



IOT BASED SMART PARKING SYSTEM

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Abstract : The Internet of Things (IoT) has revolutionized various aspects of our daily lives, and one such impactful application is the implementation of smart parking systems. The concept of an IoT-based smart parking system, leverages interconnected devices and sensors to optimize the utilization of parking spaces in urban environments.

In today's world, finding parking spaces for vehicles is a big challenge, especially in crowded cities. Our project focuses on solving this problem using IoT technology. We've developed a smart parking system that helps drivers find parking spots more easily. Our system works by using sensors placed in parking spaces to detect if the parking slots are occupied or vacant. These sensors send information to a central system, which then displays real-time parking availability to drivers through a mobile app or digital displays.

The goal of our project is to make parking simpler and less stressful for drivers, while also reducing traffic congestion and pollution caused by cars circling around in search of parking. By using IoT technology, we're able to create a smarter, more efficient parking solution for modern cities. IoT-based smart parking system aims to make urban life easier and more convenient for everyone. We believe that by leveraging technology in this way, we can contribute to building smarter, more sustainable cities for the future.

Index Terms - Component,formatting,style,styling,insert.

1.

INTRODUCTION

The Internet of Things (IoT) is all about connecting everyday objects to the internet so they can communicate and interact with each other. Imagine your phone, computer, or even your cars being able to connect and interact with each other. This opens up a world where things become smart and can do things on their own, like sensing information, computing data, and communicating with other devices. One big idea in IoT is making cities smarter. Take parking, for example. In busy cities, finding a parking spot can be a real hassle. With IoT, we can make this process easier by using sensors and smart devices to monitor parking spots and tell drivers where the available spaces are. This saves time, reduces traffic jams, and even helps prevent accidents.

Our project focuses on creating a Smart Parking System using Arduino . This system helps drivers find parking spots more easily by using technology to track available spaces and guide them to the nearest one. This isn't just useful for parking , IoT technology is being used in many areas like healthcare, building management, and even disaster prevention. Overall, IoT is making our lives easier and our cities smarter.

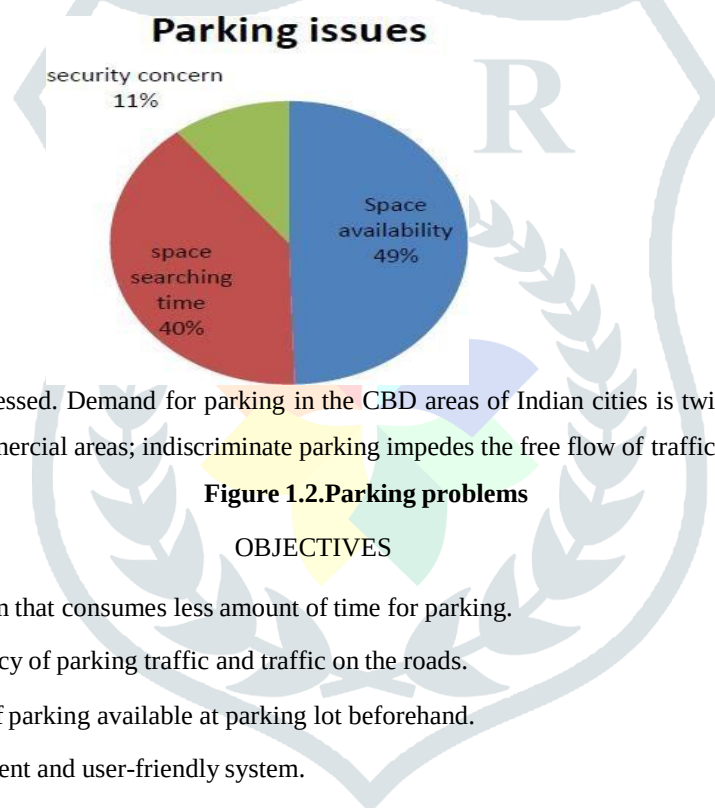
In today's world, finding parking for vehicles like cars and vans is a big problem. With more people and more vehicles on the road, parking spaces are getting scarce. This often leads to cars being parked on the streets, causing traffic jams. That's where an IoT-based smart parking system comes in. Instead of traditional parking lots, this system uses technology to manage parking more efficiently. It's like a high-tech version of a multi-story car park, but smarter. This system automatically parks vehicles on different floors, saving a lot of space compared to traditional parking lots. It's perfect for places where lots of cars need to be parked, like busy city centers or large buildings. With IoT technology, we can monitor how many cars are inside the parking lot, track when cars come and go, and even guide drivers to empty parking spaces. This makes parking faster, easier, and safer for everyone . **Figure 1.4**

1.2. Parking Issues in India



India has more than 40 million vehicles. But the traffic on roads and parking space has been an area of concern in majority of Indian cities. In most of the cases, 40 per cent of the road space is used for parking rather than for traffic movement on a normal working day. With affordable cars launching in the market, almost every middle-class family owns a car which adds to the vehicular population in our country. If this trend is followed, no amount of space will be enough to accommodate stationary vehicles, which will lead to narrower lanes for movement of public transport. Indian cities face a severe problem of congestion due to the runaway growth of personal vehicles. Traffic management in the many cities is marked by the introduction of a series of one-way traffic systems, which have implications on pedestrian safety and fuel consumption.

One-way traffic is generally desirable only when complementary roads are available and the additional traveling distance is not more than 300 meters as per IRC. This ensures that whenever such systems are introduced, the interests of public transport modes



and pedestrians are duly addressed. Demand for parking in the CBD areas of Indian cities is twice the supply. Acute shortage of parking supply is seen in commercial areas; indiscriminate parking impedes the free flow of traffic and causes accidents.

Figure 1.2. Parking problems

2.

OBJECTIVES

1. To develop a system that consumes less amount of time for parking.
2. To avoid contingency of parking traffic and traffic on the roads.
3. To show the slots of parking available at parking lot beforehand.
4. To provide convenient and user-friendly system.
5. To deliver the benefit of customization as per user preferences and requirements, the IoT- based smart parking system can offer configurable settings such as preferred parking spot
6. To reduced pollution: Searching for parking burns around one million barrels of oil a day. An optimal parking solution will significantly decrease driving time, thus lowering the amount of daily vehicle emissions and ultimately reducing the global environmental footprint.

3.

