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DEVELOPMENT OF A FORUM TO IMPLEMENT IOT THAT SHOWCASES THE WEATHER INFORMATION OF A BUILDING WITHIN A COMMUNITY.

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Abstract

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ABSTRACT

The use of IoT devices in monitoring the condition of the environment has significantly enhanced the manner at which environmental data is collected and presented as these devices facilitate access to real time data which can be used in making forecast and enabling fast decision. For this thesis, the documentation of the development of IoT-based weather monitoring system has been well presented with the objective to design a reliable and trustworthy weather monitoring system integrated with community forums that displays weather data such as surrounding temperature, humidity, UV intensity and motion detection using selected sensors to read the data and a microprocessor to process and transmit it to the Blynk mobile application and a custom built web platform to facilitate accessibility and community engagement. In the development ESP8266 microcontroller was used as the main microprocessor which other sensors such as DHT22 sensors for temperature and humidity, a UV sensor for light intensity, and a PIR sensor for motion detection were all connected. The Blynk app where the weather data was retrieved from the microprocessor was visualized ensured the display of weather data in real-time while the web interface which retrieved the data through the API of the blynk app and was built using HTML, CSS, React and MYSQL provided a dynamic view of the data and facilitate community interaction with the system.
After the system development, testing was done to validate the functionality and performance of the system. The functionality testing ensured that the sensors produced accurate result and ensure seamless transmission from the microprocessors to where it is visualized while the performance testing confirmed low latency in system updates and stable operation. The outcome of the testing indicated that the system was reliable and also the sensor readings also align closely with external weather platforms like AccuWeather and Weather.com.
This findings shows the potential of the system to provide localized real-time weather data and foster community interaction through the developed web application. This study contributes to the field of IoT by showing how affordable IoT systems can address environmental challenges particularly in vulnerable communities where they may not have the luxury to acquire expensive components. It also provides a foundation for further exploration where there can be integration of predictive analytics, more user friendly interface and integration of more weather readings.

Keywords
Internet of Things (IoT), Weather Monitoring System, Temperature and Humidity Sensors (DHT22), UV Light Intensity Sensor, PIR Motion Detection, Blynk App Integration, Web Interface Development, Community Engagement, Remote Monitoring Systems.

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1 INTRODUCTION

In the recent decade, IoT has emerged as an innovative technology that provides state-of-the-arts technology in enhancing numerous operations across several fields leading to improved output. According to Kinza Yasar and Gillis (2024), IoT was defined as a network of interconnected devices that communicates and transmit data across IoT devices and cloud platforms. Emphasizing that these devices typically uses sensors and software tools for efficient performance and for optimizing various operations. This definition is further supported by Khatua, Ramachandaramurthy, Kasinathan, Yong, Pasupuleti, and Rajagopalan (2020) by asserting that IoT devices comprises of network of physical objects which includes different devices, vehicles, buildings and other items equipped with sensors, software and internet connection. This connection enables these objects to process and visualize data which then is utilized by various industries including healthcare, agriculture, transportation and smart cities (Kinza Yasar and Gillis 2024).

In recent years, vulnerable communities all around the world face significant challenges in extreme weather occurrences, with reports of activities such as storms, floods and heat waves. The resilience of these communities towards the extreme weather occurrences depends on the availability of reliable weather information, which enable people and businesses to make wise decisions and act swiftly to reduce the effect. (Lamsal, Karthikeyan, Otero & Ariza 2023, 15.) The conventional means of sharing weather data typically involve the use of mass media channels such as television broadcasts, radio announcements and newspaper reports. Additionally, official meteorological websites and mobile apps provide weather forecasts and updates. However, these methods might offer broad and generalized weather information. As an instance, weather forecasts which are televised are usually based on regional overviews rather than street-level conditions. Similarly, radio and newspapers provide weather summaries which do not show real-time updates. Although weather monitoring technologies have advanced, there is still a gap in efficiently distributing real-time, localised weather data to localised communities thereby promoting involvement and proactive action. Many communities depend on mass-media general weather forecasts, which might not accurately depict the microclimates and particular weather patterns of smaller geographic locations. Furthermore, there is currently an absence of systems that let people living in the same community communicate with one another, post observations, experiences and preparedness advice on a platform that visualizes weather information. (Wang, Lim, Wang, and Tseng 2021.)

Moreover, there are a plethora of web-based measurement systems that have been developed as a result of extensive research on the changing built environment (Sathya, Madhan and Jayanthi 2018; Afreen and Bajwa 2021). Universal adoption of this platforms has been hindered by the complexity of these systems which necessitates sufficient upgrades and simplification for non-technical users (Sethi and Sarangi 2017). Nonetheless, the capacity to develop the weather measuring platforms has far-reaching impact for all aspects of society and economy as it influences fields such as farming, manufacturing, and building (Khatua *et al.* 2020).

Furthermore, the information gathered from IoT-based weather monitoring systems can be applied to create climate forecasting models, therefore offering vital data for improved decision-making in many spheres. In agriculture, where crop development and output are directly affected by weather, IoT devices are significantly helpful. IoT technology integrated with community forums allows one to construct platforms that not only offer real-time weather reports but also encourage community involvement by letting users post observations and preparedness suggestions. This strategy can improve communal knowledge and resilience, hence improving readiness for catastrophes connected to the weather. (Wang *et al.* 2021.)

The main goal of this research project is to create a community forum showcasing real-time weather data which cater for a particular community of people using IoT technologies. The specific objectives are as follows: to design and implement an IoT-based weather monitoring system that gathers real-time weather data, to develop a web-based community forum that displays the collected weather information and supports community interaction and engagement, to evaluate the effectiveness of the community forum in enhancing community awareness and preparedness for weather-related events, and so assess the user satisfaction and usability of the developed platform by community feedback.

This research holds tremendous value for various reasons. The community forum can improve community resilience by offering real-time, localised weather information, therefore enabling people and businesses to better plan for and react to weather occurrences. The forum will provide a venue for members of the community to present observations and experiences connected to the weather, therefore promoting a feeling of community and shared knowledge. The project shows how IoT technology may be practically applied to meet needs unique to a community, therefore highlighting IoT's possibilities to change other facets of communal life. Accurate and timely weather data can help community members decide how best to plan their everyday activities and handle emergencies.

The scope of this study includes the design, development, and evaluation of an IoT-based weather monitoring system and a web-based community forum. The study will focus on a specific community, selected based on predefined criteria, to ensure the relevance and applicability of the findings. The research will encompass the development of a system comprising sensors, data collection modules, and data transmission infrastructure to gather real-time weather data. It will also include the creation of a web-based platform that displays the collected weather data and facilitates community interaction. The assessment of the platform's effectiveness and usability through user feedback and data analysis will be a key component of the study.

This thesis will be structured as follows, chapter one will provide an introduction to the research where details such as the problem statement, specific objectives, significance will be presented. In the following chapter, which is chapter two, the literature review will be presented where subtopics like the evolution of IoT, Uses of IoT, review of existing systems and many related topics will be discussed. The chapter three, will be centred on the discussion pertaining to the system design of the system (design of the IoT architecture and the web app). The following chapter which is chapter four will detail testing and implementation of the system where the testing methodologies used in ensuring the system operates effectively will be described. It will also present the functionalities of the system and how efficiently it works. In the last chapter, key findings, conclusions, future work and recommendations as well as lessons learnt will be discussed.

2 EVOLUTION OF INTERNET OF THINGS (IOT).

One of the most revolutionary technical advances in the past few years is the Internet of Things (IoT) and its progression. It started out as an idea in the early 2000s and has since developed into a vital component of contemporary technology systems, influencing everything from the medical field to the agricultural sector. This development is a result of the quick development of networking technology as well as the increasing desire among consumers for interconnection across computers, gadgets, and people.

2.1 Early Beginnings and Definition

The origins of IoT may be dated to 1982, when researchers at Carnegie Mellon University developed a basic system for remotely tracking the condition of a soda vending machine. This simple kind of connectivity hinted to the immense potential of the Internet of Things (IoT), where even commonplace devices may join a worldwide network. Nonetheless, in 1999, during a presentation at Proctor & Gamble, Kevin Ashton officially invented the phrase "Internet of Things". He envisioned a society in which devices might be monitored and controlled over the internet using technology such as RFID (Radio Frequency Identification). Ashton's idea signified the formal inception of the conceptual trajectory of the Internet of Things. (Wang et al. 2021.)

In spite of these early breakthroughs, the World Wide Web, which was invented by Tim Berners-Lee in 1989, was the fundamental step that made the Internet of Things possible. A reliable and easily available internet was necessary for gadgets to be able to connect, and Berners-Lee's design made this possible. This innovation then facilitated the interconnection of physical items thereby promoting the shift from a machine-exclusive internet to an innovative "internet of things". (Aggarwal 2024.)

2.2 Evolution through Key Milestones

A number of significant occurrences and technical advancements throughout the first ten years of the twenty-first century had broadened the scope of the Internet of Things. These occurrences, which included the first internet-controlled toaster in 1990 and the 2008 IoT conference in Zurich, demonstrated the increasing awareness of the possibilities of IoT (Kulkarni 2022). An important turning point was the official acknowledgement of the Internet of Things (IoT) by the United Nations International Telecommunication Union in a 2005 study, which paved the way for its widespread use and worldwide influence. IoT has gained recognition as a topic of research by 2008, when it was named as one of six disruptive civil technologies by the US National Intelligence Council. (Digital Matter 2024.)

The internet-enabled gadget population surpassed that of humans in 2009, a testament to the speed at which IoT made the leap from idea to widespread reality. This change represented both the emergence of machine-to-machine communication and the growing connection of humans, making it a pivotal point in the history of the Internet of Things. This was the "true birth" of the Internet of Things, according to a 2011 white paper from Cisco, because there were more connected devices than there were connected people. (Wang et al. 2021.)

The Internet of Things (IoT) industry is growing quickly right now; estimates indicate that by 2026, it will reach a value of $11.03 billion globally (Fortune Business Insights 2019). The advancements in machine learning, artificial intelligence, and cloud computing have made it possible for IoT devices to gather, store, and analyze data more effectively, which has led to this increase. Furthermore, the need for IoT technology has increased due to the growing significance of smart cities, transport networks, and healthcare (Khatua et al. 2020). IoT-centric development strategies are now being implemented by countries including the USA, China, and the EU as a consequence of IoT's integration into global economic and technical development (Kshetri 2017, 60).

The rapid development of IoT has also expanded its conceptual foundation as scholars are now debating the Internet of Services (IoS), Internet of People (IoP), and Internet of Knowledge (IoK), which go beyond basic device interconnection (Zainab, Hesham and Mahmoud 2015; Sethi and Sarangi 2017). This broader perspective on IoT draws attention to the possibility of more human-centered applications that integrate people, information, and services into the connection loop, in doing so, IoT becomes a socio-technical innovation rather than just a technological one. These frameworks highlight how IoT may transform sectors by bringing forth smart environments in supply chains, urban development, and transportation. (Lamsal et al. 2023, 18.)

