Mini-project #2:

Cloud Data Upload Using WiFi

TEAM MEMBERS

RAJ VARSHITH – 16325723

SHIVA REDDY – 16352875

KARTHIKEYA – 16354793

Introduction:

This project utilizes an ESP32 microcontroller to read temperature and humidity data from a DHT11 sensor, format the data into JSON, and send it to a Flask server for storage and display. The server is set up to receive data via HTTP POST requests.

Components Required

- ESP32 Development Board
- DHT11 Temperature and Humidity Sensor
- Jumper wires
- Breadboard (optional)
- Computer with Python and Flask installed

Libraries Used

1. **WiFi.h**: For connecting the ESP32 to a Wi-Fi network.
2. **DHT.h**: To interface with the DHT11 sensor.
3. **ArduinoJson.h**: For formatting data into JSON.
4. **HTTPClient.h**: For making HTTP requests.

Project Setup

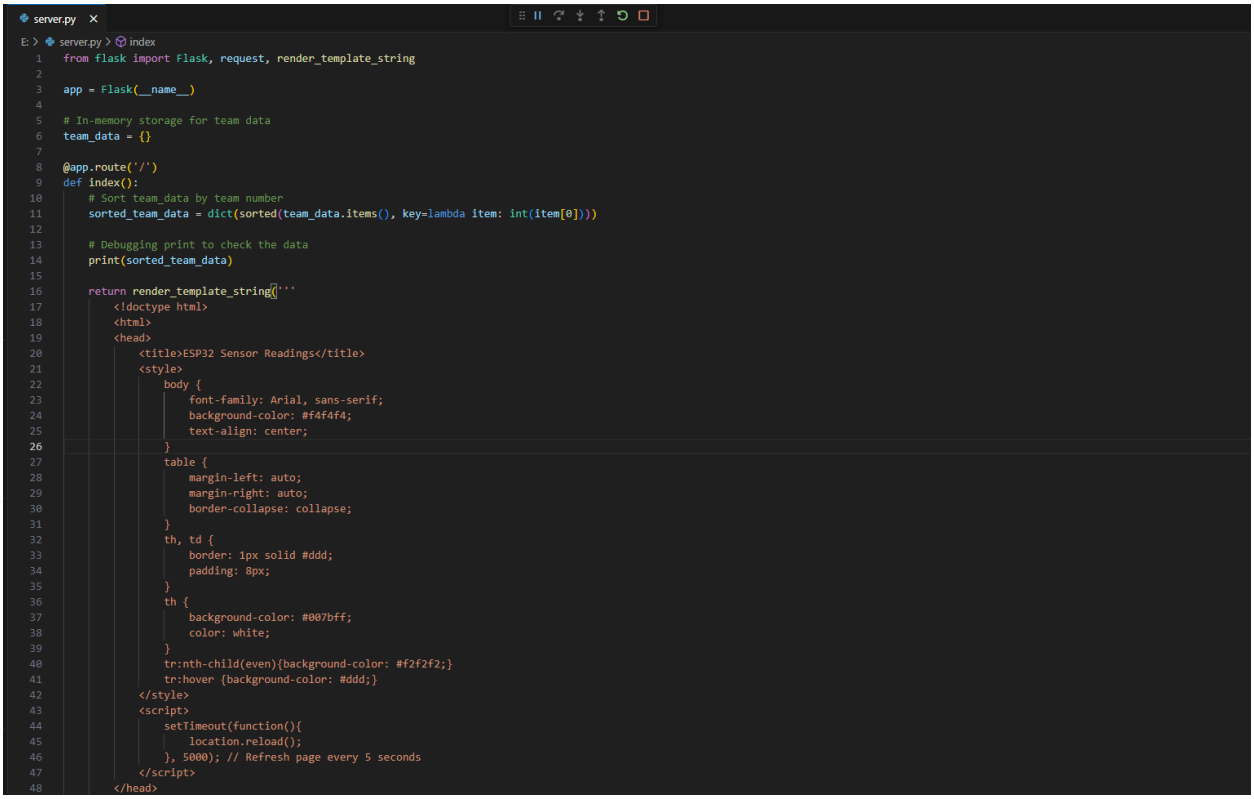
Hardware Connections

1. Connect the DHT11 sensor:
    - **VCC** to **3.3V** on the ESP32
    - **GND** to **GND** on the ESP32
    - **Data Pin** to **GPIO14** on the ESP32

Software Setup

1. **Install Arduino IDE**: Ensure you have the Arduino IDE installed on your computer.
2. **Install Required Libraries**: Use the Library Manager in Arduino IDE to install the following:
    - DHT sensor library
    - ArduinoJson library
3. **Set Up Flask Server**:
    - Create a Python file named server.py (see the code below).
    - Ensure you have Flask installed: pip install Flask.
    - Run the server using the command: python server.py.