LITERATURE REVIEW

Developing a smart parking management system using the Internet of Things. (2019) ITI : In this paper author explains that searching for parking wastes significant amounts of time and effort and leads to substantial financial costs. This is particularly the case for people who are always pressured to be on time. Smart cities employ all kinds of modern technologies to manage and enhance resources effectively. Urban parking facilities are one of the essential assets that must be managed." [1]

An IoT-based e-parking system for smart cities (2017) ICACCI: The huge proliferation in the number of vehicles on the road along with mismanagement of the available parking space has created parking related problems as well as increased the traffic

congestion in urban areas. Thus, it is required to develop an automated smart parking management system that would not only help a driver to locate a suitable parking space for his/her vehicle, but also it would reduce fuel consumption as well as air pollution. It has been found that a driver's search for a suitable parking facility takes almost 15 minutes which increases the fuel consumption by the vehicle, traffic congestion, and air pollution." [2]

Smart parking-based system for smarter cities (2018) ICSCET: India is getting motorized i.e., the rate of private vehicles is more as compared to public transports. As the rate of people owning their vehicles increases, the need for parking slots to park vehicles also increases. But currently the scenario is that there are not sufficient parking slots available or there is also a possibility that people are not now aware of the legal parking slots available in their locality. This situation leads to the unnecessary crowding of vehicles on the road and also results in the inconvenience of people walking on the road. To overcome the above problems, we are proposing the solution in the form of a multilingual android application which will be helpful for the people to find their parking slots digitally." [3]

Smart parking system to reduce traffic congestion (2020) ICECIE: Transportation is the key-success for any of the country. Nowadays, many people have options to use their own vehicle for traveling. This will surely increase the demand in trading but one of the problems created by road traffic is 'parking'. To park all these vehicles in the major metro cities is quite a tedious and difficult task and it became problematic to park vehicles. Lot of research and development is being done all over the world to implement better and smarter parking management mechanisms. The current smart parking systems or Wireless Sensors Network Parking requires the combination of wireless sensor

networks module, Embedded web-server, Central WebServer. Sensor networks make use of Infrared (IR) Sensor nodes to check the parking slot state and send this information to the embedded web-server. It thereby displays the information on an LED screen with which the user can check for empty vehicle slots." [4]

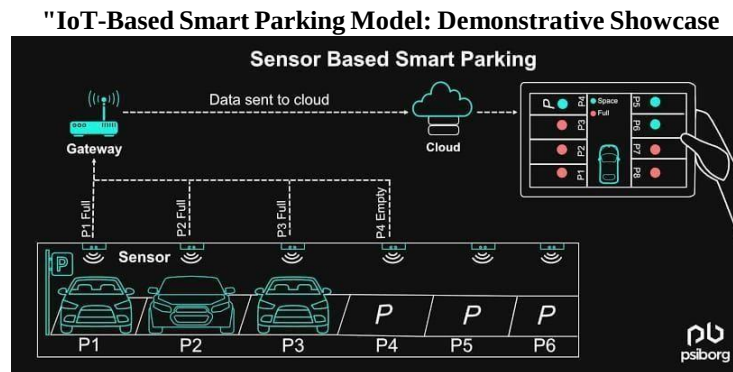
An IoT-Based Intelligent System for Real-Time Parking Monitoring and Automatic Billing (2020) IEEE, ICIoT : Today, the parking industry is being transformed by new technologies that are allowing cities to reduce rates of congestion significantly. Sensor networks that sense vehicle occupancy are providing the basic intelligence behind smart parking systems. Thanks to the Smart Parking technology, it is now possible to know in real-time the location of free parking spaces and to help drivers to get to their ultimate destination. A variety type of vehicle detectors has been used in parking information acquisition. These vehicle detectors mainly include the inductive loop, acoustic sensor, infrared sensor, or ultrasonic sensor." [5]

4. METHODOLOGY

System Overview:

The Smart Parking System is a concept to combine real time reservation with share time reservation, in which a driver can book a slot few minutes ago or any time before arrival at the destination. The system consists of Wi-Fi technology and the IR sensors to monitor the empty spacefor parking.

Figure 4.1.



In this system, the user will look on android application installed in his mobile for the convenient space accordingly. After logging into the system, the user will choose the space available for the slot which will be suitable for him. Information regarding parking location will be given to the user via notification. After that the system updates the status of parking slots and the slot will be booked for the time being.

Components used:

1.Arduino Uno:

The Arduino Uno is a microcontroller board that serves as the central processing unit of our smart parking system. It's responsible for controlling and coordinating the operation of all other components. The Uno is programmed to read input from the sensors, process the data, and send commands to the servo motors and LCD display based on the parking availability status.



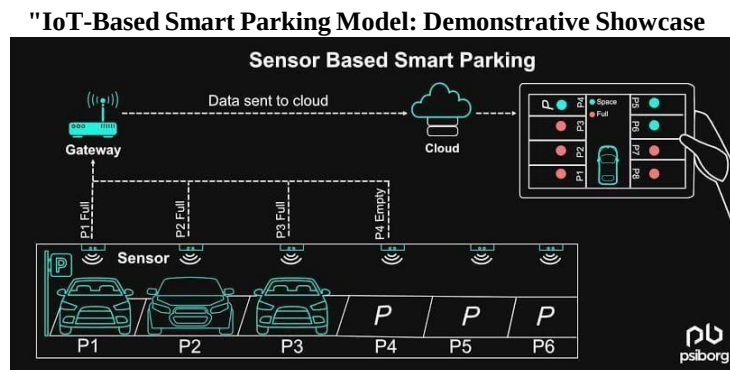
Figure 4.2.1

DC Current per I/O Pin: 20 mA DC Current for 3.3V Pin: 50 mA

Flash Memory: 32 KB (0.5 KB used by boot loader)

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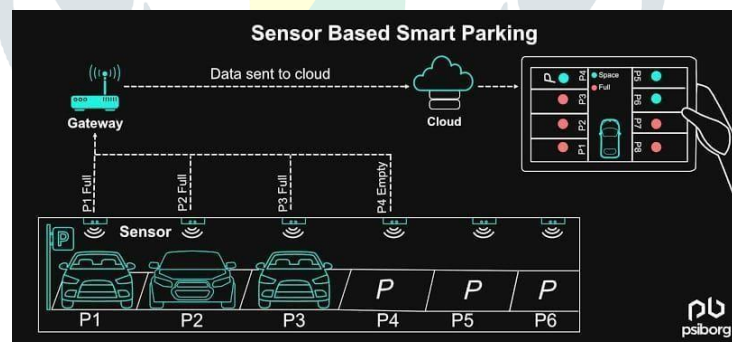
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Specifications: Microcontroller: ATmega328P Operating Voltage: 5V
 Digital I/O Pins: 14 (of which 6 provide PWM output) Analog Input Pins: 6
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"IoT-Based Smart Parking Model: Demonstrative Showcase"



