Smart Parking System using MQTT Communication Protocol and IBM Cloud

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Abstract— In today’s world, the vast majority of people in large cities rely on automobiles. As a result, automobile parking has become an important part of our daily life. As a result, with such a vast population and a fast-paced world, vehicle parking has become a major concern. Such issues cause stress and strain, which might result in accidents. To help them out in such situations, a “smart” approach for running multilevel parking systems efficiently. To automate the parking procedure by monitoring metrics such as distance and available parking spaces, NodeMCU and IBM Cloud are used. The distance is measured, and the information is sent to Node-RED over the MQTT protocol. The Node-RED dashboard allows the user to view availability from any location. If the distance is too great, the space is unoccupied. If the parking area is fully occupied, the owner or person in control of the parking lot is also notified. This is accomplished by combining IFTTT and Node-RED. Watson is a virtual assistant that helps consumers with a variety of questions.

Keywords— Smart Parking, IoT, Arduino IDE, NodeMCU, Ultrasonic sensors, NodeRED, IFTTT, Watson Assistant

1. Introduction

Finding parking space is a very common problem, especially in big cities. According to an IoT Analytics Report, it is expected that smart parking services and products will grow at 14% which can surpass $3.8B by 2023. The traffic problems would be resolved due to the growth of this market. It will force people to develop different technologies that can be incorporated with Smart Parking. An M2M/IoT system is developed for Smart Parking. This is integrated with a web/mobile application, so it sends data on whether the parking space is vacant or not. The “machine”, which includes sensors and microcontrollers, is located in each parking place. The availability of space is visualized for the user and live updates are provided to choose the best one. This research is implemented to investigate and find new technologies to help smart parking. The main idea was the creation of smart parking as an M2M solution using ultrasonic sensors, where available parking places could be displayed in a mobile application. The main focus is to display the vacancy in parking lots by monitoring the distance parameter and alerting the owner/security of the parking area to take immediate action when necessary. The sensor data is simulated using Node MCU and is sent to the cloud through IBM Bluemix. The data is transmitted to the Node-RED platform using the MQTT protocol. The Node-RED dashboard is developed for the user to access all details related to the statistics of parameters gathered by the sensor data and keep track of the parking area from anywhere. An email notification is also sent to the owner/security by interfacing Node-RED with IFTTT. In doing so, the customers can save time from looking for parking space in the area when it's full. A Watson assistant is built and trained for the customers to clarify their queries.
2. Related works

Saidur Rahman and Poly Bhoumik have focused on providing sustainable parking management in urban areas. This system has an automated door with a DC servo motor and ultrasonic sensor. The use of an Ethernet shield for internet connectivity is to be noted. The web application integrated with the system makes it easier for the drivers by displaying the free parking spaces available [1]. Paul Melnyk et al. developed a sensing platform along with a mobile application to enable real-time interaction between the drivers and the parking infrastructure and localize their vehicles in the large multi-storey car parks. RFID technology and the usage of MQTT protocol to update parking space availability are the main features of the system [2]. Rishi Gupta et al. have proposed a reservation-based Smart Parking System. An Android App is developed to book vacant parking spots. The vacant spot is detected by Ultrasonic Sensors in real-time and is updated in Cloud MQTT. The system gets updated in real-time which helps users to find vacant spots sooner [3].

Norah Farooqi et al. have designed a system that mainly focuses on registered vehicles. The ANPR camera captures the image of the vehicle’s plate number to verify the booking and to open the door. The system is integrated with a website and a mobile application [4]. Thilina Weliwita and Hiran Ekanayake have designed a low-cost parking system using a received signal strength indicator (RSSI). The measures of Time of flight (TOF) and Angle of Arrival (AOA) are used to measure the distance and free slots for parking. The MQTT protocol and transport layer security have been used for high security. For 40 parking slots, this designed system costs 75.95[5]. Yash Agarwal et al. have proposed an automated smart parking system using RFID and cloud servers. An e-payment system is implemented for the customer’s convenience. The main motive of this system is to reduce human intervention in parking areas [6]. Mehala Chandran et al. have proposed a system that detects the amount of light reflected back from the obstacle to determine the presence of the vehicle. With the help of the GSM module, the user is able to extend or pay via a simple text message. It also sends text messages through the android application about the parking details [7].

