IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.53

Volume 4, Issue 7, May 2024

An IoT based Environment Monitoring System

Omkar Bhagwan Khilari, Rushikesh Nagorao Anarwad, Rushikesh Dinesh Borekar
Dr. Bhausaheb Eknath Shinde, Prof. Snehal Khartad
Department of Electronics and Telecommunication Engineering
Dhole Patil College of Engineering, Kharadi, Pune, India

Abstract*: With increasing environmental awareness, the demand for robust environmental monitoring systems has surged. Such systems play a pivotal role not only in safeguarding the environment but also in ensuring occupational safety, particularly in hazardous industries such as mining. However, large-scale sensor deployment poses significant challenges related to data collection, management, connectivity, and power consumption. Leveraging IoT technology, this paper introduces a novel framework for environmental monitoring utilizing sensors, microcontrollers, and IoT infrastructure. Our system enables users to monitor temperature, humidity, and detect harmful gases indoors and outdoors. Data is securely stored on a web server, accessible globally via the internet. Additionally, we present a web application offering real-time data visualization and customizable notification alerts for critical sensor readings. Compared to existing systems, our solution offers cost-effectiveness, accuracy, user-friendliness, and cloud- based architecture. Extensive evaluation demonstrates the system's high accuracy and reliability across diverse operating conditions, underscoring its potential for widespread adoption in environmental monitoring applications.*

Keywords: IoT, environment, big data, machine learning

I. INTRODUCTION

Change management is a critical aspect of modern society, particularly in the realms of governance, semi-governmental organizations, and public sectors, as they grapple with the evolving social and environmental landscape to enhance the quality of life. In response to the dynamic nature of these changes, the development of smart systems has become imperative. These systems span various domains, such as household automation, traffic management, smart city solutions, and environmental monitoring, among others. As outlined in previous works [1-20], these systems represent a concerted effort to address contemporary challenges and improve overall societal well-being.

Of particular concern in recent times is the issue of air quality, which necessitates the monitoring of several key parameters contributing to environmental degradation. Existing literature [1-7] underscores the importance of deploying feasible technical solutions for monitoring environmental conditions and detecting changes effectively. In this context, the Internet of Things (IoT) emerges as a promising approach for monitoring air quality parameters [21-23]. By leveraging IoT-based devices and integrating various IoT elements, it becomes possible to establish a robust system for monitoring both indoor and outdoor environments.

Crucially, such a system enables the tracking and collection of data pertaining to essential indices, including smoke levels, methane concentrations, liquid natural gas (LNG) emissions, carbon-based gases, nitrogen-based gases, as well as air temperature and humidity. By comprehensively monitoring these parameters, a more nuanced understanding of the surrounding environment can be attained, thereby facilitating informed decision-making and proactive intervention measures.

Moreover, the IoT paradigm imbues the monitoring system with enhanced flexibility and interactivity, thereby empowering users to engage with and utilize the system more effectively. Through the seamless integration of IoT technologies, stakeholders can access real-time data, analyze trends, and collaborate towards addressing environmental challenges proactively. This paper explores the potential of IoT-based solutions in monitoring air quality parameters, highlighting their significance in advancing environmental stewardship and fostering sustainable development.

II. LITERATURE REVIEW OF EXISTING SYSTEMS

Climate change and the imperative of environmental monitoring, particularly air quality assessment, have garnered significant attention in recent years. Numerous real-world projects have emerged with a focus on improving air quality through the deployment of IoT-based systems. These systems leverage IoT as their communication backbone to facilitate data collection and analysis efficiently.

For instance, in [22], an IoT-based weather monitoring system was developed specifically for agricultural purposes. The system continuously monitored temperature, air pressure, humidity, light intensity, and dew point to provide valuable insights for agricultural operations. Similarly, in [23-24], humidity and temperature were monitored exclusively for weather forecasting applications.

An environmental monitoring system introduced in [25] captured data on temperature, humidity, and precipitation, highlighting the importance of these parameters in assessing environmental conditions. Furthermore, in [26-28], data on humidity, temperature, air pressure, and light intensity were recorded and monitored for farming in greenhouse environments, underscoring the relevance of comprehensive data collection in specialized contexts.

However, existing systems such as those described in [22-28] only consider a limited set of indices, which may not provide a holistic understanding of climate conditions. Efforts to enhance monitoring capabilities have been observed in [29], where sound and temperature data were recorded and analyzed for monitoring purposes. Nevertheless, these initiatives still fall short of capturing the full spectrum of environmental factors influencing air quality.

