AN
IOT HONOR'S PROJECT REPORT
ON

Real-time temperature and humidity data collection and visualization

Submitted by

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CERTIFICATE

This is to certify that project entitled

Real-time temperature and humidity data collection and visualization

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WALCHAND INSTITUTE OF TECHNOLOGY, SOLAPUR
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INDEX

ABSTRACT

"Real-Time Temperature and Humidity Data Collection and Visualization," focuses on the design and development of a system that enables continuous monitoring and real-time visualization of environmental conditions, specifically temperature and humidity. Utilizing a DHT22 sensor, the system collects data, which is then transmitted to a cloud database via a wireless connection. The project leverages InfluxDB for efficient time-series data storage and uses Grafana for dynamic and interactive data visualization.

The primary goal of this project is to create an effective, reliable, and real-time solution for environmental monitoring. This system can be particularly beneficial in applications such as smart agriculture, environmental research, and industrial settings where maintaining certain climate conditions is critical. Data collected by the sensors are processed and displayed in real-time, allowing users to track changes and make data-driven decisions.

By integrating sensor , cloud-based data storage, and advanced data visualization tools, this project demonstrates a practical implementation of the Internet of Things (IoT) for real-world environmental monitoring challenges. The system's scalability and flexibility make it suitable for a wide range of use cases, including remote monitoring and automated alerts for significant climate variations.

CHAPTER 1: INTRODUCTION

1.1 Introduction:

In today's world, real-time data monitoring and visualization play a crucial role in various fields, from industrial environments to agriculture and environmental science. Monitoring environmental conditions such as temperature and humidity is essential for ensuring optimal performance, safety, and decision-making across a range of applications. The need for accurate, continuous, and real-time monitoring of environmental data has led to the integration of sensor technologies and Internet of Things (IoT) solutions.

This project, titled **"Real-Time Temperature and Humidity Data Collection and Visualization,"** focuses on the development of an IoT-based system that continuously monitors and visualizes environmental temperature and humidity levels. The project uses a **DHT22 sensor**, known for its accuracy and reliability, to collect temperature and humidity data. This sensor data is transmitted wirelessly to a cloud-based platform, where it is stored and processed using **InfluxDB**, a time-series database designed to handle high volumes of real-time data efficiently.

To provide users with a user-friendly and dynamic way of interacting with the data, **Grafana** is used as the visualization tool. Grafana allows for the creation of custom dashboards, where real-time data is displayed in various formats, such as graphs, gauges, and time-series plots. This not only provides a clear view of current conditions but also enables the user to observe trends and make informed decisions based on historical data.

The primary aim of this project is to develop a scalable, real-time monitoring solution that can be applied in multiple domains, such as **smart agriculture**, **environmental research**, **industrial climate control**, and **remote sensing**. The system is designed to alert users in real-time in the event of significant deviations in temperature and humidity, providing a proactive solution for environmental control.

In addition, the project showcases the potential of integrating IoT with cloud computing for real-time data processing and visualization. The combination of hardware (DHT22 sensor), software (InfluxDB and Grafana), and cloud infrastructure enables the creation of an automated, reliable, and scalable monitoring system.

1.2: Purpose of Project

The purpose of the **"Real-Time Temperature and Humidity Data Collection and Visualization"** project is to design and implement a system that enables continuous monitoring, data collection, and real-time visualization of environmental conditions, specifically focusing on temperature and humidity. The project aims to provide a reliable and efficient solution for tracking climate data, offering users real-time insights through interactive dashboards.

CHAPTER 2 : Literature Survey

2.1 Literature Survey

"Real-Time Temperature and Humidity Data Collection and Visualization" is based on the convergence of Internet of Things (IoT) technologies, cloud computing, and data visualization tools. These technologies have been widely researched and implemented in various fields for monitoring environmental conditions. This literature survey aims to explore the existing research and technologies relevant to the project's objectives, including real-time monitoring, sensor networks, cloud storage solutions, and data visualization.

1. Real-Time Monitoring Systems

Real-time monitoring of environmental parameters, particularly temperature and humidity, has become increasingly important in domains such as smart agriculture, industrial automation, and healthcare. Numerous studies have highlighted the benefits of using real-time monitoring to ensure efficient operations and quick responses to environmental changes.

In smart agriculture, for example, real-time monitoring systems help optimize irrigation schedules and ensure proper crop growth by continuously monitoring soil and atmospheric conditions (Jha et al., 2019). Industrial applications use similar systems to maintain ideal working conditions for machinery and products, reducing downtime and improving energy efficiency (Sikarwar et al., 2020).

The ability to collect and transmit data in real-time is enabled by sensors such as the DHT22, which is widely recognized for its accuracy and reliability in temperature and humidity measurement (Parameswari et al., 2018). The sensor's low cost and ease of integration into IoT systems make it an ideal choice for environmental monitoring applications.

