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Smart Parking Management System

Dr. M Murali, Ranabothu Sandeep, Akiti Rohith Reddy, V. Shiva Pachimatla Sanjay, Pulipati Naresh
CSE-IOT
ACE Engineering College, Hyderabad, India

Abstract: *The Smart Parking Management System (SPMS) is an innovative IoT-based solution designed to address the escalating parking challenges in urban environments. By leveraging technologies like IoT, cloud computing, and real-time analytics, the system automates parking space monitoring, availability tracking, and user communication through a mobile application. SPMS enables users to locate, reserve, and pay for parking seamlessly while optimizing resource usage and reducing traffic congestion. Integration of RFID and License Plate Recognition ensures secure, automated entry and exit. Additionally, sensors such as fire and rain detectors enhance safety, making SPMS a scalable and eco-friendly model for modern smart cities.*

Keywords: *Smart Parking Management System*

I. INTRODUCTION

Urbanization and the proliferation of private vehicles have exacerbated parking space shortages, resulting in congestion, delays, and environmental degradation. Traditional manual systems are inadequate, lacking real-time updates and automated control. SPMS addresses these gaps through smart technologies, transforming static parking lots into intelligent, adaptive infrastructures. The system incorporates sensors to detect vehicle presence, microcontrollers for control, cloud servers for data storage, and mobile applications for user interaction. Features like real-time availability, automated gate control, and cashless payments enhance the user experience while promoting sustainability through efficient space utilization and reduced emissions.

II. OBJECTIVES

The Smart Parking Management System aims to reduce parking search time using real-time space tracking. It enables automated entry and exit through RFID and LPR. Users can reserve and pay via a mobile app, enhancing convenience. Safety is improved with fire, rain sensors, and surveillance. The system supports dynamic pricing through analytics, reduces emissions by minimizing traffic, and is scalable for deployment in various urban, commercial, and residential environments.

III. PROBLEM STATEMENT

Traditional parking systems face several significant challenges. They often lead to long queues and delayed access due to manual processes. The absence of real-time space availability information causes inefficiencies and user frustration. These systems also incur high operational and labor costs, while being prone to security vulnerabilities and revenue leakages. Additionally, vehicles searching for parking contribute to environmental degradation through increased fuel consumption and harmful emissions, worsening urban traffic conditions.

IV. PROPOSED SYSYTEM

SPMS uses IoT sensors to detect parking occupancy, sending real-time data to a cloud platform accessible through a mobile app. RFID and License Plate Recognition automate access control, reducing human intervention. The app allows users to locate, reserve, and pay for parking digitally. Fire and rain sensors enhance safety, while analytics support data-driven decisions. The modular architecture ensures adaptability to malls, airports, residential complexes, and public areas.

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V. HARDWARE AND SOFTWARE REQUIREMENTS

HARDWARE REQUIREMENTS:

- IR/Ultrasonic Sensors
- Arduino UNO
- RFID Reader
- Wi-Fi Module (ESP8266/ESP32)
- DC Motor & Gate Controller
- LCD Display (16x2)

SOFTWARE REQUIREMENTS:

- Arduino IDE
- Embedded C
- Android App (for user interaction)
- Cloud Server (for real-time data and payments)

VI. TECHNOLOGY DESCRIPTION:

SPMS integrates sensor data with cloud-based systems via microcontrollers. Real-time occupancy is displayed on a user-friendly mobile app. The app supports navigation, payment, and reservation. Gate controllers function via RFID and LPR to allow seamless vehicle access. Safety sensors trigger alerts for fire and rain. Data is processed for usage patterns, dynamic pricing, and demand forecasting, ensuring efficiency and sustainability.

VII. PACKAGES USED

The Smart Parking Management System utilizes a range of software packages to ensure seamless integration of hardware and cloud-based services. The Arduino IDE is used for programming the microcontroller, with essential libraries such as WiFi.h or ESP8266WiFi.h for network communication. The LiquidCrystal_I2C library manages the LCD display, while Adafruit_Sensor aids in accurate sensor readings. For cloud interaction and real-time updates, Firebase or MQTT protocols are used. The Android app may utilize Retrofit for API calls, Firebase SDK for data syncing, and third-party payment gateways for secure transactions. Together, these packages support real-time monitoring, user interaction, and backend management efficiently.

VIII. ALGORITHM

The Smart Parking Management System begins by initializing the hardware and establishing a Wi-Fi connection. It continuously monitors sensor values, such as IR data, to detect vehicle presence. This information is transmitted to the cloud, where the user app retrieves real-time parking status. Once a user selects a spot, the reservation system locks it. RFID or License Plate Recognition enables automated gate access. Payments are verified digitally through the app. Upon exit, the system updates the database to reflect the spot's availability. The admin dashboard provides usage analytics and supports dynamic pricing adjustments.

