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Implementation and Research Paper on IoT Based Water Quality Monitoring System with Real Time Dashboard

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Abstract: *Water quality monitoring is essential for ensuring safe drinking water, industrial usage, and environmental protection. Conventional laboratory-based monitoring techniques are time-consuming, costly, and unsuitable for continuous real-time observation. This research presents the design and implementation of an IoT-based Water Quality Monitoring System capable of measuring critical parameters such as pH, turbidity, total dissolved solids (TDS), and temperature. The proposed system uses an ESP32 microcontroller integrated with calibrated sensors and communicates data to a backend server and web-based dashboard for visualization and analysis. The system architecture supports reliable data acquisition, real-time monitoring, alert generation, and historical analysis. Experimental evaluation demonstrates high accuracy, low latency, and cost-effectiveness, making the system suitable for urban, rural, and industrial deployments. The proposed solution offers scalability, enhanced data accessibility, and timely detection of water contamination.*

Keywords: IoT, Water Quality Monitoring, ESP32, pH Sensor, Turbidity, TDS, Real-Time Dashboard.

I. INTRODUCTION

Access to clean and safe water is a critical global concern, with increasing pollution levels affecting natural and municipal water sources. Traditional water quality monitoring relies on manual sampling and laboratory testing, resulting in delayed detection of contamination. Recent advancements in Internet of Things (IoT) technologies enable real-time monitoring using embedded sensors and wireless communication. This research focuses on developing an automated IoT-based water quality monitoring system that continuously measures essential parameters and provides real-time visualization through a web dashboard. The proposed system aims to improve response time, reduce operational costs, and enhance monitoring reliability.

II. METHODOLOGY

The methodology involves integrating sensing hardware, embedded processing, data communication, storage, and visualization modules.

A. Sensor Integration

pH, turbidity, TDS, and temperature sensors are interfaced with the ESP32 microcontroller. Sensors are calibrated using standard solutions to ensure accuracy.

B. Embedded Processing

The ESP32 reads sensor values using ADC and digital interfaces, applies noise filtering, and converts raw signals into standard units.

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C. Data Communication

Sensor data is transmitted using HTTP/MQTT protocols over Wi-Fi to a backend server for storage and processing.

D. Data Storage and Visualization

Collected data is stored in a NoSQL database and displayed on a real-time web dashboard with graphical trends and alerts.

III. MODELING AND ANALYSIS

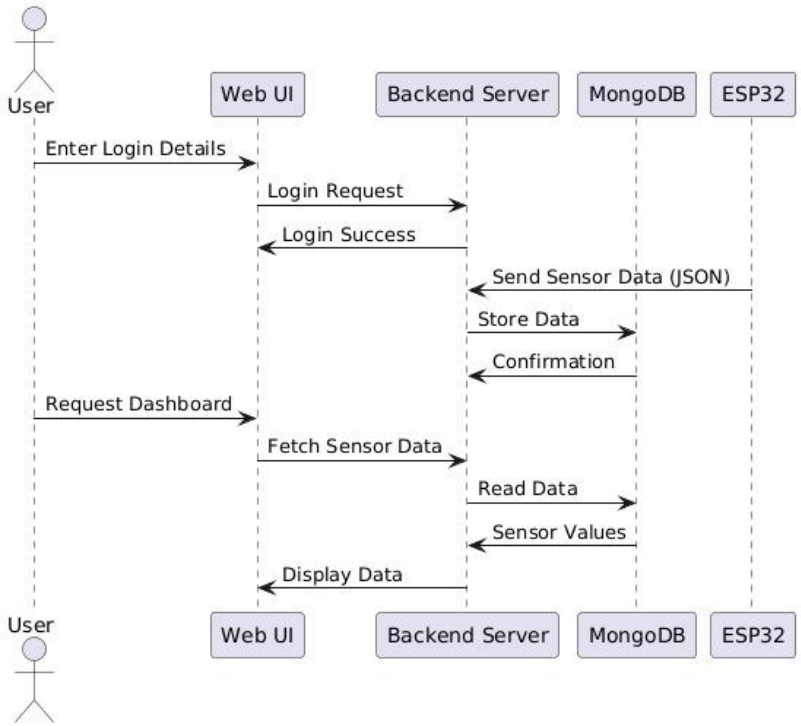
The modeling of the proposed IoT-based Water Quality Monitoring System is represented using standard UML diagrams to describe system behavior, interactions, and structure. These diagrams help in understanding the workflow, object relationships, and operational logic of the system.

A. Sequence Diagram – IoT Water Quality Monitoring System

The sequence diagram illustrates the interaction between sensors, ESP32, backend server, database, and web dashboard during real-time monitoring.

Sequence of Operations:

Sensors collect water quality parameters.
ESP32 reads and processes sensor data.
ESP32 sends data to Backend Server via HTTP/MQTT.
Backend stores data in MongoDB/Firebase.
Dashboard requests and displays real-time data.