As an example, smart agriculture has become a prominent Internet of Things application that enables more effective crop management, pest control, and water utilisation via real-time environmental monitoring (Mat, Mohd Kassim, Harun and Yusoff 2018). IoT applications in the healthcare industry allow for remote patient monitoring, which improves access to treatment and lowers costs (Yeole and Kalbande 2016). These applications improve sustainability as well as efficiency since IoT systems lessen environmental damage by improving resource management.

The usage of IoT in weather monitoring is another invention on which this paper focusses. IoT-based systems capture real-time data on temperature, humidity, wind speed and other environmental conditions using networked sensors. Early warning systems for natural catastrophes and strengthening of weather forecasts then benefit from this information. (Bhagat, Thakare and Choudhary 2019.) For example, IoT weather stations in agriculture help farmers to quickly monitor local climate conditions, therefore enhancing irrigation and lowering water waste. Similarly, IoT-based weather systems are essential for disaster planning as they provide real-time information on weather anomalies, therefore enabling communities to react efficiently (Afreen and Bajwa 2021).

3 THE ROLE OF IOT IN WEATHER MONITORING

The role of IoT devices has fundamentally improved the way weather data is collected, processed and utilized. This has then boosts the accuracy of forecasting as it allow for timely collection of atmospheric data. This technology has been accepted by various industries such as agriculture, urban planning, disaster management, and environmental conservation, leveraging it to optimize their various activities. The use of this system also ensure that traditional weather monitoring systems which traditionally depended on manual data collection have been totally replaced by a more sophisticated system that rapidly retrieves environment data and also provides evaluation needed by those using it. (Kulkarni and Mukhopadhyay 2018.) The potential to utilize wireless networks to connect sensors that detect diverse environmental characteristics such as temperature, humidity, wind speed and pressure together with display of their data is what characterizes the internet of things (IoT) in weather monitoring. These networked sensors automatically transport data to central platforms known as the microprocessors, enabling real-time monitoring and analysis of atmospheric conditions. (Bhagat, Thakare and Choudhary 2019.) According to Kulkarni and Mukhopadhyay (2018), the application of IoT technology in weather monitoring provides continuous and immediate data collecting, therefore lowering latency and boosting forecast accuracy. As such, due to their offering of early warning, they may reduce the damage posed by natural disasters, and hence they are especially valuable in areas with unpredictable or severe weather.

Also, IoT-based weather monitoring systems depend substantially on its technical components for effective operation and efficiency. The major components of the system normally collect information on a variety of meteorological characteristics, including temperature, humidity, pressure, wind direction, and precipitation. And, because these sensors may be positioned in far-off locales, they are great for keeping a watch on places like offshore sites and mountainous regions that are tough to physically access. The data acquired by these sensors is communicated to cloud-based systems utilising wireless communication technologies like LoRaWAN, Zigbee, and LTE-M so that it may be processed and stored. In faraway areas, where they ensure long-range connectivity and energy efficiency, these low-power, wide-area network (LPWAN) technologies are highly beneficial. Cloud computing platforms like Microsoft Azure and Amazon Web Services (AWS) also offer the processing capability necessary to examine this data in real time and give rapid weather predictions. (Dang, Piran, Han, Min, & Moon 2019.)

Using machine learning (ML) and artificial intelligence (AI) algorithms increases the data analytics capabilities of Internet of Things (IoT) weather monitoring sensors. With the use of these technologies, it is feasible to study previous weather data and uncover patterns and trends that may be utilised to strengthen forecast models.

Additionally, these systems also offer various benefits, among which the most important of this potential is offering data in real-time. IoT sensors constantly monitor environmental conditions and send this data in real time, in contrast to traditional weather stations that may only update data at specified intervals. This is particularly critical in disaster-prone locations, where early and accurate weather forecasts may save property and human fatalities. For instance, IoT-based flood monitoring systems may inform individuals living near rivers or coastal areas in advance of imminent catastrophes, allowing them to evacuate or take preventative measures (Kulkarni and Mukhopadhyay 2018). For companies like agriculture, where crop yields may be dramatically influenced by weather, real-time data is particularly vital. IoT technologies aid farmers in making data-driven decisions regarding irrigation, fertilisation, and harvesting by measuring temperature, precipitation, and soil moisture levels (Lamsal et al. 2023).

In addition to providing real-time information, Internet of Things devices provide accessibility from a distance. The installation of IoT systems in remote areas presents a continuous environmental monitoring approach without the need for human to manually collect data. This is especially crucial for areas that are physically isolated and suffer from severe weather conditions. According to Sharma and Prakash (2021), the potential to collect meteorological data remotely decreases the requirement for human engagement, hence boosting the reliability and efficiency of weather monitoring approach. The study further stresses that better resource management is also made possible through remote accessibility of the weather conditions and allowing decision-makers to collect meteorological data from diverse places and base their judgements on reliable databases.

Another significant benefit is the possibility of IoT-based weather monitoring to enhance the engagement of the community in environmental conservation and proper disaster preparation. IoT devices empower individuals and communities to respond more actively to environmental problems by democratizing access to meteorological data. IoT devices empower individuals and communities to respond more actively to environmental issues by democratising access to meteorological data. Through the use of a decentralized platform, the communities in a locality can contribute their insights on the weather condition of an area and to include preparation ahead of a disaster, hence boosting the granularity of weather monitoring systems. These networks perform is particularly effective in under-served and rural areas where there may be little to no infrastructure for centralised weather monitoring (Zainab, Hesham and Mahmoud 2015). Furthermore, the public may access real-time weather information via mobile applications that interface to IoT weather monitoring equipment, allowing individuals to plan their activities based on current circumstances and make smart decisions.

Several case studies also show how IoT is changing how weather information is collected. For instance, Afreen and Bajwa (2021), who examined the role of the Internet of Things in environmental sustainability, pointed out that IoT devices continuously measure the levels of pollutants in the air and water and send out early warnings when pollution exceeds allowable limits. In order to reduce the effect of pollutants on the environments, this real-time data could drive prompt action. An example of this include reducing runoffs from agricultural facilities and regulating industrial pollutants. Additionally, IoT is becoming more and more integrated into the infrastructure of smart cities in metropolitan regions, where it is utilised to optimise energy use, traffic management, and environmental monitoring. This has facilitated cities to cut their energy waste, increase public safety and become more resilient to catastrophic weather events through the integration of data weather monitoring systems with other Internet of Things (IoT)-enabled devices (Khatua et al. 2020).

There are downsides to IoT in weather monitoring despite its tremendous benefits. These include worries regarding scalability, data security, and the costs of deploying IoT equipment in underserved or rural places (Kshetri 2017, 58). The importance of building robust data encryption techniques to secure crucial meteorological data from attacks was underlined by Kulkarni and Mukhopadhyay (2018). Furthermore, as the number of IoT sensors grows, scalability becomes a key challenge because processing the vast amounts of data generated by weather monitoring networks involves substantial investments in cloud infrastructure and data management systems. To continue the growth and efficiency of IoT devices in weather monitoring, it is necessary that these difficulties be carefully addressed.

4 EXISTING METHODS AND APPLICATIONS

Several researchers have explored IoT-based weather monitoring systems, with each study targeting specific applications. Indu and Kumar (2022) work on a real-time local weather station for precision agriculture in India exemplifies the fusion of IoT and agriculture to support decision-making in response to unpredictable weather conditions. The authors propose a system that leverages IoT platforms to collect data on parameters like temperature, humidity, air pressure, and rainfall. Moreover, the incorporation of an artificial neural network (ANN)-based prediction system offers a forward-thinking approach by aiding farmers in making informed decisions on irrigation, fertilization, and harvesting. While the paper presents an efficient, low-cost solution for farmers in India, the system's broader scalability and adaptability in regions with more complex weather systems remain unexplored. This highlights a common limitation in IoT research, where localized solutions may not always translate to global applications. (Murthy, Kumar, Saikiran, Nagaraj and Annavarapu 2023.)

Varghese, Deepak and Santhanavijayan (2019) developed an IoT-based climate forecast system using a Raspberry Pi and sensors to monitor temperature and air pressure. Their work contributes significantly to the field by demonstrating the system's practical implementation and relatively accurate forecasting capabilities. However, while the hardware integration is compelling, the study lacks an extensive exploration of machine learning models to enhance forecast precision, a gap highlighted in related studies that emphasize the importance of advanced predictive algorithms (Abaa, Vidal and Valiente 2022).

In another study, the implementation of an IoT system using Arduino UNO and DHT11 sensors for real-time monitoring of temperature and humidity has proven the cost-effectiveness and feasibility of such systems for smaller scale operations (Sharma and Prakash 2021). The study's design offers practical applications in industries that rely on constant environmental monitoring, yet it remains limited by the scope of weather parameters monitored. Expanding the system to integrate additional sensors for wind speed or rainfall would increase its relevance to broader environmental and industrial needs, as seen in the work by Zainab, Hesham and Mahmoud (2015), who implemented multi-sensor IoT networks in remote regions.

The research by Abaa, Vidal and Valiente (2022) highlights a more sophisticated IoT approach for weather monitoring by incorporating additional parameters like air quality index, CO2 concentrations, and light levels, employing energy-efficient custom-designed sensors. The study leverages the ESP8266 Wi-Fi module for data transmission and ThingSpeak for analysis and visualization, emphasizing both usability and cost-efficiency. However, while the inclusion of a mobile application for real-time monitoring represents a significant advancement, the study does not fully address concerns related to energy consumption in long-term deployments, a challenge recognized in similar works that address sustainability (Bhagat, Thakare and Choudhary, 2019).

To enhance communication between various sensors used for weather monitoring, Yeole and Kalbande (2016) developed an IoT system that makes use of Message Queuing Telemetry Transport (MQTT) technology. The effectiveness of this technology was further emphasized by the author to deliver data to a central hub which then analysis the data for real-time decision making. This technology, although efficient, presents issues about data quality and security, particularly in cases where crucial environmental data is handled remotely. The integration of Wireless Sensor Networks (WSNs) with IoT-based weather monitoring has also seen considerable developments. The utilisation of Zigbee-based sensor networks, as discussed by Lamsal et al. (2023), ensures efficient monitoring of ambient conditions with minimum local computing. Zigbee's low power consumption and flexible network configurations make it excellent for applications in agricultural and urban planning. However, the reliance on Zigbee restricts the system's range and capacity to handle huge data files, which is a major downside when compared to systems employing more sophisticated communication protocols like LoRa or NB-IoT, which provide greater coverage and better data throughput (Pauzi and Hasan 2020).

