CONTENTS

ABSTRACT

In this paper, we propose a novel IoT-based smart parking (**SP**) solution which has been designed to provide information on the status of parking spots offered in on-street parking areas. We mostly focused on the following issues of the state-of-the-art solutions: scalability, interoperability to address the heterogeneity of IoT devices, low energy consumption, and timely prediction of the availability of the parking spots. To this we leverage the Social IoT (**SIoT**) Lysis environment to create virtual entities of the real-world objects involved in the SP system for on-street parking areas. The usage of the social virtual entities allows for addressing the interoperability issues among different types of IoT devices used by separate solutions deployed in adjacent areas. Magnetometer sensors are used to automatically detect the presence of a vehicle in each parking spot and the sensors data are collected through concentrators that cover the whole parking areas through low-energy Wi-Fi. Additionally, a control dashboard has been designed and developed to manage the monitored parking areas and provide responsive data analytics regarding the occupancy of parking areas in the city, which can be accessed through an Android App. Finally, a smart payment service allows the users to automatically pay for the used services making use of Bluetooth beacons. Experiments have been performed with the developed test-bed to show the performance of the system to timely detect the presence of a vehicle and identify the owner ID to trigger the payment procedure.

Keywords: Internet of Things, Vehicle detection, Smart Parking.

INTRODUCTION

In this current era of modern world, almost everyone owns a personal vehicle and it has become a basic need for the humans. Hence, it has been proven statistically that the usage of vehicles is increasing rapidly yearly [1]. Due to the growth, it is very difficult to find parking slots in cities, especially during the peak time.

This creates a necessity to introduce an automated system that allows users to book their spot just by making a few clicks through a custom-made Android Mobile Application. This serves to hassle free situation for every user. The main motivation behind the Smart Parking System is to help the drivers to find areas where parking is available in that area [3]. Prior to his expected arrival, drivers can book a slot in the area if it is available. Drivers can search the parking slot through the mobile application installed and book the available slot. Besides that, user can also view the duration of parking usage through the application and charges can be calculated through the online application sent to the user for notification. Not only this, user can opt to extend their duration by simply requesting on the application by few clicks. All you need is a working Internet.

The system works primarily on the detection of parking slots through sensors that are mounted on every parking slot which facilitates the information. Then this is then processed by microcontroller which helps to serve as a medium of communication between those peripherals or devices. The final stage would be when user uses their smart phones to retrieve the slot occupancy in selected areas prior to reservation.

OBJECTIVE

The objective of an IoT-based smart parking system is to use connected devices and sensors to efficiently manage parking spaces and provide a seamless parking experience for users.

The system aims to reduce the time and effort required for drivers to find available parking spaces and minimize traffic congestion caused by drivers searching for parking. This can be achieved through real-time monitoring of parking spaces using sensors that detect the presence or absence of vehicles.

The system can also provide information to drivers through mobile apps or digital signage that displays the availability of parking spaces in real-time. This allows drivers to quickly locate an available parking spot and reduces the likelihood of congestion caused by vehicles circling around looking for a spot. In some studies [4], image processing is given more importance instead of sensor-based system. Driver's number plate is captured by Image processing is used to capture the number plate of the drivers and the information is stored in database. This is to avoid theft and illegal car entry.

In research paper [5] "Smart Parking System based on Reservation", states that the expansion of monetary conduct for everyday comfort has rapidly increases the ratio of people who owns vehicles giving boost to busy cities traffic.

Other objectives of an IoT-based smart parking system may include improving the utilization of parking spaces, reducing energy consumption, and providing data insights for parking management and planning purposes. By leveraging IoT technology, the system can also be remotely managed and monitored, reducing the need for manual intervention, and improving overall efficiency.