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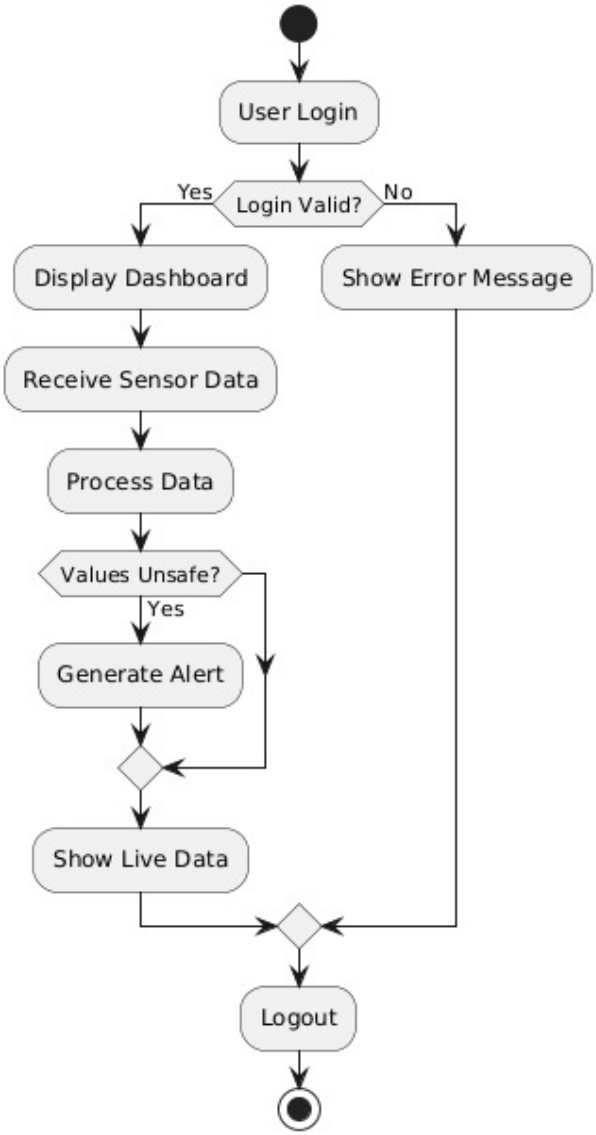
B. Activity Diagram – System Workflow

The activity diagram represents the overall workflow of the system from sensing to alert generation.



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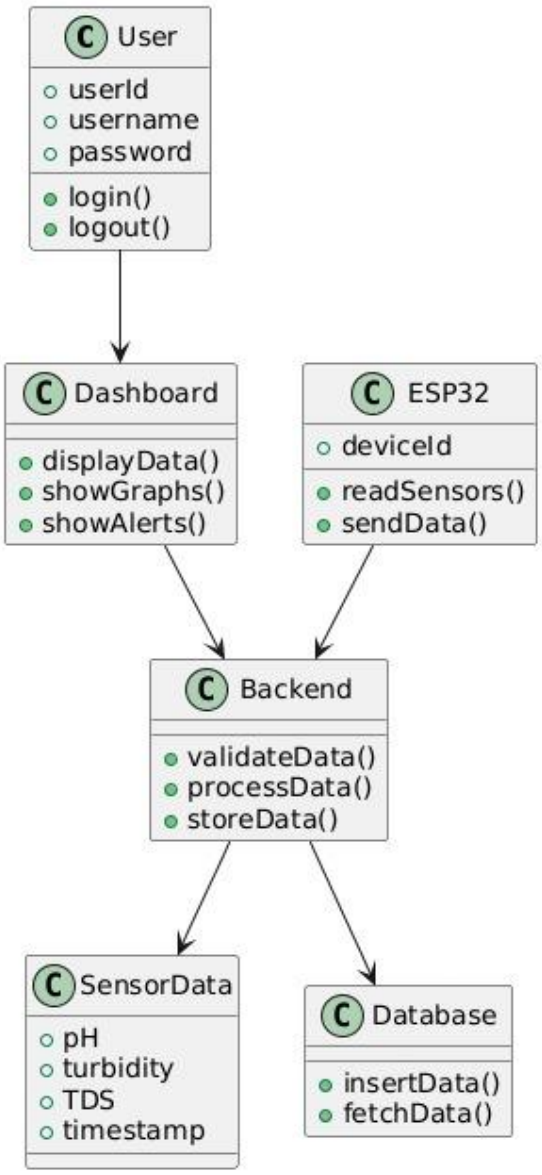
C. Class Diagram – System Structure

The class diagram defines the structural relationship between major system components.