Further advancement in sensor technology may be observed in RFID-enabled devices, which have been adapted for environmental monitoring. RFID tags, traditionally used in manufacturing for monitoring, have been reused in research to monitor environmental metrics such as temperature and humidity (Mezzanotte, Palazzi, Alimenti, and Roselli 2021). While RFID has benefits in terms of low power consumption and great durability, its range is restricted, and the technology may not be ideal for real-time data collecting across wide geographical areas.

Mobile phone sensors have also been applied in urban contexts to monitor pollution and other weather-related characteristics, adopting both participatory and opportunistic sensing approaches (Murthy et al., 2023). These approaches, although creative, present substantial hurdles, such as power restrictions and the static nature of many mobile sensor applications. Moreover, the dependence on user engagement in data gathering causes uncertainty in data quality, as stated by Mezzanotte et al. (2021).

IoT-based weather monitoring systems have made great leaps, enabling real-time, low-cost options for environmental data collecting. While these systems have proved useful in fields like agricultural and disaster management, there is a need for more sophisticated systems that solve current difficulties related to scalability, energy efficiency, and data security. Integrating cutting-edge technology such as machine learning and energy-efficient networks will be important for the future generation of weather monitoring systems.

4.1 Technological Components for IoT Weather Systems

The introduction of IoT systems in weather monitoring has enhanced the collection, analysis and interpretation of weather data in real-time for advanced weather forecasting. To boost weather forecasting skills, Internet of Things (IoT) weather systems are developed employing many various types of technical parts, such as sensors, communication networks, data storage, cloud-based analytics, and mobile interfaces like Blynk. (Lamsal et al. 2023.)

IoT weather systems mainly include of sensors, which are in charge of acquiring critical meteorological data including temperature, humidity, air pressure, and wind speed. System dependability relies largely on sensor lifespan and accuracy. (Murthy et al. 2023.) Pauzi and Hasan (2020) claim that developments in sensor technology are crucial for Internet of Things weather systems, especially in terms of enhancing accuracy and energy economy under demanding situations. A significant component of these systems are wireless sensor networks (WSNs), which permit data transmission and collecting across enormous distances with no obtacles (Sathya, Madhan and Jayanthi 2018).

Moreover, communication networks like Zigbee, LoRaWAN, and low-power wide-area networks (LPWANs), which are frequently used in internet of things weather systems due to their long range and low power consumption, even in remote areas, enable the effective transfer of sensor data to local servers or cloud storage (Sharma and Prakash 2021). To successfully keep system efficiency and decrease latency, Zainab, Hesham and Mahmoud (2015) highlighted that it is vital to apply the right communication protocols since this is one of the fundamental component of IoT based weather monitoring systems. Additionally, to handle the vast amount of data created by IoT weather devices exploitation of cloud computing and data storage medium are important. This will ease data processing and analysis as well as providing scalable storage and computing capabilities. Predictive analytics and machine learning may also be linked for increased forecasting skills via the usage of big data technology in IOT weather systems. (Yeole and Kalbande 2016.) The opinion of Pauzi and Hasan (2020), who assert that AI-driven analytics significantly improves the accuracy and timeliness of weather forecasts, supports the idea that the use of sophisticated algorithms like artificial intelligence (AI) and machine learning, cloud-based analytics, and others helps to convert raw meteorological data into actionable insights.

In prior study, real-time visualisation and remote control of IoT equipment are made feasible via the mobile interface platform Blynk, which is a fundamental element of IoT weather systems. Blynk is a well-liked tool for developers to design customised weather monitoring dashboards because of its compatibility with a large selection of sensors and communication protocols. Users may monitor weather data and receive alerts from their IoT weather gadgets via smartphones employing Blynk's user-friendly interface. Based on the evaluation of Varghese, Deepak and Santhanavijayan (2019), Blynk's adaptability has made it a significant tool for both amateur and expert IoT projects, thus boosting the simplicity of use and availability of IoT-derived meteorological monitoring systems.

5 METHODOLOGY AND SYSTEM DESIGN

As the objective of the study is to develop a real-time weather monitoring system using IoT technology to collect, analyses and display weather data in real time specific to a community through a web interface. The approach used in designing this system is well explained in this section.

5.1 System architecture

The system overview is shown by the system architecture in figure 1. The system fundamentally depends on sensors to collect weather data, including temperature and humidity, which are subsequently processed by a microprocessor. The data is stored in the cloud via the Blynk app, allowing users to access weather updates at any time.

Users must first register on the platform to create a profile, view articles, and post new content. The weather update section is essential as it presents weather readings, thereby enhancing accessibility for community members. The internet would be linked to the sensors and devices, and the settings made to them would guarantee that data is delivered to the Blynk app and saved in its database with ease. The web interface would then fetch and show this data.

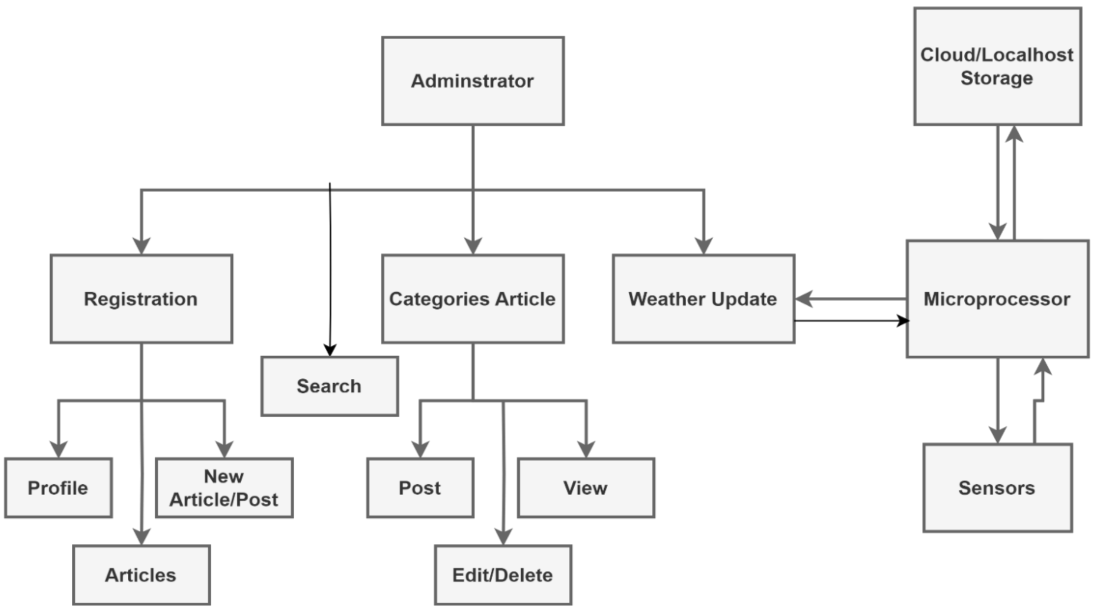

Figure 1. System architecture of the weather monitoring system.

5.2 System components description

The system components are the necessary tools used for the system development. These components have been carefully selected and connected to ensure that the aim of the study is reached. The description of the components and how they are connected is provided below.

5.2.1 ESP8266 Microcontroller

The ESP8266 is a microcontroller that act like the central core of the system which is responsible for collecting sensor data and transferring the data to the cloud and local database such as blynk app and the built website. The microcontroller manages the sensors and offers Wi-Fi connection and USB port. It was linked to the breadboard via USB as the power supply source. The rationale for selecting this component is due to its compact size and integrated Wi-Fi as well as its affordability and compatibility with broad variety of IoT applications.

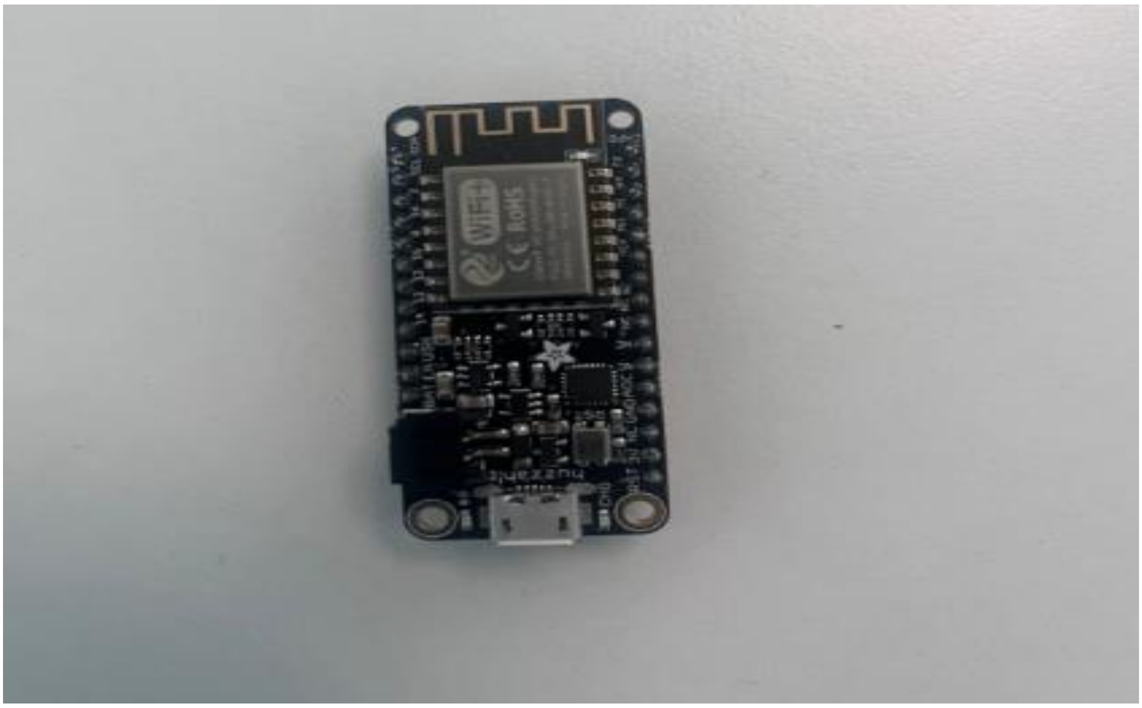

Figure 2. ESP8266 Microcontroller

The ESP8266 micro controller shown in figure 2, was connected to the breadboard to facilitate easy connection and component placement. The microcontroller was powered via a USB cable attached to a power source supplying a continuous 5V to its USB port. The output of the USB was connected to the positive power rail on the breadboard to distribute power throughout the arrangement, while the GND pin was linked to the negative rail to give a common ground. The GND pin of the ESP8266 was attached to the GND rail of the breadboard to preserve uniform grounding for the full circuit. Sensors or other peripherals needed for the project might be connected to the ESP8266's GPIO pins. This configuration guaranteed that the ESP8266 could constantly process and deliver data which make up the backbone of the weather monitoring system.