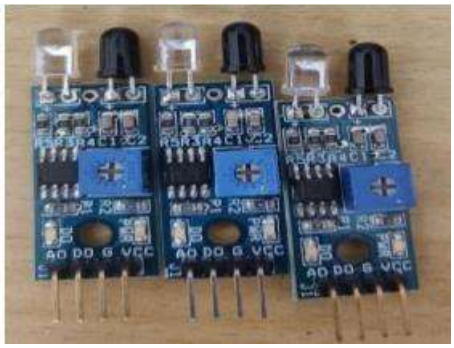
COMPONENT LIST

NAME OF THE COMPONENTS	QUANTITY (in pieces)
IR Sensor	8
Servo Motor	1
WIFI Module	1
RFID Module	1
Arduino UNO	1
Jumper/Connecting Wire	100+
I2C Module	1
LCD Display	1
Vehicles	4

COMPONENT DESCRIPTION

1. IR Sensor

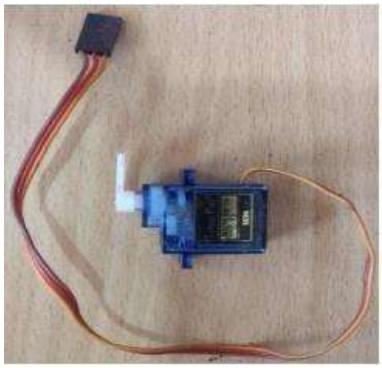
IR Sensors will be attached in each slot to detect the presence of the vehicles. [6] This sensor detects the presence of a vehicle in terms of the amount of light reflected back from the obstacle and in this case it will be the wall of the parking slot. If no obstacle is present, IR light cannot be detected by the sensor. The typical Infrared Transmitter found is a Light Emitting Diode (LED) which functions by emitting infrared pulse.



IR Sensor

2. Servo Motor

A servo motor is a type of electric motor that is designed to rotate to a specific position and maintain that position, based on a control signal. Servo motors are commonly used in applications that require precise control over the position, such as robotics, CNC machines, and industrial automation.

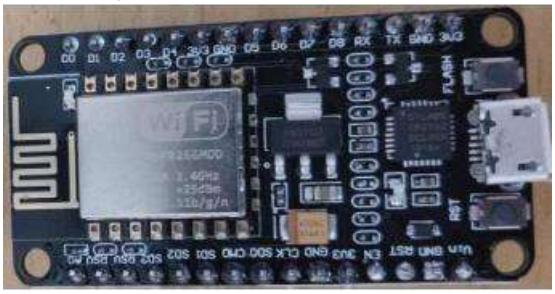


Servo Motor

3. WIFI Module

A Wi-Fi module is a small electronic component that allows devices to

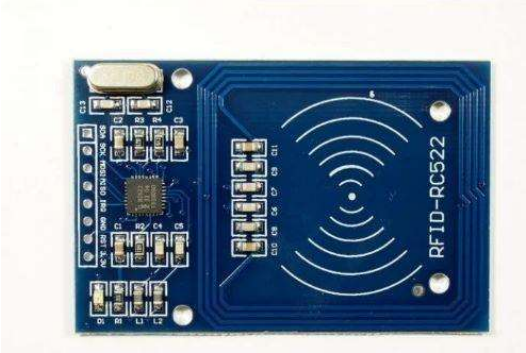
connect to a Wi-Fi network. It typically contains a wireless network chip, an antenna, and firmware that enables wireless communication. Wi-Fi modules are commonly used in a variety of applications, such as smart homes, IoT devices, and industrial automation.



WIFI Module

4. RFID Module

The RFID module typically consists of an antenna, a reader, and a controller. The antenna is used to transmit and receive signals to and from the RFID tag, while the reader is used to decode the information on the tag. The controller manages the communication between the antenna and the reader, and processes the data that is read from the tag.



RFID Module

5. Arduino UNO

Arduino Uno is a microcontroller board based on the ATmega328P microcontroller. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button.

Arduino UNO

6. Jumper Wire

A jumper wire is a type of wire used to connect two points on an electronic circuit board or breadboard. It is typically a thin, flexible wire with connectors on each end, and can be made from various materials such as copper, aluminum, or gold.

Jumper Wire

7. I2C Module

An I2C module is an electronic module that interfaces with other devices using the I2C protocol. It typically consists of a microcontroller or a dedicated I2C controller, which can be used to send and receive data from other I2C devices on the same bus.

I2C Module

8. LCD Display

An LCD (Liquid Crystal Display) display is a flat-panel display that uses the light modulating properties of liquid crystals to display images, text, or other information. LCD displays are commonly used in consumer electronics, such as televisions, computer monitors, and mobile phones, as well as in industrial applications, such as digital signage and instrumentation.

