A Project Report

On

“Real Time Weather Monitoring and Reporting using IoT Devices”

NIELIT Kokrajhar EC

A project report submitted in partial fulfillment of the requirement for the completion of **One Month Summer Internship**

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CERTIFICATE

This is to certify that the project work entitled “**Real Time Weather Monitoring and Reporting using IoT Devices**”, done by **Pritam Sutradhar (CIT Kokrajhar, 7th Sem)** in partial fulfillment of the requirement for the completion of One Month Summer Internship.

This report has not been submitted for any other examination and does not form part of any other course undergone by the candidate.

Date:
Place: Kokrajhar

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Scientist “D” /Centre In-charge
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DECLARATION

I hereby declare that the project work entitled "**Real Time Weather Monitoring and Reporting using IoT Devices**" submitted for the partial fulfillment of the completion of One Month Summer Internship is my own approach under the guidance of **Mrs. Banti Das, Scientist 'C' NIELIT Kokrajhar EC**.

I also declare that the project report has not formed the basis for the award of any other degree, fellowship or any other similar title undergone by me.

Date**:**
Place: Kokrajhar

Pritam Sutradhar
(7^{th} Sem CSE,CIT Kokrajhar)

ACKNOWLEDGMENT

I would like to express my humble gratitude to the Centre in- charge, Dr. Bipul Roy (Scientist 'D'), ECIC and my supervisor Mrs. Banti Das, Scientist 'C', NIELIT Kokrajhar EC, Assam for supervising and always guiding me in the right direction throughout this project work. I offer my sincere thanks to Mrs. Banti Das for her constant support, guidance and knowledge given all stages of this work.

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Date**:** **Pritam Sutradhar**

Place: Kokrajhar (7th Sem CSE,CIT Kokrajhar)

PREFACE

In pursuit of practical knowledge in the realm of computer science and technology within the framework of the NIELIT institute, the undertaking of a project has been deemed essential. This project encompasses various facets of the course, including the fundamentals of electronic components, computer hardware and peripherals, internet connections, and protocols. The overarching objective is to delve into the diverse branches of this multifaceted domain and acquire a comprehensive understanding.

As per the curriculum outlined by NIELIT, the project on real-time temperature and humidity monitoring using IoT devices has been chosen for this year's endeavor. This preface serves as an introduction to the culmination of efforts invested in this project, encapsulating the data and results gleaned throughout its duration.

This preface sets the stage for the exploration and documentation of our journey through the realm of IoT-based environmental monitoring, underscoring the significance of practical learning in augmenting our understanding of theoretical concepts.

Date**:**
Place: Kokrajhar

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Table Of Contents

CHAPTER – I

Introduction to IOT

The Internet of Things (IoT) represents a revolutionary paradigm shift in the way we interact with the world around us. At its core, IoT refers to the network of physical objects—devices, vehicles, buildings, and other items—that are embedded with sensors, software, and other technologies to connect and exchange data with other devices and systems over the internet. This interconnected network is designed to collect and share data, enabling unprecedented levels of automation, control, and insight into the environment and processes.

IoT encompasses a broad spectrum of applications across various industries and sectors. In the realm of consumer electronics, IoT has given rise to smart homes, where appliances, lighting, heating systems, and security devices are interconnected to create a cohesive and responsive living environment. Smart home devices can be controlled remotely via smartphones or voice commands, offering convenience, energy efficiency, and enhanced security.

In the industrial sector, IoT is a critical component of Industry 4.0, the current trend of automation and data exchange in manufacturing technologies. Industrial IoT (IIoT) involves the use of sensors and actuators in manufacturing plants and industrial equipment to monitor conditions, optimize operations, and predict maintenance needs.

Healthcare is another area where IoT has made significant inroads. IoT-enabled medical devices, such as wearables and remote monitoring systems, allow for continuous tracking of patients' vital signs and health metrics. This data can be transmitted to healthcare providers in real-time, facilitating early diagnosis, timely interventions, and personalized treatment plans. IoT in healthcare enhances patient outcomes, improves the efficiency of care delivery, and reduces the burden on healthcare systems.