Elakya R et al. have integrated RFID technology into the work and made RFID tag mandatory criteria to enter the parking area. An RFID tag consists of all the necessary information about the user (driver) and the car. Similar to the previously mentioned work, this system also has a GSM module to send text messages about the parking information to the driver [8]. Amira. A. Elsonbaty and Mahmoud Shams designed a parking system inclusive of booking options using a mobile application [9]. A Web Application supported with a DNS and Server is used in the system designed by Poonam Mangwani. This is integrated with IR Sensors to detect the ambient response of any vehicle. In order to minimize the complexity of Hardware, it is converted into PCB Layout [10]. Abhirup Khanna and Rishi Anand have proposed a system with a secure IBM Cloud. Using the MQTT protocol, the hardware is connected to the cloud. This system is integrated with an Android application that supports the option of booking spots. This system is robust, scalable and due to the integration of IBM Cloud, it provides various other features to upgrade the system [11]. The system proposed by Pampa Sadhukhan uses a Parking Meter mechanism. In each parking spot, a parking meter is allotted to check-in and out timings. It consists of a flowchart-based design making it work more accurately and efficiently [12]. The system proposed by Agustina Ampuni et al. contains an Automatic Cashier system along with a Mobile App. It can monitor parking spots in real-time, check the in and out time of cars. It also supports image recognition which can be used to detect license plates [13]. Somani et al. have brought into light the OTP-based system for slot booking. Once a slot is booked, the user gets the OTP, which is required when entering the parking area. This system is helpful to find parking spaces in nearby areas whenever necessary [14].

3. Proposed system

In this work, a smart parking system that uses sensor data to monitor the distance compares it against a threshold and if the value does not fall under the optimal range, displays that the parking space is full, or alerts the owner/security when necessary, is used. The distance data is collected by the Ultrasonic sensor.
In addition to recognizing the free parking slot PARKER, an application for tracking parking spots in a place and receiving live updates by email and Watson assistant is created. Long-distance travelers will benefit from this innovation because it will allow them to communicate with specific parking places. MQTT protocol will reduce security threats. This data represents how far the nearest surrounding object (when practically assumed, “vehicles”) is located from the sensor. The LED in the circuit will glow when there is no object in the surrounding of the sensor, i.e., the parking area is free. The sensor data is fed to the NodeMCU which pushes the data over to the IBM Cloud Platform using the MQTT communication protocol. The entire smart system process is carried out using Wi-Fi as the wireless technology. In the IBM Cloud platform, the data is verified to be received using the recent logs in device history. Next, the Node-RED dashboard is developed to notify the parking area owner/security of the parameters and send an alert if the parking area is full. An email notification is sent to the owner by interfacing Node-RED with IFTTT whenever the parking lot is full. An android app created using MIT app inventor is used to display the current location of the parking area, no. of free parking spaces. Lastly, a Chatbot is designed using Watson Assistant and is integrated with the app to solve the queries raised by the customers.