5.2.2 Breadboard

The breadboard, which offered a flexible and temporary foundation for circuit construction, was essential to the creation and deployment of the weather monitoring system. It lets components like the ESP8266 microcontroller and other sensors to be efficiently mounted, adjusted and replaced without requiring soldering which make it excellent for prototyping and iterative testing.

The terminal strips in the centre of the breadboard consist of parallel connected holes. These strips were employed to securely attach the ESP8266 microcontroller and enable connections between its pins and other elements in the design. The ESP8266 was positioned so that its pins were accessible on either side of the breadboard's central divider, providing clear and ordered wiring to other components. Additionally, using the breadboard facilitated the circuit-building process since it provided flexibility and mistake free connections.

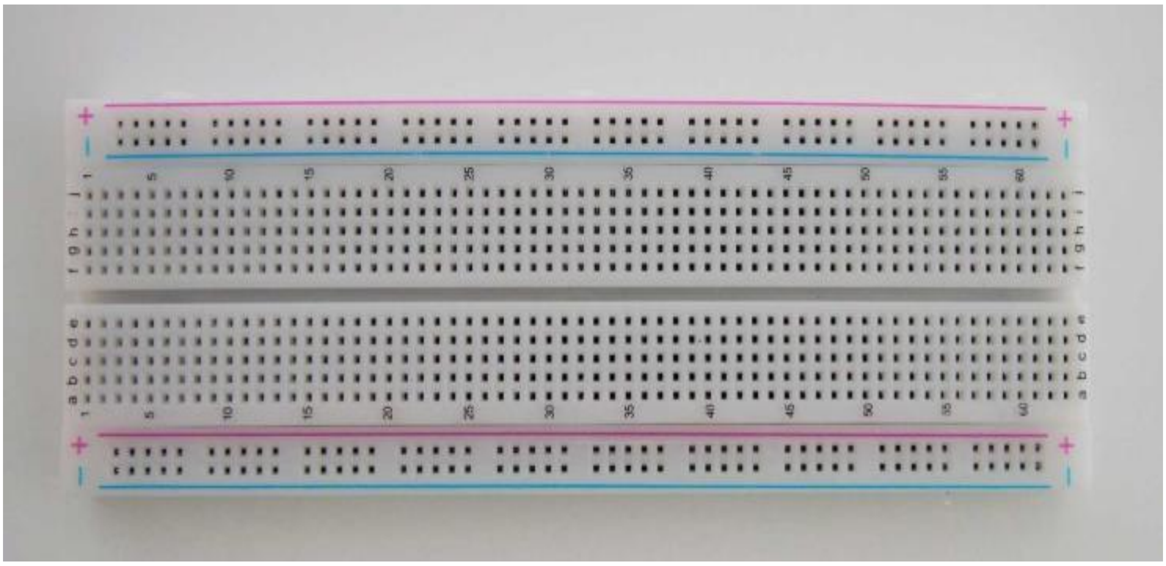

Figure 3. Breadboard.

5.2.3 UV Light Intensity Sensor

The UV light intensity sensor is a critical component in detecting ultraviolet (UV) radiation which is commonly represented as the UV index. The data gives critical information on the intensity of sunshine which has numerous use cases like monitoring environmental conditions, assessing UV exposure risk and aiding in making choices relating to agriculture where sunlight plays a significant role. This sensor was used due to its capacity to provide precise UV data making it ideal for use in achieving the aim of the study.

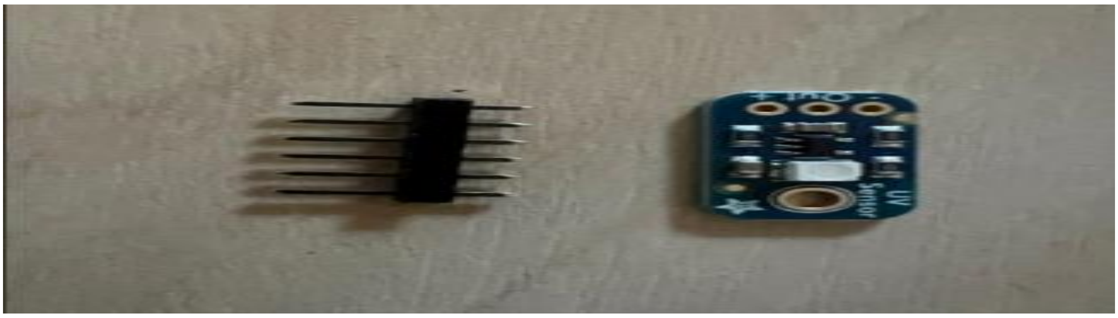

Figure 4. UV light intensity sensor.

The sensor has three principal pins which are the VCC (for power supply), GND (ground), and signal output. These pins were carefully selected for their compatibility with the ESP8266 microprocessor which is the component previously discussed. The sensor operates on a low voltage (3.3V) which marches perfectly with the ESP8266’s 3.3v output. It is simple to connect with the ESP8266's analogue pin (A0) due to its analogue signal output, which ensures precise data transfer. This sensor was selected based on its low power consumption attribute, high sensitivity and simplicity of connection which are important in designing an IoT system. The sensor was first connected to the breadboard, then its VCC pin was joined to the 3.3v rail on the breadboard which was itself powered by the ESP8266’s 3.3V output pin. To maintain efficient current circulation across the circuit, the sensor GND pin was connected to the ground wire of the breadboard. Also for the signal output, the analog output pin of the sensor was linked to the A0 pin on the ESP8266 through the use of jumper wire. This connection ensured that the UV intensity values red by the sensor is transferred in real-time to the microprocessor and for display.

5.2.4 PIR (Passive Infrared Sensor) Motion Sensor

A key element of motion detection is the use of the Passive infrared (PIR) motion sensor which assist in detecting changes in infrared light within its range. This sensor now finds application for use in systems such as the one developed for this study where tracking movement may provide important information such as assessing the degree of animal or human activity in a specific region. The sensor was also selected due to its low power consumption, a simple integration into a device as well as its capacity to generate digital signals.

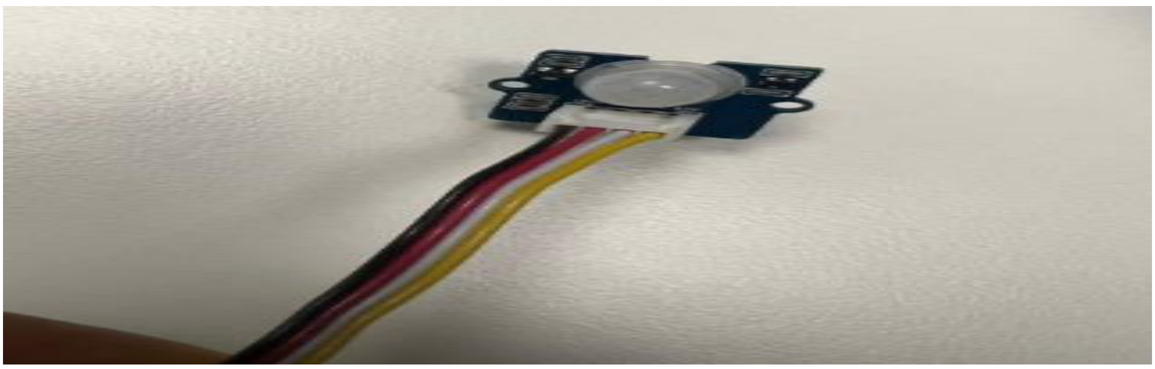

Figure 5. PIR Motion Sensor

The three pins of the PIR motion sensor which are the VCC, GND, and OUT were carefully organized and linked to the ESP8266 microcontroller on the breadboard. The VCC pin of the sensor was linked to the 3.3V rail on the breadboard, which was powered by the 3.3V output pin of the ESP8266. The GND pin of the PIR sensor was linked to the ground rail on the breadboard, establishing a good ground connection. Finally, the OUT output of the sensor was linked to the GPIO4 (D2) pin of the ESP8266 with the help of a jumper wire. With this design, the sensor was assured to be able to transmit digital signals to the microcontroller anytime motion was detected within its working range. Upon detecting motion, this sensor sends signal to the ESP8266's GPIO4 pin via the OUT pin. After the microprocessor reads this input, the data is then turns the data into a motion detection event which may subsequently send out notifications via the IoT through the integrated blynk app or web interface. This seamless connection makes it easy for the system to easily read motion within the working range.

5.2.5 DHT22 Temperature and Humidity Sensor

The DHT22 temperature and humidity sensor is a vital component for detecting weather condition metrics, which include ambient temperature and humidity levels. It is widely used because of its high precision, dependability, and affordability, which makes it suitable for use in developing the system. The sensor also monitors a range of temperature and humidity readings as well as offering digital output and allowing for integration with the microcontroller.

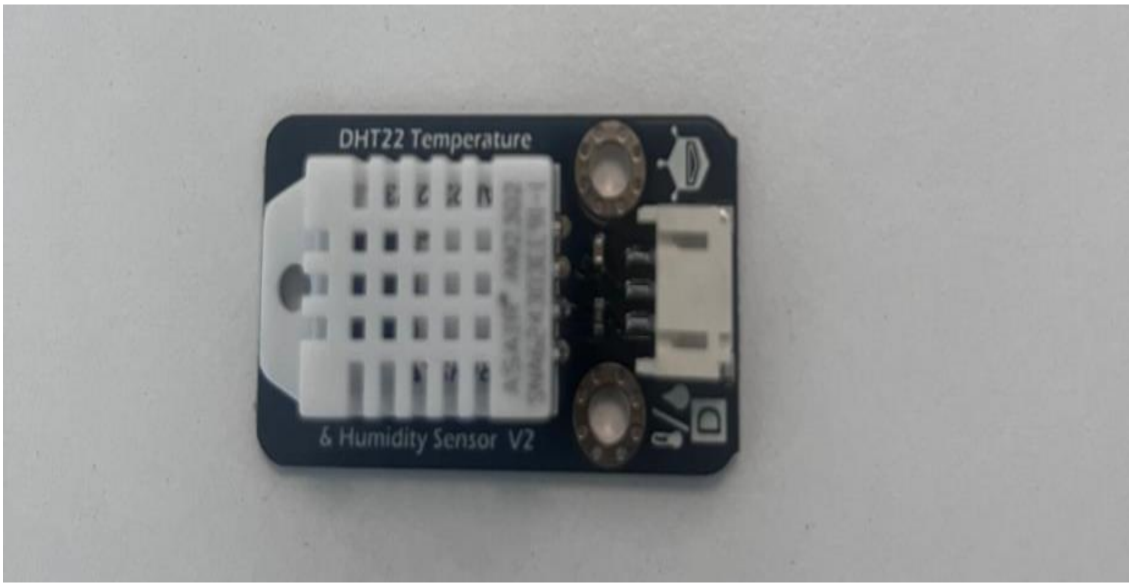

Figure 6. DHT22 sensor.