The underlying technology of IoT involves a complex interplay of hardware and software components. Sensors and actuators serve as the eyes and hands of IoT systems, collecting data from the physical world and performing actions based on that data. Microcontrollers and microprocessors process the collected data and make decisions, while communication modules facilitate the transmission of data to central servers or cloud platforms. Advanced analytics and machine learning algorithms analyze the data to derive meaningful insights and drive intelligent actions.

Security and privacy are critical considerations in the deployment of IoT systems. The proliferation of connected devices increases the attack surface for cyber threats, necessitating robust security measures to protect data integrity and user privacy. Encryption, authentication, and access control are essential components of a secure IoT infrastructure. Additionally, the ethical implications of IoT data collection and usage must be carefully managed to ensure compliance with regulations and to maintain public trust.

The future of IoT holds immense potential as advancements in technology continue to drive innovation. The integration of IoT with artificial intelligence (AI), blockchain, and 5G networks is expected to unlock new possibilities and transform various industries. AI-powered IoT systems can perform complex data analysis and autonomous decision-making, while blockchain can enhance security and transparency in IoT transactions. The widespread adoption of 5G will provide the high-speed, low-latency connectivity required for real-time IoT applications, further accelerating the growth of the IoT ecosystem.

CHAPTER – II

Objective

The primary objective of this project is to design and implement a real-time temperature and humidity monitoring system using IoT devices. This project aims to provide an in-depth understanding of IoT technology and its applications in environmental monitoring. By integrating various electronic components, such as sensors, microcontrollers, and communication modules, the project seeks to capture accurate and timely data on temperature and humidity levels.

This data will be transmitted to a central server or cloud platform, where it can be processed, analyzed, and visualized in real-time. The ultimate goal is to develop a robust system capable of providing reliable environmental data, which can be utilized for a wide range of applications, including smart home automation, agricultural monitoring, industrial control, and climate research.

Through this project, we aim to enhance our skills in circuit design, sensor interfacing, data acquisition, wireless communication, and web development. Additionally, the project seeks to illustrate the practical applications of IoT in creating smart and efficient solutions for everyday challenges.

By the end of this project, we aspire to have a comprehensive understanding of the design and implementation of IoT systems, as well as the ability to apply this knowledge to real-world scenarios, thus bridging the gap between theoretical learning and practical application.

CHAPTER – III

Methodology

1. Project Planning and Design

Objective Definition: The system aims to provide accurate and timely environmental data that can be accessed remotely.

Requirements Gathering: Identified the need for real-time monitoring, remote data access, and data visualization. The requirements included:

Hardware: DHT11 sensor, ESP32 microcontroller, power supply, connecting wires.

Software: Arduino IDE for programming, XAMPP for server setup, PHP for data handling, MySQL for database management, HTML/CSS/JavaScript for front-end development.

Network: Wi-Fi for data transmission.

System Design:

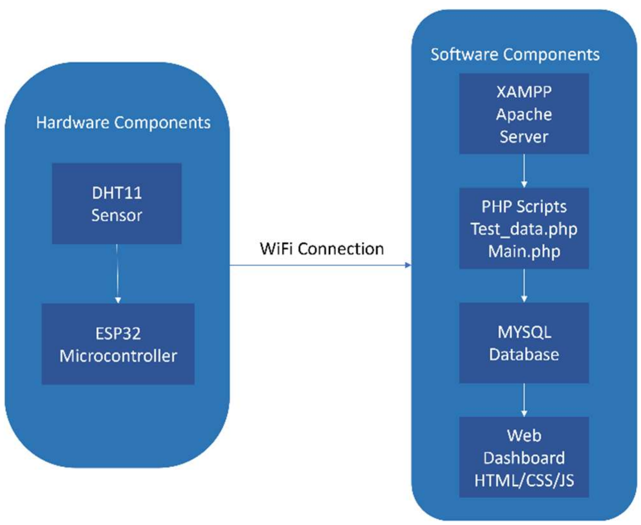


Fig 1: System Architecture

1.1 Data Collection and Processing:

The DHT11 sensor collects temperature and humidity data, then the ESP32 microcontroller reads the data from the DHT11 sensor. Then the ESP32 processes the data and prepares it for transmission.