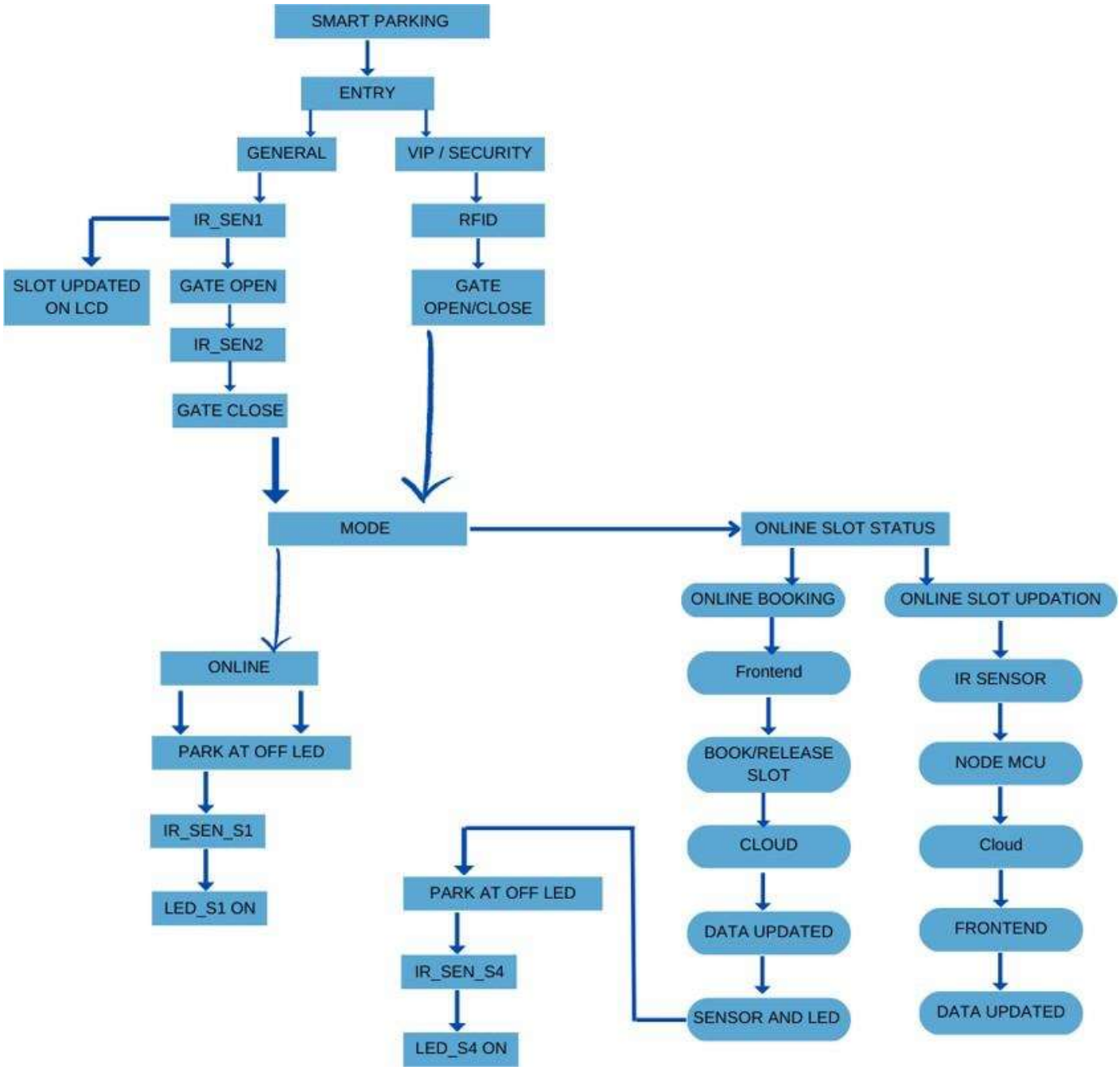
LCD Display

9. Vehicle

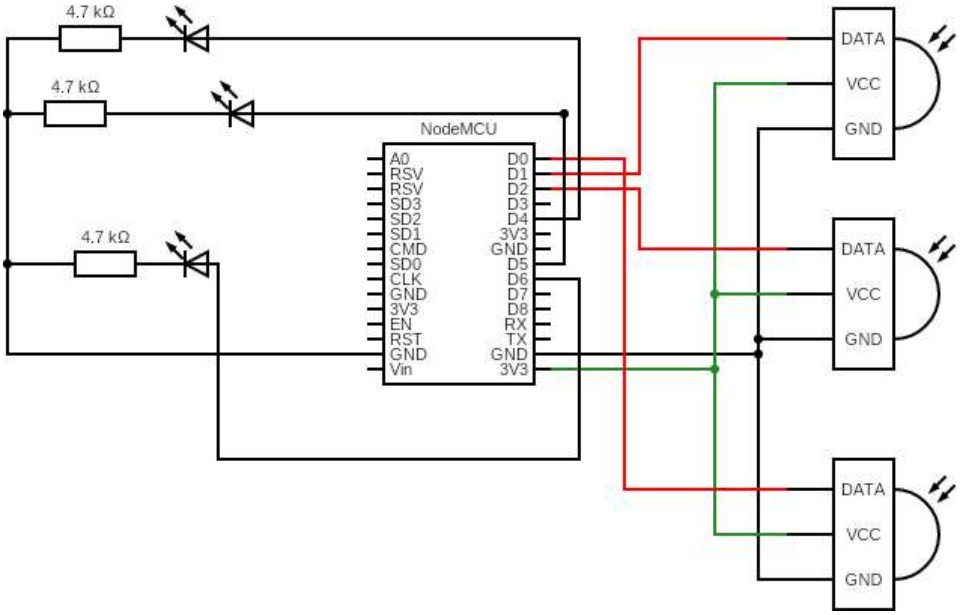
Vehicle plastic refers to the plastic parts and components used in the manufacturing and assembly of vehicles. Plastic is a lightweight and durable material that can be molded into various shapes, making it ideal for use in the automotive industry.