The DHT22 was affixed to the breadboard to ensure effective performance and efficient data transfer. Its VCC pin was linked to the 3.3V rail on the bread-board, which was powered by the 3.3V output pin of the ESP8266. This connection supplied the required power source for the sensor. A stable and shared ground with the ESP8266 was produced by connecting the DHT22's GND pin to the breadboard's ground wire. The data port of the DHT22 was linked to GPIO5 (D1) on the ESP8266 via a jumper wire. The DATA pin and the VCC rail were connected to a 10kΩ pull-up resistor in order to stabilize the connection between the sensor and the microcontroller. This resistor assures that the signal stays stable, lowering the probability of noise or errors during data transfer.

When the DHT22 is operating, it sends digital signals with temperature and humidity information to the ESP8266 over the DATA port. The ESP8266 examines this information and makes it available for subsequent analysis or display on the IoT platform. The straightforward and secure connection on the breadboard assures that the sensor works consistently, supplying accurate and fast environmental data for the system.

5.2.6 12C OLED

The 12C OLED is a small display module employed in the system to deliver real-time visual feed-back of sensor information. Its integration increases the weather monitoring system's utility by allowing users to get vital information like temperature, humidity, UV intensity, and motion detection without being totally dependent on the web interface. The display is affordable and suited for IoT applications due of its low power consumption and great contrast, guaranteeing readability even in low-light settings. This component was picked because it leverages the I2C communication protocol, which minimises the number of pins required for connection, making it well-suited for compact systems like the one based on the ESP8266.

Figure 7. 12C OLED display

The ESP8266 microcontroller was connected to the pins of the 12C OLED module, which was affixed to the breadboard. The 3.3V rail on the breadboard, which was powered by the ESP8266's 3.3V output pin, was connected to the OLED's VCC pin. The microcontroller and the OLED shared a ground by connecting the GND pin of the OLED to the breadboard's ground rail.

The OLED requires two pins for data transfer: SDA (Serial Data) and SCL (Serial Clock). On the ESP8266, the SDA pin was connected to GPIO4 (D2) and the SCL pin to GPIO5 (D1). These connections let the microcontroller to use the I2C protocol to send commands and data to the OLED. When switched on, the OLED shows the sensor readings in real time after receiving data from the ESP8266. Users may interact with and understand environmental data with ease because to the display's modular design and effective communication protocol, which provide seamless operation inside the Internet of Things weather monitoring system.

5.2.7 Device connection layout

In order to facilitate seamless interaction and operation, the device connection layout shows how all system components are arranged and integrated on the breadboard. Every component of the system, including the sensors, CPU, and OLED display, was precisely positioned to guarantee efficient data flow and stability.

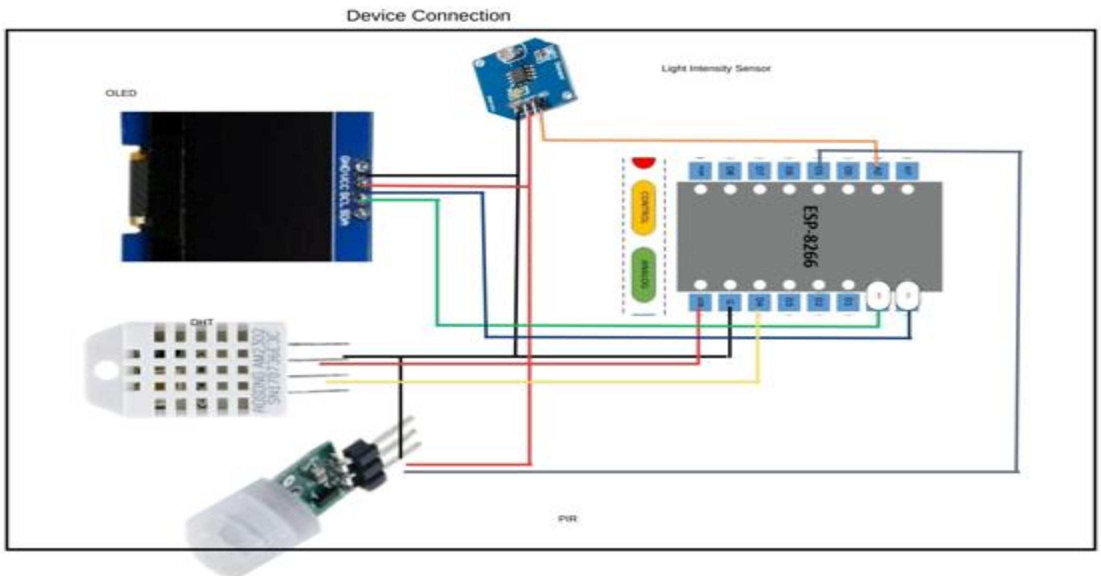

Figure 8. Device connection layout

The system begins with the fixing of the ESP8266 microcontroller working as the central hub of the system. Its 3.3V pin was linked to the power rail on the breadboard, supplying power to all components. The GND pin of the ESP8266 was attached to the ground rail, establishing a common ground needed for consistent circulation of current. Each sensor's power (VCC) and ground (GND) pins were connected to their respective rails on the breadboard to receive power and secure consistent functioning. The data lines for the DHT22 temperature and humidity sensor, PIR motion sensor, UV light sensor, and I2C OLED display were linked to the respective GPIO pins on the ESP8266. Additionally, the OLED display's SDA and SCL pins were connected to GPIO4 (D2) and GPIO5 (D1), respectively, while the DHT22 data port was attached to GPIO5 (D1). A 10kΩ pull-up resistor was also added to the setup to stabilize the signal and increase the reliability of the communication with the microcontroller. Each of the component were then placed in a container and well positioned to prevent cable congestion and electrical interference. The overall system setup shows how the components interact together. The ESP8266 retrieves weather data from the sensors, process it, and transmit it to the OLED display for visualization while also sending it to the web interface designed.

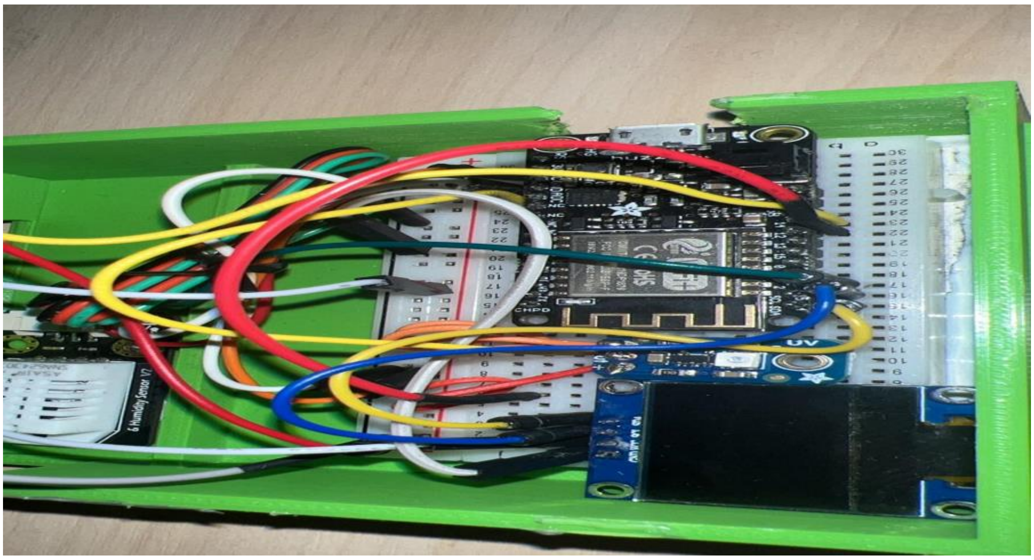

Figure 9. Overall system setup

5.2.8 Arduino coding for cloud interaction

The Arduino code is also a key aspect of the system design as it facilitates the collection of data from the ESP8266 microcontroller to the blynk app and web interface. To ensure effective interaction with the ESP8266 microcontroller, the code was uploaded on the microprocessor using the Arduino IDE. The code then makes it possible to use Wi-Fi technology and also transmission of data from the microcontroller to the blynk app.

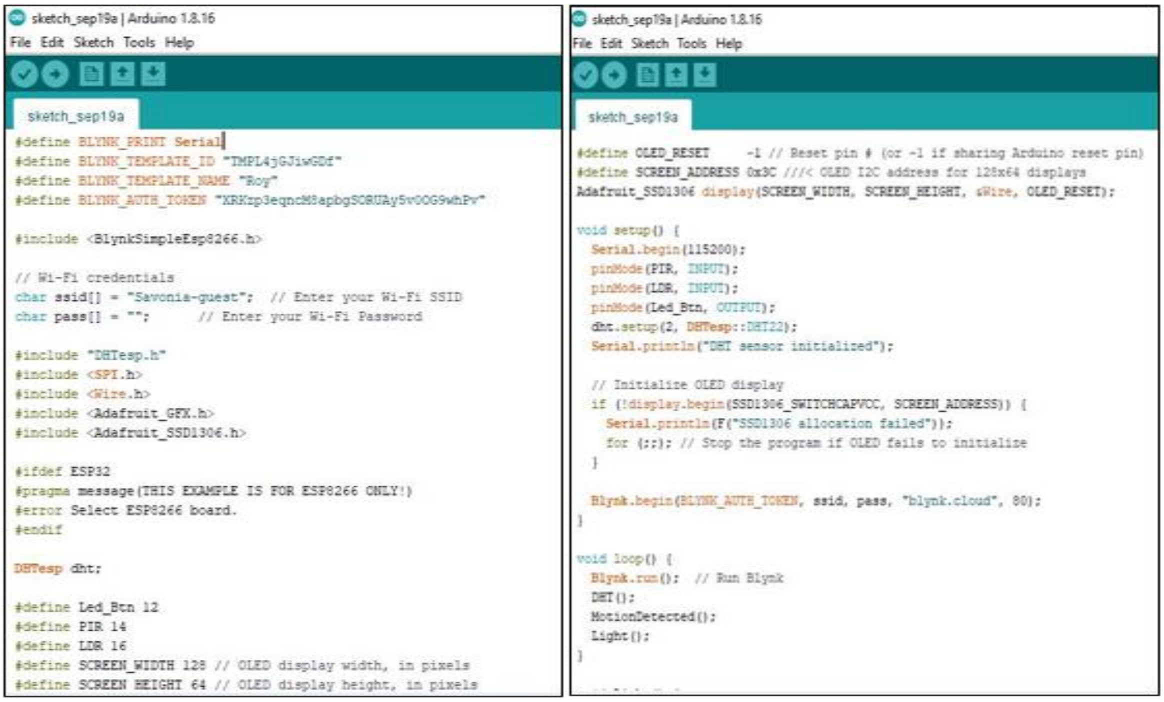

Figure 10. Arduino program.