4. Implementation

The Smart Parking System is implemented using NodeMCU and is monitored by using Node-RED Dashboard and Mobile Application successfully. In the Parking Slots, an ultrasonic sensor to detect the presence of cars is used. The data regarding parking slots is collected from the sensor using the Arduino IDE. This data is then sent to the IBM IoT Platform using the MQTT Protocol. The data is acquired in real-time and is processed in the IBM Platform. This IBM cloud is used as the platform because the Node-RED dashboard, Watson assistant, and all the applications are managed within it using the free access provided by the IBM cloud. It is then transferred to NodeRED using IBM IoT Node. A flow is created to process the data and display it in the NodeRED Dashboard. The Node-RED dashboard is developed to notify the parking area owner/security of the parameters and send an alert if the parking area is full. An email notification is also sent to the owner by interfacing Node-RED with IFTTT. An App is also used to display the current location of the parking area, no. of free parking spaces. A Watson Assistant is designed and integrated with the app to solve the queries raised by the customers.
The entire smart system process is carried out using Wi-Fi as the wireless technology. In the IBM Cloud platform, the data is verified to be received using the recent logs in device history. The hardware setup of the smart parking system is shown in Figure 3.

It can be seen from the setup that the Ultrasonic sensor and the LED are connected to the NodeMCU microcontroller. The LED can be seen to glow when there is no hindrance to the transmission of ultrasonic waves emitted by the sensor, indicating free slots available for parking. On the other hand, the LED stops glowing when the hand, as shown in the picture, blocks its path, indicating no vacant spots in the parking zone.
Figure 4. Code in Arduino IDE

Figure 4. displays a part of the code used to define control conditions on when the LED shall turn on and how the data collected by the sensor shall be pushed to the cloud. Once the data is pushed to the cloud service, IBM Cloud Platform, the data can be verified through the “recent events” in the device tab, as shown in Figure 5.

Figure 5. Recent events in IBM Cloud Platform
Node-RED is used to direct the sensor data to various locations in the form of a flow. As can be seen from Figure 6., a flow in Node-RED is created for the proposed system.

The data is visualized in the Node-RED UI using gauges as shown in Figure 7. Push notifications as shown in Figure 8. and feedback forms as shown in Figure 9., with respective nodes in the flow. The “HTTP request” node is used to create a webhooks connection with the IFTTT server which will send an email to the user when the event “Parking area is fully accommodated” is triggered.

**Figure 6.** Flow in Node-RED

**Figure 7.** Node-RED Dashboard – Gauges and Web UI – Notification

**Figure 8.** Node-RED – Displaying Chatbot

**Figure 9.** Node-RED Web UI – Feedback form
Additionally, an android application was created using MIT app inventor that will help users track their parking location and navigate through the parking lot with much ease. A chatbot built using Watson assistant was created for the benefit of the users using the android app for running quick clarifications on the parking slot vacancies, parking range timings, and charges.

5. Results

The system has been implemented and the following results are obtained. The Node-RED dashboard has features to customize and develop the UI of the prototype using gauges. It consists of a Notification Node which is used to display pops-up on the Node-RED dashboard. It displays a “Parking fully accommodated” notification, whenever the parking space has zero vacant spots. The dashboard provides an option for the user to chat with the chatbot to solve their queries. Feedback is taken from the user to optimize the UI of the system. When the parking area is fully occupied, it sends an alert mail to notify the person in charge of the parking to resolve the issue as shown in Figure 10.

The Android application integrated with the system provides three options to the user to enhance their experience. The Chatbot directs the user to the Watson Assistant where all the queries are resolved.
6. Conclusion

Due to urbanization, population rises in the parking area crowd control is tough to handle. Using this smart parking system, the customer’s time searching for the parking spaces is greatly reduced to nearly 75%. The efficiency of this system stays the same whether the Parking area is too crowded or if the spaces are vastly unoccupied. Using the app and email system the accommodation status is obtained very easily without much communication and the admin can get the real-time data without contacting people using the IBM cloud. Smart parking systems help fulfill drivers’ needs without compromising
on living and recreation space. Also, the percentage of errors and malfunction of IBM Cloud was found to be less than 1%. In the future, this system can be extended and a few features like booking slots, online payment, and login portal can be added. RFID tags can be attached to the vehicles and an RFID reader can be used to read the tags. The information can be added to the user’s login. In the future there will be rising use of auto-driving car users and smart parking system devices can be developed to get direct contact with the car server and using message protocols the smart car is obtained.

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