1.2 Data Transmission:

The ESP32 connects to a Wi-Fi network to send the data to the XAMPP Apache server using an HTTP POST request to test_data.php.

1.3 Data Storage:

The test_data.php script on the server receives the data. This script inserts the data into the MySQL database.

1.4 Data Visualization:

The main.php script extracts data from the MySQL database. The web dashboard uses HTML, CSS, and JavaScript to create a visually appealing interface.

DataFlow:

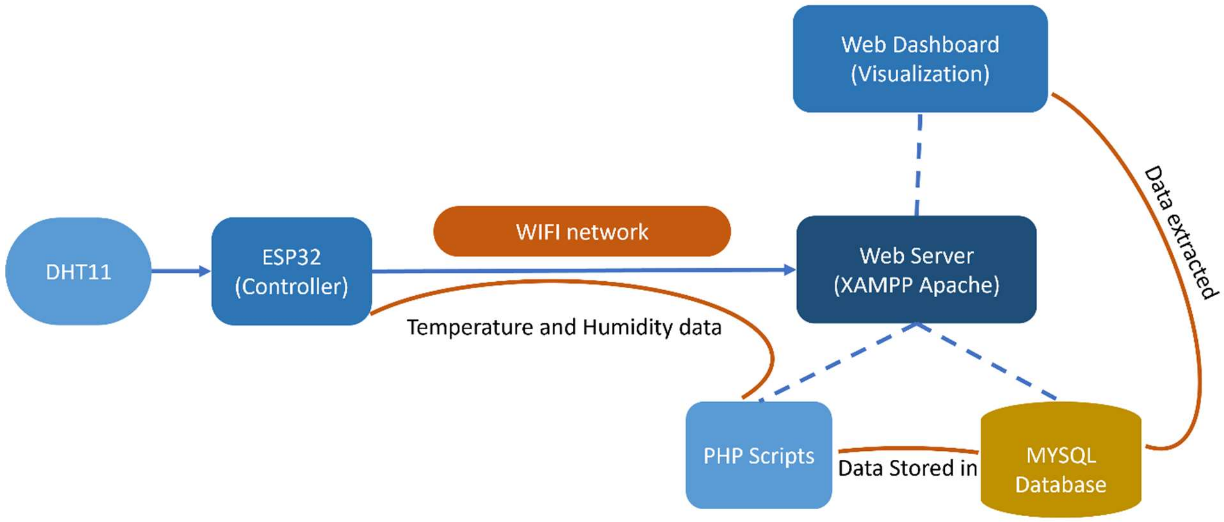


Fig 2: Data Flow Diagram

2. Hardware Selection and Setup

Component Selection:

Sensor:

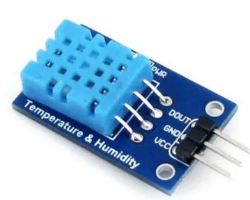


Fig 3: DHT11 Sensor Module

DHT11/DHT22 for assuring temperature and humidity due to its ease of use and sufficient accuracy

Microcontroller:

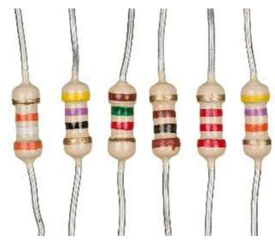
Fig 4: ESP32 WROOM 32

ESP32 for its built-in Wi-Fi and Bluetooth capabilities, which simplify wireless data transmission.