Source Code :

```
#include <WiFi.h>
#include <Wire.h>
#include <LiquidCrystal_PCF8574.h>

// WiFi credentials
const char* ssid = "iq";
const char* password = "7569605591";
```

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```
WiFiServer server(80);

// LCD setup
LiquidCrystal_PCF8574 lcd(0x27);

// IR sensor pins for slot 1, slot 2, slot 3
const int irPins[3] = {32, 33, 34};  // Adjust pins if needed

// Slot status: 1 = Available, 0 = Booked
int slots[3] = {1, 1, 1};  // Booking status
int physicalStatus[3] = {1, 1, 1};  // IR sensor status
bool lcdNeedsUpdate = true;

// Payment handling
bool waitingForPayment = false;
int paymentSlot = -1;

void setup() {
 Serial.begin(115200);
 delay(500);

 // Setup IR pins
 for (int i = 0; i < 3; i++) {
  pinMode(irPins[i], INPUT);
 }

 // Setup LCD
 lcd.begin(16, 2);
 lcd.setBacklight(255);
 lcd.setCursor(0, 0);
 lcd.print("Smart Parking");

 // Connect to WiFi
 WiFi.begin(ssid, password);
 Serial.print("Connecting to WiFi");
 int attempts = 0;
 while (WiFi.status() != WL_CONNECTED && attempts < 20) {
  delay(500);
  Serial.print(".");
  attempts++;
 }

 if (WiFi.status() == WL_CONNECTED) {
  Serial.println("\nWiFi Connected!");
  Serial.println(WiFi.localIP());
  server.begin();
 } else {
  Serial.println("\nWiFi Failed. Restarting...");
```

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```
    ESP.restart();
  }

  updateLCDIfChanged();  // Initial display
}

void loop() {
  updateSlotsFromIR();      // Update physical presence via IR
  updateLCDIfChanged();     // LCD refresh
  handleWebRequests();      // Process web inputs
}

void updateSlotsFromIR() {
  for (int i = 0; i < 3; i++) {
    int ir = digitalRead(irPins[i]) == LOW ? 0 : 1;  // IR LOW = vehicle present
    if (ir != physicalStatus[i]) {
      physicalStatus[i] = ir;

      // Vehicle arrived
      if (physicalStatus[i] == 0 && slots[i] == 1) {
        slots[i] = 0;
        lcdNeedsUpdate = true;
      }
      // Vehicle left
      else if (physicalStatus[i] == 1 && slots[i] == 0) {
        slots[i] = 1;
        lcdNeedsUpdate = true;
      }
    }
  }
}

void updateLCDIfChanged() {
  if (!lcdNeedsUpdate) return;

  lcd.clear();
  int available = 0;
  for (int i = 0; i < 3; i++) {
    if (slots[i] == 1) available++;
  }

  lcd.setCursor(0, 0);
  lcd.print("Available: ");
  lcd.print(available);
  lcd.setCursor(0, 1);
  lcd.print(WiFi.localIP());

  lcdNeedsUpdate = false;
```


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```
}

void handleWebRequests() {
 WiFiClient client = server.available();
 if (!client) return;

 String request = client.readStringUntil('\r');
 client.flush();
 request.trim();
 Serial.println("Request: " + request);

 // Booking slots
 if (request.indexOf("/book1") != -1 && slots[0] == 1) {
  slots[0] = 0; lcdNeedsUpdate = true;
}
 if (request.indexOf("/book2") != -1 && slots[1] == 1) {
  slots[1] = 0; lcdNeedsUpdate = true;
 }
 if (request.indexOf("/book3") != -1 && slots[2] == 1) {
  slots[2] = 0; lcdNeedsUpdate = true;
 }

 // Payment trigger
 if (request.indexOf("/pay1") != -1 && slots[0] == 0) {
  paymentSlot = 0; waitingForPayment = true;
  sendPaymentPage(client); return;
 }
 if (request.indexOf("/pay2") != -1 && slots[1] == 0) {
  paymentSlot = 1; waitingForPayment = true;
  sendPaymentPage(client); return;
 }
 if (request.indexOf("/pay3") != -1 && slots[2] == 0) {
  paymentSlot = 2; waitingForPayment = true;
  sendPaymentPage(client); return;
 }

 // Payment confirmation
 if (request.indexOf("/confirm") != -1 && waitingForPayment && paymentSlot != -1) {
  slots[paymentSlot] = 1;
  waitingForPayment = false;
  paymentSlot = -1;
  lcdNeedsUpdate = true;
 }