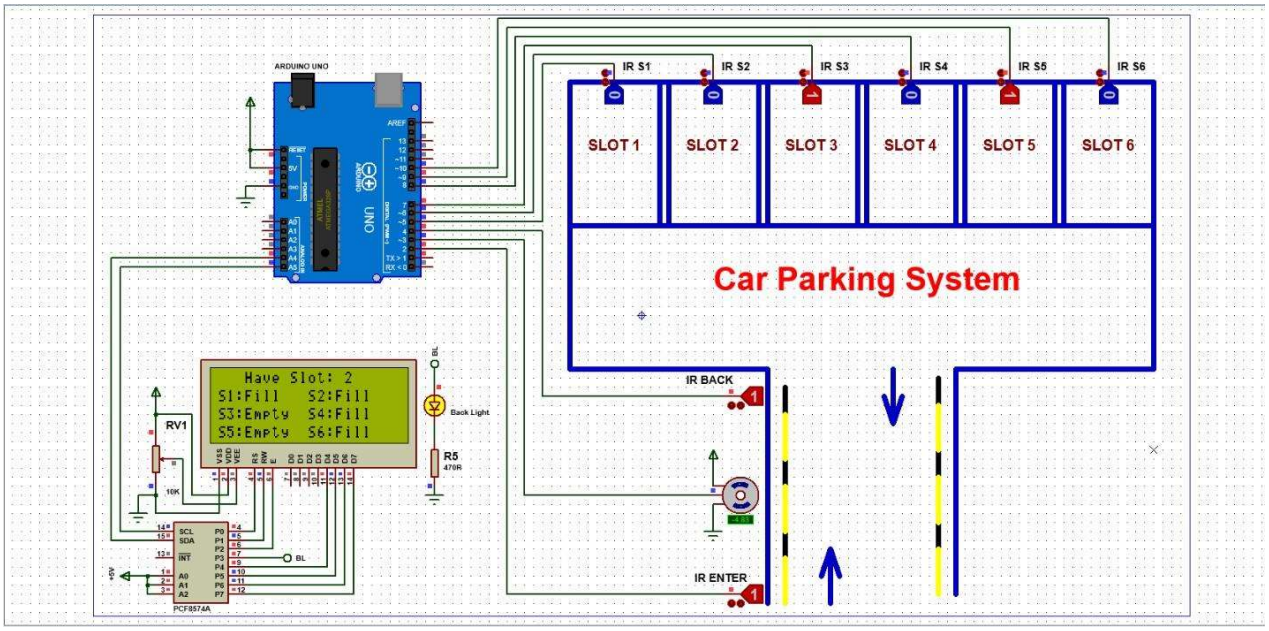
Vehicles

BLOCK DIAGRAM



CIRCUIT DIAGRAM





WORKING PRINCIPLE

The working principle of a web-based smart parking system involves the use of various technologies such as sensors, IoT devices, and cloud computing to manage parking in busy areas.