The initial approach was defining and initializing libraries which are needed for Wi-Fi and sensor communication. Each of the sensor and components were assigned a GPIO pin on the ESP8266 based on the connections on the breadboard. For instance, the DHT22 library handles temperature and humidity readings, while the I2C protocol regulates connection with the OLED display.

The code also contains instructions on how to connect the ESP8266 to a preset Wi-Fi network. Once linked, the software assures that users may access weather updates via the Blynk mobile app or online platform by transmitting data packets from the sensors to the Blynk cloud in real time. To guarantee uninterrupted data flow in the case of a separation, the software contains error-handling algorithms that reattach the microcontroller to the network.

Additionally, the code transfers the sensor data to the cloud while locally processing it on the ESP8266 and showing the findings on the OLED panel in real time. Its dual function allows users to monitor both local and distant weather conditions. An interactive dashboard where users may monitor data, create alarms, and connect with the IoT weather system is made possible by the usage of the Blynk library.

5.3 Integration of the system with Blynk app and developed website layout.

The system integration entails altering the layout to support the Blynk app and a customized web interface. The ESP8266 microcontroller gathered weather data from the linked sensors and uploaded it to the Blynk app, which would provide real-time readings and allowed remote monitoring and control. Simultaneously, the web interface, collected data from the Blynk REST API to give an interactive and detailed display of temperature, humidity, UV intensity and motion. The flow diagram is provided in the figure 11 below.

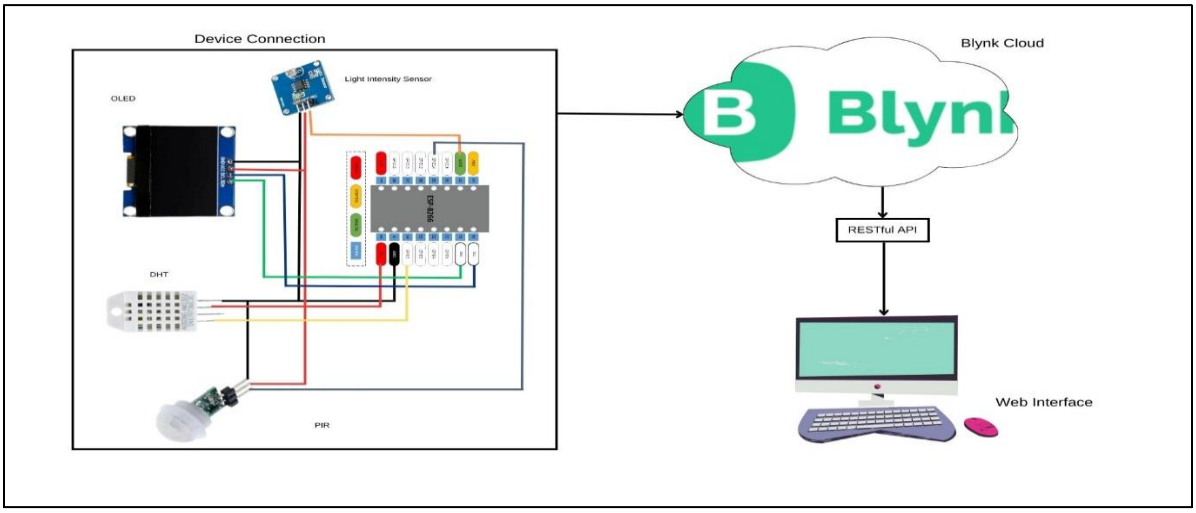

Figure 11. Updated layout with the Blynk App and web interface.

The Blynk app's design is seen in figure 12 below. The ESP8266 microcontroller uses Wi-Fi to provide real-time sensor data to the app, including motion, temperature, humidity, and UV light. The app's built-in widgets, such buttons, gauges, and displays, allow users to remotely monitor environmental conditions. Additionally, users may manage specific actions, like turning sensors on or off, and get alerts when certain conditions—like motion detection—are met.

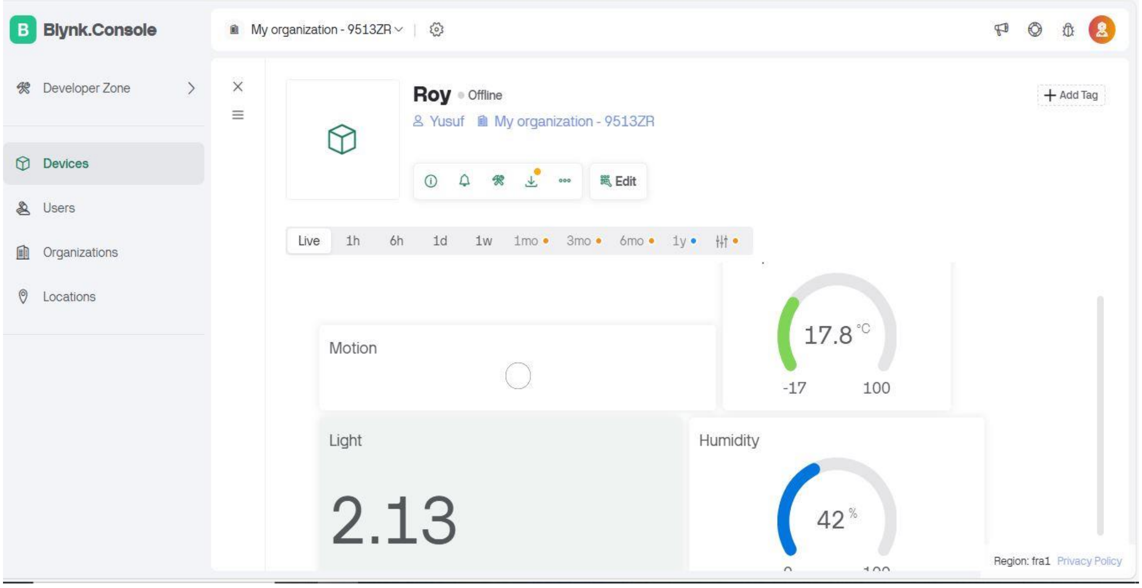

Figure 12. Blynk app interface displaying sensor readings.

5.4 Website Design

In this section, the website design process and description is provided here. The system was designed using HTML, CSS (cascading style sheets), bootstrap, JavaScript react and MySQL. This combination facilitates efficient navigation and interaction among the users.

5.4.1 Use case diagram of the website

The use case graphic demonstrates the interactions between users and different system functionalities inside the IoT-integrated weather forum. Two users (actors) are seen engaging with the system, executing operations such as Registration, Log In, Log Out, and Viewing Articles. These activities enable users to engage with the platform, control content, and interact with the weather data. Key use cases include publishing and finding new articles, watching weather updates, and amending or removing content. The Weather Update is crucial, as users may get real-time weather information acquired by sensors. On the system's backend, the Microprocessor and Sensors handle weather data, while Cloud/Localhost Storage ensures data is preserved and available for users.

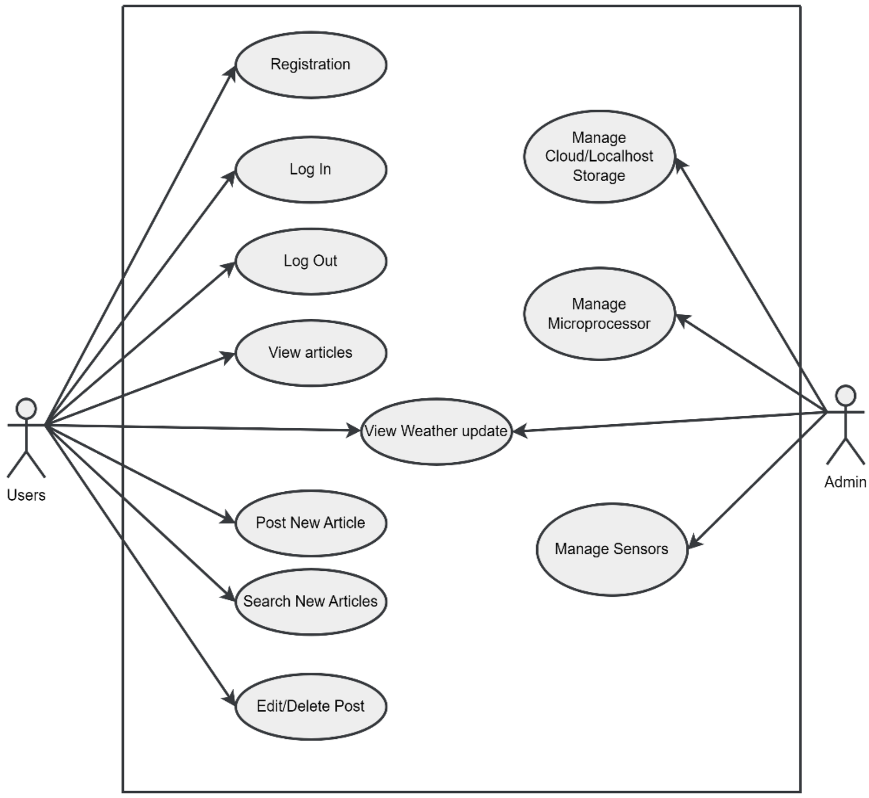

Figure 13. Use case diagram of the website designed.

5.5 Web Application design

The website for the IoT weather monitoring system was created to let the users of the site have real-time interaction and view weather data of the local place they are. The site as seen in figure 14, was developed using React and real-time sensor data and weather information from received via the Blynk App Rest API. The interface receives data from the Blynk API and presents the measurements for temperature, humidity, motion, and light intensity.

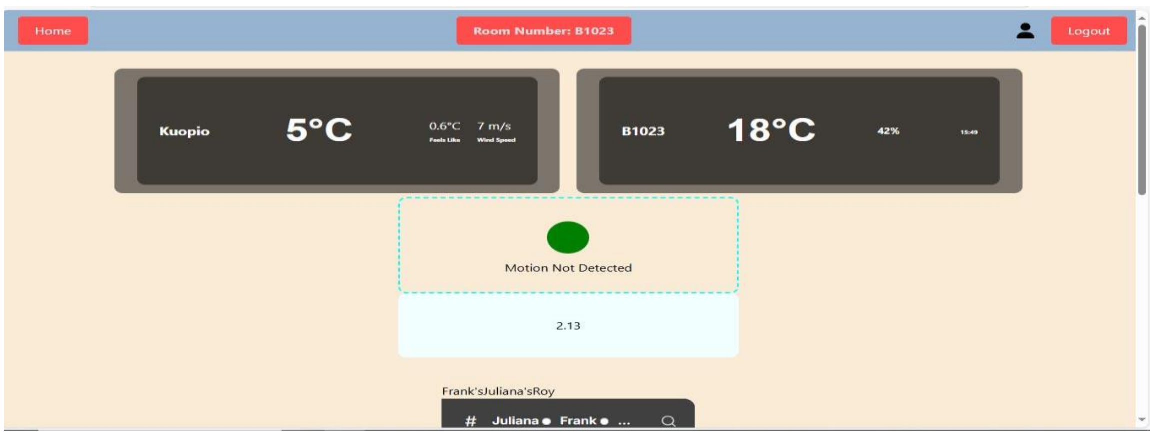

Figure 14. Interface of the designed website showing the weather data.