 // Payment cancel
 if (request.indexOf("/cancel") != -1) {
  waitingForPayment = false;
  paymentSlot = -1;
```

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```
  }

  sendWebPage(client);
}

void sendWebPage(WiFiClient client) {
  client.print("HTTP/1.1 200 OK\r\nContent-Type: text/html\r\n\r\n");
  client.print("<html><head><title>Smart Parking</title>");
  client.print("<style>");
  client.print("body { font-family: Arial; text-align: center; background: linear-gradient(#ffffff, #d4fc79); }");
  client.print("h1 { color: #333; }");
  client.print("table { margin: auto; border-collapse: collapse; width: 90%; }");
  client.print("th, td { padding: 15px; border: 2px solid #666; font-size: 18px; }");
  client.print(".available { background-color: lightgreen; }");
  client.print(".booked { background-color: tomato; }");
  client.print(".present { background-color: orange; }");
  client.print("button { padding: 10px 18px; font-size: 16px; }");
  client.print("</style></head><body>");
  client.print("<h1>Smart Parking System</h1>");
  client.print("<table>");
  client.print("<tr><th>Slot</th><th>Booking                                    Status</th><th>IR
Presence</th><th>Action</th><th>Payment</th></tr>");

  for (int i = 0; i < 3; i++) {
    client.print("<tr>");
    client.print("<td>Slot " + String(i + 1) + "</td>");

    // Booking status
    if (slots[i] == 1)
      client.print("<td class='available'>Available</td>");
    else
      client.print("<td class='booked'>Booked</td>");

    // IR presence logic
    if (slots[i] == 1) {
      client.print("<td>Empty</td>");
    } else {
      if (physicalStatus[i] == 0)
        client.print("<td class='present'>Vehicle Present</td>");
      else
        client.print("<td>Empty</td>");
    }

    // Booking button
    if (slots[i] == 1)
      client.print("<td><a href='/book" + String(i + 1) + "'><button>Book</button></a></td>");
    else
      client.print("<td>-</td>");
```

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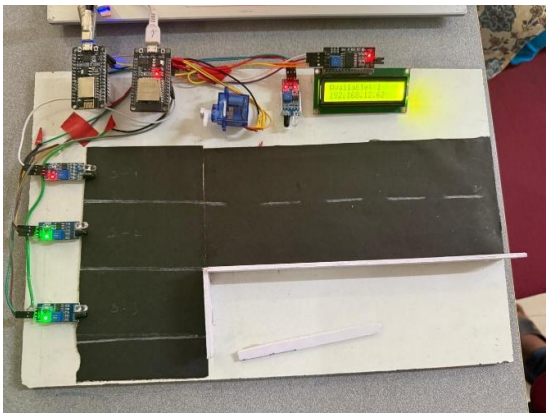
```
  // Payment button
  if (slots[i] == 0)
    client.print("<td><a href='/pay" + String(i + 1) + "'><button>Pay</button></a></td>");
  else
    client.print("<td>-</td>");

  client.print("</tr>");
 }

 client.print("</table>");
 client.print("<br><p><strong>Designed by FIN Team</strong></p>");
 client.print("</body></html>");
}

void sendPaymentPage(WiFiClient client) {
 client.print("HTTP/1.1 200 OK\r\nContent-Type: text/html\r\n\r\n");
 client.print("<html><head><title>Payment</title></head><body style='text-align:center;'>");
 client.print("<h2>Scan QR Code to Pay</h2>");
 client.print("<img src='https://api.qrserver.com/v1/create-qr-code/?size=200x200&data=ParkingPaymentSlot"
+ String(paymentSlot + 1) + "' alt='QR Code'><br><br>");
 client.print("<a href='/confirm'><button style='padding: 12px 25px; font-size: 18px;'>Yes, Payment
Done</button></a><br><br>");
 client.print("<a href='/cancel'><button style='padding: 12px 25px; font-size: 18px;'>No,
Cancel</button></a>");
 client.print("</body></html>");
}
```

X. RESULTS



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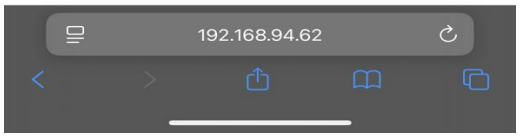

