MQTT-Based Temperature Prediction System

1. Introduction

This project presents a comprehensive IoT-based system for real-time environmental monitoring, specifically focusing on temperature prediction using MQTT communication. It is designed to demonstrate the integration of hardware, cloud services, and web-based visualization. The system is built using an ESP32 microcontroller and a DHT22 sensor for capturing real-world temperature and humidity data. The data is transmitted using the MQTT protocol to AWS IoT Core, processed, and visualized through a dynamic dashboard. the final implementation utilizes a locally defined or simpler cloud-based prediction mechanism. The frontend is supported by Firebase for real-time data storage and authentication, and it provides an intuitive web interface for live monitoring and trend analysis.

2. System Overview

- ESP32 + DHT22 Sensor: Captures live temperature and humidity readings from the environment.

- AWS IoT Core: Acts as a secure MQTT broker to manage communication between the ESP32 and cloud services.

- Firebase: Stores temperature data and predictions in real-time, and provides user authentication for secure dashboard access.

- LCD Display: Displays the current and predicted temperatures to the user for immediate feedback.

- Web App: Developed using HTML, CSS, and JavaScript, it visually presents the data in real time along with historical trends and prediction accuracy.

3. Hardware used

- ESP32 Dev Board

- DHT22 Temperature & Humidity Sensor

- 16x2 I2C LCD Display

- Breadboard + Jumper Wires

- Power Supply (USB or Battery)

4. Software

- Arduino IDE with ESP32 board support for firmware development
- Firebase Realtime Database and Authentication services
- AWS IoT Core for MQTT protocol management
- HTML, CSS, JavaScript for frontend development

5. Circuit Diagram

The image below demonstrates the physical connections between the ESP32, DHT22 sensor, and the 16x2 I2C LCD display:

6. Functional Workflow

1. Data Collection: The ESP32 reads real-time temperature and humidity from the DHT22 sensor.

2. MQTT Communication: Sensor readings are published to the topic `sensor/temp_data` via AWS IoT Core.

3. Firebase Sync: The web application subscribes to the Firebase database, which mirrors sensor values and predicted outputs.

4. Prediction Logic: Using historical patterns, the system estimates upcoming temperature values and logs them.

5. LCD Display: The ESP32 displays both current and forecasted temperature values in a readable format:

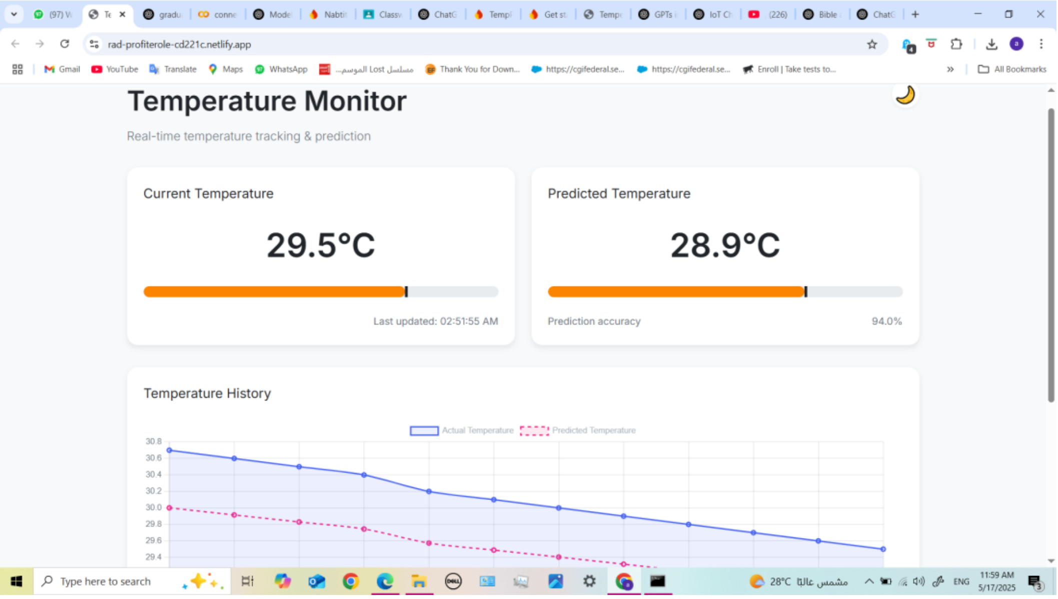
   Temp: 29.5°C

   Pred: 28.9°C

6. Web Dashboard: The website updates dynamically to reflect real-time data, showcasing trends, statistics, and prediction confidence.