2. IoT and Environmental Monitoring

The Internet of Things (IoT) has revolutionized how we interact with and monitor the environment. IoT devices, such as sensors, collect data and transmit it to cloud platforms for storage and analysis. In recent years, IoT has played a critical role in improving the precision and efficiency of environmental monitoring systems (Perera et al., 2014).

Researchers have implemented IoT-based environmental monitoring solutions in various fields. For instance, Bharathwajan et al. (2017) presented an IoT-based system to monitor environmental conditions such as temperature and humidity, which is vital for smart city applications. The integration of IoT devices with cloud services ensures data accessibility and storage scalability, allowing for long-term monitoring and historical data analysis.

3. Cloud-Based Storage Solutions

Cloud computing offers scalable and flexible storage solutions for handling large datasets generated by IoT devices. The use of time-series databases, such as InfluxDB, has gained significant attention for storing sensor data due to their ability to handle timestamped data efficiently (Pierson et al., 2020). InfluxDB, a purpose-built time-series database, is designed to manage high-write and query loads, making it ideal for real-time environmental monitoring systems.

Time-series databases have been used in various fields for storing sensor data. A study by Batth et al. (2018) highlights the use of cloud-based storage and InfluxDB in smart agriculture, where it is used to store large amounts of sensor data for real-time and historical analysis. The integration of InfluxDB with other cloud services provides a robust infrastructure for IoT systems that require real-time data processing and retrieval.

4. Data Visualization with Grafana

Data visualization plays a crucial role in understanding and analyzing real-time sensor data. Tools such as Grafana are widely used to visualize time-series data due to their ability to create dynamic and customizable dashboards. Grafana allows users to monitor trends, set alerts, and make data-driven decisions based on visual insights (Hershey, 2020).

The combination of InfluxDB and Grafana has been explored in several studies as a powerful framework for real-time monitoring systems. For example, Zeng et al. (2019) demonstrated how Grafana can be integrated with InfluxDB to visualize sensor data from an IoT-based environmental monitoring system. The study highlights the benefits of using such visualization tools to gain insights from large datasets and enable users to track changes in environmental conditions.

5. Related Works in Environmental Monitoring

Numerous research projects have explored real-time environmental monitoring using IoT devices and cloud-based platforms. Some notable works include:

IoT-Based Smart Agriculture System (Sharma et al., 2017): This system monitors temperature, humidity, soil moisture, and other environmental factors to optimize agricultural practices. The data is stored in the cloud and visualized using tools like Grafana for better decision-making.

Real-Time Environmental Monitoring in Industrial Settings (Lee et al., 2018): This study highlights the importance of continuous monitoring of industrial environments to ensure worker safety and equipment efficiency. It uses IoT sensors to collect real-time data and stores it in cloud databases for remote access and visualization.

IoT-Driven Weather Monitoring (Patel et al., 2020): A comprehensive IoT-based solution for weather monitoring, including parameters like temperature, humidity, and air quality, stored in the cloud and visualized in real-time.

6. Challenges and Future Directions

Despite the advancements in real-time environmental monitoring, there are still challenges related to scalability, data security, and the integration of heterogeneous sensor networks. Research is ongoing to improve the energy efficiency of IoT devices, enhance data processing speeds, and ensure data privacy in cloud-based systems (Ahmed et al., 2020).

In the future, advancements in machine learning and artificial intelligence (AI) could be integrated with environmental monitoring systems to provide predictive insights and automated responses to environmental changes. Additionally, enhancing the interoperability of IoT devices and platforms can improve the scalability and adaptability of real-time monitoring systems across various sectors.

2.2 Problem Statement:

The need for real-time monitoring of environmental conditions, such as temperature and humidity, is critical in several domains, including agriculture, industrial automation, and smart buildings. Conventional methods of monitoring are either manual or offer delayed insights, which can result in inefficiencies, loss of productivity, or even hazardous situations.

2.3 Objectives:

1.To develop a system that continuously collects real-time temperature and humidity data using a DHT22 sensor and transmits it via Wi-Fi to a cloud-based storage platform.

2.To integrate the sensor system with a cloud-based time-series database (InfluxDB) to efficiently store large amounts of timestamped data for easy retrieval and analysis.

3.To implement a dynamic visualization dashboard using Grafana, allowing users to monitor temperature and humidity trends, and provide real-time alerts based on sensor readings.

4.To ensure the system is scalable and flexible enough to accommodate additional sensors and can be easily adapted to different environments, such as agriculture, industrial sites, or building management.

5.To allow for remote access to the data and visualization dashboard, enabling users to monitor environmental conditions from anywhere and make informed decisions based on real-time data.

6.To provide historical data analysis, allowing users to track long-term trends in temperature and humidity for research or optimization purposes.

