interplay and integration of various technologies for a seamless and effective parking experience.

4. PROPOSED SYSTEM

The Smart Parking System with Multi-Layered Security is a cutting-edge project designed to revolutionize the parking experience. It integrates advanced technologies to provide a secure and user-friendly solution for parking management.

4.1 KEY FEATURES OF OUR SYSTEM

[i] Two-Factor Authentication (2FA) with Biometric:

The project implements a robust 2FA system, ensuring heightened security.

The first layer of authentication involves username and password verification. The second layer employs biometric authentication through a mobile app, enhancing user validation.

[ii] User Interface and Parking Selection:

Upon successful authentication, users are presented with a user-friendly interface displaying available parking slots. Users can select a desired slot and proceed to park their vehicle.

[iii] Fingerprint Registration:

When a user parks their car, the chosen slot is registered with the user's fingerprint. This creates a unique association between the user, the parking slot, and the vehicle.

[iv] Fingerprint Unlocking:

When collecting the vehicle, the user must first unlock it using their registered fingerprint via the mobile app. This ensures that only authorized users can retrieve their vehicles.

[v] Security Alert System:

If the fingerprint authentication is not completed and an attempt is made to collect the car, an immediate alert notification is sent to the user's mobile device. This feature acts as a theft deterrent, allowing users to promptly inform authorities of any suspicious activity.

[vi] Motion Sensors for Vehicle Detection:

Motion sensors are employed to detect if a vehicle has moved out of its designated parking slot. This ensures accurate monitoring of parking spaces and prevents unauthorized vehicle movements.

4.2 HARDWARE AND SOFTWARE TOOLS USED

1) Hardware Tools:

- ESP32 Microcontroller
- Passive Infrared (PIR) motion sensors

2) Software Tools:

- Node RED for flow-based programming and integration of IoT devices.
- IBM Cloud for cloud-based data storage and processing.
- MIT App Inventor for creating the mobile application with 2FA and biometric features.
- Firebase for SSO Security.

4.3 NODE RED SETUP

Node-red is the MQTT connection being provided between the Microcontroller and the Mobile application used by the user. Since MQTT works on publisher-subscriber (pub-sub) model, the node-red configuration is made in such a way that both the mobile application and the microcontroller can be either pubs or subs. Node-red is powered by IBM Watson cloud service of the IBM Family; hence all configurations require the IBM node. The function

nodes implemented hold some sort of computation that needs to be carried out. All other nodes are signifying the roles being played by any of the components at any given time (either pub or sub). The pub nodes will be connected to the function nodes, which will in

turn be connected to the sub nodes and will be presenting some information. This information can be useful (like status of a sensor) or can be a garbage value (like “null” in case of a disconnect).

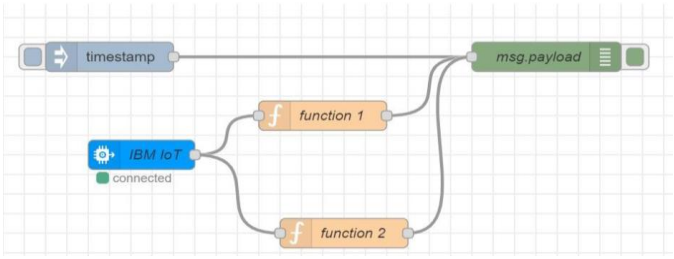

Fig. 1 -First Connections made with the Simulation

In Fig. 1, the "msg.payload" node is the payload message that is being received from the simulation, that is the Wokwi microcontroller and sensors. This message is then processed in either of the function nodes, which depends upon the message, and then sent to the "IBM IoT" node. The "timestamp" node will refresh the payload node so that there is a constant flow of messages.

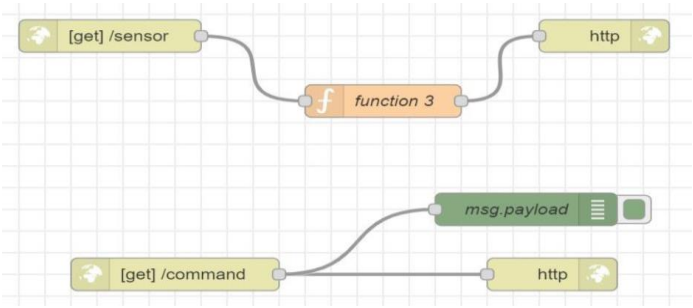

Fig. 2 - Node-red setup for Messages on a Website

Fig. 2, is another configuration for Node-red where either the payload message (lower graph) or the sensor status (upper graph) can be viewed on a website, as a JSON file. This is facilitated by the "http" nodes. The "get" nodes will be fetching the information and converting it in a JSON format.