Flask Server Code (server.py)



```python
from flask import Flask, request, render_template_string

app = Flask(__name__)

# In-memory storage for team data
team_data = {}

@app.route('/')
def index():
    # Sort team_data by team number
    sorted_team_data = dict(sorted(team_data.items(), key=lambda item: int(item[0])))

    # Debugging print to check the data
    print(sorted_team_data)

    return render_template_string('''
        <!doctype html>
        <html>
        <head>
            <title>ESP32 Sensor Readings</title>
            <style>
                body {
                    font-family: Arial, sans-serif;
                    background-color: #f4f4f4;
                    text-align: center;
                }
                table {
                    margin-left: auto;
                    margin-right: auto;
                    border-collapse: collapse;
                }
                th, td {
                    border: 1px solid #ddd;
                    padding: 8px;
                }
                th {
                    background-color: #007bff;
                    color: white;
                }
                tr:nth-child(even){background-color: #f2f2f2;}
                tr:hover {background-color: #ddd;}
            </style>
            <script>
                setTimeout(function(){
                    location.reload();
                }, 5000); // Refresh page every 5 seconds
            </script>
        </head>
```

```
        <body>
            <h1>ESP32 Sensor Readings</h1>
            <table>
                <tr>
                    <th>Team #</th>
                    <th>Temperature</th>
                    <th>Humidity</th>
                    <th>Timestamp</th>
                    <th>Post Count</th>
                </tr>
                {% for team, data in sorted_team_data.items() %}
                    <tr>
                        <td>{{ team }}</td>
                        <td>{{ data.temperature }}°C</td>
                        <td>{{ data.humidity }}%</td>
                        <td>{{ data.timestamp }}</td>
                        <td>{{ data.count }}</td>
                    </tr>
                {% endfor %}
            </table>
        </body>
        </html>
    ''', sorted_team_data=sorted_team_data)

@app.route('/post-data', methods=['POST'])
def receive_data():
    data = request.get_json()  # Get JSON data from request
    if data:
        team_number = data.get('team_number')
        temperature = data.get('temperature')
        humidity = data.get('humidity')
        timestamp = data.get('timestamp')

        if team_number not in team_data:
            team_data[team_number] = {
                'temperature': temperature,
                'humidity': humidity,
                'timestamp': timestamp,
                'count': 1  # Initialize count
            }
        else:
            team_data[team_number]['temperature'] = temperature
            team_data[team_number]['humidity'] = humidity
            team_data[team_number]['timestamp'] = timestamp
            team_data[team_number]['count'] += 1  # Increment count

```

```
            print(f"Data from Team number: {team_number}, Temperature: {temperature}, Humidity: {humidity}")
            return "Data Received", 200
        else:
            return "Invalid data", 400

if __name__ == "__main__":
    app.run(host='0.0.0.0', port=8888)

```

from flask import Flask, request, render_template_string

app = Flask(__name__)

In-memory storage for team data

team_data = {}

@app.route('/')

