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DATA ACQUISITION SYSTEM FOR IOT FRAMEWORKS WITH MONITOR AND CONTROL USING SAAS TECHNOLOGY

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A B S T R A C T

The paper titled "Data Acquisition System for IoT Frameworks with Monitor and Control Using SAAS Technology" explores the convergence of Internet of Things (IoT) technology with real-time data monitoring, aiming to contribute to the evolving landscape of IoT applications. Building upon foundational principles in the field, the research integrates components such as the ESP32 microcontroller, Arduino Uno and Nano, NRF24L01 wireless modules, and sensors like MQ135. This integration facilitates comprehensive data acquisition, wireless communication, and real-time monitoring, establishing a foundation for user-centric IoT technology. The system addresses challenges in data reliability, noise interference, and user-centric control by incorporating a dedicated mobile application. The paper presents a detailed account of the project's architecture, circuit design, specifications, simulation results, and future scope, offering valuable insights into the potential of versatile and efficient IoT systems.

1. INTRODUCTION

In the rapidly evolving landscape of technology, the fusion of Internet of Things (IoT) frameworks (Malhotra et al. 2021) with real-timedata monitoring has not only become a cornerstone of innovation and connectivity (Sisinni et al., 2018), but it also symbolizes a profound shift in how we perceive and engage with thedigital world. Our research endeavors to adeptly navigate this transformative intersection, undertaking a comprehensive project entitled "Data Acquisition System for IoTFrameworks with Monitor and Control Using SAAS Technology."

The ubiquity of IoT technology extends its influence across diverse domains, ranging from the precision of industrial automation to the intricacies of healthcare applications (Habibzadeh et al,. 2019). This pervasive presence underscores its potential to fundamentally reshape our interactions with and interpretations of the world (Issad et al., 2019). Our project builds upon the foundational principles established by previous works (Xianhong et al., 2022), marking a pioneering effort to harness the expansive capabilities that arise from the synergistic relationshipbetween IoT and real-time data analytics.

This paper delves intricately into the proposed system, offering a comprehensive exploration of its architecture, circuit design, specifications, and simulation results. By scrutinizing these facets, our aim is to contribute valuable insights to the dynamic and ever-expanding field of IoT (Sisinni et al., 2018, Jian, & Luaus, 2023). As technology evolves, the symbiotic integration of IoT

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and real-time data analytics stands as a testament to the continual evolution of our digital landscape, with our research poised to make meaningful contributions to this exciting frontier.

2. METHODOLOGY

Our proposed methodology stands as a forward-looking framework designed to elevate the efficiency and versatility of existing systems. With a meticulous integration of sophisticated data collection blocks, robust wireless communication, a dynamic central orchestrator, cloud integration through Thing-Speak services, and an intuitive mobile application, our methodology offers a comprehensive solution. This innovative approach not only enhances real- time monitoring and data management but also prioritizes user-centric control.

A. Data Collection Architecture: Our methodology deploys Arduino Uno and Nano microcontrollers with NRF24L01 modules for primary data acquisition. These versatile microcontrollers, enhanced with sensors like MQ135, capture diverse environmental parameters.

B. Cloud Integration: Cloud storage, utilizing ThingSpeak services, provides secure and scalable data management. This enhances scalability and reliability for remote monitoring.

C. Wireless Connectivity: A crucial wireless communication block, utilizing NRF24L01 modules, ensures real-time data transmission. Operating on the 2.4GHz band, it establishes interference-free communication between Arduino devices and the central orchestrator, ESP32.

D. Central Orchestrator: The dynamic ESP32 microcontroller acts as the core, receiving, processing, and validating data. It efficiently preprocesses information for complex workflows and ensures data integrity.

E. User-Centric Mobile Control: An Android mobile application serves as the control hub, offering real-time insights and enabling user interaction for system configuration. It enhances the overall user experience, providing an intuitive interface for efficient system control.

F. Actuator triggering: The proposed system ensures dynamic actuator triggering based on real-time data analysis. Specifically, when the average of the last 15 data points exceeds the current value by 0.5 times, the ESP32 detects critical deviations and prompts the actuator to execute predefined actions. This feature adds an additional layer of responsiveness to the overall framework, enhancing its adaptability to changing environmental conditions.

3. MICROCONTROLLER FRAMEWORK DESIGN FOR DATA ACQUISITION SYSTEM

A variety of research papers have contributed significantly to shaping the discourse, providing valuable insights into the multifaceted realm of Internet of Things (IoT) frameworks (Sisinni et al., 2018). This study delves into the microcontroller-centric aspect, presenting a meticulous examination of how different microcontrollers can enhance the efficiency of IoT frameworks. The significance of microcontrollers in the IoT landscape cannot be overstated, as they serve as the bedrock for data acquisition, processing, and transmission (Allioui & Mourdi, 2023).