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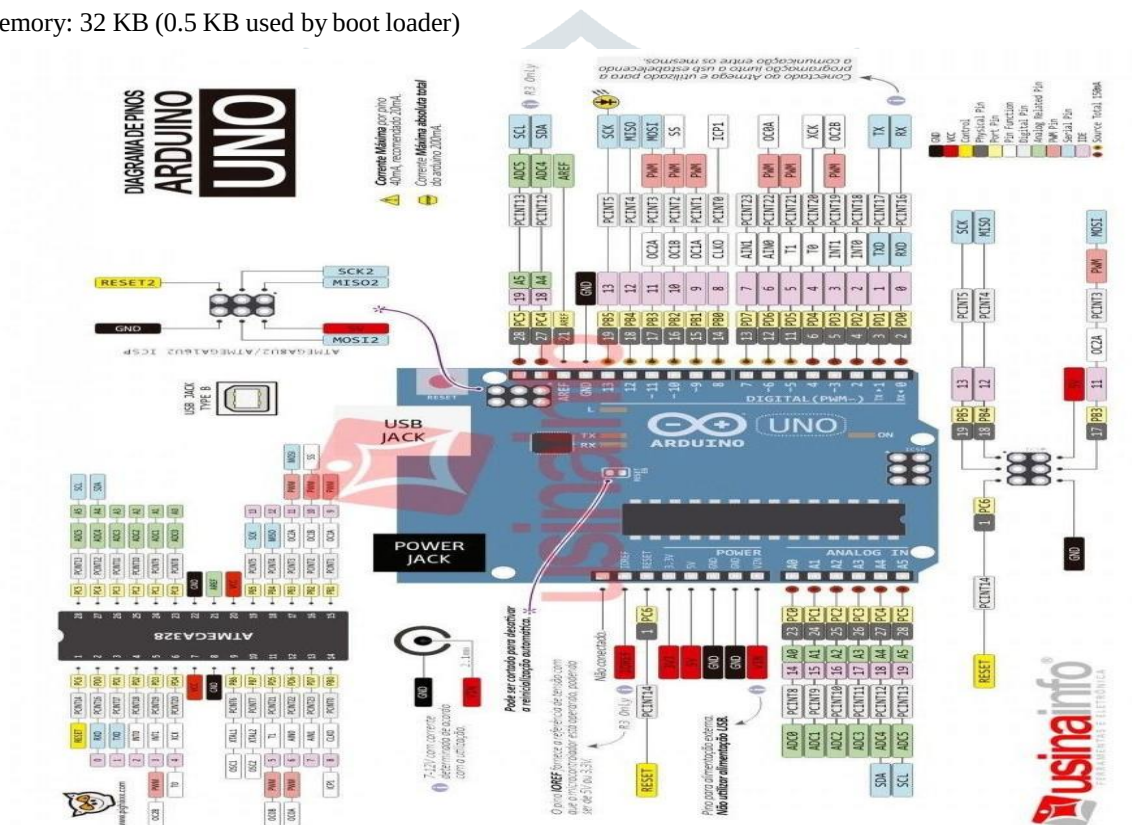


Figure 4.2.2

- **Power :**

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V.** This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.
- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND.** Ground pins.
- **Memory**

The ATmega328 has 32 KB (with 0.5 KB used for the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

□ **Input and Output**

Each of the 14 digital pins on the Uno can be used as an input or output, using `pinMode()`, `digitalWrite()`, and `digitalRead()` functions. They operate at 5 volts. Each pin can provide or receive

a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

4. IR Proximity Sensors :

IR proximity sensors are used to detect the presence of vehicles in parking spaces. These sensors emit infrared light and measure the reflection to determine if a car is parked in a specific spot. When a vehicle enters or leaves a parking space, the IR sensor detects the change in reflection and sends a signal to the Arduino Uno, indicating the status of the parking space (occupied or vacant).



Figure 4.2.3

The IR sensor module consists mainly of the IR Transmitter and Receiver, Variable Resistor (Trimmer pot), output LED in brief. IR LED Transmitter. IR LED emits light, in the range of Infrared frequency. IR light is invisible to us as its wavelength (700nm – 1mm) is much higher than the visible light range.

An IR sensor consists of an IR LED and an IR Photodiode; together they are called as Photo-Coupler or Opto-Coupler. As said before, the Infrared Obstacle Sensor has built-in IR transmitter and IR receiver. Infrared Transmitter is a light emitting diode (LED) which emits infrared radiations. Hence, they are called IR LED's. Even though an IR LED looks like a normal LED, the radiation emitted by it is invisible to the human eye. Infrared receivers are also called as infrared sensors as they detect the radiation from an IR transmitter. IR receivers come in the form of photodiodes and phototransistors. Infrared Photodiodes are different from normal photo diodes as they detect only

infrared radiation. When the IR transmitter emits radiation, it reaches the object and some of the radiation reflects back to the IR receiver. Based on the intensity of the reception by the IR receiver, the output of the sensor is defined.

5. Servo Motors:

Servo motors are small, controllable motors used to actuate the barriers or gates at the entrance and exit of parking spaces. In the smart parking system, servo motors are connected to the Arduino Uno and are programmed to open or close the barriers in response to commands from the microcontroller. This allows for automated control of vehicle entry and exit from parking spaces.



Figure 4.2.4

Specifications:

Size	:	38 x 11.5 x 24mm (Include tabs) 28 x 12.7 x 27mm (Not include tabs)	Weight	:	17g
Speed	:	0.14sec/60degrees (4.8V) 0.12sec/60degrees (6.0V)	Torque	:	2.5kgf-cm (4.8V) 3.0kgf-cm (6.0V)
Voltage	:	4.8V-6.0V			

Servo Motor Working Principle:

A servo consists of a Motor (DC or AC), a potentiometer, gear assembly, and a controlling circuit. First of all, we use gear assembly to reduce RPM and to increase torque of the motor. Say at initial position of servo motor shaft, the position of the potentiometer knob is such that there is no electrical

signal generated at the output port of the potentiometer. Now an electrical signal is given to another input terminal of the error detector amplifier. Now the difference between these two signals, one comes from the potentiometer and another comes from other sources, will be processed in a feedback mechanism and output will be provided in terms of error signal. This error signal acts as the input for motor and motor starts rotating. Now motor shaft is connected with the potentiometer and as the motor rotates so the potentiometer and it will generate a signal. So as the potentiometer's angular position changes, its output feedback signal changes. After sometime the position of potentiometer reaches at a position that the output of potentiometer is

same as external signal provided. At this condition, there will be no output signal from the amplifier to the motor input as there is no difference between external applied signal and the signal generated at potentiometer, and in this situation motor stops rotating.

6. Jumper Wires:

Jumper wires are used to create electrical connections between the various components of the smart parking system. They provide a convenient and flexible means of connecting sensors, motors, and other electronic devices to the Arduino Uno and breadboard. Jumper wires come in different lengths and colors to facilitate organization and ease of assembly.