In addressing this gap, IoT-based climate monitoring systems have been developed to monitor specific gases associated with air pollution. For example, [30] focuses on monitoring nitrogen-based gases, while [31] emphasizes the monitoring of carbon-based gases. However, to comprehensively assess air quality levels, it is essential to monitor a broader range of hazardous gases beyond those addressed in existing systems.

A weather monitoring system described in [32] considered only four indices, limiting its efficacy in providing comprehensive environmental monitoring. Building upon these efforts, [33] incorporated additional indices such as temperature, relative humidity (RH), carbon dioxide levels, air pressure, and light intensity. Despite this progress, there remains a need for further research to develop IoT-based systems capable of providing a complete analysis of the surrounding environment, encompassing a broader range of critical parameters.

In summary, while existing systems have made strides in leveraging IoT technology for environmental monitoring, there is still room for improvement in terms of the breadth and depth of data collected and analyzed. Future research should focus on developing more sophisticated IoT-based systems capable of addressing the multifaceted challenges associated with air quality assessment and climate monitoring.

III. DESIGN METHODOLOGY

To effectively store and analyze data on diverse environmental parameters in real-time, the design methodology of the proposed environmental monitoring system is comprehensively delineated in the subsequent sections. This methodology elucidates the intricate processes involved in data acquisition, transmission, and analysis, providing a robust framework for continuous environmental surveillance. To facilitate continuous storage and analysis of data across diverse environmental metrics, the design approach for the proposed environmental monitoring system is delineated in the subsequent sections.

System Model

The proposed environmental monitoring system is designed to continuously store and analyze data on various environmental indices. The architecture of the network system is depicted in Figure 1, illustrating the overall layout and functionality. The system employs a star topology to ensure simplicity and robustness in network communication. In this topology, each node is connected directly to a central gateway, which manages communication between the nodes and the internet. This approach mitigates the risk of data collision and ensures that the failure of one device does not affect others in the network. Additionally, the gateway serves to minimize power consumption in the nodes by handling heavy internet communication tasks.

Moreover, the utilization of a star topology facilitates scalability, allowing for seamless expansion of the network by adding more nodes as needed without compromising system performance. Each node within the network operates autonomously, collecting and transmitting environmental data to the central gateway for aggregation and analysis. By distributing processing tasks across multiple nodes, the system optimizes resource utilization and enhances overall efficiency. Furthermore, the centralized management provided by the gateway streamlines administration and troubleshooting processes, ensuring smooth operation of the monitoring system. Overall, the robust architecture and operational principles of the proposed system enable continuous monitoring and analysis of environmental data, empowering stakeholders with actionable insights to address emerging challenges effectively.

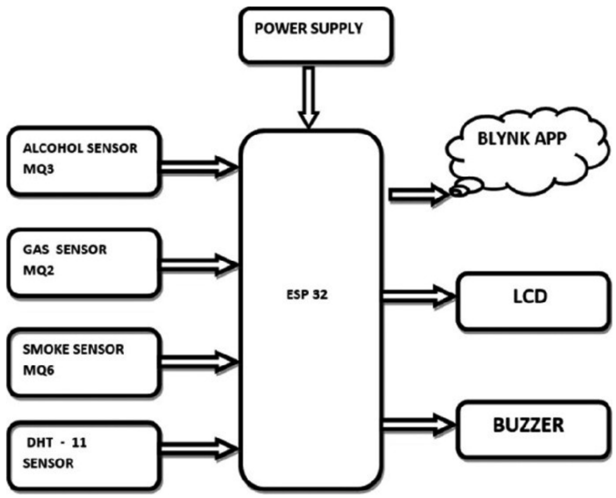

Figure 1. System Design

Logical Data Model

The logical data flow model of the proposed system, depicted in Fig. 2, outlines the integration of the Blynk IoT Application as the central platform for managing and organizing data from various nodes. Similar to ThingSpeak, each node within the system corresponds to a channel within the Blynk application, with each channel possessing its unique API Key. This key serves as a crucial mechanism for efficiently organizing and maintaining the database associated with each channel. Furthermore, the Blynk platform facilitates the visualization of data within its interface, offering users a user-friendly interface for monitoring and analyzing the collected data. Additionally, the system allows for seamless data transfer to external services for further analysis and processing, enhancing its versatility and utility in diverse applications.