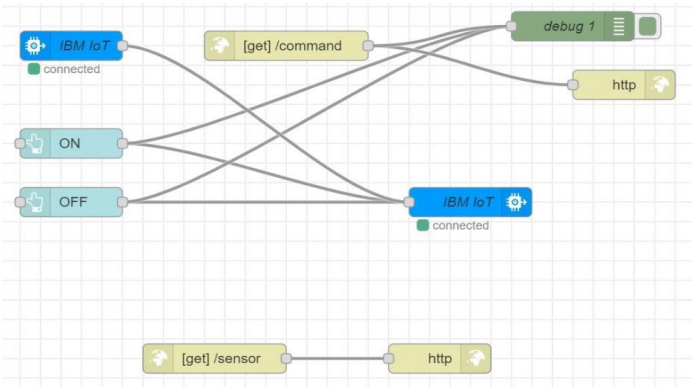

Fig. 3-Final Node-red Graph

The "IBM IoT" node from Fig. 1 will be sending the data to the "IBM IoT" node in Fig. 3. This is the final step in sending the data to the sub. The output "IBM IoT" node will be sending it to the required destination, facilitated by the "function" node. All other nodes seen in this flow are placed as a failsafe. In any case if the Mobile Application fails to work, then a website can be designed without using any web development tools for launching a website that can perform almost the same functions as the Mobile Application.

5. RESULTS AND DISCUSSION

The MIT App Inventor Tool has been used to create a Mobile Application that serves as the interface for the user to register/login and park their car in the desired location. Following are screenshots of various pages in the app:

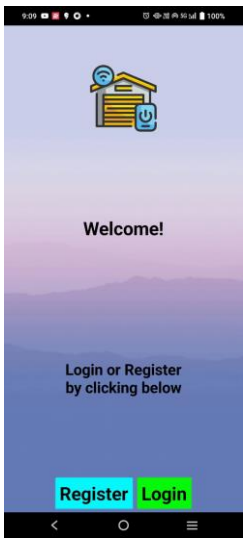

Fig. 4 – Home Page

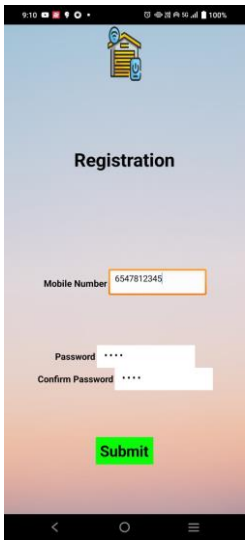

Fig. 5 – Registration Page

Upon initial load-up, the home page (Fig. 4) is displayed with the options to Register or Login. On clicking on register, the registration page (Fig. 5) is displayed. Here the user makes a new account with their mobile number and a password.

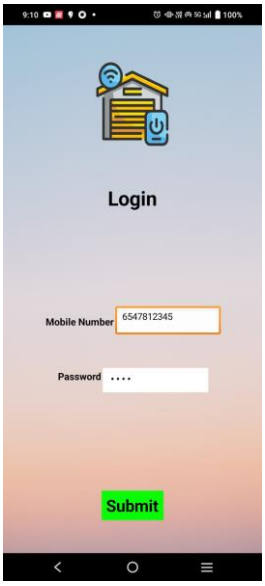

Fig. 6 – Login Page

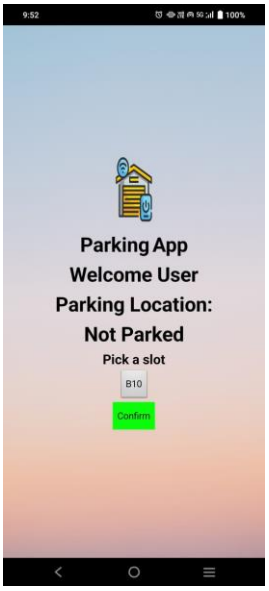

Fig. 7 – Initial interface

Login page is shown on the left (Fig. 6). Here the user can enter their credentials, and log in to the app. The Parking lot selection interface is shown in the figure on the right (Fig. 7). Here the user can select a parking slot from available slots (Fig. 8) and upon clicking on confirm, a biometric authentication is performed as multi factor authentication to ensure that it is the user who will park their car.