Figure 4.2.5

7. 20x4 I2C Interface LCD:

The 20x4 I2C interface LCD (Liquid Crystal Display) is a display module that provides visual feedback to drivers about parking space availability. It communicates with the Arduino Uno using the I2C (Inter-Integrated Circuit) protocol, allowing for easy integration and minimal wiring. The

LCD display shows messages such as "Vacant" or "Occupied" to indicate the status of each parking space in real-time.



Figure 4.2.6

□ Specifications

- Compatible with Arduino/Genuino UNO, Leonardo, Mega, 101 (Intel Curie), Micro, Nano, Mini.
- I2C Address: 0x20-0x27 (0x20 default)
- Back lit (Blue with white char color)
- Supply voltage: 5V.
- Interface: I2C/TWI x1, Gadgeteer interface x2.
- Adjustable contrast.

Liquid crystal display (LCD) has material which joins together the properties of both liquid and crystals. They have a temperature range within which the particles are essentially as mobile as they might be in a liquid, however are gathered together in an order form similar to a crystal.

The LCD is much more informative output device than a single LED. The LCD is a display that can easily show characters on its screen. They have a couple of lines to large displays. Some LCDs are specially designed for specific applications to display graphic images. 20x4 LCD (HD44780) module is commonly used. These modules are replacing 7-segments and other multi-segment LEDs. LCD can be easily interfaced with microcontroller to display a message or status of the device. It can be operated in two modes: 4-bit mode and 8-bit mode. This LCD has two registers namely command register and data register. It is having three selection lines and 8 data lines. By connecting the three selection lines and data lines with the microcontroller, the messages can be displayed on LCD.

□ Important command codes for LCD

Sl.No.	Hex Code	Command to LCD instruction Register
1	01	Clear display screen
2	02	Return home
3	04	Decrement cursor (shift cursor to left)
4	06	Increment cursor (shift cursor to right)
5	05	Shift display right
6	07	Shift display left
7	08	Display off, cursor off

8	0A	Display off, cursor on
9	0C	Display on, cursor off
	100E	Display on, cursor blinking
	110F	Display on, cursor blinking



12	10	Shift cursor position to left
13	14	Shift cursor position to right
14	18	Shift the entire display to the left
15	1C	Shift the entire display to the right
16	80	Force cursor to beginning (1st line)



LCD connections in 4-bit Mode

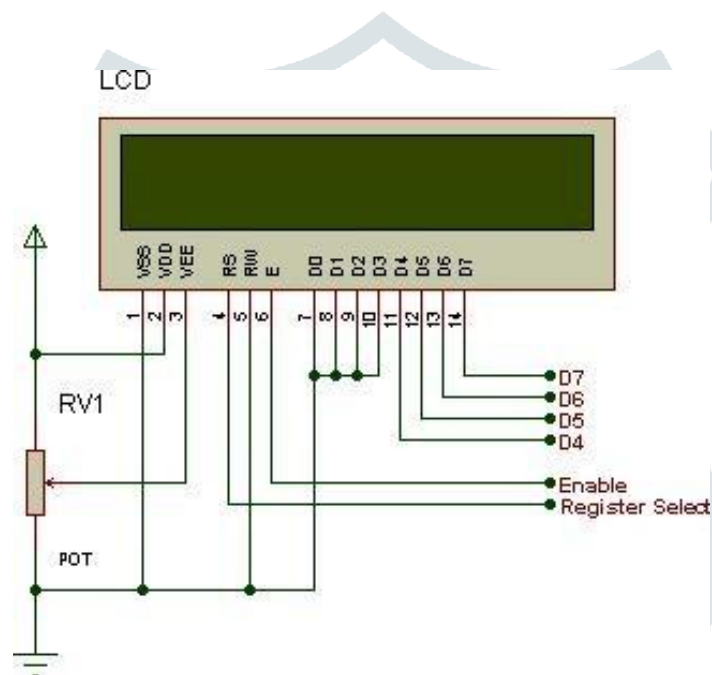


Figure 4.2.7

Above is the connection diagram of LCD in 4-bit mode, where we only need 6 pins to interface an LCD. D4-D7 are the data pins connection and Enable and Register select are for LCD control pins. We are not using Read/Write (RW) Pin of the LCD, as we are only writing on the LCD so we have made it grounded permanently. If you want to use it. Then you may connect it on your controller but that will only increase another pin and does not make any big difference. Potentiometer RV1 is used to control the LCD contrast. The unwanted data pins of LCD i.e. D0-D3 are connected to ground.

8. DFPlayer Mini MP3 Player :

The DFPlayer Mini MP3 player is a compact audio module capable of playing sound files stored on a microSD card. In the smart parking system, the DFPlayer Mini is used to provide audio feedback or instructions to drivers, such as guiding them to available parking spaces or announcing parking restrictions. It interfaces with the Arduino Uno and can be triggered to play specific audio files based on predetermined conditions or user inputs.