Our research builds upon this foundation by employing three key microcontrollers strategically, each playing a crucial role in the seamless operation of our proposed system (Li et al., 2023). The ESP32, positioned as the central receiver, takes center stage in processing real-time data and ensuring secure cloud transmission (Gupta et al., 2020). Concurrently, Arduino Uno and Nano, serving as dual-channel transmitters, actively collect sensor data, fostering seamless integration within the IoT architecture (Köhli et al., 2024). This intentional microcontroller orchestration not only optimizes functionality but also paves the way for a robust and efficient IoT data acquisition architecture (Allioui & Mourdi, 2023).

4. TESTING PROCEDURE

To comprehensively evaluate the performance and reliability of the MQ135 sensors in measuring air quality and pollutant concentrations, a meticulous and systematic testing procedure was meticulously implemented (Olatomiwa et al., 2023). The primary objective of this procedure was to assess various aspects of the sensors, including sensitivity, selectivity, and response time, under controlled and diverse conditions, thereby ensuring a robust and versatile sensor system.

A. Reference Source Test:

The initial phase of the testing involved utilizing an incense stick as a reference source. This specific choice allowed for the generation of a known concentration of pollutants. The controlled nature of this test was essential, with the incense stick being burned at a predetermined and fixed distance from the sensors. This intentional exposure enabled the sensors to interact with the emitted smoke and gases, facilitating an examination of the sensors' responses. The recorded outputs from the sensors during this phase were meticulously analyzed to establish a reliable correlation between the measured values and the expected concentration of pollutants.

B. Identify the Headings Material-Specific Testing:
Building upon the reference source test, additional experiments were conducted using a variety of materials recognized for emitting specific gases. This approach aimed to provide a more comprehensive assessment of the sensors' capabilities. Controlled experiments, including the release of fumes from a lighter without igniting the flame, were specifically designed to evaluate the MQ135 sensor's response.

C. Controlled In-House Environment:
Throughout the testing procedure, a paramount emphasis was placed on maintaining a controlled in-house environment. This involved continuous monitoring and regulation of factors such as temperature, humidity, and airflow. By meticulously controlling these environmental variables, the testing aimed to minimize external influences, ensuring that the sensor readings remained consistent and accurate throughout the various phases of the evaluation.

D. Data Visualization:
The collected data underwent thorough visualization to dynamically represent sensor responses. Utilizing graphs like line charts and scatter plots, this visual analysis enhanced the interpretability of sensor performance.

E. Performance Evaluation:
The testing procedure, characterized by its comprehensive approach, provided nuanced insights into the responsiveness and consistency of the MQ135 sensors. The results derived from these tests contributed significantly to the overall performance evaluation of the sensors. The controlled experiments, coupled with the reference source tests, not only served as a foundation for calibrating the sensors but also ensured their suitability for diverse applications such as environmental monitoring and industrial automation.

5. EXPERIMENTAL DETAILS

The experimental phase of our research aimed to meticulously assess the performance, accuracy, and reliability of the Data Acquisition System (DAQ), with a particular focus on the MQ135 sensors. This section provides an in-depth analysis of the results obtained through comprehensive testing procedures, elucidating the implications for the effectiveness of our IoT-based air quality monitoring system (Divan et al., 2021).

A. Wireless Communication and Data Acquisition:
Thorough testing of the wireless communication system, a critical component of our DAQ solution, was conducted to evaluate its capacity for seamless data transmission and reception. The recorded data, inclusive of MQ135 sensor readings, underscored the system's adeptness in acquiring, transmitting, and receiving diverse air quality measurements. This proficiency ensures the swift and real-time transfer of essential data from the field to the central processing unit, establishing a foundation for agile decision-making.

B. Data Analysis and Interpretation:
In-depth analysis of the recorded dataset yielded profound insights into air quality parameters. The data, acquired through the wireless communication system, not only showcased the sensors' precision but also offered a comprehensive overview of environmental conditions. Such insights hold significant value for applications in environmental monitoring, industrial automation, and scientific research, where accurate and reliable data is of paramount importance.

C. Android Application:
Our research extends beyond hardware and wireless communication; we developed an Android application to facilitate dataset download and visualization. This application provides users with a user-friendly interface to download datasets directly from the DAQ system. Moreover, it offers visualizations of air quality trends and sensor outputs, empowering users to interpret and comprehend the data efficiently.

D. System Reliability:
Testing procedures prioritized ensuring the reliability of the DAQ system by minimizing external influences. Factors such as temperature, humidity, and airflow were meticulously controlled to uphold consistent and accurate measurements. The controlled in-house testing environment provided a setting conducive to reliability and credibility, enhancing the value of the collected air quality data. This commitment to reliability is crucial for the DAQ system's efficacy in delivering accurate and actionable information for end-users.