Other Components:

Breadboard for prototyping

connecting wires



Resistors for proper voltage division

3. Website Development

Designed and structured the webpage using HTML.

Enhanced visual appeal and user experience with CSS.

Integrated dynamic data retrieval and display functionalities using PHP to present real-time temperature, humidity, and heat index

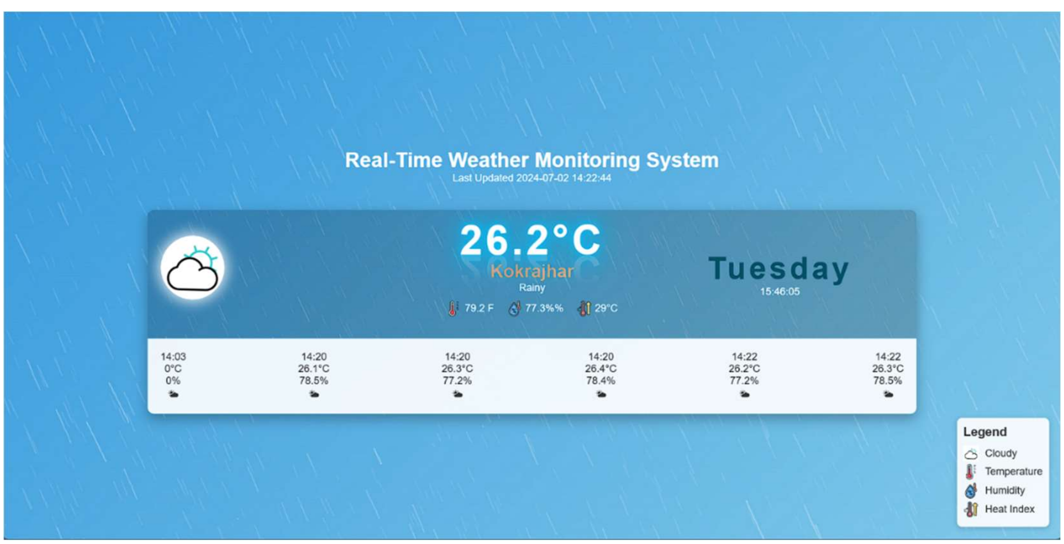


Fig 5: Web Page

4. Code Development:

Initialization: Wrote code to initialize the DHT11 sensor and ESP32 pins.

Data Reading: Developed code to read temperature and humidity data from the DHT11 sensor at regular intervals.

Data Processing: Processed the sensor data to format it for transmission.

Data Transmission: Implemented Wi-Fi connectivity to send data to the XAMPP server via HTTP requests.

Testing and Debugging: Conducted thorough testing and debugging:

Unit Tests: Tested individual components of the code, such as sensor reading and data transmission.

Integration Tests: Verified the complete system's functionality by combining all code components.

5. Data Transmission and Storage

Web Server Setup: Installed and configured XAMPP on a local machine to set up an Apache server with PHP and MySQL support.

