

An IoT-Enabled Real-Time Weather Monitoring and Intelligence System

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Abstract—The integration of Internet of Things (IoT) technology into weather monitoring systems enables real-time environmental data collection, transmission and analysis. This paper presents an IoT-based weather monitoring and reporting system using a NodeMCU/ESP8266 processing platform and sensors for temperature, humidity, atmospheric pressure and rainfall. The sensed parameters are processed by the controller and transmitted through Wi-Fi so that the measurements can be viewed remotely through a web interface. The system is designed as a low-cost and scalable solution for continuous environmental monitoring, with potential applications in agriculture, urban infrastructure, industrial environments and local weather observation. The source implementation also demonstrates a browser-based dashboard for displaying live sensor values and provisions for storing or transmitting the collected data for later analysis. A prototype implementation was assembled and tested, and real-time readings were displayed through the web interface. The proposed approach provides a practical IoT framework for monitoring local weather conditions and can be extended with additional sensors and predictive analytics.

Index Terms—environmental monitoring, ESP8266, Internet of Things, NodeMCU, weather station

I. INTRODUCTION

Weather monitoring involves sensing and recording environmental parameters at different locations so that the information can be analyzed for forecasting, alerts and long-term studies. Conventional monitoring arrangements can be expensive to deploy and maintain, particularly where observations are required at multiple locations. IoT provides a practical approach by connecting sensors, embedded controllers, communication networks and cloud or

web services so that environmental information can be accessed remotely.

The source work describes a smart weather reporting system that continuously measures temperature, humidity, atmospheric pressure and rainfall and transfers the measurements over a Wi-Fi connection. The system uses an Arduino/NodeMCU-based controller architecture, with the ESP8266 providing wireless connectivity. The collected data can be viewed through a web browser and an Android application, allowing remote access to current weather conditions.

Previous work has investigated affordable automatic weather stations, IoT weather stations, Wi-Fi and ZigBee-based monitoring, cloud-connected weather information systems and weather prediction using machine-learning approaches [1]–[5]. These studies motivate the development of compact systems that combine low-cost sensing with remote data access. The contribution of the present work is the integration of multiple weather sensors with an ESP8266-based web reporting mechanism in a prototype suitable for local and distributed environmental monitoring.

II. RELATED WORK

The literature reviewed in the source manuscript identifies several directions in weather monitoring. An automatic weather station based on wireless sensor networking was proposed to improve the availability of weather observations while considering cost, power consumption, accuracy, reliability and data transmission [1]. IoT-based weather stations have also used multiple sensors to measure humidity, temperature, pressure and rainfall, with cloud storage and alert mechanisms for remote users [2], [5].

A WeMos-based weather information prototype demonstrated real-time weather display and cloud-based information access [3]. Another study combined mobile sensing, bus information and machine-learning models for real-time weather monitoring and prediction [4]. These developments indicate that IoT weather systems can progress from simple measurement toward distributed sensing, visualization and predictive analytics.

III. SYSTEM ARCHITECTURE AND DESIGN

3.1. IoT Framework

An IoT system combines sensors, connectivity, processing and applications. In the proposed weather monitoring system, the sensors acquire environmental parameters, the microcontroller processes the measurements, and the ESP8266 provides network connectivity. The data are then made available through a web server for remote viewing. The architecture therefore supports data collection, device integration and real-time visualization.

3.2. Functional Block Diagram

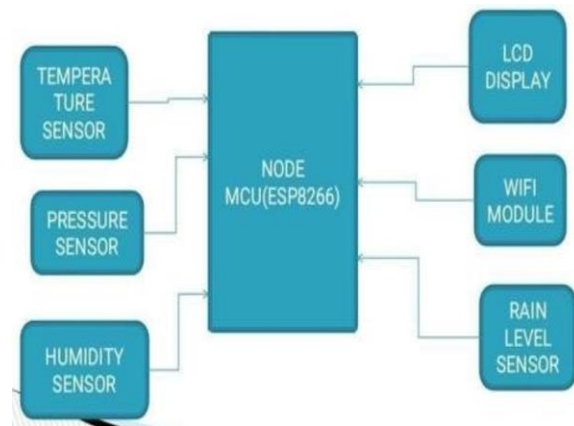


Fig. 1. Functional block diagram of the IoT weather monitoring system.

The system combines temperature/humidity sensing, pressure sensing and rainfall detection with a microcontroller and Wi-Fi interface. The collected measurements are forwarded to the IoT data collection and storage layer. The source manuscript also presents a NodeMCU block diagram in which temperature, pressure and humidity sensors are connected to the NodeMCU and the controller communicates with a display, Wi-Fi module and rain-level sensor.