For this design, the code snippet in figure 15 below have been used in developing the system.

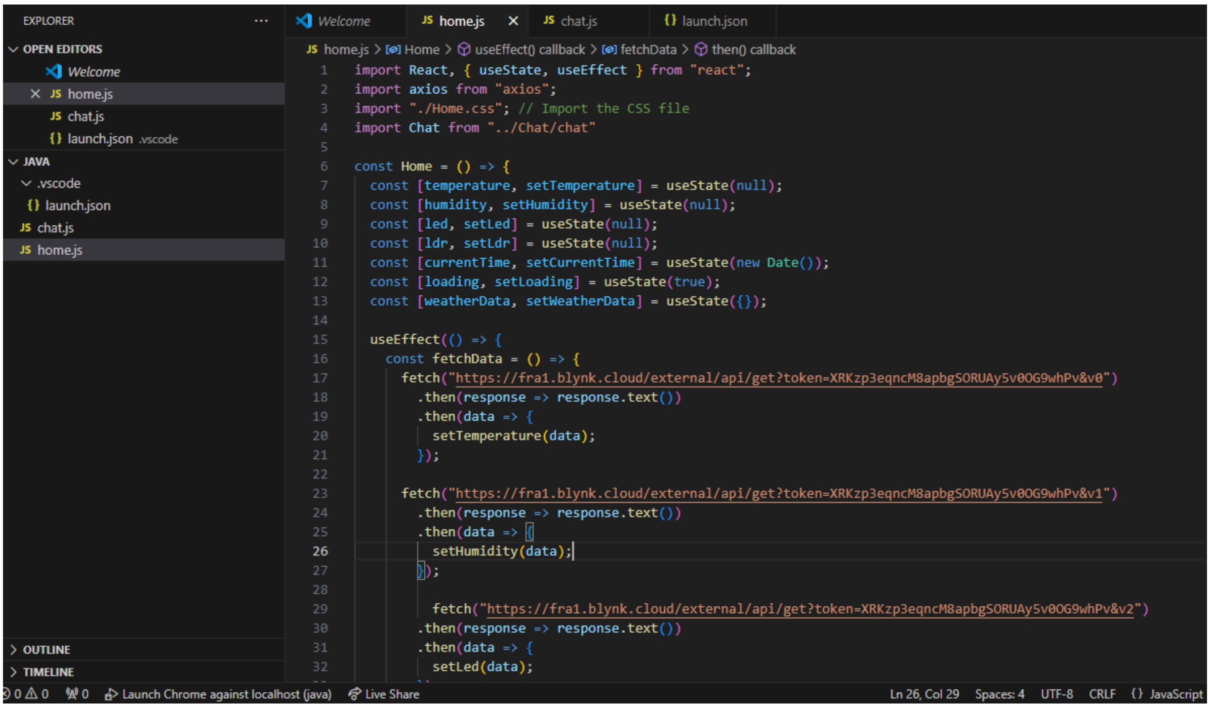

Figure 15. Javascript and React code to design the website.

A chat function was also included, allowing users to communicate in real time. The chat features provide a communal platform for talking about private matters and anything related to the environment. In figure 16, the interface is shown. Furthermore, figure 17 contains the code snippet used to construct the chat function.

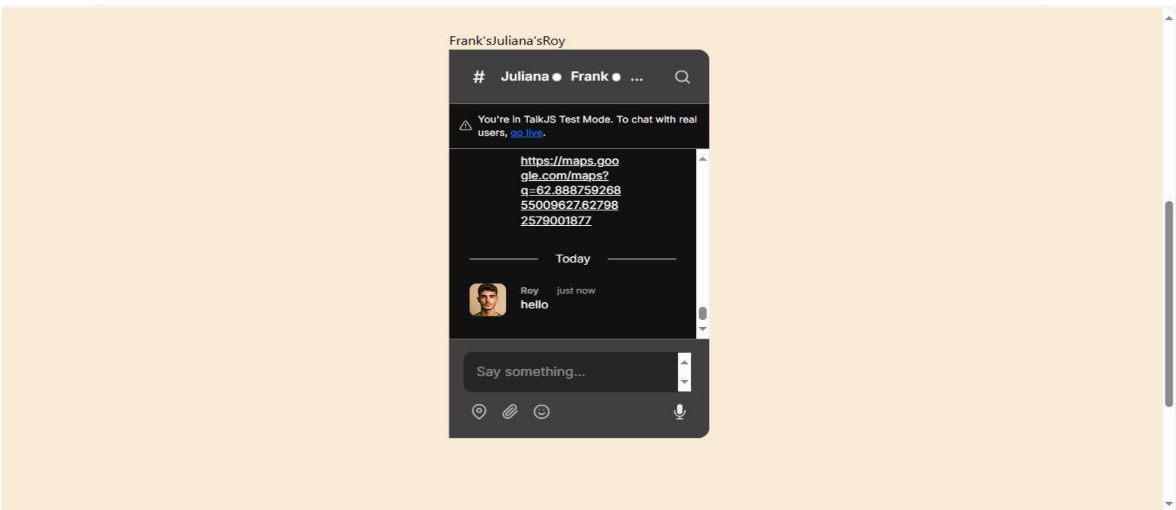

Figure 15. Chat box design.

This is the JavaScript code used in creating the chat box.

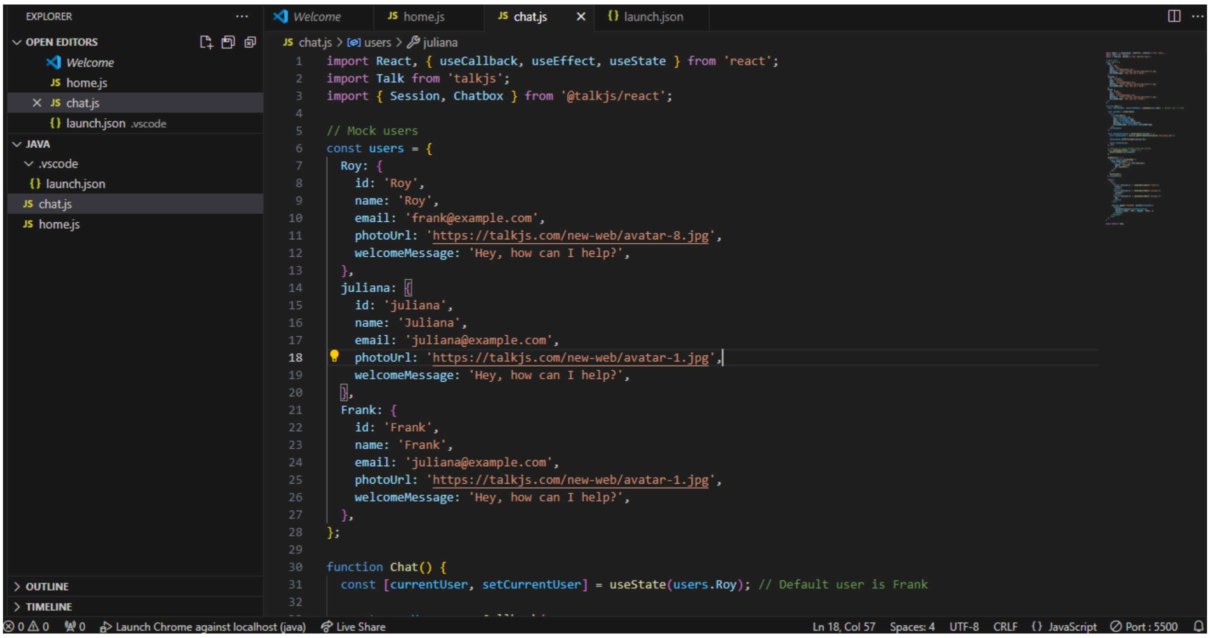

Figure 16. Chat box

In summary, the data visualization process starts with the temperature and humidity readings from the DHT22, motion detection from the PIR sensor, and UV light sensor—all of which were employed in the system's design. As shown in figure 10, these sensors were connected to the ESP8266 microcontroller, which uses Arduino code to read the data. After the Blynk app was configured, a token was created and included into the Arduino code. Additionally, the website used the REST API of the Blynk app to visualise the data. The program then showed the temperature, humidity, motion status, and light intensity in an interactive manner.

6 TESTING OF THE SYSTEM

Testing is an important step in checking that the system runs properly and performs effectively under various scenarios. The testing procedure was done using two basic testing types like the functionality testing and performance testing. Each approach of the testing assesses a distinct component of the system which helps in evaluating the reliability and overall performance of the system.

6.1 Functionality Testing

Functionality testing is a testing approach which assist in guaranteeing that the system executes its intended functions as it was initially planned (Afreen and Bajwa 2021). This test method involves validating that all sensors successfully relate the measured data, which it efficiently relay to both the Blynk app and the web interface and ensure that users can easily engage with the system via both platforms. A test case that gets a pass indicates that the system operates as intended in all potential cases with no faults or malfunctions during normal usage.

Table 1. Functionality testing 1.

Test Case ID	**Description**	**Expected Outcome**	**Result (Pass/Fail)**	**Comments**
F1	Check the sensor readings for temperature readings	Temperature value should be red correctly and displayed.	Pass	Readings from DHT22 are accurate
F2	Check sensor readings for humidity readings	Humidity value should be red correctly and displayed.	Pass	Humidity sensor is functioning properly
F3	Check UV light intensity readings	UV data is red and displayed accurately	Pass	Data from UV sensor is transmitted correctly
F4	Check motion detection functionality	Motion status should be displayed in Blynk app and website	Pass	PIR sensor detects movement correctly
F5	Test data transmission to Blynk app	Data is sent from ESP8266	Pass	No data loss or delay

		to Blynk app in real-time		
F6	Test remote control functionality (turn sensors on/off)	Sensors can be turned on/off via Blynk app	Pass	Remote control through app works
F7	Test data update frequency	Data updates every 5 seconds on both platforms	Pass	Data is updated when the system is refreshed.

Table 2. Functionality Testing 2.