7. Web Dashboard Features

- Live current temperature and forecast display
- Visual gauge for temperature intensity
- Real-time update timestamp
- Graphical temperature history (via Chart.js)
- Prediction accuracy calculation and visualization
- User authentication and access control
- Responsive design with dark/light mode toggle



Temperature Monitor

Real-time temperature tracking & prediction

Current Temperature

29.5°C

Last updated: 02:51:55 AM

Predicted Temperature

28.9°C

Prediction accuracy 94.0%

Temperature History

8. Firebase Integration

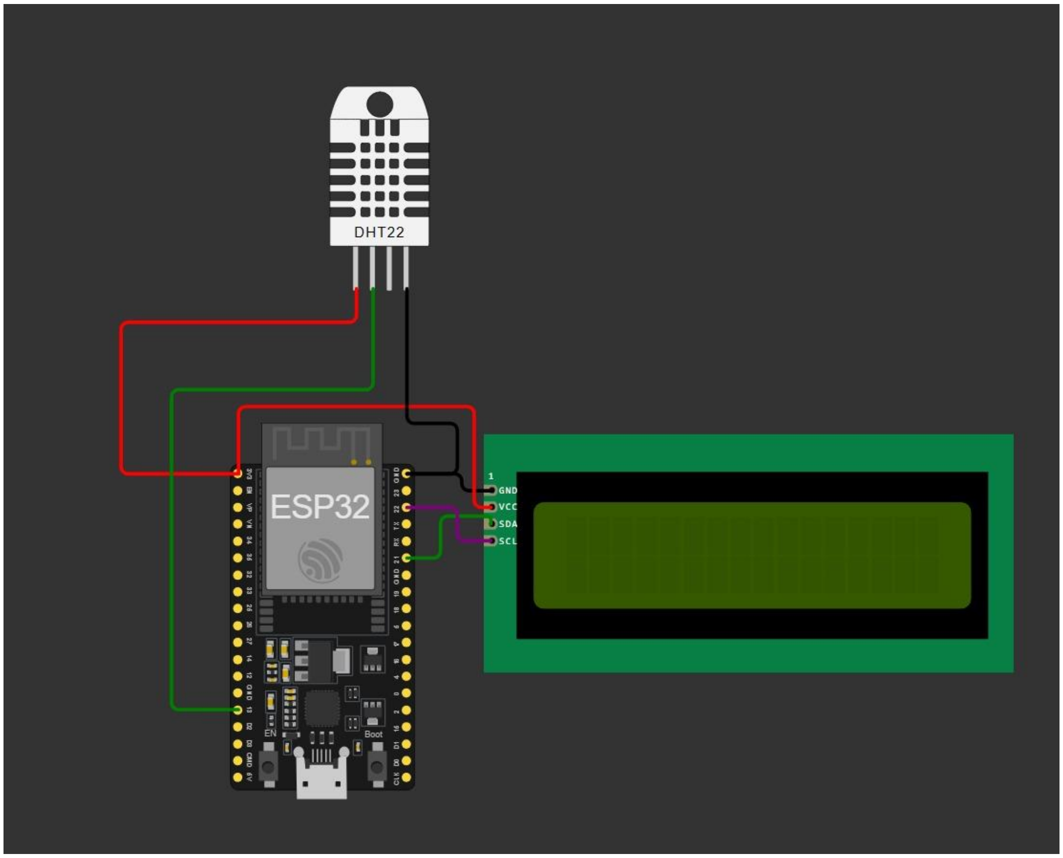
Firebase plays a central role in:

- Handling user login/signup securely using Firebase Authentication
- Storing temperature data and predictions in the Realtime Database
- Automatically pushing updates to connected clients through listeners in `firebase-config.js`
- Supporting the dynamic frontend built in `app.js`, which updates DOM elements and graphs in real-time

9. Files & Deliverables

- `sketch_may14a.ino`: Arduino firmware for sensor reading and MQTT publishing

- Web Frontend:
  - `index.html`: Page layout and structure
  - `styles.css`: Dashboard styling and theme responsiveness
  - `app.js`: UI logic, data handling, chart rendering, theme control
  - `firebase-config.js`: Firebase setup and real-time data fetching
- Project Screenshots (Fritzing circuit and dashboard view)



- Deployment hosted via Netlify

10. Conclusion

The MQTT-Based Temperature Prediction System showcases a real-world application of IoT in environmental monitoring. By combining ESP32 hardware, cloud services (Firebase and AWS IoT), and a modern web interface, this project provides a reliable and extendable platform for temperature tracking and forecasting. The architecture supports further development, such as remote control features, alert systems, and advanced ML-based prediction pipelines. It is a practical solution that bridges hardware sensing with interactive, real-time user interfaces, suitable for academic, agricultural, and industrial use cases.