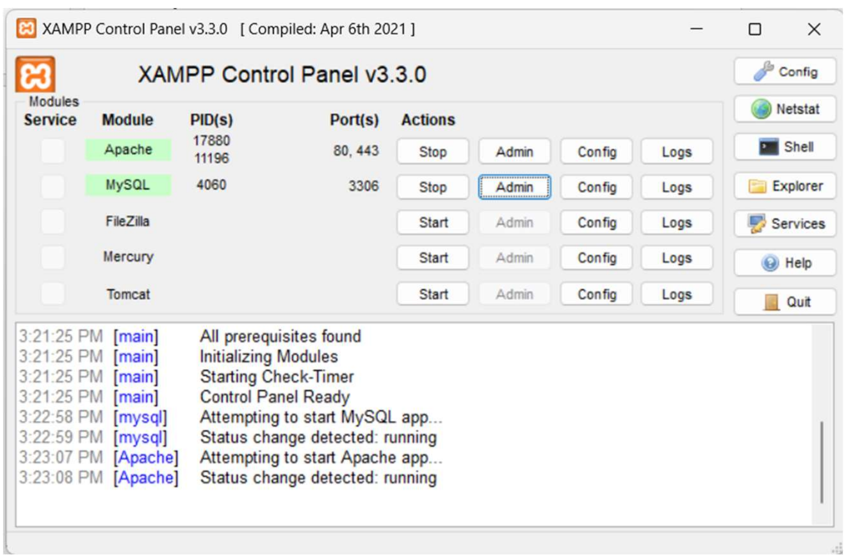
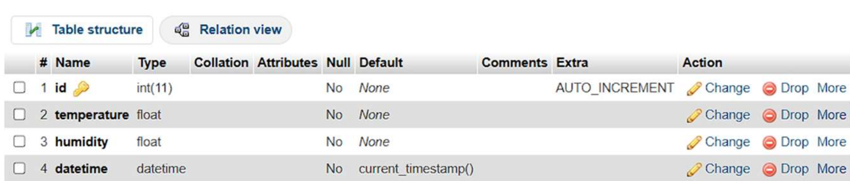


Fig 6: XAMPP Control Panel

Database Creation: Created a MySQL database and designed tables to store temperature and humidity data:

Database Schema: Defined the schema with fields for timestamp, temperature, and humidity.



#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	id	int(11)			No	None		AUTO_INCREMENT	Change Drop More
2	temperature	float			No	None			Change Drop More
3	humidity	float			No	None			Change Drop More
4	datetime	datetime			No	current_timestamp()			Change Drop More

Fig 7: Database Schema

Table Creation: Executed SQL commands to create tables and set up relationships if needed.

Communication Protocols: Used HTTP protocol for communication between ESP32 and server:

HTTP Requests: Developed code in ESP32 to send POST requests with sensor data to the server

Data Handling: Created test_data.php to receive data and insert it into the MySQL database using SQL queries.

6. Deployment and Monitoring

Deployment: Deployed the system in the intended environment (e.g., home, office, greenhouse):

Installation: Set up the hardware components and ensured stable power supply.

Configuration: Configured the ESP32 to connect to the local Wi-Fi network.

Monitoring: Continuously monitored system performance and data accuracy:

Regular Checks: Performed regular checks to ensure accurate data collection and transmission.

Adjustments: Made necessary adjustments to maintain optimal functionality.

Maintenance: Planned for regular maintenance:

Hardware Maintenance: Checked and cleaned hardware components to prevent malfunctions.