3.3. Hardware Components

Table 1. Major hardware components and their functions.

Component	Function	Key details from source
Arduino UNO	Microcontroller board used in the source architecture	ATmega328P; 14 digital I/O and 6 analog inputs
ESP8266	Wi-Fi connectivity and web-server functions	3.3 V operation; integrated TCP/IP stack
DHT11	Temperature and humidity measurement	Digital output; 0–50 °C temperature range in source
BMP180	Atmospheric pressure and temperature measurement	Pressure range 300–1100 hPa in source
Rain sensor	Rainfall/moisture detection	Analog and digital outputs; LM393-based module

3.4. Circuit Implementation

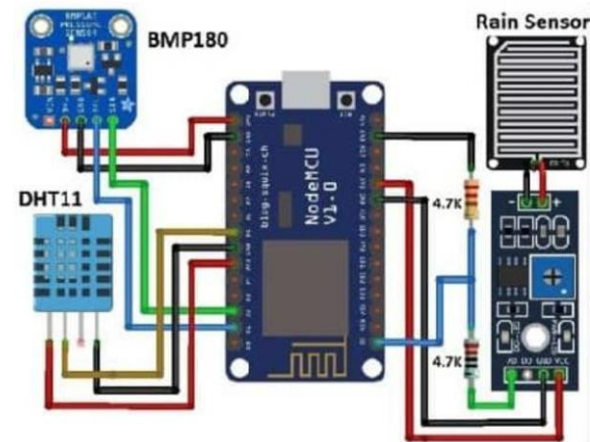


Fig. 2. Sensor and controller interconnection used in the prototype.

The prototype connects the environmental sensors to the controller and uses the ESP8266 Wi-Fi interface to provide network access. The source document includes separate circuit representations for the BMP180, DHT11 and rain sensor connections. The implementation was programmed using the Arduino IDE.

IV. SOFTWARE AND SYSTEM OPERATION

4.1. System Flow

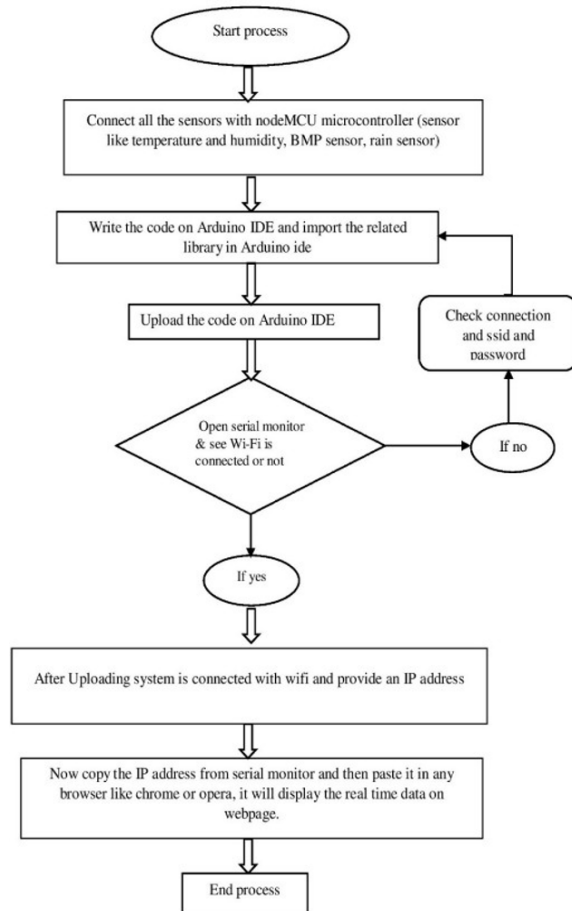


Fig. 3. Flow chart of the weather monitoring system.

After initialization, the controller establishes communication with the sensors and attempts to connect to the configured Wi-Fi network. Sensor readings are acquired periodically, processed and returned through an HTTP request. The web page uses JavaScript/AJAX to request updated measurements from the ESP8266 and refresh the displayed values without requiring a complete page reload.

4.2. Web dashboard and data exchange

The source implementation contains an HTML-based dashboard that displays temperature, pressure, rain and humidity. The ESP8266 web server provides a readADC endpoint that returns the measurements in JSON form. The browser parses the JSON response and updates the corresponding fields on the dashboard. This mechanism supports near-real-time visualization through a standard web browser.