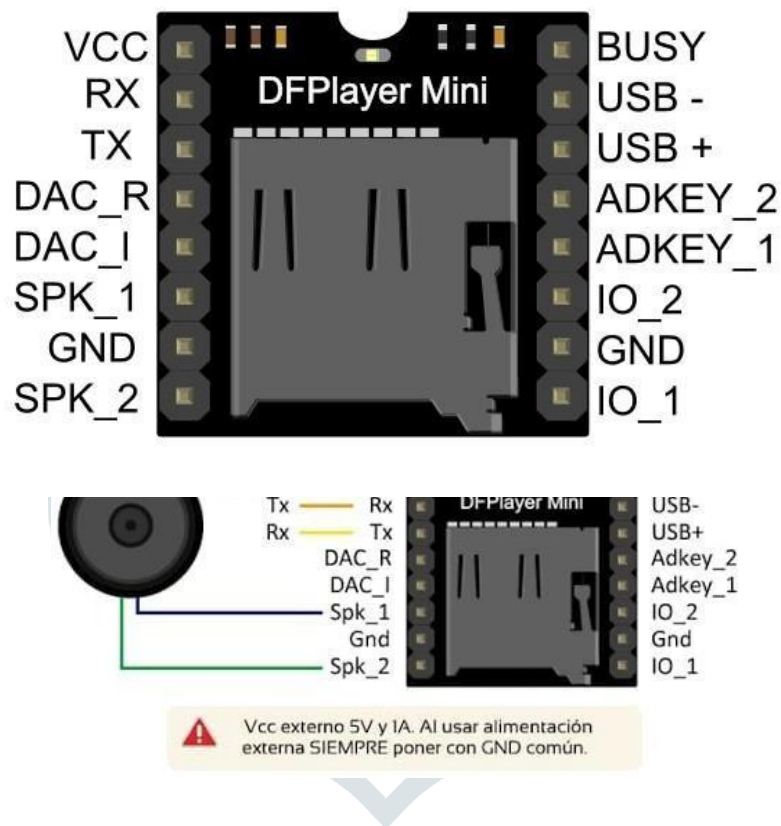


Figure 4.2.8

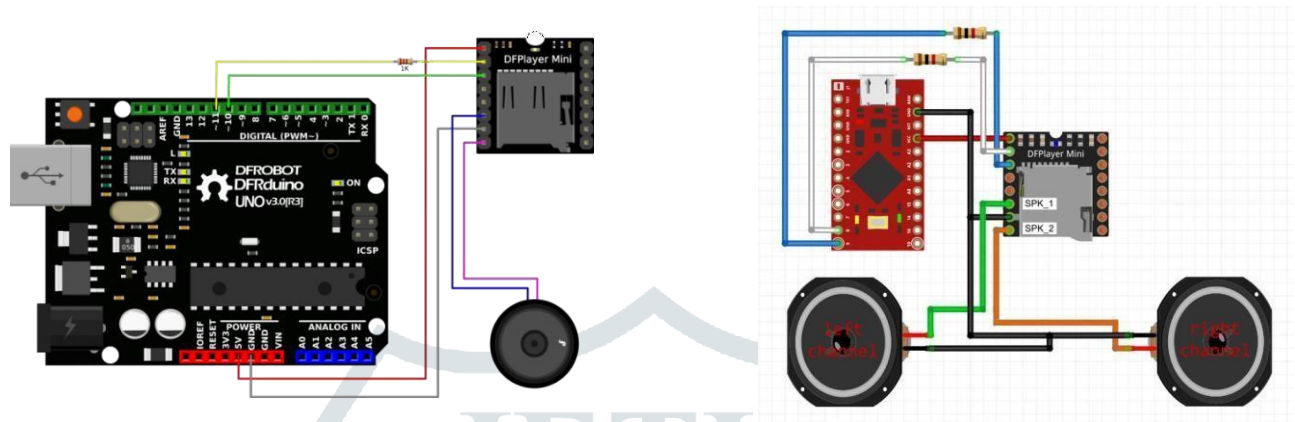


Figure 4.2.9

Specifications:

- Size: 21 x 20 x 3.8mm
- Weight: 3g
- Supported File Formats: MP3, WAV, WMA
- Voltage: 3.2V-5V
- Output Power: 2 x 3W (4 ohms)
- Storage Medium: Micro SD Card (up to 32GB)
- Audio Sample Rate: 8-48kHz
- Distortion: <0.1%
- SNR (Signal-to-Noise Ratio): 90dB
- Operating Temperature: -20°C to 60°C
- Interface: Serial Control (UART)
- Consumption Current: 20mA (standby), 30mA-100mA (playing)

9. Wi-Fi Module:

The Wi-Fi module enables the smart parking system to connect to a WiFi network and communicate with other devices or servers. It allows the system to send data, such as parking availability information, to a central database or receive commands from a smart phone app. The Wi-Fi module expands the capabilities of the smart parking system by enabling remote monitoring and control.

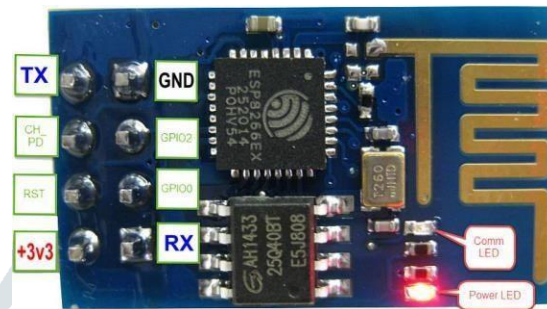
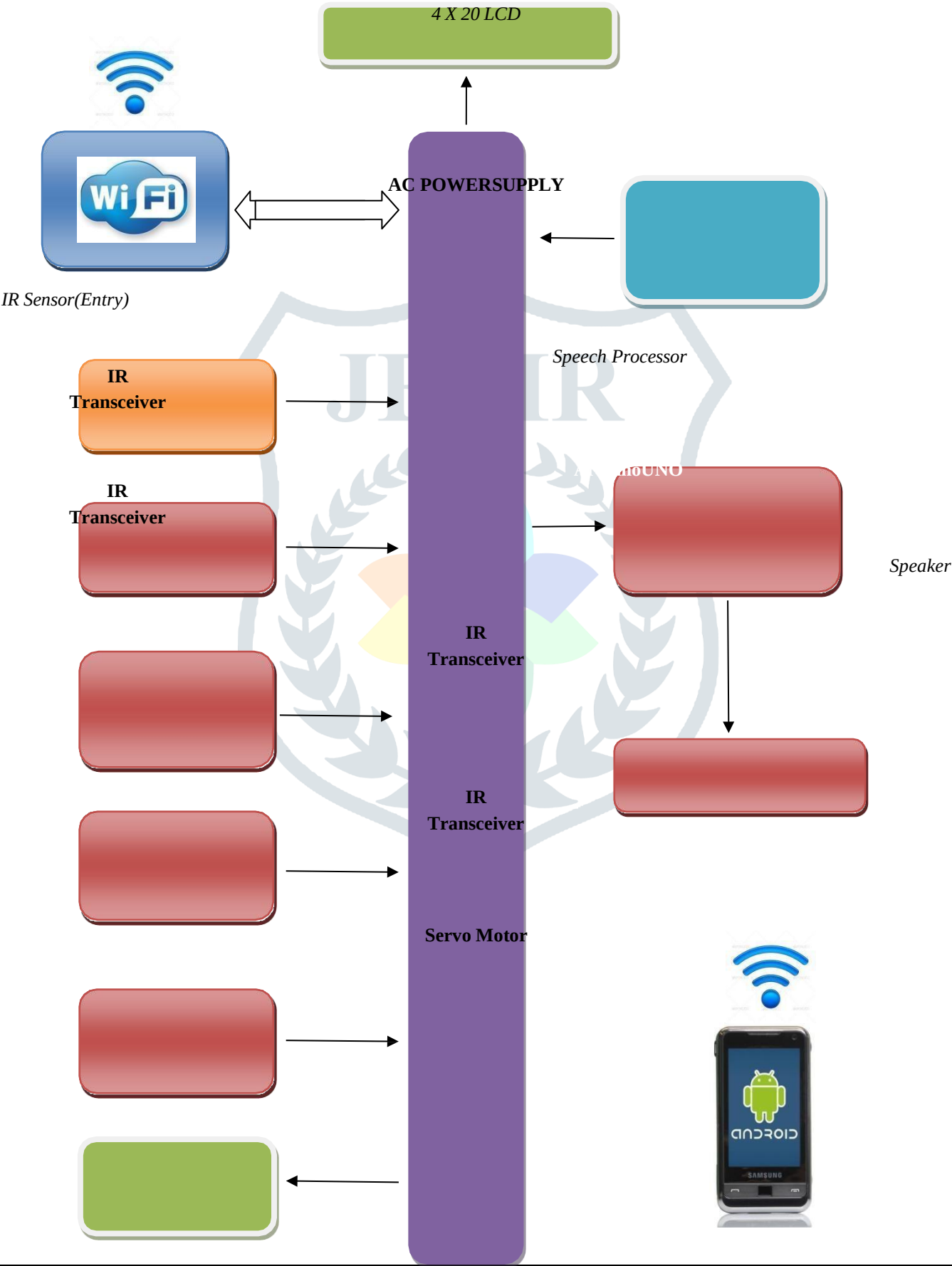