2.4 Scope Of Project:

IoT-based system for continuous monitoring of temperature and humidity using DHT22 sensors. The collected data will be transmitted via Wi-Fi to a cloud-based time-series database (InfluxDB) for storage and visualized in real time using Grafana dashboards. The system will provide remote access for users to monitor environmental conditions from anywhere and will be scalable for future expansion, such as adding more sensors or integrating advanced analytics. The project is applicable in fields like smart agriculture, industrial automation, and building management systems.

CHAPTER 3: SYSTEM DESCRIPTION

3.1 Flow Chart:

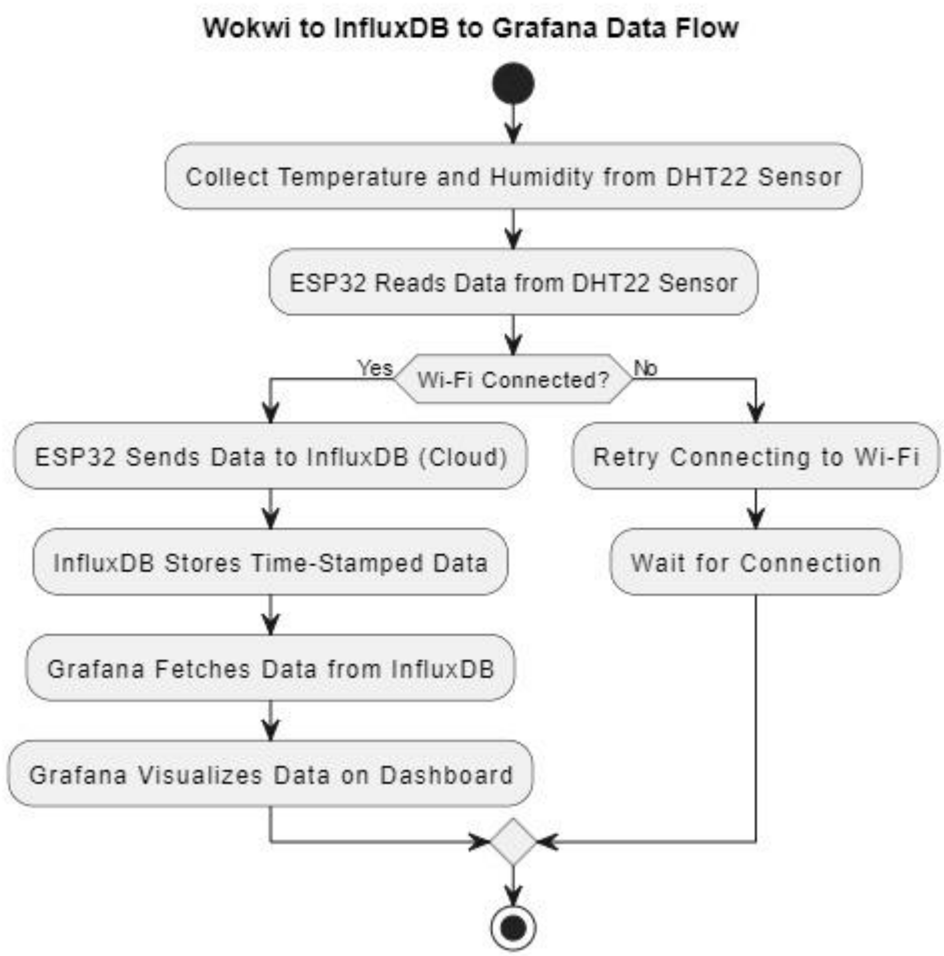

Fig.3.1:Flowchart of Project

3.2 Methodology:

1. System Design and Architecture:

1.1 DHT22 Sensor: For measuring temperature and humidity data.

1.2 ESP32 (Wokwi Simulator): A microcontroller used to collect sensor data and send it to the cloud.

1.3 Wi-Fi Communication: The ESP32 module is connected to Wi-Fi to transmit data to the cloud.

1.4 InfluxDB Cloud: A time-series database where the sensor data is stored.

1.5 Grafana: A real-time data visualization tool to display temperature and humidity readings on dynamic dashboards.

2. Simulation on Wokwi:

2.1 DHT22 Sensor Connection: Using the Wokwi platform, the DHT22 sensor is connected to the ESP32 microcontroller to simulate data collection.

2.2 Data Collection Code: Code is written on Wokwi to read temperature and humidity data from the sensor.

2.3 Wi-Fi Setup: The ESP32 is configured to connect to Wi-Fi and transmit data using HTTP POST requests.

3. Sending Data to InfluxDB Cloud

3.1 InfluxDB Setup: Create an account on InfluxDB Cloud and set up a bucket to store the incoming time-series data.

3.2 API Integration: The ESP32 sends sensor data to the InfluxDB Cloud using HTTP POST requests with the following details:

- InfluxDB Endpoint URL.
- Authentication Token.
- Organization ID and Bucket Name.
- Data is sent in the line protocol format.