Test Case ID	Description	Test Method	Expected Outcome	Time of Day	External Weather Apps	Developed System Readings	Result
W1	Check the accuracy of the temperature readings	Compare system temperature data with data from AccuWeather and Weather.com	System temperature should be within ±2°C of external apps' readings	Morning (09:00 AM)	AccuWeather: 15°C, Weather.com: 14.8°C	System: 15.1°C	Pass
W2	Test humidity data accuracy	Compare system humidity data with data from AccuWeather and Weather.com	System humidity should be within ±5% of external apps' readings	Morning (09:00 AM)	AccuWeather: 60%, Weather.com: 59%	System: 61%	Pass
W3	Test UV light intensity accuracy	Compare UV index data from system with AccuWeather and Weather.com	System UV intensity should match or be within ±1 of the	Morning (09:00 AM)	AccuWeather: 3, Weather.com: 3	System: 2.8	Pass

			external apps' readings				
W4	Test temperature data accuracy	Compare system temperature data with data from AccuWeather and Weather.com	System temperature should be within ±2°C of external apps' readings	Afternoon (03:00 PM)	AccuWeather: 22°C, Weather.com: 21.9°C	System: 22.1°C	Pass
W5	Test humidity data accuracy	Compare system humidity data with data from AccuWeather and Weather.com	System humidity should be within ±5% of external apps' readings	Afternoon (03:00 PM)	AccuWeather: 50%, Weather.com: 52%	System: 48%	Pass
W6	Test UV light intensity accuracy	Compare UV index data from system with AccuWeather and Weather.com	System UV intensity should match or be within ±1 of the external apps' readings	Afternoon (03:00 PM)	AccuWeather: 6, Weather.com: 5.9	System: 5.8	Pass

6.2 Performance testing

The performance testing is a test method which examines how effectively the system manages varied levels of load and response times. The testing entails checking the reaction times for data updates and user interactions ensuring that the system can work smoothly and effectively without any delay or breakdown.

Table 3. Performance testing

Test Case ID	Description	Expected Outcome	Performance Criteria	Result (Pass/Fail)	Comments
P1	Test data transfer rate to Blynk app	Data is sent with minimal delay	Response time < 2 seconds	Pass	Measure time taken for data to appear on app
P2	Test website response time	Web interface loads without significant delay	Page load time < 3 seconds	Pass	Ensures fast loading of web interface
P3	Test simultaneous sensor data updates	Multiple sensors update data at the same time	No lag or data loss	Pass	Test for simultaneous data handling
P4	Test Wi-Fi connection stability	No loss of data during Wi-Fi signal fluctuations	Data sent without interruptions	Pass	Test with varying Wi-Fi signal strength

To summarize, the performance and functionality tests assures the accuracy of the system, its dependability and efficiency. The results of the tests show that the system is effective and fit for monitoring weather metrics for which it is designed for. Additionally, the testing confirmed essential functions of the developed system as well as its robustness capability under different environmental conditions.

From the functional standpoint, the device precisely provided accurate readings pertaining to environmental metrics such as temperature, humidity, UV light intensity and motion. This testing approach closely mirrors what was done in the work of Kulkarni and Mukhopadhyay (2018). Firstly, the capacity and reliability of the system is also shown through the flawless transfer of this data to the Blynk app and web interface as intended and providing accurate weather data.

Additionally, the performance testing also verified the reliability of the system as it showed low latency in data updates and user interactions, emphasizing its capacity to perform efficiently. The cross-verification with existing weather platforms such as AccuWeather and Weather.com also significantly confirms its accuracy and dependability.

7 EVALUATION OF WORKDONE

In this chapter, the summary of work done will be provided, along with presentation of conclusion and key findings from the thesis. Additionally, relevant recommendations of future work in that can further provide more exploration on the topic will be provided followed by description of lessons learned and overview of ethical considerations was considered for the study.

7.1 Summary of work done

To summarise this project is focussed on creating and developing IoT-based weather monitoring system that incorporates microcontroller and essential sensors to provide an optimal functioning and dependable system. The system design started with the mounting of the ESP8266 microprocessor on the breadboard which then was followed by the fixing of sensors such as the DHT22 for temperature and humidity, UV light sensor for measuring light sensitivity and PIR motion sensor for detecting motion. This configuration ensured that the system could accurately transmit and monitor environmental data. The link of the Blynk app with the built website also enables real-time data display and user involvement. The dual-platform interface, achieved via the use of a web-based dashboard and the Blynk app, was an essential part of the system's development. The Blynk app provided a seamless user experience by providing sensor data in real time and allows remote operation of sensors. Additionally, its REST API made data retrieval possible for the website interface, which was created using a combination of HTML, CSS, MySQL, and React. The website design was purposefully created to be easy allowing users to engage with meteorological data dynamically. Additionally, the integration of a chat feature also ensured that the focus of the research on community forum is achieved.

Throughout testing, the system demonstrated strong technical dependability. Functionality testing revealed that the sensors operated within expected bounds and produced values that were in good agreement with those from well-known weather systems such as AccuWeather and Weather.com. The testing approach was vital in verifying the accuracy of temperature, humidity, UV intensity, and motion detection data. These results emphasise the resilience of the system’s architecture, but they also raise issues about its scalability beyond the constrained testing conditions. While the system performed effectively with five or more concurrent users, the prospect of sustaining similar performance under much larger user loads remains a problem for more exploration.

7.2 Conclusion

The development of the IoT based weather monitoring system is a significant technology in enhancing the accessibility of environmental data and also to ensure its real-time monitoring. The system have been successfully design and integrated with necessary components. Moreover, there are key findings from the study, which are presented below:

- System functionality: The system provided a reliable and accurate data collection from the sensors which was confirmed by functionality testing. The readings from the system were also showed to stay within acceptable limits when compared with existing weather services like AccuWeather and Weather.com.
- Real-Time interaction: The Blynk app and the online interface provided seamless monitoring and management of the system. Users may interact with the system to access weather information particularly those within the area of design, and get warnings for certain conditions.
- Performance Robustness: Performance testing showed the potential of the system to handle simultaneous data updates from various sensors and retain functioning with several concurrent users of the web interface.
- Data accuracy and consistency: The system was compared with external weather services and the readings when compared with the created system exhibited slight discrepancies which all were within acceptable levels. This validates the efficacy of the sensors utilized in the system.
- Scalability: The architecture and design of the system enabled scalability, allowing for more sensors or features to be incorporated without affecting the performance or reliability of the present arrangement.

Overall, the system accomplished its major objectives by producing a fully working IoT-based weather monitoring system. The way that the components were combined to create a seamless and easy to do solution showed how IoT technology can support environmental awareness and decision-making in real time. Additionally, the insights obtained throughout the project offer a solid platform for future enhancement ensuring the system stays relevant and flexible to changing demands.

7.3 Future Work and Recommendations

The built IoT-based environmental monitoring system has proved its usefulness in real-time environmental data collecting and accessibility. However, there is scope for future research and refinement to expand its capabilities, scalability, and effect. Below are the important topics for further development and recommendations:

- Integration of the web-interface with Advanced Analytical Tools: Modern data analytics and machine learning algorithms can be incorporated into the system which might allow the system to provide predictive insights such as weather forecasting or anomaly identification. This might increase its usability for applications in agriculture, urban planning or environmental management.

- Incorporation of Additional Sensors: In the future, the system might add additional sensors for detecting air quality, noise pollution or soil moisture levels. This will increase the scope of the system to monitor additional environmental metrics which makes it relevant in varied use cases like smart agriculture or urban settings.
- Mobile application development: Even though, the present system in linked with Blynk app, building a dedicated mobile application with special features suited to individual user demands will boost user experience and system flexibility.
- Improved Web Interface: The web interface might be more designed to include more capabilities such as customized dashboards, data visualization and analysis tools as well as personalized settings.
- Cloud Storage and Data Archiving: Additionally, further study might integrate efficient cloud storage system which would allow for long-term data reservation for historical trend research. This could further be used in academic and environmental policy and in comprehending long-term environmental changes.
- Geolocation and Multi-Node Support: Adding geolocation functionality and allowing multi-node deployment would enable the system to monitor data from different places, establishing a full environmental monitoring network. This might assist large-scale applications such as city-wide environmental monitoring.

This recommendations would solve present limit of the system while exploring new prospects for the utilization of the system. Following this recommendation would enable the system to emerge into a diverse, scalable and effective solution for solving environmental concerns in real-time.

7.4 Lessons Learned

In the process of developing this IoT-based weather monitoring system, invaluable lessons were acquired in both technical and personal level underscoring the importance of interdisciplinary knowledge, blending hardware and software skills and applying critical thinking to solve real-life problems.

One of the most crucial skills I gained was the basis of coding for web development as I was able to work with tools like React, HTML, CSS, and JavaScript as well as obtaining hands-on experience in building functional and visually attractive interfaces. In addition, I learnt how to develop an Internet of Things system and integrate it with other applications, such Blynk, which was used in the project. I managed to comprehend the process of connecting sensors and microcontrollers to the breadboard and making sure they communicate with one another. Learning to combine these components additionally provided me the skills to be able to handle difficulties that came from the development.

When my original effort to design the system failed, I learnt resilience and problem-solving. For instance, troubleshooting why a sensor wasn't functioning, whether due to wiring, compatibility or code faults helped me to address unfamiliar issues effectively. Through these experiences, I improved my ability to recognize problems and take appropriate action.

Additionally, I was able to obtain some project management abilities which were another crucial area of personal improvement. I was able to strike a balance between my deliverables, time, and resources, which called for an organized strategy. I also gained research skills which played a significant role as I regularly depended on earlier research and publications, online courses and documentations from multiple platforms to fill the knowledge gaps. Additionally, I developed the ability to carefully apply instructions from my supervisor, documentation, and feedback in real-world development circumstances. Furthermore, the development process also heavily relied on feedback and collaboration with my supervisor. Engaging with my supervisor showed me the significance of taking constructive criticism and adjusting to new ways. Also, learning to operate autonomously without continual supervision fostered confidence and enhanced my decision-making abilities.

Overall, this experience fostered personal growth in areas like persistence, flexibility, and independent learning while offering a strong foundation in website development, IoT systems, and project execution. I have no doubt that these lessons will influence how I tackle future tasks and difficulties.

7.5 Ethical considerations

Even though third parties were not directly involved in the creation of this IoT-based weather monitoring system, ethical concerns were closely upheld at every stage to guarantee the project's accountability and integrity.

The first ethical standard adhered to was guaranteeing accuracy and transparency in the data given by the system. The sensor readings and data displayed on the Blynk app and web interface were confirmed against trusted sources to ensure accuracy. This dedication to reliability guarantees that consumers may make educated choices based on the facts. Transparency was also preserved by detailing the procedures, methods, and approaches employed in the system's creation.

Secondly, data privacy and security was ensured across the system development. Although, the system mainly displays real-time environmental data, all connection between the microcontroller and cloud-based platforms such as the Blynk app was protected to prevent unauthorized access or modification of the data. This approach demonstrate commitment to preserving ethical standards in processing data even when sensitive user information is not involved.

Thirdly, the system also help in improving awareness of environment concept as it meant to monitor weather conditions, hence, encouraging responsible conduct, and supporting sustainable development methods.

Lastly, inclusiveness was also ensured as the system could be utilized by a broad variety of people. The interface design for both the Blynk app and the online application was simple and accessible which ensures that even those without technical experience could successfully engage with the system.

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