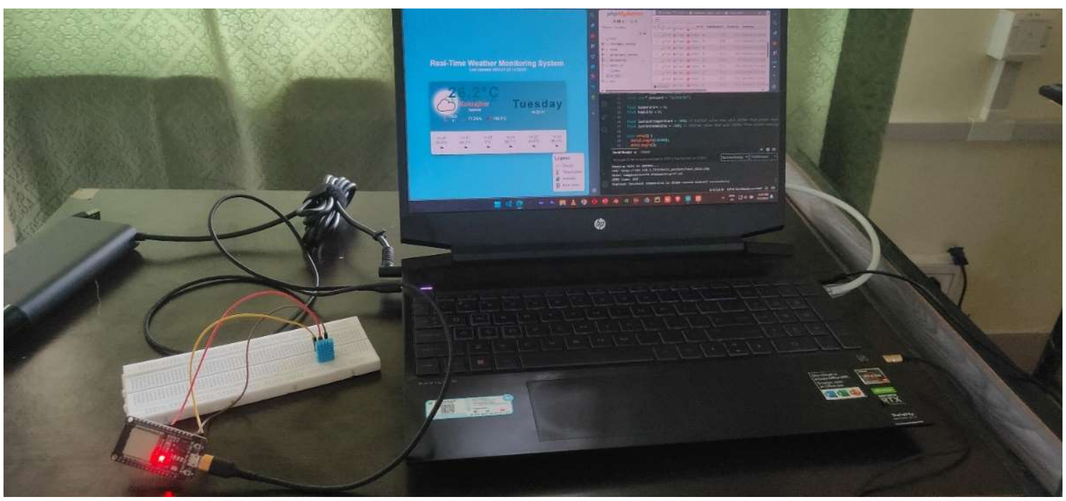


Fig 8: Deployment and Monitoring

CHAPTER – IV

Circuit Diagram

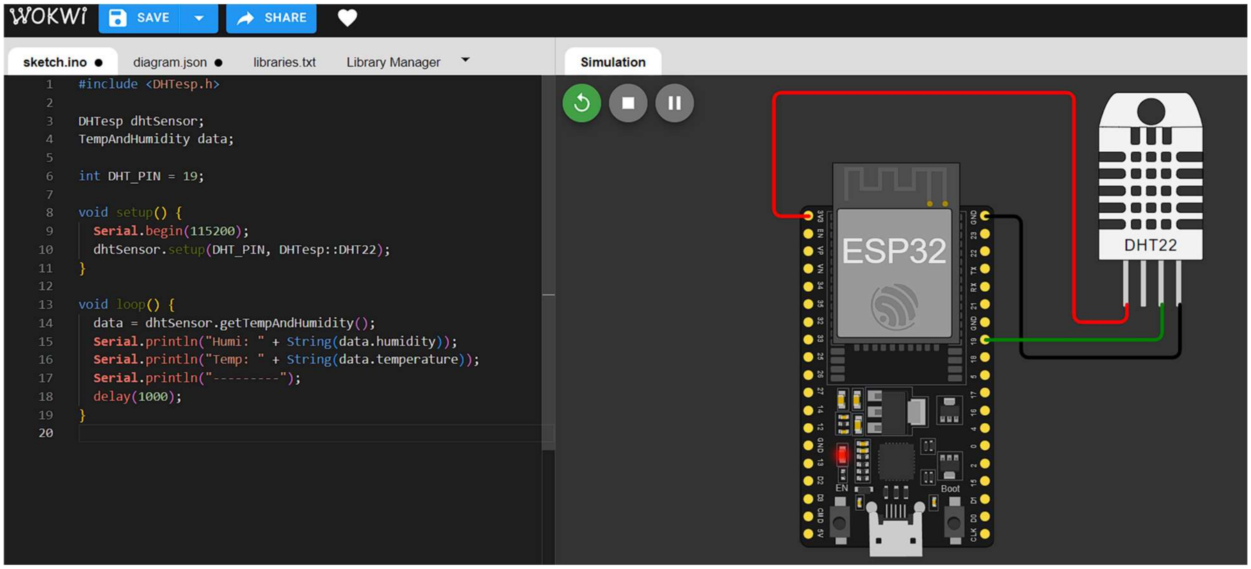


Fig 9: Circuit Diagram with sample code

<u>Power Supply:</u> Ensured the DHT11 is powered with 3.3V from the ESP32.

<u>Data Pin:</u> Connected the data pin of the DHT11 to a digital I/O pin on the ESP32.

<u>Connections:</u> Verified connections for ground and signal transmission using a multimeter.

<u>Assembly:</u> Assembled the hardware components on a breadboard, ensuring stable and reliable connections:

<u>Prototyping:</u> Used a breadboard for easy modifications and adjustments.

<u>Verification:</u> Tested the assembled circuit with a multimeter to ensure proper voltage levels and connectivity.

CHAPTER – V

Results

The system successfully demonstrated the capability to collect, transmit, store, and visualize environmental data in real-time. The following sections outline the key results and findings from the project.

1. Sensor Data Collection and Accuracy

The DHT11 sensor was used to collect temperature and humidity data. The sensor was tested in various environmental conditions to verify its accuracy and reliability. The key findings include:

Temperature Measurement: The DHT11 sensor provided temperature readings with an accuracy of ±2°C. The sensor was able to consistently measure the ambient temperature within the expected range, making it suitable for general monitoring purposes.