def index():

```
# Sort team_data by team number
sorted_team_data = dict(sorted(team_data.items(), key=lambda item: int(item[0])))

return render_template_string('''
  <!doctype html>
  <html>
  <head>
    <title>ESP32 Sensor Readings</title>
    <style>
      body {
        font-family: Arial, sans-serif;
        background-color: #f4f4f4;
        text-align: center;
      }
      table {
        margin-left: auto;
        margin-right: auto;
        border-collapse: collapse;
      }
      th, td {
        border: 1px solid #ddd;
        padding: 8px;
      }
      th {
        background-color: #007bff;
        color: white;
      }
```

```
        tr:nth-child(even) { background-color: #f2f2f2; }
        tr:hover { background-color: #ddd; }
    </style>
    <script>
        setTimeout(function() { location.reload(); }, 5000);
    </script>
</head>
<body>
    <h1>ESP32 Sensor Readings</h1>
    <table>
        <tr>
            <th>Team #</th>
            <th>Temperature</th>
            <th>Humidity</th>
            <th>Timestamp</th>
            <th>Post Count</th>
        </tr>
        {% for team, data in sorted_team_data.items() %}
            <tr>
                <td>{{ team }}</td>
                <td>{{ data.temperature }}°C</td>
                <td>{{ data.humidity }}%</td>
                <td>{{ data.timestamp }}</td>
                <td>{{ data.count }}</td>
            </tr>
        {% endfor %}
    </table>
```

```
        </body>
        </html>
    ''', sorted_team_data=sorted_team_data)

@app.route('/post-data', methods=['POST'])
def receive_data():
    team_number = request.json['team_number']
    if team_number not in team_data:
        team_data[team_number] = {
            'temperature': request.json['temperature'],
            'humidity': request.json['humidity'],
            'timestamp': request.json['timestamp'],
            'count': 1  # Initialize count
        }
    else:
        team_data[team_number]['temperature'] = request.json['temperature']
        team_data[team_number]['humidity'] = request.json['humidity']
        team_data[team_number]['timestamp'] = request.json['timestamp']
        team_data[team_number]['count'] += 1  # Increment count
    return "Data Received"

if __name__ == "__main__":
    app.run(host='0.0.0.0', port=8888)
```

Output:

```
{'7': {'temperature': 23.4, 'humidity': 60, 'timestamp': 1727229739, 'count': 35}}
192.168.1.208 - - [24/Sep/2024 21:02:23] "GET / HTTP/1.1" 200 -
Data from Team number: 7, Temperature: 23.4, Humidity: 60
192.168.1.48 - - [24/Sep/2024 21:02:29] "POST /post-data HTTP/1.1" 200 -
{'7': {'temperature': 23.4, 'humidity': 60, 'timestamp': 1727229749, 'count': 36}}
192.168.1.208 - - [24/Sep/2024 21:02:29] "GET / HTTP/1.1" 200 -
{'7': {'temperature': 23.4, 'humidity': 60, 'timestamp': 1727229749, 'count': 36}}
192.168.1.208 - - [24/Sep/2024 21:02:35] "GET / HTTP/1.1" 200 -
Data from Team number: 7, Temperature: 23.4, Humidity: 60
192.168.1.48 - - [24/Sep/2024 21:02:39] "POST /post-data HTTP/1.1" 200 -
{'7': {'temperature': 23.4, 'humidity': 60, 'timestamp': 1727229759, 'count': 37}}
192.168.1.208 - - [24/Sep/2024 21:02:41] "GET / HTTP/1.1" 200 -
```

ESP32 Code (main.ino)