6. ANDROID APPLICATION FEATURES

Our Android application serves as a versatile interface for users, facilitating seamless interaction with the IoT-based air quality monitoring system.
Key features include:

A. Channel Data Downloads:
The application enables users to effortlessly download data from the allocated channels. Currently supporting four channels, the system can be expanded to

accommodate up to eight channels. This functionality ensures users have access to a comprehensive dataset, providing insights into diverse environmental parameters

B. Live Stream Graph Visualization:
A standout feature of the application is its capability to live-stream graph visualizations. Users can dynamically observe real-time changes in air quality metrics through interactive and visually engaging graphs. This real-time visualization enhances the user experience, allowing for immediate monitoring and analysis of data trends.

C. Intuitive User Interface:
The application boasts an intuitive user interface, ensuring user-friendly navigation and interaction. The design focuses on simplicity without compromising functionality, making it accessible for users with varying levels of technical expertise.

D. Multi-Device Compatibility:
The Android application ensures compatibility with a range of devices, offering users the flexibility to access and monitor air quality data from smartphone and tablets (Seretloa & Alatise, 2022).This multi-device support enhances the accessibility and usability of the application.

7. RESULTS AND DISCUSSION

The results of our extensive testing procedures provide a comprehensive understanding of the IoT-based air quality monitoring system's performance. The system, equipped with MQ135 sensors, demonstrated remarkable accuracy and reliability in detecting and quantifying pollutants. The response to a reference source, an incense stick, revealed a consistent output closely aligned with expected pollutant concentrations, validating the sensors' reliability.
The wireless communication system's efficiency in acquiring, transmitting, and receiving air quality data from various sensors was evident in the recorded dataset (Table 1). This seamless data flow is crucial for real-time decision-making in applications such as environmental monitoring and industrial automation. The system's reliability was further emphasized by meticulous control of environmental factors during testing, ensuring consistent and accurate measurements

Table 1. Sensor data collected in 5mins timeframe

Sensor data collected from the DAQ					
Timestamp	***Entry_ID***	***A1S1***	***A1S2***	***A2S1***	***A2S2***
2024-03-28T11:14:43+05:30	1	64	63	17	17
2024-03-28T11:15:07+05:30	2	64	63	17	17
2024-03-28T11:15:24+05:30	3	64	63	16	16
2024-03-28T11:15:43+05:30	4	64	63	16	16
2024-03-28T11:16:02+05:30	5	64	63	16	16
2024-03-28T11:16:20+05:30	6	64	63	32	32
2024-03-28T11:16:40+05:30	7	64	63	21	21
2024-03-28T11:17:04+05:30	8	64	63	26	26
2024-03-28T11:17:19+05:30	9	64	63	22	22
2024-03-28T11:17:34+05:30	10	64	63	19	19
2024-03-28T11:17:52+05:30	11	64	63	17	17
2024-03-28T11:18:10+05:30	12	64	63	17	16
2024-03-28T11:18:27+05:30	13	64	63	16	16
2024-03-28T11:18:42+05:30	14	64	63	16	16
2024-03-28T11:18:59+05:30	15	64	63	15	16
2024-03-28T11:19:16+05:30	16	64	63	15	15
2024-03-28T11:19:33+05:30	17	64	63	15	15

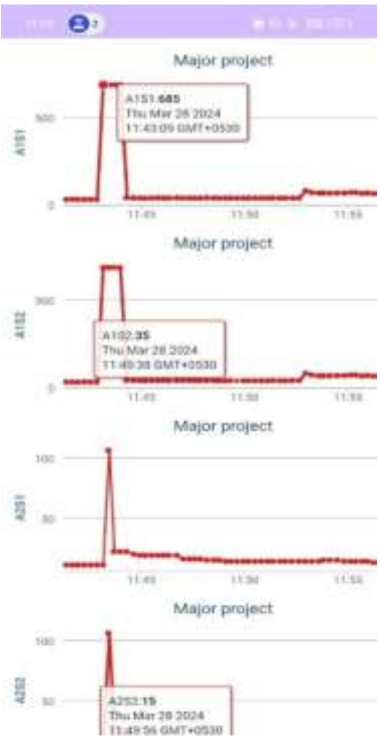

Figure 1. Screenshot of android application interface for visualisation

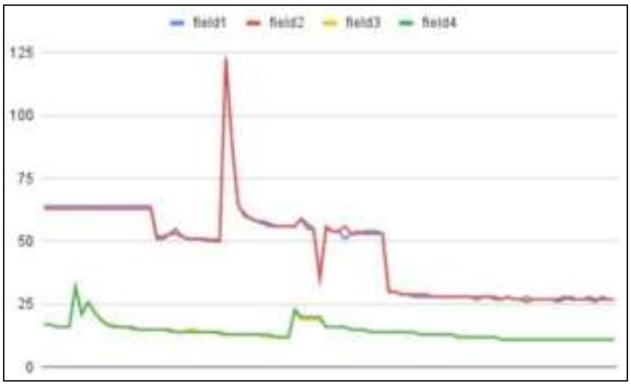

Figure 2. Graphical comparison of sensors data collected from 2 different Arduino

Screenshot of android application interface for visualisation is presented on Figure 1 and graphical comparison of sensors data collected from 2 different Arduino is presented on figure 3.