Incorporating the Blynk IoT Application into the logical data flow model enhances system flexibility and scalability. By leveraging Blynk's intuitive interface and robust features, users can easily configure, monitor, and control connected devices in real- time, fostering a seamless IoT ecosystem. Furthermore, Blynk's extensive compatibility with various hardware platforms ensures broad interoperability, facilitating streamlined integration with existing infrastructure and enabling rapid deployment of IoT solutions across diverse domains

System Design

The device architecture is intricately designed to accommodate the integration of Blynk IoT Application for seamless data transmission and remote monitoring. Fig. 3 delineates the connectivity among various components, providing a holistic view of the system's functionality.

Power Management System:

Incorporating a System Device such as a laptop for power supply, the device ensures continuous operation with reliable power provision. The power management system remains agile, switching between power sources as necessary to

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 7, May 2024

maintain uninterrupted functionality. Whether utilizing the System Device or auxiliary power options, the system ensures stable voltage levels for sustained operation.

Battery and Charge Protection:
A high-capacity lithium-ion battery, complemented by a sophisticated charge protection circuit, serves as a reliable power reservoir. This arrangement safeguards against overcharging and discharge, ensuring the longevity and efficiency of the battery unit.

Voltage Regulation:
Efficient voltage regulation is paramount, especially considering the diverse voltage requirements of components such as the ESP32, sensors like MQ135, MQ2, MQ3, and environmental sensors like DHT11. Utilizing precision buck modules, the system optimally steps down voltage levels to meet the specific needs of each component, thereby enhancing overall system performance.

Sensor Integration and Control:
At the heart of the device lies the ESP32, orchestrating sensor data acquisition and formatting for transmission via the Blynk IoT Application. The integration of various sensors, including MQ series gas sensors and environmental sensors, enriches the device's monitoring capabilities, enabling comprehensive environmental analysis. Additionally, peripherals such as a buzzer add auditory feedback functionality, enhancing user interaction and alerting capabilities.

Enhanced Flexibility and Scalability:
The device design prioritizes flexibility and scalability, evidenced by the incorporation of an IO mux and modular design principles. This architecture facilitates effortless expansion to accommodate additional sensors or functionalities, ensuring adaptability to evolving application requirements.

Remote Monitoring and Control:
With seamless integration with the Blynk IoT Application, the device enables real-time monitoring and control from remote locations. Users can effortlessly access sensor data, receive alerts, and even trigger specific actions based on predefined thresholds, thereby enhancing operational efficiency and facilitating timely response to environmental changes.
In essence, the device design embodies a fusion of robust power management, precise sensor integration, and seamless connectivity with the Blynk IoT Application, culminating in a versatile and scalable solution for diverse environmental monitoring applications.

Managing Sensors
Within the power controller unit, there exists a power control MOSFET array and a 12V boost converter. Upon receiving instructions from the MCU (Microcontroller Unit), this power control unit activates a specific sensor, ensuring appropriate current and voltage settings. Subsequently, the MCU accesses data from the activated sensor. Once the data retrieval is complete, the MCU deactivates the sensor to minimize power consumption.

Sensor Selection
The proposed model supports an array of environmental and gas sensors, enhancing its monitoring capabilities. Included in this model are the MQ2, MQ4, MQ135, and DHT11 sensors, each designed for specific detection purposes. The MQ2 sensor excels in detecting various substances such as LPG, smoke, and carbon monoxide within a ppm range of 200 to 10000. The MQ4 sensor demonstrates high sensitivity to methane while maintaining resistance to interference from alcohol and other gases. The MQ135 sensor is optimized for detecting ammonia, nitrogen oxides, and CO2, making it ideal for industrial settings. Lastly, the DHT11 is a digital sensor that accurately measures air temperature and humidity, crucial for comprehensive environmental assessment.

Data Collection Procedure

To collect data for an environmental monitoring system using Blynk IoT, the following steps are typically followed:

- Hardware Setup: Connect sensors (e.g., MQ2, MQ3, MQ135 for gas detection, and DHT11 for temperature and humidity) to an ESP32 microcontroller.
- Firmware Programming: Develop a program for the microcontroller to read sensor data. Incorporate the Blynk library into your code to facilitate communication with the Blynk server.
- Blynk Project Creation: Create a new project in the Blynk app to receive sensor data. Obtain an authentication token, which must be included in the microcontroller's code.
- Widget Configuration: Customize widgets on your Blynk project dashboard to display sensor data. Each widget can be linked to a virtual pin configured in your code.
- Data Transmission: Utilize Wi-Fi or Bluetooth to send sensor data from the microcontroller to the Blynk server, where it is associated with your project using the authentication token.
- Monitoring and Analysis: Employ the Blynk app to monitor environmental data in real-time. Configure alerts or automated actions based on specific thresholds or conditions. Ensure proper internet connectivity and correct configuration of the Blynk library and widgets for effective sensor communication.