Final_code.ino

```ino
#include <WiFi.h>
#include <DHT.h>
#include <ArduinoJson.h>
#include <HTTPClient.h>
#include <time.h>

#define DHTPIN 14          // Pin where the DHT11 data pin is connected
#define DHTTYPE DHT11      // DHT 11

DHT dht(DHTPIN, DHTTYPE); // Initialize DHT sensor
const char* ssid = "SpectrumSetup-BA";         // Your Wi-Fi SSID
const char* password = "Hotpoint@1252"; // Your Wi-Fi Password
const char* serverUrl = "http://192.168.1.208:8888/post-data"; // Replace with your Flask server's IP

void setup() {
    Serial.begin(115200);
    dht.begin();  // Start the DHT sensor
    connectToWiFi(); // Connect to Wi-Fi
    configTime(0, 0, "pool.ntp.org"); // Set the timezone to UTC, adjust if necessary
}

void loop() {
    float temperature = dht.readTemperature(); // Read temperature
    float humidity = dht.readHumidity();       // Read humidity

    // Check if any reads failed and exit early
    if (isnan(temperature) || isnan(humidity)) {
        Serial.println("Failed to read from DHT sensor!");
        return;
    }

    // Format data into JSON
    String jsonData = createJsonData(temperature, humidity);

    // Print the JSON data for debugging
    Serial.println(jsonData);

    // Send the data to the server
    sendDataToServer(jsonData);

    delay(10000); // Delay between readings (10 seconds)
}
```

```
void connectToWiFi() {
    WiFi.begin(ssid, password);
    Serial.print("Connecting to WiFi");
    while (WiFi.status() != WL_CONNECTED) {
        delay(500);
        Serial.print(".");
    }
    Serial.println("\nConnected to WiFi");
}

String createJsonData(float temperature, float humidity) {
    StaticJsonDocument<200> doc;
    doc["team_number"] = "7"; // Your team number
    doc["temperature"] = temperature;
    doc["humidity"] = humidity;

    // Get current time in seconds since epoch
    time_t now = time(nullptr);
    doc["timestamp"] = now; // This will give you a 10-digit timestamp

    String jsonData;
    serializeJson(doc, jsonData);
    return jsonData;
}

void sendDataToServer(String jsonData) {
    if (WiFi.status() == WL_CONNECTED) {
        HTTPClient http;
        http.begin(serverUrl); // Specify destination for HTTP request
        http.addHeader("Content-Type", "application/json"); // Specify content-type header as JSON

        // Send the request
        int httpResponseCode = http.POST(jsonData);

        if (httpResponseCode > 0) {
            String response = http.getString(); // Get response payload
            Serial.printf("HTTP Response code: %d\n", httpResponseCode);
            Serial.println("Response: " + response);
        } else {
            Serial.printf("Error in HTTP request: %s\n", http.errorToString(httpResponseCode).c_str());
        }
        http.end(); // Free resources
    } else {
        Serial.println("WiFi Disconnected");
```

```
#include <WiFi.h>
#include <DHT.h>
#include <ArduinoJson.h>
#include <HTTPClient.h>
#include <time.h>

#define DHTPIN 14         // Pin where the DHT11 data pin is connected
#define DHTTYPE DHT11     // DHT 11

DHT dht(DHTPIN, DHTTYPE); // Initialize DHT sensor
const char* ssid = "Your_SSID";         // Your Wi-Fi SSID
```

```
const char* password = "Your_Password"; // Your Wi-Fi Password

const char* serverUrl = "http://192.168.1.208:8888/post-data"; // Replace with your Flask server's IP


void setup() {
  Serial.begin(115200);
  dht.begin();  // Start the DHT sensor
  connectToWiFi(); // Connect to Wi-Fi
  configTime(0, 0, "pool.ntp.org"); // Set the timezone to UTC
}


void loop() {
  float temperature = dht.readTemperature(); // Read temperature
  float humidity = dht.readHumidity();       // Read humidity

  // Check if any reads failed and exit early
  if (isnan(temperature) || isnan(humidity)) {
    Serial.println("Failed to read from DHT sensor!");
    return;
  }

  // Format data into JSON
  String jsonData = createJsonData(temperature, humidity);

  // Print the JSON data for debugging
  Serial.println(jsonData);
```

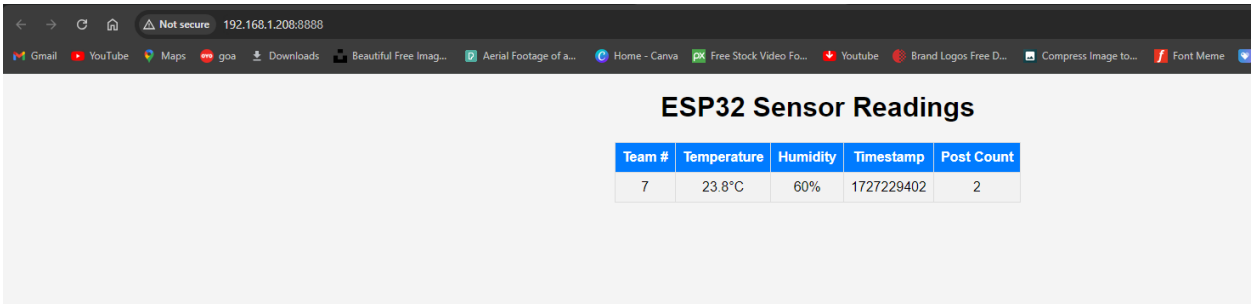
```
    // Send the data to the server
    sendDataToServer(jsonData);

    delay(10000); // Delay between readings (10 seconds)
}

void connectToWiFi() {
    WiFi.begin(ssid, password);
    Serial.print("Connecting to WiFi");
    while (WiFi.status() != WL_CONNECTED) {
        delay(500);
        Serial.print(".");
    }
    Serial.println("\nConnected to WiFi");
}

String createJsonData(float temperature, float humidity) {
    StaticJsonDocument<200> doc;
    doc["team_number"] = "9"; // Your team number
    doc["temperature"] = temperature;
    doc["humidity"] = humidity;

    // Get current time in seconds since epoch
    time_t now = time(nullptr);
    doc["timestamp"] = now; // This will give you a 10-digit timestamp

    String jsonData;
```

```
  serializeJson(doc, jsonData);
  return jsonData;
}

void sendDataToServer(String jsonData) {
  if (WiFi.status() == WL_CONNECTED) {
    HTTPClient http;
    http.begin(serverUrl); // Specify destination for HTTP request
    http.addHeader("Content-Type", "application/json"); // Specify content-type header as JSON

    // Send the request
    int httpResponseCode = http.POST(jsonData);

    if (httpResponseCode > 0) {
      String response = http.getString(); // Get response payload
      Serial.printf("HTTP Response code: %d\n", httpResponseCode);
      Serial.println("Response: " + response);
    } else {
      Serial.printf("Error in HTTP request: %s\n", http.errorToString(httpResponseCode).c_str());
    }
    http.end(); // Free resources
  } else {
    Serial.println("WiFi Disconnected");
  }
}
```