Figure 4.2.10

Specification:

- Size : 38 x 11.5 x 24 mm
- Weight: 17g
- Speed (at 4.8V): 0.14 sec/60 degrees
- Speed (at 6.0V): 0.12 sec/60 degrees
- Torque (at 4.8V): 2.5 kgf-cm
- Torque (at 6.0V): 3.0 kgf-cm
- Voltage Range: 4.8V - 6.0V

BLOCK DIAGRAM:



5.

PHYSICAL MODELLING

Constructing the physical model of our IoT-based smart parking system was like assembling a miniature version of a real parking lot. We carefully gathered various components, such as sensors for detecting cars, microcontrollers for making decisions, and actuators for controlling gates.

Assembling the model involved meticulous planning and attention to detail. We positioned the sensors strategically to ensure they could accurately detect vehicles, and we connected everything together with wires, much like putting together pieces of a puzzle. Powering the model was essential, either through batteries or a reliable power source, to ensure smooth operation.

Once the model was assembled, we conducted thorough testing to ensure its functionality. We observed how the sensors detected cars, how the microcontrollers processed information, and how the actuators responded to commands. This testing phase allowed us to identify any issues and fine-tune the system for optimal performance.

Building the physical model not only provided practical experience but also deepened our understanding of IoT principles. It was a hands-on opportunity to apply theoretical knowledge to real-world engineering challenges. Moreover, it exemplified our commitment to professionalism and excellence in engineering education.

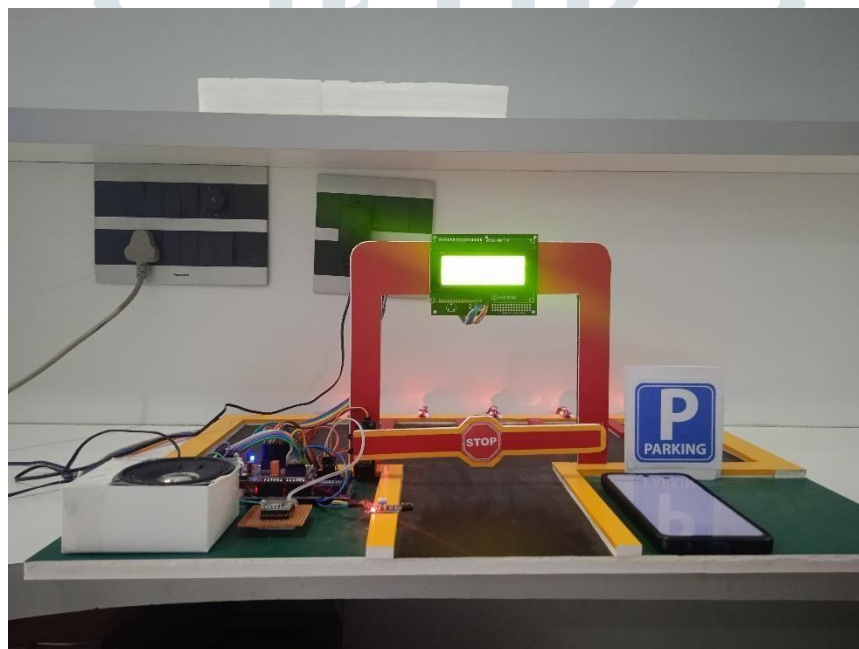




Figure 5.2



Figure 5.3

6.

WORKING

The Smart Parking System is designed to monitor available empty slots in a parking lot in away that is both economical and reliable, helping to save fuel and time for drivers. At the heart of this system are Infra-Red (IR) sensors, which are widely used due to their affordability and efficiency. Unlike cameras, IR sensors require less memory, making them a practical choice for monitoring parking spaces.

Each parking slot is equipped with an IR sensor that detects whether the space is occupied by a car or is empty. When a car enters the parking lot, the IR sensor detects it and sends a signal to an Arduino. The Arduino processes this signal and controls servo motors that manage the barrier gate, opening it to allow the car to enter.

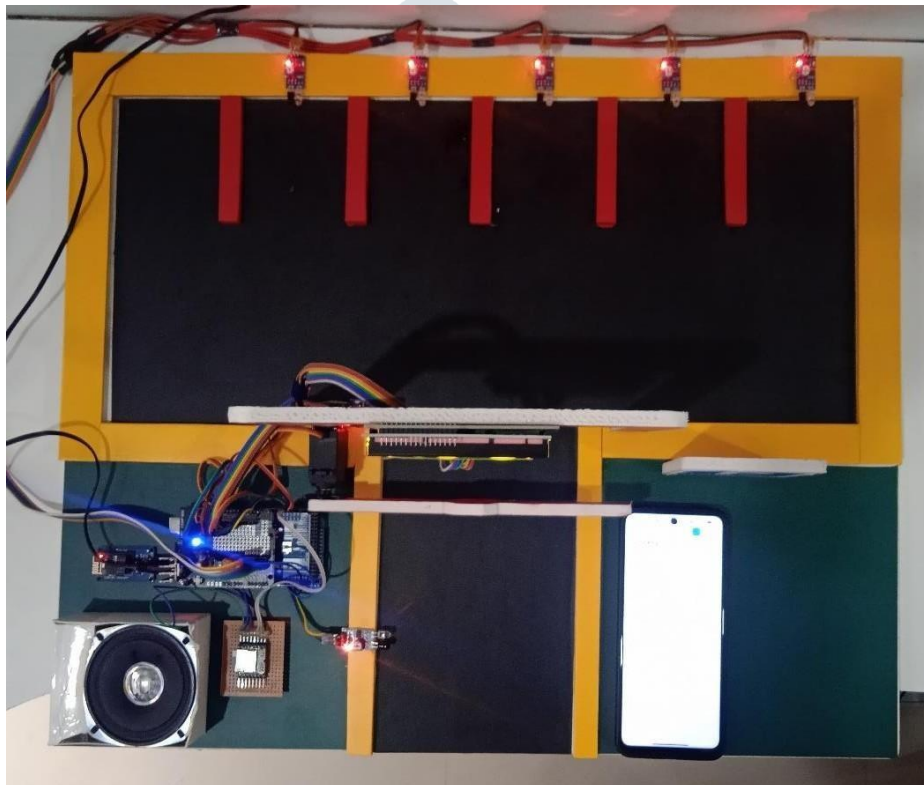


Figure 6.1



Figure 6.2

Once the car is parked, the IR sensor detects the presence of the vehicle and sends another signal to the Arduino. The Arduino then updates the status on the LCD screens placed around the parking lot. These screens show real-time information about which slots are available, helping drivers quickly find an open spot. If all the parking slots are full, the screen will display a message saying "Sorry, parking lot is full." Simultaneously, a speech processor connected to a speaker will announce the same message, ensuring that drivers are promptly informed without having to check the screens.