3.3 Timestamp Addition: Use the NTP client to retrieve the current time, allowing the system to attach accurate timestamps to the collected data.

4. Data Storage in InfluxDB

4.1 Time-Series Data Management: InfluxDB stores the sensor data (temperature, humidity) with associated timestamps.

4.2 Data Retrieval: The stored data can be queried for analysis, filtering, or visualization.

5. Real-Time Visualization with Grafana

5.1 Grafana Setup: Add InfluxDB as a data source in Grafana by providing the necessary credentials (organization, token, bucket).

5.2 Dashboard Creation:

5.3 Create a Grafana dashboard with panels to visualize the temperature and humidity data.

5.4 Set the time range for real-time updates.

5.5 Data Querying: Use Flux query language to retrieve data from InfluxDB for visualization.

6. Data Analysis and Visualization

6.1 Real-Time Graphs: The dashboard shows real-time trends for temperature and humidity readings.

6.2 Historical Data: The system also allows for analysis of past data to observe long-term trends.

6.3 Alerts (Optional): Setup thresholds and alerts in Grafana to notify the user if the temperature or humidity levels cross certain limits.

Chapter 4. Software Components:

1. Wokwi (Simulator):

- An online platform used to simulate the ESP32 and DHT22 sensor setup.
- Allows code development and testing in a simulated environment.

2. InfluxDB Cloud:

- A cloud-based time-series database for storing the sensor data (temperature and humidity) along with timestamps.
- Provides efficient storage and retrieval of time-series data.

3. Grafana:

- A powerful data visualization and monitoring tool used to display real-time sensor data in customizable dashboards.
- Integrated with InfluxDB as a data source for querying and visualizing data.

4. HTTP Client Library (For ESP32):

- Used in the code to send HTTP POST requests from the ESP32 to InfluxDB.
- Enables secure communication with the InfluxDB Cloud API.

5. NTPClient Library (For ESP32):

- A library used to get the current time from an NTP server.
- Adds timestamps to the sensor data before sending it to InfluxDB.

6. Wi-Fi Library (For ESP32):

- Enables the ESP32 to connect to a Wi-Fi network.
- Used to transmit sensor data to InfluxDB Cloud.
- Optional Software Components:

7. InfluxDB Query Language (SQL):

- For querying and retrieving the stored data from InfluxDB.
- Used in Grafana to visualize the sensor data.

Chapter 5. Project Implementation:

1. Simulation Setup on Wokwi

1. Simulation Setup on Wokwi

- Wokwi Environment Setup

- Open the Wokwi Simulator and create a new project.

- In the Wokwi workspace, drag and drop the following components: ESP32 microcontroller

DHT22 temperature and humidity sensor

- Connect the DHT22 sensor to the ESP32 as follows:

DHT22 VCC pin to 3.3V on the ESP32.

DHT22 GND pin to GND on the ESP32.

DHT22 Data pin to GPIO 15 on the ESP32.

- Use the Wokwi to write the code for collecting data from the DHT22 sensor and sending it to InfluxDB.

Include the necessary libraries:

- WiFi.h: For Wi-Fi connectivity.

- HTTPClient.h: To send HTTP requests.

- DHT.h: To read temperature and humidity from the DHT22 sensor.

- NTPClient.h: To get the current timestamp for InfluxDB.