Output:

```
HTTP Response code: 200
Response: Data Received
{"team_number":"7","temperature":23.8,"humidity":61,"timestamp":1727229336}
HTTP Response code: 200
Response: Data Received
{"team_number":"7","temperature":23.8,"humidity":60,"timestamp":1727229346}
HTTP Response code: 200
Response: Data Received
{"team_number":"7","temperature":23.8,"humidity":60,"timestamp":1727229356}
HTTP Response code: 200
Response: Data Received
{"team_number":"7","temperature":23.8,"humidity":60,"timestamp":1727229366}
HTTP Response code: 200
Response: Data Received
{"team_number":"7","temperature":23.8,"humidity":60,"timestamp":1727229376}
Error in HTTP request: connection refused
{"team_number":"7","temperature":23.8,"humidity":60,"timestamp":1727229391}
HTTP Response code: 200
Response: Data Received
```

Final Output from the Web Page:



Explanation of the Code

Flask Server (server.py)

- **Imports**: The necessary Flask modules are imported.
- **Data Storage**: A dictionary team_data is used to store sensor readings from different teams.
- **Routes**:
    - **GET /**: Displays a webpage with the sensor readings in a table format.
    - **POST /post-data**: Receives data sent from the ESP32 and updates or initializes the data for each team.
- **HTML Template**: A simple HTML table is generated to display the sensor data, which refreshes every 5 seconds.

ESP32 Code (main.ino)

- **Libraries**: Necessary libraries for Wi-Fi, DHT sensor, JSON handling, and HTTP communication are included.

- **Setup Function**:
    - Initializes serial communication.
    - Starts the DHT sensor.
    - Connects to Wi-Fi and synchronizes time using an NTP server.
- **Loop Function**:
    - Reads temperature and humidity values.
    - Checks if the readings are valid.
    - Formats the data into JSON.
    - Sends the JSON data to the Flask server.
- **Helper Functions**:
    - connectToWiFi(): Connects to the specified Wi-Fi network.
    - createJsonData(): Creates a JSON string containing team number, temperature, humidity, and timestamp.
    - sendDataToServer(): Sends the JSON data to the Flask server using an HTTP POST request.

Testing

1. **Start the Flask Server**: Run the server.py file to set up the local server.
2. **Upload ESP32 Code**: Load the ESP32 code into your board using Arduino IDE.
3. **Check Serial Monitor**: Monitor the ESP32 serial output to verify successful readings and HTTP responses.
4. **View Data on Server**: Open a web browser and go to http://<your_computer_ip>:8888 to view the sensor data.

Code Explanation:

Flask Server Code (server.py)

1. Imports and Setup

```
from flask import Flask, request, render_template_string


app = Flask(__name__)
```

- **Flask Imports**: Here, we import the Flask class and the request object from the Flask module to handle HTTP requests and responses.
- **App Initialization**: We create an instance of the Flask class, which will be our web application.

2. In-Memory Data Storage

```
team_data = {}
```

- **Dictionary Initialization**: This dictionary will store the sensor data from each team. Each entry will have the team number as the key and a dictionary of sensor data as the value.