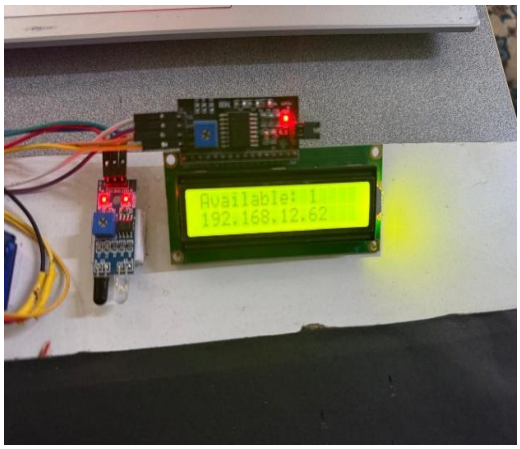

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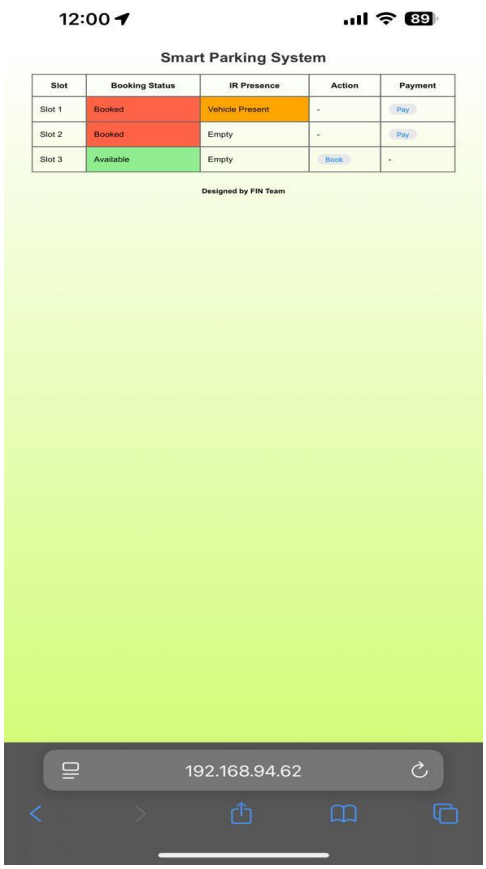

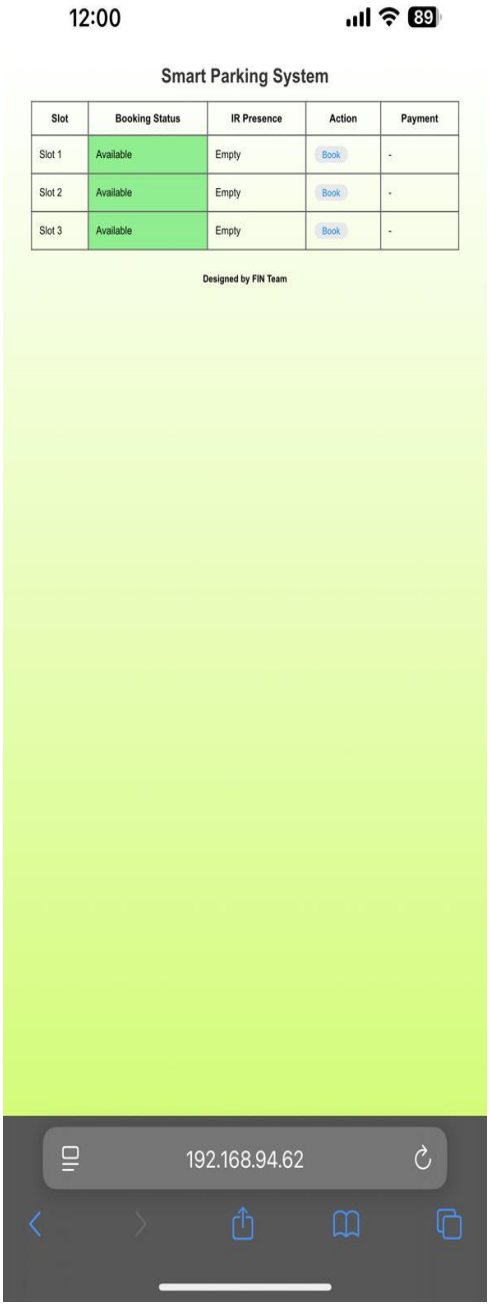

X. TESTING

Testing in the context of the Smart Parking Management System (SPMS) ensures that the system performs consistently and accurately over an extended period under expected (and sometimes unexpected) conditions. This type of testing is critical for any real-time, user-facing system that interacts with physical hardware and IoT infrastructure.

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A reliable parking system must ensure continuous uptime and require minimal maintenance, providing seamless service without interruptions. It should deliver accurate and timely parking status updates to help users find available spots efficiently. The system must offer trustworthy entry, exit, and payment processing, ensuring secure transactions. Lastly, it should maintain robust performance even under high user load, handling peak traffic effectively while maintaining speed and reliability for a smooth parking experience.

XI. CONCLUSION

The Smart Parking Management System offers a robust, scalable, and eco-conscious solution to urban parking challenges. Through automation, real-time analytics, and IoT integration, it enhances user convenience, security, and operational efficiency. Its modular design and cloud integration make it adaptable to various deployment scenarios, from smart campuses to city-scale parking infrastructures.

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