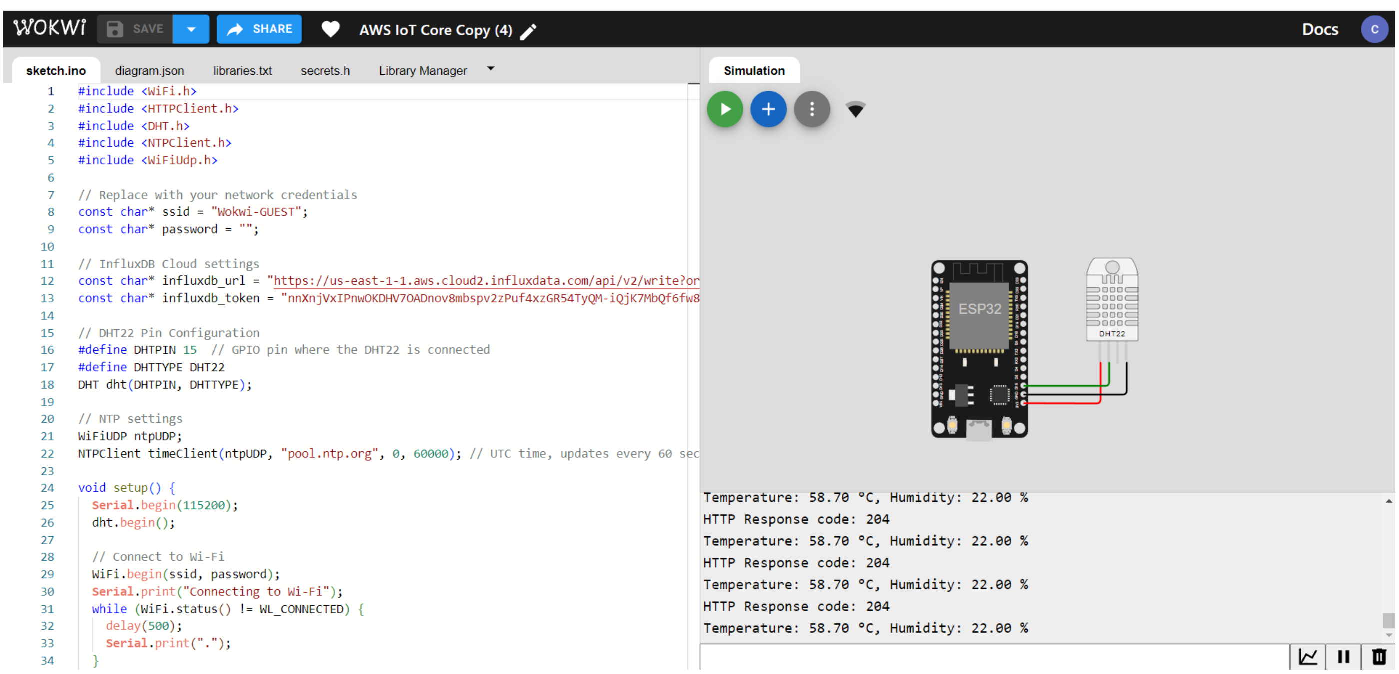

Fig. 5.1:Wokwi Dashboard

2. Setup InfluxDB Cloud

InfluxDB is a time-series database designed for high-performance data storage, making it ideal for real-time sensor data.

Step 2.1: Create an InfluxDB Cloud Account

- Go to InfluxDB Cloud and create an account.
- After signing in, create an organization and bucket:
- Organization: Name your organization (e.g., "MyIoTOrg").
- Bucket: Create a bucket to store your data (e.g., "final").

Step 2.2: Generate an InfluxDB API Token

- In InfluxDB Cloud, go to Data → Tokens.
- Create a token with Read/Write access to the bucket you created.
- Copy the token and organization ID for use in your ESP32 code.

Step 2.3: Test Data Transmission

- Run the ESP32 code in Wokwi and ensure that the temperature and humidity data are being sent to InfluxDB.
- In the InfluxDB Cloud UI, navigate to Data Explorer to verify that the data is being received and stored correctly.