3. Routes

a. Index Route

```
@app.route('/')
def index():
    sorted_team_data = dict(sorted(team_data.items(), key=lambda item: int(item[0])))


    return render_template_string('''
        <!doctype html>
        ...
    ''', sorted_team_data=sorted_team_data)
```

- **Route Definition**: The @app.route('/') decorator defines the root URL of the web application. When this URL is accessed, the index() function is called.
- **Sorting Data**: The sorted_team_data variable sorts the team_data dictionary by team number, ensuring the displayed data is organized.
- **Rendering HTML**: The function uses render_template_string to generate an HTML page dynamically. The HTML template contains a table that displays the sensor readings.

b. Post Data Route

```
@app.route('/post-data', methods=['POST'])
def receive_data():
    ...
```

- **Route Definition**: The @app.route('/post-data', methods=['POST']) decorator defines an endpoint for receiving data from the ESP32 via HTTP POST requests.
- **Data Handling**:
    - The function checks if the incoming team_number is already in team_data.

- If it is not, it initializes the entry with temperature, humidity, timestamp, and a count of how many times data has been sent.
- If it is, it updates the existing data and increments the count.

4. HTML Template

The HTML template is written in the render_template_string function, which uses Jinja2 syntax to create a dynamic web page:

```
<!doctype html>
<html>
<head>
  <title>ESP32 Sensor Readings</title>
  <style>
    ...
  </style>
  <script>
    setTimeout(function() { location.reload(); }, 5000);
  </script>
</head>
<body>
  <h1>ESP32 Sensor Readings</h1>
  <table>
    <tr>
      <th>Team #</th>
      <th>Temperature</th>
      <th>Humidity</th>
      <th>Timestamp</th>
      <th>Post Count</th>
    </tr>
    {% for team, data in sorted_team_data.items() %}
```

```
        <tr>
          <td>{{ team }}</td>
          <td>{{ data.temperature }}°C</td>
          <td>{{ data.humidity }}%</td>
          <td>{{ data.timestamp }}</td>
          <td>{{ data.count }}</td>
        </tr>
      {% endfor %}
    </table>
</body>
</html>
```

- **HTML Structure**: The page includes basic HTML elements, a title, and a header.
- **Styling**: Basic CSS is applied for better visual presentation.
- **JavaScript**: A script is included to automatically refresh the page every 5 seconds to get the latest data.
- **Dynamic Content**: The table is populated with data from sorted_team_data, iterating over each entry using Jinja2 syntax.

5. Main Block

```
if __name__ == "__main__":
    app.run(host='0.0.0.0', port=8888)
```

- **Main Execution Block**: This checks if the script is being run directly and starts the Flask application on all available IP addresses at port 8888.

ESP32 Code:

1. Includes and Definitions

```
#include <WiFi.h>
#include <DHT.h>
#include <ArduinoJson.h>
#include <HTTPClient.h>
```

```
#define DHTPIN 14         // Pin where the DHT11 data pin is connected
#define DHTTYPE DHT11     // DHT 11
```

- **Library Inclusions**: This section includes libraries for Wi-Fi functionality, DHT sensor interface, JSON handling, and HTTP client communication.
- **Pin Definitions**: DHTPIN defines the GPIO pin used to read data from the DHT11 sensor, and DHTTYPE specifies the type of DHT sensor.

2. Global Variables

```
DHT dht(DHTPIN, DHTTYPE); // Initialize DHT sensor
const char* ssid = "Your_SSID";        // Your Wi-Fi SSID
const char* password = "Your_Password"; // Your Wi-Fi Password
const char* serverUrl = "http://192.168.1.208:8888/post-data"; // Flask server URL
```

- **Sensor Initialization**: An instance of the DHT class is created to manage the sensor.
- **Wi-Fi Credentials**: The SSID and password for connecting to the Wi-Fi network are defined.
- **Server URL**: The URL of the Flask server's endpoint to send data is specified.