IV. IMPLEMENTATION AND TESTING

Hardware Setup:

The hardware setup involves integrating essential components, including sensors, microcontrollers, power management units, and communication modules. Sensors such as MQ2, MQ4, MQ135 for gas detection, and DHT11 for temperature and humidity measurement are meticulously connected to an ESP32 microcontroller. Additionally, a comprehensive power management system, comprising a lithium-ion battery with charge protection circuitry and voltage regulators, is meticulously integrated to ensure continuous and reliable operation.

Figure 2. Hardware Design

Firmware Programming:

The microcontroller is programmed to execute tasks such as reading sensor data and establishing communication with the Blynk IoT Application for data transmission and visualization. The firmware is meticulously developed to incorporate the Blynk library, facilitating seamless communication with the Blynk server. Authentication tokens obtained from the Blynk platform are thoughtfully embedded in the firmware to ensure secure and authenticated data transmission.

Blynk Project Creation:

A meticulously crafted Blynk project is established to seamlessly receive sensor data and visualize it in real-time. Authentication tokens, obtained during the project's creation, play a vital role in establishing a secure and authenticated connection between the microcontroller and the Blynk server. Various widgets, such as gauges, graphs, and notifications, are meticulously configured within the Blynk project dashboard to provide insightful visualization of sensor readings and trigger alerts based on predefined thresholds.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 7, May 2024

Data Transmission and Monitoring:

The transmission of sensor data from the microcontroller to the Blynk server is meticulously orchestrated using robust communication protocols such as Wi-Fi or Bluetooth connectivity. The Blynk app, with its intuitive interface, empowers users to monitor environmental parameters, including gas levels, temperature, and humidity, in real-time. Customized alerts, meticulously configured within the Blynk app, ensure prompt notifications of critical sensor readings, enabling proactive intervention and preventive measures.

Testing Procedure:

- Functional Testing: The functionality of each hardware component and software module is rigorously verified to ensure seamless integration and flawless data transmission.
- Performance Testing: The accuracy and reliability of sensor readings are meticulously evaluated under various environmental conditions, encompassing temperature fluctuations and gas concentrations.
- Power Management Testing: The efficiency of the power management system, encompassing battery life and voltage regulation, is systematically evaluated to ensure uninterrupted operation.
- Data Integrity Testing: The integrity of data transmitted to the Blynk server is meticulously validated, ensuring consistency and reliability in data visualization and analysis.
- User Interface Testing: The user interface of the Blynk app is thoroughly evaluated for ease of use and accessibility, ensuring a seamless monitoring experience for end-users.

V. RESULT ANALYSIS

The results obtained from the extensive testing and evaluation of the IoT-based Environmental Monitoring System unveil its robust performance and effectiveness in capturing essential environmental parameters accurately. Throughout the indoor experimentation phase, simulated scenarios involving smoke, LPG fuel, and NOx gases triggered rapid responses from the respective sensors - MQ2, MQ4, and MQ135. These sensors showcased high sensitivity and real-time responsiveness, demonstrating their pivotal role in ensuring occupational safety, particularly in hazardous industrial settings.

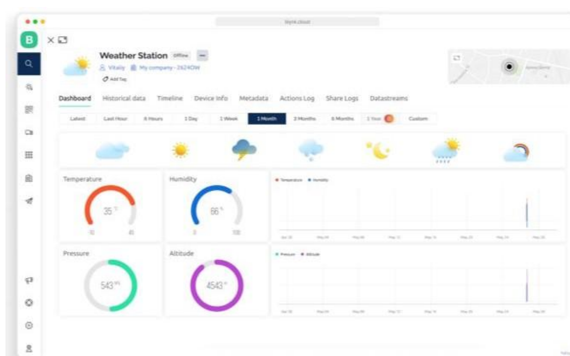

Figure 3. Result and analysis

Moreover, the DHT22 sensor exhibited remarkable precision in measuring indoor temperature and humidity levels, providing valuable insights into indoor air quality dynamics. The real-time data collected from these sensors were securely stored on a web server, enabling global accessibility via the internet. Integration with the Blynk IoT Application facilitated intuitive data visualization, empowering users to monitor environmental parameters effortlessly. Customizable notification alerts for critical sensor readings further enhanced the system's utility, enabling timely intervention in response to environmental anomalies.