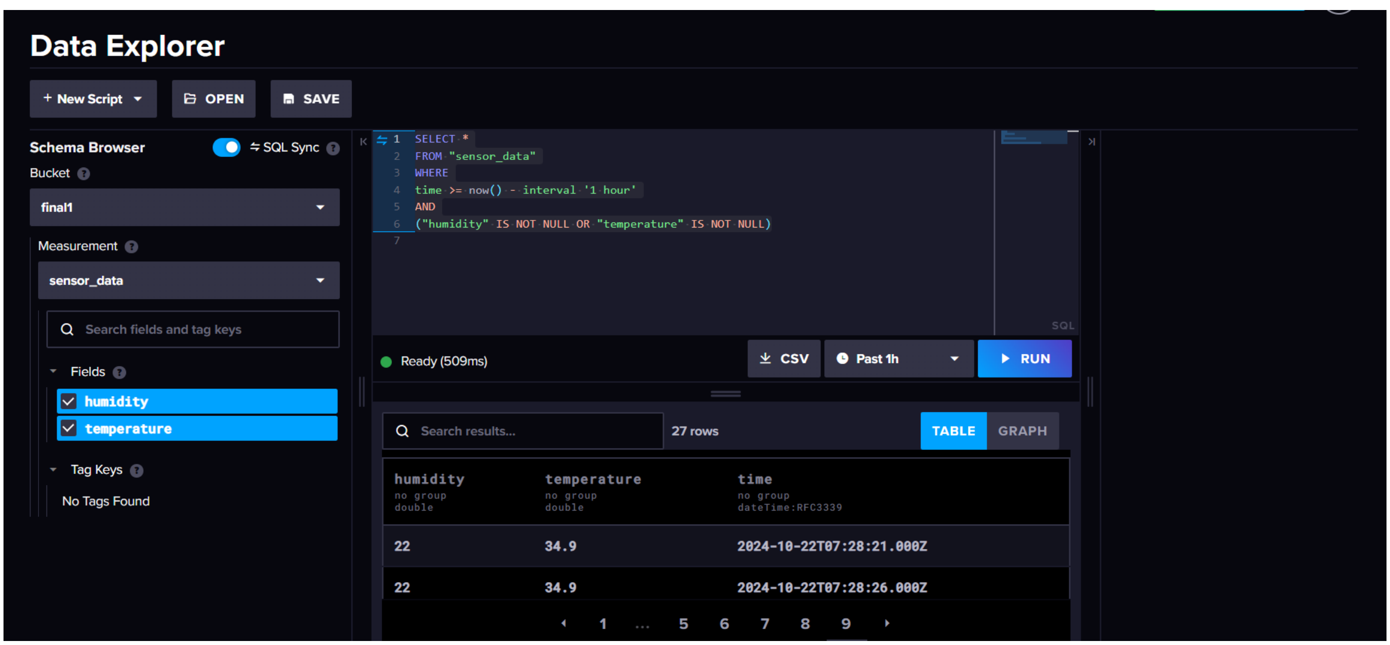

Fig. 5.2:InfluxDB Cloud Dashboard

3. Data Visualization with Grafana

Grafana is a visualization tool that can pull data from InfluxDB and display it in real-time dashboards.

Step 3.1: Set Up Grafana

- Sign up for a Grafana Cloud account or use a local Grafana instance.

- In Grafana, add InfluxDB as a data source:

- Go to Configuration → Data Sources.

- Add InfluxDB and configure it with the following details:

- URL: Your InfluxDB Cloud API endpoint.

- Bucket: The bucket you created (e.g., "final").

- Token: The API token generated in InfluxDB Cloud.

Step 3.2: Create a Dashboard

- Create a new dashboard in Grafana.

- Add panels for Temperature and Humidity:

- Use Flux queries to pull data from InfluxDB.

- Customize the visualization (e.g., graphs, alerts) to display the real-time data.

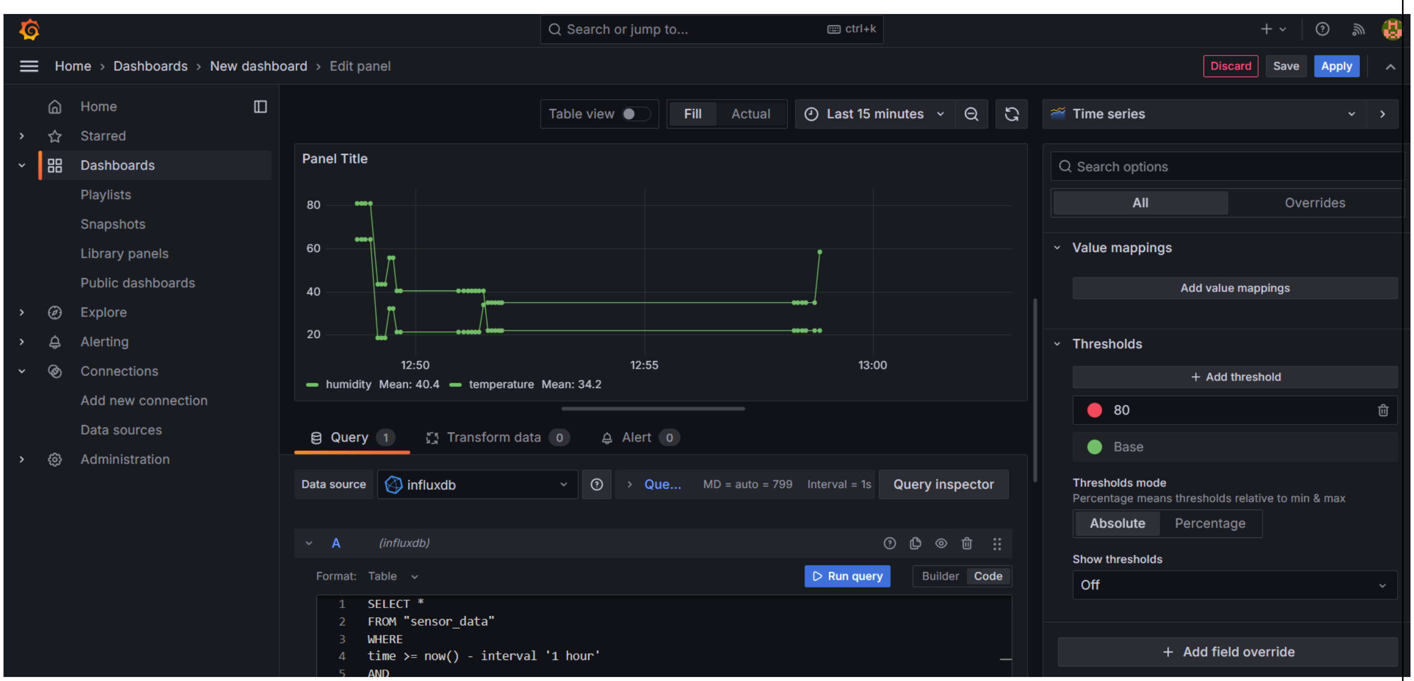

Fig. 5.3:Grafana Dashboard

Chapter 6. Results:

The Grafana dashboard shows real-time temperature and humidity data over the last 15 minutes. The average temperature is 34.2°C, and the average humidity is 40.4%. The graph visualizes fluctuations, and a threshold of 80 is set, which will trigger alerts if exceeded. The data is queried from InfluxDB, ensuring continuous monitoring of the environment for applications like agriculture or smart homes. This allows quick detection of changes in conditions for better control and management.

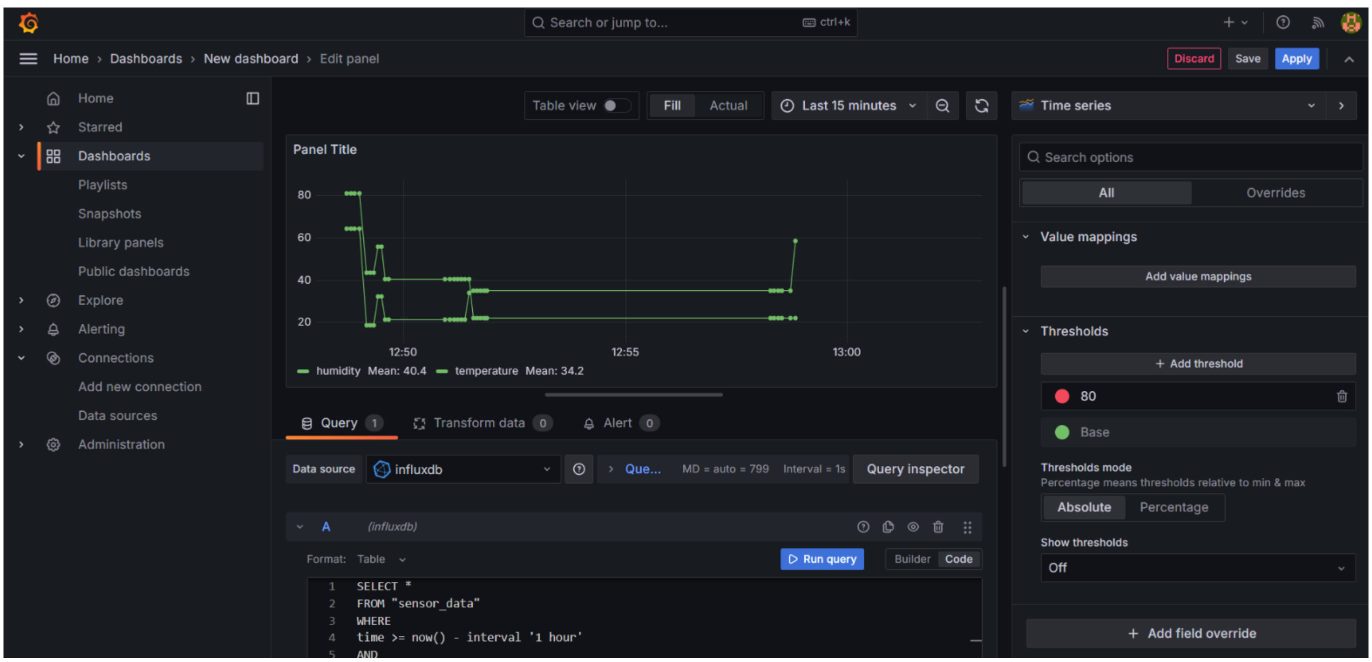

Fig. 6.1: Grafana Dashboard

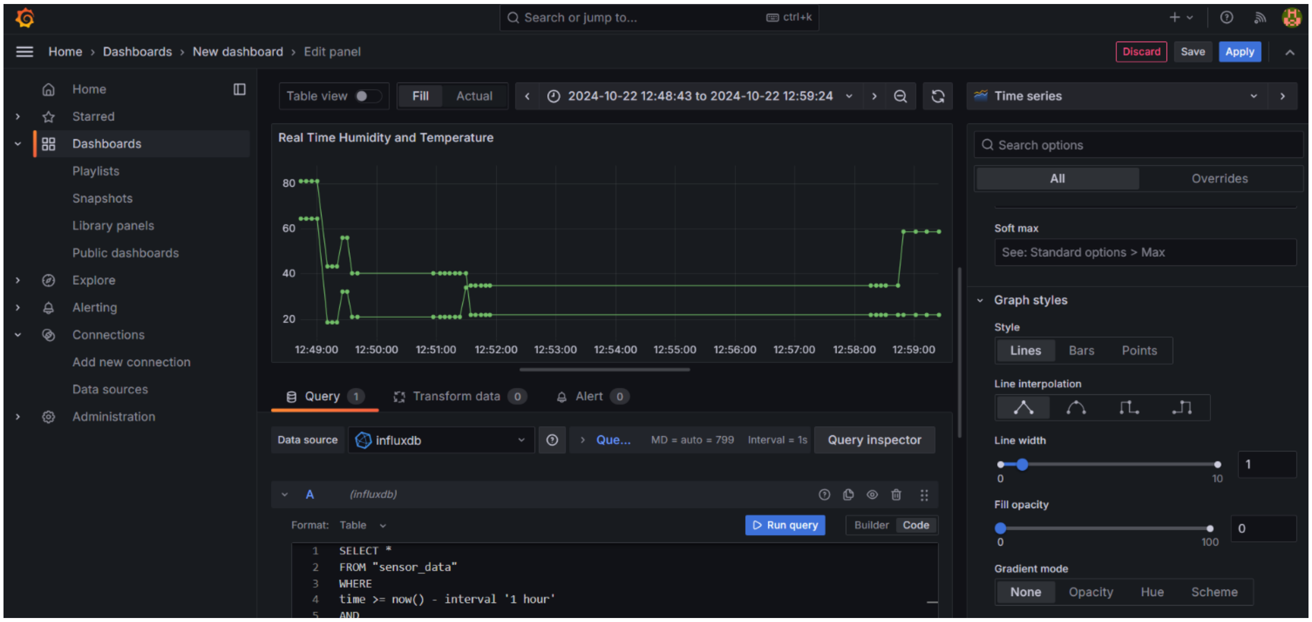

Fig. 6.2: Grafana Dashboard

Chapter 7. Applications

1. Agricultural Monitoring: Helps farmers monitor and control the environment for crops, optimizing growth conditions by keeping track of temperature and humidity levels in real-time.

2. Smart Homes: Enables smart home systems to regulate HVAC systems by providing real-time feedback on indoor temperature and humidity levels, enhancing comfort and energy efficiency.

3. Industrial Environment Control: Used in factories and storage areas to monitor and maintain optimal environmental conditions, preventing damage to sensitive equipment or materials due to extreme temperatures or humidity.

4. Greenhouses: Allows real-time monitoring and control of the microclimate inside greenhouses, ensuring the optimal environment for plant growth.

5. Health Monitoring in Hospitals: Helps in maintaining proper humidity and temperature levels in critical hospital areas like operation theaters or ICUs to ensure a sterile and safe environment for patients.

6. Weather Stations: Collects accurate real-time temperature and humidity data for local weather forecasting and analysis.

7. Data Centers: Ensures that temperature and humidity in data centers are constantly monitored to prevent overheating of servers and protect sensitive electronic equipment.

Chapter 8. Conclusion