Humidity Measurement: The humidity readings from the DHT11 sensor showed an accuracy of ±5% RH (Relative Humidity). The sensor effectively captured changes in humidity levels, providing reliable data for analysis.

2. Data Transmission and Connectivity

The ESP32 microcontroller, with its built-in Wi-Fi capabilities, was responsible for transmitting the collected sensor data to the server. The connectivity and transmission performance were evaluated based on several criteria:

Wi-Fi Connection Stability: The ESP32 maintained a stable connection to the Wi-Fi network throughout the testing period. The data transmission was consistent, with minimal packet loss or disconnection issues.

Data Transmission Frequency: The system was configured to transmit data at regular intervals of 10 seconds. This frequency was found to be optimal for capturing real-time changes in temperature and humidity without overloading the network.

3. Server-Side Data Handling and Storage

The XAMPP Apache server, along with PHP scripts and a MySQL database, was used to handle and store the incoming data. The server-side components were evaluated for performance and reliability:

Data Reception and Storage: The test_data.php script effectively received data from the ESP32 and inserted it into the MySQL database. The data storage process was efficient, ensuring that all transmitted data was accurately recorded.

Database Integrity: The MySQL database maintains data integrity, with no instances of data corruption or loss observed during the testing period. The database structure was optimized to handle the incoming data load.

4. Data Visualization and User Interface

A web dashboard was developed using HTML, CSS, and JavaScript to visualize the collected data. The dashboard provided real-time and historical views of the temperature and humidity data. Key features and findings include:

Real-Time Data Display: The dashboard successfully displayed real-time data updates, providing users with current temperature and humidity readings. The use of AJAX ensured that the data was refreshed without reloading the entire web page.