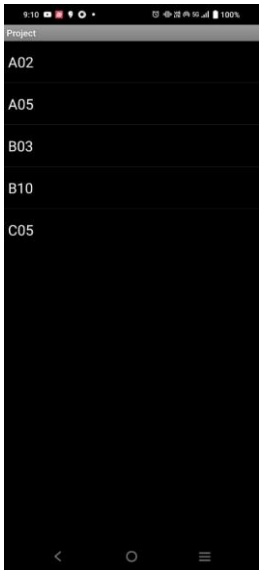

Fig. 8 – Available slots

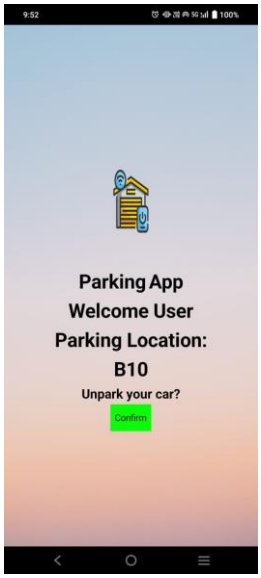

Fig. 9 –After parking

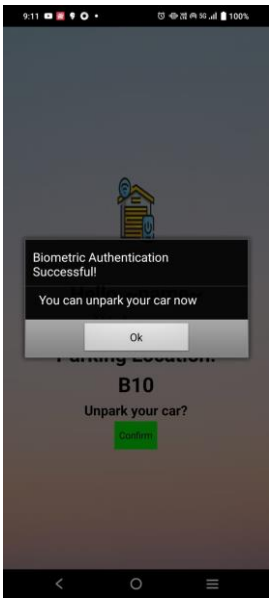

Fig. 10 – Successful Biometric

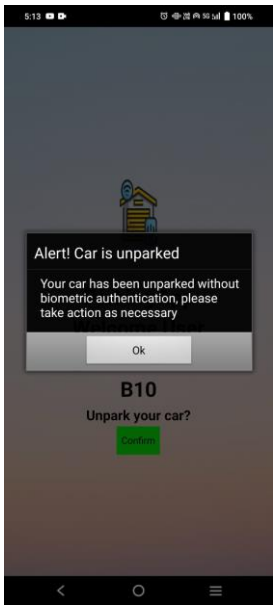

Fig. 11 – Alert message

After selecting a parking slot and performing biometric authentication, this data is stored in the backend and the selected parking slot is marked as occupied so that other users do not access it. The option to unpark the car is displayed (Fig 9), and upon selecting confirm, biometric authentication is performed and if successful, an alert is displayed (Fig. 10). If the user tries to take their car out now, a notification will not be sent. If this biometric authentication is not performed and the car is taken out, a notification is sent to the user by the app (Fig. 11).

We have used Wokwi online simulator to simulate the hardware that uses a PIR sensor to sense the motion of the car in a parking lot. If motion is sensed, it is forwarded via Node-Red using MQTT to the mobile app. Fig. 11 shows the output when we try to simulate motion in the PIR sensor. The output "Motion sensed is displayed", the bulb is illuminated and a connection is established with the Node-Red server as shown in the console. If some motion is sensed and biometric authentication has not been performed to unpark the car, an alert is sent to the user via the mobile app (Fig 10).

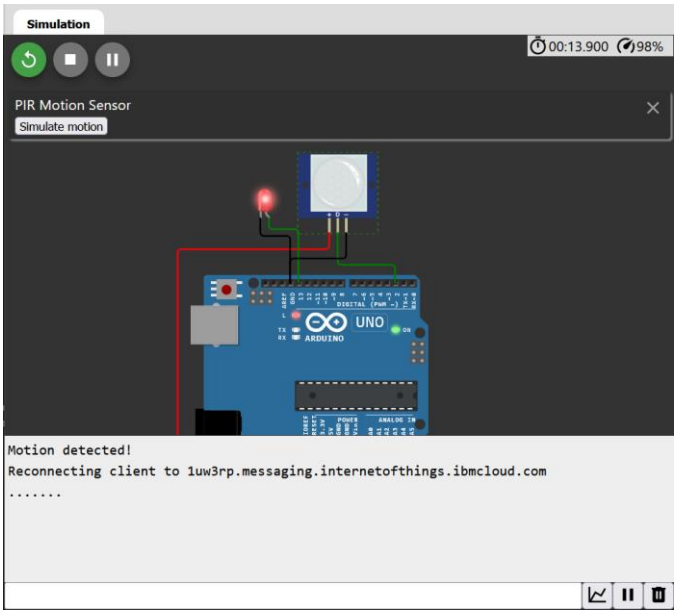

Fig. 12 – Wokwi Circuit Simulation

6. CONCLUSIONS

In conclusion, this paper presents a robust smart parking system implemented through MIT App Inventor, integrating biometric security and motion detection. The devised app seamlessly facilitates user registration, parking slot selection, and secure biometric authentication for both parking and unparking. Leveraging Node RED and MQTT, the system efficiently communicates with external devices like PIR motion sensors, enhancing real-time monitoring. The comprehensive testing protocol ensures the app's reliability, responsiveness, and security features. The successful outcomes affirm the viability of the proposed smart parking solution, offering a user-friendly interface while prioritizing security measures through biometric authentication and motion sensing.

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