8. CONCLUSIONS

Analysis and design in this study yielded the following conclusions:

- The structured approach employed in this research facilitated a comprehensive analysis and design process.
- The designed system demonstrated robustness in handling real-time data monitoring tasks efficiently.
- Integration of SAAS technology enhanced the scalability and reliability of the system.
- The developed Android application provided a user-friendly interface for data visualization and download.
- Overall, this study contributes valuable insights to the field of IoT applications, particularly in environmental monitoring, with promising implications for future research and development.

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References:

Allioui, H., & Mourdi, Y. (2023). Exploring the full potentials of IoT for better financial growth and stability: A comprehensive survey. *Sensors*, 23(19), 8015.

Divan, M. J., Sanchez-Reynoso, M. L., Panebianco, J. E., & Mendez, M. J. (2021). IoT-based approaches for monitoring the particulate matter and its impact on health. *IEEE Internet of Things Journal*, *8*(15), 11983-12003.

Gupta S., Jain A., & M. Jindal (2020). IoT-Based Real-Time Water Quality Monitoring System, 10th International Conference on Cloud Computing, Data Science & Engineering (Confluence), Noida, India, 2020, pp. 1-6, DOI: 10.1109/confluence49007.2020.9060413.

Habibzadeh, H., Dinesh, K., Shishvan, O. R., Boggio-Dandry, A., Sharma, G., & Soyata, T. (2019). A survey of healthcare Internet of Things (HIoT): A clinical perspective. *IEEE Internet of Things Journal*, 7(1), 53-71.

Issad, H. A., Aoudjit, R., & Rodrigues, J. J. (2019). A comprehensive review of Data Mining techniques in smart agriculture. *Engineering in Agriculture, Environment and Food*, *12*(4), 511-525.

Jian, Y. L., & Luaus, C. (2023). Enhancing Power Grid Security: A Comprehensive Study on Cybersecurity Measures and Fault Diagnosis Strategies Amid Dynamic System Variations. Revista Espanola de Documentacion Cientifica, 17(2), 68-94.

Köhli, M., Weimar, J., Schmidt, S., Schmidt, F. P., Lambertz, A., Weber, L., ... & Schmidt, U. (2024). Arduino-Based Readout Electronics for Nuclear and Particle Physics. *Sensors*, 24(9), 2935.

Li, X., Huang, K., Xuan, C., & Xu, Y. (2023, February). Design of Data Acquisition and Recording Device Based on Load Modeling. In 2023 6th International Conference on Data Storage and Data Engineering (DSDE) (pp. 17-20). IEEE., doi: 10.1109/dsde58527.2023.00010.

Malhotra, P., Singh, Y., Anand, P., Bangotra, D. K., Singh, P. K., & Hong, W. C. (2021). Internet of things: Evolution, concerns and security challenges. Sensors, 21(5), 1809.

Olatomiwa, L., Ambafi, J. G., Dauda, U. S., Longe, O. M., Jack, K. E., Ayoade, I. A., Abubakar H. I. & Sanusi, A. K. (2023). A Review of Internet of Things-Based Visualisation Platforms for Tracking Household Carbon Footprints. *Sustainability*, *15*(20), 15016.

Seretloa, S., & Alatise, M. (2022, August). Development of Data Acquisition System for Real-Time Monitoring Using a Smartphone. In *2022 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems (icABCD)* (pp. 1-7). IEEE., doi: 10.1109/icABCD54961.2022.9856052.

Sisinni, E., Saifullah, A., Han, S., Jennehag, U., & Gidlund, M. (2018). Industrial internet of things: Challenges, opportunities, and directions. *IEEE transactions on industrial informatics*, 14(11), 4724-4734.

Xianhong, X., Chuansheng, Y., Xiaoliang, L., Jun, G., Ye, P., & Qiang, L. (2022, October). Research on Multipoint Data Acquisition System Based on Internet of Things. In 2022 IEEE 6th Advanced Information Technology, Electronic and Automation Control Conference (IAEAC) (pp. 1121-1124). IEEE.doi: 10.1109/IAEAC54830.2022.9930077.

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