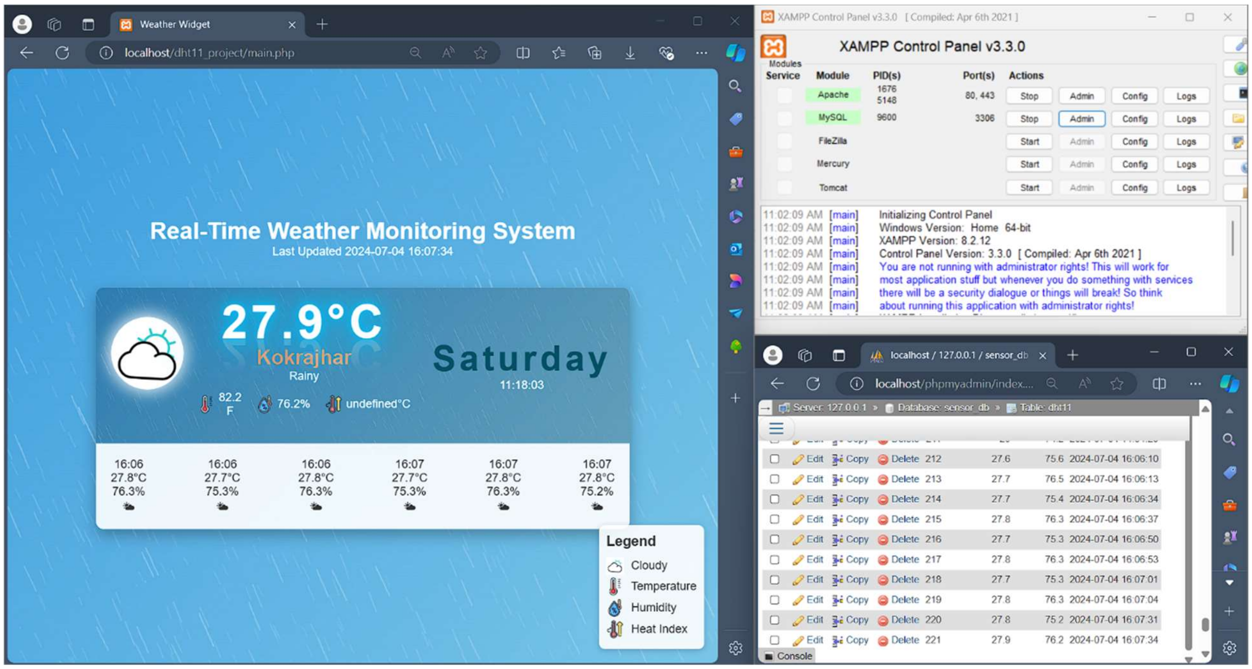


Fig 10: Data Visualization

5. System Performance and Reliability

The overall performance and reliability of the system were evaluated through extensive testing and monitoring

System Uptime: The system demonstrated high uptime, operating continuously without significant interruptions. This reliability is critical for real-time monitoring applications.

Data Accuracy and Consistency: The collected data was consistently accurate, with no significant discrepancies observed. The system effectively captured environmental changes in real-time.

Scalability: The system design and architecture allowed for potential scalability. Additional sensors and microcontrollers could be integrated to expand the monitoring coverage without significant modifications to the existing setup.

6. Practical Applications and Use Cases

The project highlighted several practical applications and use cases for the real-time temperature and humidity monitoring system:

Environmental Monitoring: The system can be deployed in homes, offices, and industrial settings to monitor environmental conditions, ensuring optimal comfort and safety.

Agricultural Use: Farmers can use the system to monitor greenhouse conditions, optimizing plant growth by maintaining appropriate temperature and humidity levels.

Health and Safety: The system can be used in healthcare facilities to monitor indoor air quality, ensuring a healthy environment for patients and staff.

7. Challenges and Limitations

Sensor Accuracy: While the DHT11 sensor provided reasonable accuracy, more precise sensors (e.g., DHT22 or BME280) could be used for applications requiring higher accuracy.

Wi-Fi Dependence: The system's reliance on Wi-Fi connectivity may limit its use in areas with poor network coverage. Future iterations could explore alternative communication protocols such as LoRa or Zigbee.

Power Supply Stability: Ensuring a stable power supply was critical for continuous operation. Battery backup systems could be integrated to enhance reliability in power outage scenarios.

CHAPTER – VI

Conclusion

The real-time temperature and humidity monitoring system using IoT devices successfully achieved its objectives, demonstrating the capability to collect, transmit, store, and visualize environmental data. The system's performance, reliability, and practical applications were validated through extensive testing and evaluation. Future enhancements could focus on improving sensor accuracy, exploring alternative communication protocols, and enhancing system scalability. This project serves as a valuable foundation for further research and development in the field of IoT-based environmental monitoring.

Future Scope

The real-time temperature and humidity monitoring system presents numerous opportunities for enhancement and expansion. Key areas for future development include:

Enhanced Sensor Accuracy: Integrating more precise sensors like DHT22 or BME280 can improve the accuracy and reliability of temperature and humidity measurements, making the system suitable for more demanding applications.

Advanced Communication Protocols: Exploring alternative communication protocols such as LoRa, Zigbee, or cellular networks can extend the system's range and reliability, especially in areas with limited Wi-Fi coverage.

Battery Backup and Power Optimization: Incorporating battery backup systems and optimizing power consumption can ensure continuous operation during power outages, enhancing system reliability.

Scalability and Network Expansion: Expanding the network by adding more sensors and microcontrollers can cover larger areas or multiple locations, providing comprehensive environmental monitoring.

Cloud Integration and Data Analytics: Integrating the system with cloud platforms can facilitate advanced data analytics, storage, and remote access, enabling predictive maintenance and more sophisticated environmental insights.

Mobile Application Development: Developing a mobile application can provide users with real-time alerts, data access, and control capabilities on the go, enhancing user engagement and convenience.

Integration with Other IoT Systems: The system can be integrated with other IoT devices and smart home systems for automated environmental control, improving overall efficiency and user experience.

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