To enhance the system further, a Wi-Fi module is used to provide real-time availability of parking slots through a mobile application. This integration ensures that drivers have access to the latest information about parking spaces even before they enter the parking lot, adding a layer of convenience and efficiency to the system.

1. WI-FI Module Integration:

The Arduino microcontroller is equipped with a Wi-Fi module, such as the ESP8266 or ESP32. This module enables wireless communication between the Arduino and external devices, including smartphones and servers.

The Wi-Fi module is configured to connect to the local Wi-Fi network, allowing it to transmit and receive data over the internet.

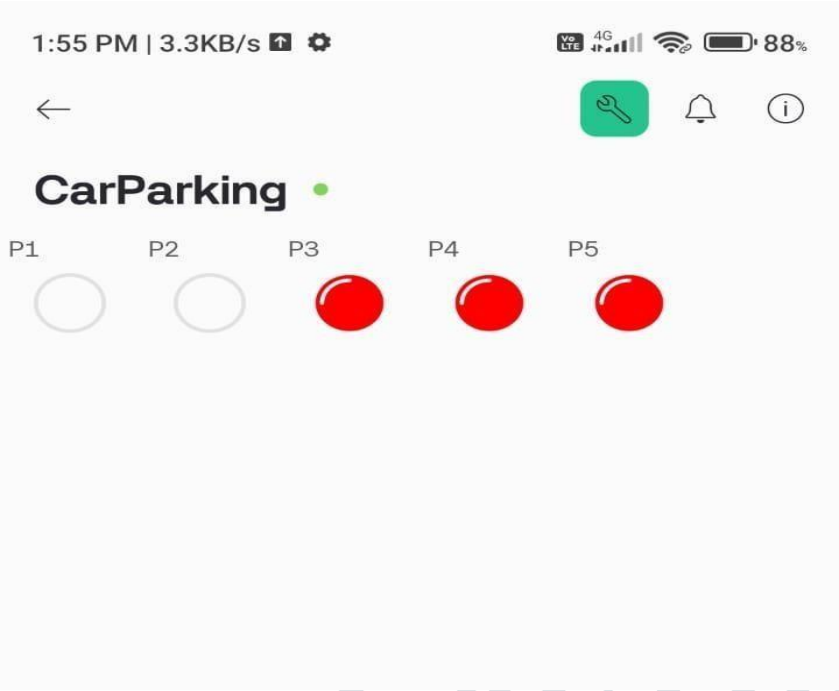


Figure 6.3: Mobile app showing status of filled slots

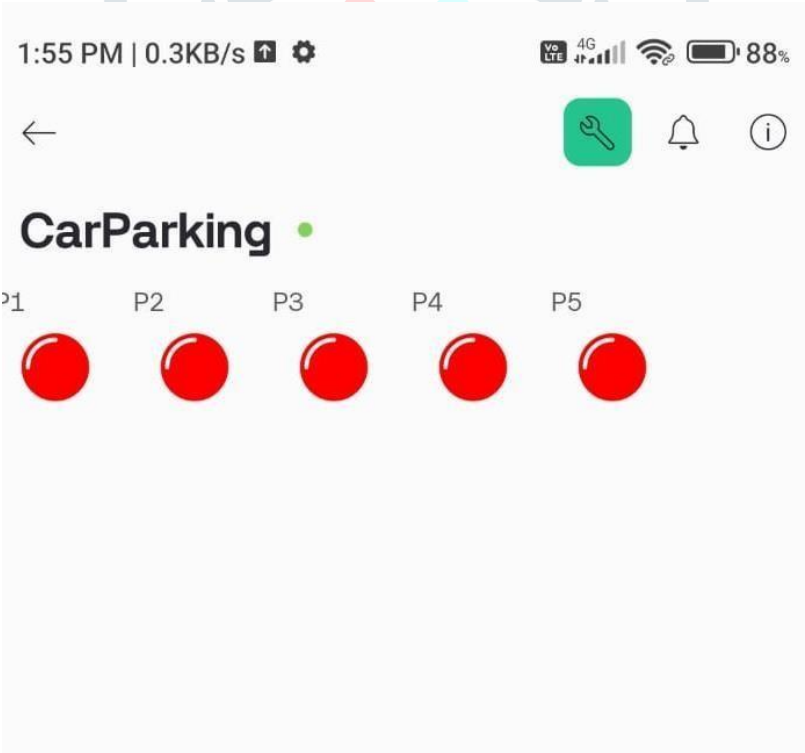


Figure 6.4: Mobile app showing all slots are full.

2. Real-Time Data Transmission:

- The IR sensors continuously monitor the status of each parking slot, sending data to the Arduino.
- The Arduino processes this data and formats it into a readable structure for the Wi-Fi module.
- The Wi-Fi module then transmits this data to a cloud server or directly to the mobile application, ensuring that the information is updated in real-time.

3. Mobile Application:

- A dedicated mobile application is developed to interface with the parking system. This app can be built for both iOS and Android platforms, making it accessible to a wide range of users.
- The app receives data from the Wi-Fi module via the cloud server. It displays the current status of each parking slot, indicating whether it is occupied or available.

7. ADVANTAGES AND DISADVANTAGES**ADVANTAGES:**

1. **Efficient Space Utilization:** Optimizes parking space, reducing congestion and enhancing efficiency.
2. **Real-time Information:** Provides users with up-to-date parking availability information for better decision-making.
3. **Cost Savings:** Reduces fuel consumption and emissions by minimizing time spent searching for parking.
4. **User Convenience:** Enhances user experience with easy access to parking information through a mobile app.
5. **Enhanced Security:** Integration with security cameras can deter theft and vandalism in parking lots.
6. **Environmental Benefits:** By minimizing time spent idling while searching for parking, emissions are reduced.
7. **Reduced Traffic Congestion:** Less time spent searching for parking translates to smoother traffic flow, especially in congested areas.

DISADVANTAGES:

1. The services cannot be provided if the person does not use smart phones.
2. **Initial Infrastructure Cost:** Implementing the necessary infrastructure, including sensors, communication devices, and a centralized control system, can incur substantial upfront costs.
3. **Maintenance Challenges:** Regular maintenance of IoT devices and sensors is required, posing challenges in terms of time, resources, and potential disruptions to the system.
4. **Dependency on Power Sources:** IoT devices and sensors rely on power sources; any power outage can disrupt the functionality of the system.