The Real-Time Temperature and Humidity Data Collection and Visualization project successfully demonstrates the integration of IoT technology with real-time environmental monitoring systems. By utilizing Wokwi, ESP32, DHT22 sensors, InfluxDB, and Grafana, the project provides an efficient solution for monitoring, storing, and visualizing temperature and humidity data in real time. This project can be applied across various industries, including agriculture, smart homes, healthcare, and industrial automation, to ensure environmental conditions are maintained within optimal ranges. The system's real-time feedback and historical data tracking allow for better decision-making, preventive measures, and improved environmental control. With further expansion, the project can support more sensors and broader applications, contributing to smarter, data-driven solutions in various fields.

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16. Amazon Simple Storage Service (Amazon S3) is an object storage service that offers industry-leading scalability, data availability, security, and performance. Customers of all sizes and industries can use Amazon S3 to store and protect any amount of data for a range of use cases, such as data lakes, websites, mobile applications, backup and restore, archive, enterprise applications, IoT devices, and big data analytics.
https://docs.aws.amazon.com/AmazonS3/latest/userguide/Welcome.html

17. AWS Lambda is an event-driven, serverless Function as a Service provided by Amazon as a part of Amazon Web Services. It is designed to enable developers to run code without provisioning or managing servers. It executes code in response to events and automatically manages the computing resources required by that code.
https://aws.amazon.com/pm/lambda/?

18. Amazon QuickSight is a unified business intelligence service that makes it easier for all employees within an organization to build visualizations, perform ad hoc analysis, and quickly get business insights from their data, anytime, on any device.
https://aws.amazon.com/pm/quicksight/?

APPENDIX

GitHub: Following Link and QR code contains project code, output images (InfluxDB, Grafana).

Link: https://github.com/Prathamesh-Khamitkar/Iot-Honor-s-Project

QR Code:

Iot Project