4.3. Implementation sequence

- Assemble the controller and sensor circuits according to the circuit design.
- Program the ESP8266/NodeMCU using the Arduino IDE and required sensor libraries.
- Initialize the DHT11 and BMP180 interfaces and configure the rain sensor input.
- Connect the controller to the available Wi-Fi network and start the HTTP server.
- Acquire sensor values and package them as JSON data.
- Serve the web page and refresh the displayed weather parameters through AJAX requests.

V. PROTOTYPE AND EXPERIMENTAL RESULTS

5.1. Prototype Implementation

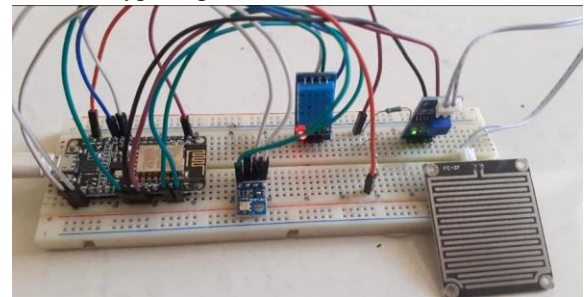


Fig. 4. Prototype hardware implementation with environmental sensors.

The prototype was assembled using the controller, environmental sensors, jumper connections and a breadboard. The source manuscript reports the use of the system for real-time local weather observation and remote viewing. The design is intended to require low maintenance and to support storage or further use of the collected measurements.

5.2. Real-Time Web Result

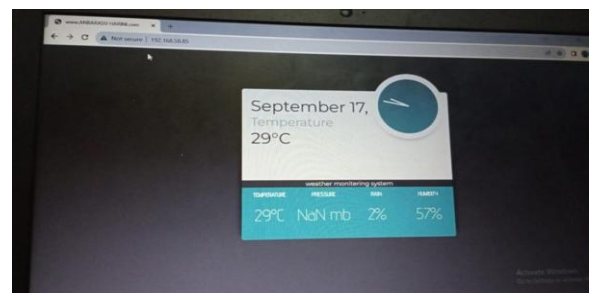


Fig. 5. Web dashboard showing real-time weather parameters.

The experimental dashboard demonstrates the presentation of live temperature, pressure, rain and humidity values. The source manuscript reports a prototype observation in which the dashboard displayed a temperature of approximately 29 °C along with pressure, rain and humidity values. The browser-based display confirms the intended end-to-end operation from sensing to wireless reporting.

5.3. Observed sample measurements

Table 2. Sample real-time measurements reproduced from the source manuscript.

Date	Temperature (°C)	Humidity	Pressure
June-12	29.1	95%	999 mbar
June-12	29.4	95%	100 mbar
June-12	29.5	95%	1003 mbar
June-12	29.6	95%	999 mbar
June-12	29.7	95%	998 mbar
June-12	29.8	95%	997 mbar
June-12	29.9	95%	999 mbar

The sample values above are reproduced from the experimental table in the supplied manuscript. They are presented as reported in the source and are not independently recalibrated or corrected in this journal manuscript.

VI. ADVANTAGES AND APPLICATIONS

The proposed system offers low-cost and relatively simple deployment for environmental monitoring. The source manuscript identifies reduced field damage, improved safety and security, high-quality data reception, lower power consumption, high accuracy, smart environmental monitoring and reduced cost/effort as advantages.

6.1. Applications

- Agriculture: monitoring temperature, humidity, rainfall and related local conditions.
- Urban infrastructure: observing microclimates and environmental conditions.
- Industrial environments: continuous monitoring of selected atmospheric parameters.
- Weather observation: local data collection for analysis and future forecasting.
- Remote monitoring: browser-based access to measurements from a connected location.

VII. LIMITATIONS AND FUTURE SCOPE

The supplied manuscript does not provide a complete quantitative uncertainty analysis, long-duration validation dataset or comparative calibration study against a reference weather station. Therefore, the experimental evidence in this paper is limited to the reported prototype observations and sample readings. Future development can incorporate additional sensors for UV index, soil moisture and air quality, together with improved sensor accuracy and environmental durability. The source manuscript also proposes advanced data analytics, machine learning for weather-pattern and anomaly prediction, and big-data integration across multiple monitoring stations. These additions can extend the system from real-time reporting toward predictive and distributed environmental intelligence.

VIII. CONCLUSION

An IoT-based real-time weather monitoring and reporting system using an ESP8266/NodeMCU platform and environmental sensors has been presented. The system acquires temperature, humidity, pressure and rainfall information and makes the measurements available through Wi-Fi and a web interface. The prototype demonstrates a practical low-cost approach for local weather observation, remote visualization and future data analysis. The modular architecture can be expanded with additional sensors, cloud storage and predictive analytics, making it suitable for applications in agriculture, urban infrastructure and industrial environmental monitoring.

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