8.APPLICATIONS

1. **Urban Parking Management:** Smart parking systems are widely used in urban areas to manage parking in busy city centers, commercial districts, and residential neighborhoods.
2. **Shopping Malls and Retail Centers:** Retail establishments utilize smart parking systems to provide convenience to customers and optimize parking resources.
3. **Airports and Transportation Hubs:** Airports, train stations, and bus terminals implement smart parking solutions to streamline parking for travelers and employees.
4. **Corporate Offices and Business Parks:** Companies deploy smart parking systems to manage employee parking and visitor parking efficiently.
5. **Smart Cities Initiatives:** Smart parking is a key component of smart city initiatives aimed at using technology to improve urban infrastructure and enhance quality of life for residents.
6. **Event Venues and Stadiums:** Sporting arenas, concert venues, and event spaces use smart parking systems to accommodate large crowds and ensure smooth parking operations during events.
7. **Hospital and Healthcare Facilities:** Hospitals and medical centers utilize smart parking to provide easy access for patients, visitors, and staff while optimizing parking capacity.
8. **Tourist Attractions and Cultural Sites:** Tourist destinations and cultural landmarks implement smart parking solutions to enhance the visitor experience and manage traffic flow effectively.

FUTURE SCOPE

1. *Solar-Powered Parking Lots:*

- **Concept:** The basic idea behind a solar parking lot is to incorporate solar panels into carports. A carport is essentially an open-sided shed with a roof, designed to shelter parked vehicles.
- **Scalability:** Solar carports can be small enough to fit a single car at a residence or scaled up for commercial and institutional purposes, such as at malls or office complexes.
- **Benefits:** The primary benefit is generating renewable energy to lower on-site utility costs. Depending on the scale, installations could also produce excess electricity that can be sold back to the grid. Additionally, solar carports help reduce the "heat island" effect in parking lots, contributing to a cooler community environment and providing protection from the elements, which can extend vehicle lifespan.
- **Energy Savings:** Solar installations typically meet up to 35% of a space's total power requirements and can save up to 15% in energy costs. These sustainable car parks have short payback periods (five to eight years) and offer multiple benefits, including providing both shade and electricity.



Figure 9.1

2. Pre-Booking and Payment System:

- **Concept:** Implementing a payment system that allows users to pre-book parking spaces for a specific time by making a reasonable payment before arriving at the location.
- **Benefits:** This feature enhances convenience for users, ensuring they have a reserved parking spot upon arrival. It also helps in managing parking lot occupancy more efficiently.

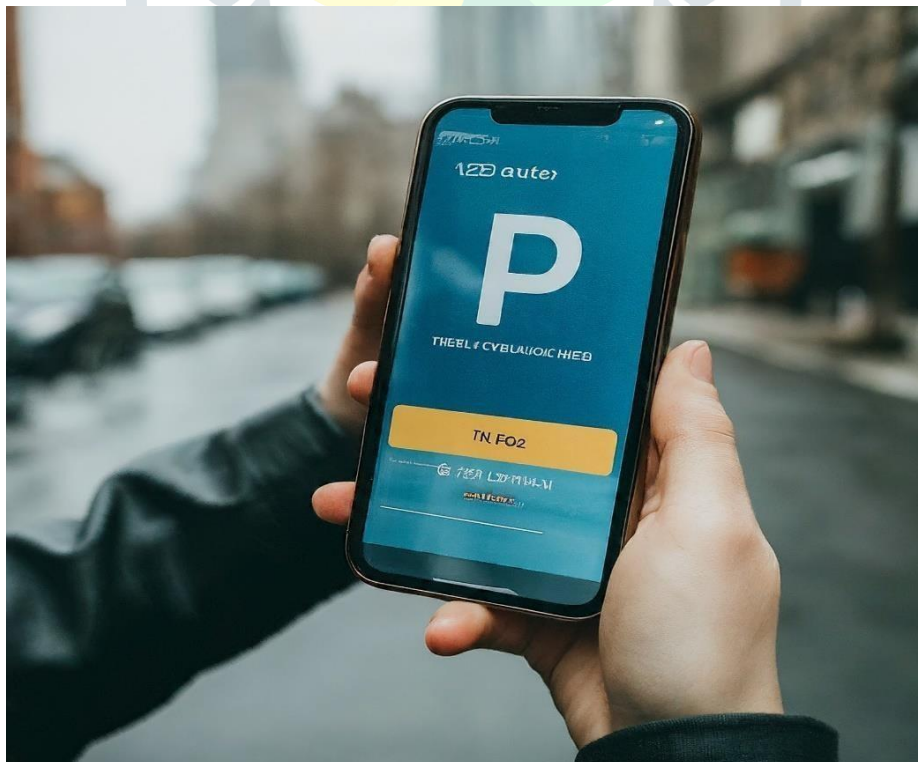


Figure 9.2

3. Smart Charging Stations for Electric Vehicles (EVs):

- **Concept:** Integrating smart charging stations for electric vehicles within the parking system.
- **Benefits:** This addition would support the growing adoption of electric vehicles by providing convenient charging options. Smart charging stations can optimize energy use, reduce charging times, and offer users real-time information on charging station availability and status through the mobile application.



Figure 9.3

4. Integration with Smart City Infrastructure:

- **Concept:** Connecting the Smart Parking System with broader smart city infrastructure.
- **Benefits:** This integration allows for better traffic management, environmental monitoring, and improved urban planning. It can facilitate seamless interactions between different smart systems within a city, such as public transportation and emergency services.



Figure 9.4

10.CONCLUSION

The proposed IoT-based smart parking system aims to revolutionize parking management by providing real-time information on parking slot availability. The system is designed to enhance the city's parking facilities and improve convenience for people. By transitioning parking management into a computational service, the system offers value-added services to both users and parking service providers.

Through successful completion and testing, the project has demonstrated the integration of hardware components to develop an automatic car parking system prototype. Utilizing microcontroller-based control systems, the project addresses the challenges of automation while prioritizing efficiency and convenience.

The benefits of the smart parking system include user-friendliness, time and fuel savings by eliminating the need to search for parking spaces, and reduced traffic congestion and pollution. By efficiently utilizing parking space, the system can accommodate more vehicles in limited areas while reducing time and costs associated with conventional parking methods. Overall, the system contributes to a more sustainable and efficient urban environment.

In essence, the IoT-based smart parking system represents a significant step forward in modernizing parking management, offering practical solutions to address the challenges of urban mobility. With its successful implementation and potential for further development, the system holds promise for improving parking experiences and enhancing city infrastructure.

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