The system works by installing sensors at each parking spot, which detect the presence or absence of a vehicle in real-time. The sensor data is then transmitted to an IoT device, which aggregates and processes the data. This data is then sent to the cloud, where it is analyzed and used to provide real-time information about available parking spots to drivers.

The driver can access this information through a web-based application or a mobile app, which shows the location and availability of parking spots in real-time. The driver can then select an available spot and reserve it in advance, or navigate to the spot using turn-by-turn directions provided by the application.

The system can also provide valuable data insights to parking lot operators and city planners, including data on parking spot utilization, peak usage times, and average parking durations. This data can be used to optimize parking resource allocation, improve traffic flow, and inform urban planning decisions.

Overall, the working principle of a web-based smart parking system is based on the integration of various technologies to provide real-time parking information to drivers and optimize parking resource allocation.

SOFTWARE IMPLEMENTATION

The software implementation of a web-based smart parking system involves several components that work together to provide a seamless user experience for drivers and parking lot operators. Some of these components include:

Web-based application: This is the main interface that drivers use to access real-time parking information and reserve parking spots. The application typically has a user-friendly interface that displays parking lot maps, availability of parking spots, and other relevant information.

IoT devices and sensors: These are the physical components that detect the presence or absence of vehicles in parking spots and transmit the data to the cloud for processing.

Cloud computing: This is the backbone of the system that aggregates and processes data from IoT devices and sensors. The cloud infrastructure typically includes data storage, data processing, and machine learning algorithms that analyze the data to provide real-time parking information and insights.

OBSERVATION & ANALYSIS

Web-based smart parking systems that utilize Internet of Things (IoT) technology are becoming increasingly popular as a solution to the challenges of urban parking. These systems typically consist of interconnected sensors, data networks, and web-based platforms that allow drivers to locate available parking spaces in real-time and make reservations or payments online. Here is an observation and analysis of a web-based smart parking system using IoT technology:

Observation:

- Real-time parking availability: One of the key benefits of a web-based smart parking system is the ability to provide real-time information about parking availability. Sensors placed in parking spaces can detect the presence of vehicles and relay this information to a web-based platform, which can then display the available parking spots in real-time. This allows drivers to quickly locate an available parking space, saving time and reducing congestion.
- Reservation and payment options: Web-based smart parking systems often offer reservation and payment options, allowing drivers to reserve a parking spot in advance and pay for it online. This can help reduce the hassle of searching for parking and provide a convenient and seamless parking experience for drivers.
- Traffic management: By providing real-time information about parking availability, web-based smart parking systems can help manage traffic flow in and around parking areas. Drivers can quickly

locate available parking spaces, reducing the time spent circling around looking for a spot, and thus minimizing traffic congestion.

- Data collection and analysis: Web-based smart parking systems collect and analyze data on parking usage, such as occupancy rates, duration of parking, and payment data. This data can be used to optimize parking operations, improve resource allocation, and inform future planning decisions.

Analysis:

- Cost-effective: Implementing a web-based smart parking system using IoT technology can be cost-effective compared to traditional parking systems that require physical infrastructure and manual management. IoT sensors can be easily deployed and require minimal maintenance, reducing operational costs.
- Enhanced user experience: Web-based smart parking systems provide an enhanced user experience for drivers by offering real-time parking availability, reservation, and payment options. This can help reduce stress and frustration associated with parking in urban areas, resulting in increased customer satisfaction.
- Improved parking management: Web-based smart parking systems can provide valuable data on parking usage and patterns, allowing parking operators to optimize their operations. For example, data on parking occupancy rates can help identify underutilized areas that can be repurposed, and data on parking duration can help in setting pricing strategies.
- Sustainability benefits: Web-based smart parking systems can contribute to sustainability efforts by reducing traffic congestion and associated emissions from circling for parking. By helping