3. Setup Function

```
void setup() {
  Serial.begin(115200);
  dht.begin();  // Start the DHT sensor
  connectToWiFi(); // Connect to Wi-Fi
  configTime(0, 0, "pool.ntp.org"); // Set the timezone to UTC
}
```

- **Serial Communication**: Initializes serial communication at a baud rate of 115200 for debugging purposes.
- **Sensor Initialization**: The DHT sensor is started.
- **Wi-Fi Connection**: Calls the connectToWiFi() function to connect to the specified network.
- **NTP Configuration**: Sets the time configuration using the Network Time Protocol (NTP) server, which will be used to get the current timestamp.

4. Loop Function

```
void loop() {
  float temperature = dht.readTemperature(); // Read temperature
  float humidity = dht.readHumidity();      // Read humidity

  // Check if any reads failed and exit early
  if (isnan(temperature) || isnan(humidity)) {
    Serial.println("Failed to read from DHT sensor!");
    return;
  }

  // Format data into JSON
  String jsonData = createJsonData(temperature, humidity);

  // Print the JSON data for debugging
  Serial.println(jsonData);

  // Send the data to the server
  sendDataToServer(jsonData);

  delay(10000); // Delay between readings (10 seconds)
}
```

- **Sensor Readings**: The ESP32 reads the temperature and humidity values from the DHT11 sensor.
- **Error Checking**: The code checks if the readings are valid using isnan(). If they are not valid, it prints an error message and exits the loop.
- **JSON Formatting**: Calls the createJsonData() function to format the data into a JSON string.
- **Debug Output**: Prints the JSON data to the serial monitor for debugging.
- **Data Transmission**: Calls the sendDataToServer() function to send the JSON data to the Flask server.

- **Delay**: Introduces a 10-second delay between readings.

5. Wi-Fi Connection Function

```
void connectToWiFi() {
  WiFi.begin(ssid, password);
  Serial.print("Connecting to WiFi");
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("\nConnected to WiFi");
}
```

- **Connection Attempt**: The ESP32 attempts to connect to the Wi-Fi network using the provided SSID and password.
- **Status Checking**: It checks the connection status in a loop, printing dots to indicate progress.
- **Confirmation**: Once connected, it prints a confirmation message.

6. JSON Data Creation Function

```
String createJsonData(float temperature, float humidity) {
  StaticJsonDocument<200> doc;
  doc["team_number"] = "9"; // Your team number
  doc["temperature"] = temperature;
  doc["humidity"] = humidity;

  // Get current time in seconds since epoch
  time_t now = time(nullptr);
  doc["timestamp"] = now; // This will give you a 10-digit timestamp

  String jsonData;
  serializeJson(doc, jsonData);
```

```
  return jsonData;
}
```

- **Static JSON Document**: A StaticJsonDocument is created to hold the JSON data. The size of 200 bytes is specified, which should be sufficient for the data.
- **Data Assignment**: The team number, temperature, humidity, and current timestamp are assigned to the document.
- **Timestamp Generation**: The current time is fetched using the time(nullptr) function, which returns the time in seconds since the epoch (January 1, 1970).
- **Serialization**: The document is serialized into a JSON string using serializeJson(), and the resulting string is returned.

7. Data Transmission Function

```
void sendDataToServer(String jsonData) {
  if (WiFi.status() == WL_CONNECTED) {
    HTTPClient http;
    http.begin(serverUrl); // Specify destination for HTTP request
    http.addHeader("Content-Type", "application/json"); // Specify content-type header as JSON

    // Send the request
    int httpResponseCode = http.POST(jsonData);

    if (httpResponseCode > 0) {
      String response = http.getString(); // Get response payload
      Serial.printf("HTTP Response code: %d\n", httpResponseCode);
      Serial.println("Response: " + response);
    } else {
      Serial.printf("Error in HTTP request: %s\n", http.errorToString(httpResponseCode).c_str());
    }
    http.end(); // Free resources
  } else {
    Serial.println("WiFi Disconnected");
```

```
  }
}
```

- **Wi-Fi Check**: Before attempting to send data, it checks if the ESP32 is connected to Wi-Fi.
- **HTTP Client Setup**: An HTTPClient object is created to manage the HTTP request.
- **Request Initialization**: The target server URL is specified, and the content type is set to application/json.
- **Sending the Request**: The JSON data is sent via an HTTP POST request. The response code is checked to determine if the request was successful.
- **Response Handling**: If successful, it prints the HTTP response code and the server's response message. If there's an error, it prints the error message.
- **Resource Cleanup**: The http.end() function frees up resources used by the HTTP client.