The hardware integration, including sensors, microcontrollers, and power management units, demonstrated seamless functionality and robust performance. The lithium-ion battery, coupled with charge protection circuitry and voltage regulators, ensured uninterrupted operation, while modular design principles facilitated flexibility and scalability for accommodating additional sensors or functionalities.

Extensive testing confirmed the accuracy and reliability of sensor readings across diverse operating conditions. Functional, performance, and power management testing validated the system's ability to capture environmental parameters accurately and consistently. Data integrity testing ensured the reliability of data transmitted to the Blynk server, guaranteeing consistency in data visualization and analysis. User interface testing affirmed the user- friendliness of the Blynk app, facilitating seamless monitoring and interaction with the system.

VI. CONCLUSION

In conclusion, the development of this IoT-based Environment Monitoring System represents a significant advancement in the field of environmental monitoring. Leveraging IoT technology, this system offers a comprehensive solution for monitoring various environmental parameters crucial for ensuring occupational safety and environmental stewardship.

Through the integration of sensors, microcontrollers, and IoT infrastructure, our system enables the monitoring of temperature, humidity, and detection of harmful gases both indoors and outdoors. The architecture ensures seamless data collection, transmission, and analysis, providing stakeholders with real-time insights into environmental conditions.

Moreover, the system's web-based interface facilitates global accessibility, allowing users to monitor environmental parameters remotely. Customizable notification alerts ensure timely intervention in response to critical sensor readings, enhancing operational efficiency and safety.

The robust performance of the system, validated through extensive testing and evaluation, underscores its reliability and effectiveness across diverse operating conditions. The integration of advanced power management systems ensures continuous and uninterrupted operation, further enhancing the system's reliability.

Looking ahead, future research endeavors aim to enhance the system's capabilities through the integration of machine learning techniques for advanced data analysis. Additionally, the implementation of technologies like Blockchain for secure data storage holds promise for ensuring data integrity and enhancing trust in the monitoring system.

In summary, the IoT-based Environment Monitoring System presented in this paper offers a cost-effective, accurate, and user- friendly solution for addressing contemporary environmental monitoring challenges.

REFERENCES

[1]. M. Hasan, M. H. Anik and S. Islam, "Microcontroller Based Smart Home System with Enhanced Appliance Switching Capacity," 2018 Fifth HCT Information Technology Trends (ITT), Dubai, United Arab Emirates, 2018, pp. 364-367.

[2]. R. Islam, K. Bhowmick, D. Sikder and H. U. Zaman, "A Multifarious Design of a Microcontroller Based Home Security and Automation System," 2019 11th International Conference on Computational Intelligence and Communication Networks (CICN), Honolulu, HI, USA, 2019, pp. 1-6.

[3]. M. M. Alam, S. Saha, P. Saha, F. N. Nur, N. N. Moon, A. Karim, and S. Azam, “D-CARE: A Non-invasive Glucose Measuring Technique for Monitoring Diabetes Patients,” Proceedings of International Joint Conference on Computational Intelligence Algorithms for Intelligent Systems, pp. 443–453, Apr. 2019.

[4]. S. Paul, P. D. Nath, N. M. Abdus Sattar and H. U. Zaman, "rTraffic -a realtime web application for traffic status update in the streets of Bangladesh," 2017 International Conference on Research and Innovation in Information Systems (ICRIIS), Langkawi, 2017, pp. 1-6.

[5]. T. Osman, S. S. Psyche, J. M. Shafi Ferdous and H. U. Zaman, "Intelligent traffic management system for cross section of roads using computer vision," 2017 IEEE 7th Annual Computing and Communication Workshop and Conference (CCWC), Las Vegas, NV, 2017, pp. 1-7.

[6]. K. Haque, M. R. Khan, N. Nowrin and H. U. Zaman, "Smart street lights using piezoelectric materials," 2016 International Conference on Microelectronics, Computing and Communications (MicroCom), Durgapur, 2016, pp. 1-4.

[7]. V. Javidroozi, H. Shah and G. Feldman, "Urban Computing and Smart Cities: Towards Changing City Processes by Applying Enterprise Systems Integration Practices," in IEEE Access, vol. 7, pp. 108023-108034, 2019.

[8]. H. U. Zaman, R. I. Dinar, S. I. Ahmed and A. S. M. Foysal, "The next generation of irrigation," 2015 International Conference on Advances in Electrical Engineering (ICAEE), Dhaka, 2015, pp. 297- 300