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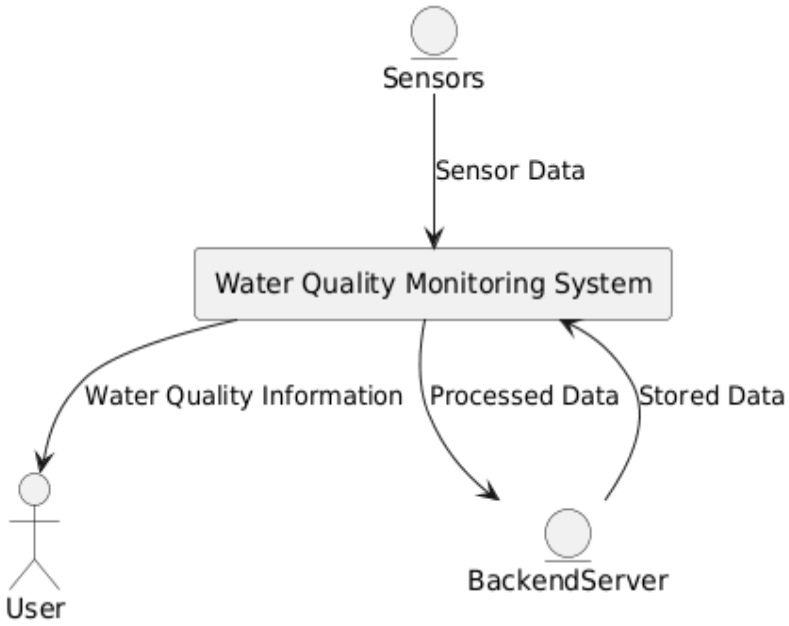
D. Data Flow Diagram (DFD)

Data Flow Diagrams represent how data moves through the system and how different processes interact.

DFD Level 0 – Context Diagram

The Level 0 DFD provides a high-level overview of the system showing external entities and overall data flow.



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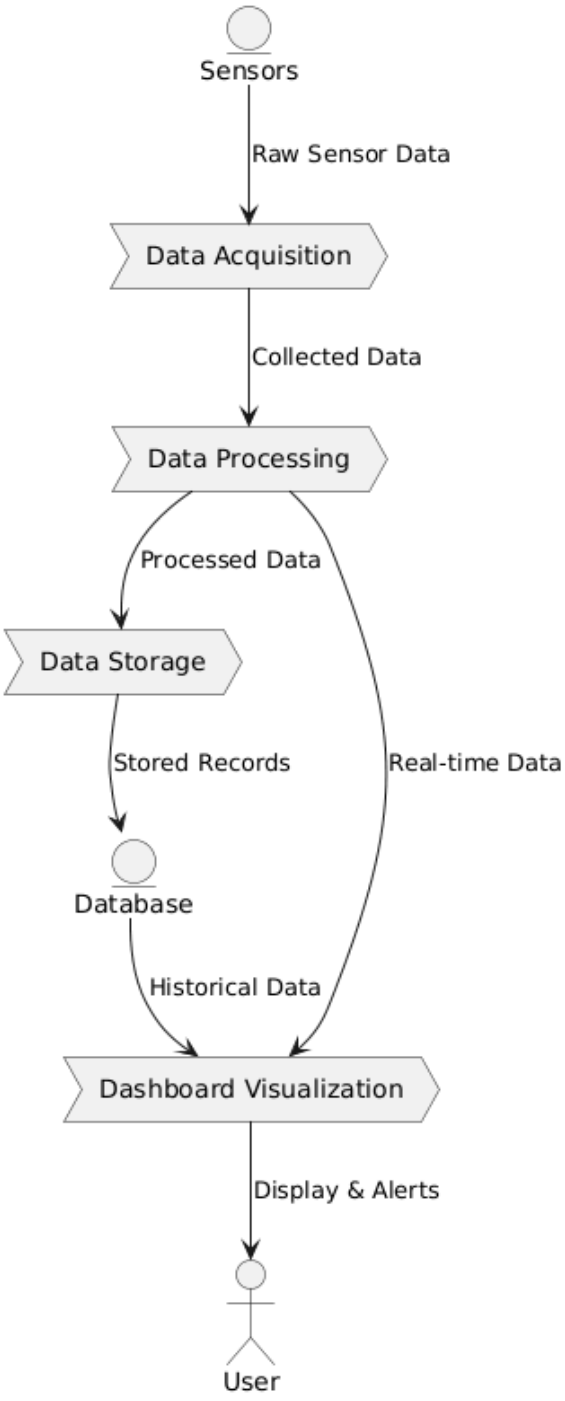
DFD Level 1 – Detailed Diagram

The Level 1 DFD breaks the system into detailed processes such as data acquisition, processing, storage, and visualization.



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IV. RESULTS AND DISCUSSION

Experimental deployment over multiple test scenarios demonstrates reliable data transmission and accurate sensing. The system achieved over 95% accuracy after calibration, with an average latency of approximately 1 second. Real-time alerts effectively notify users when parameters exceed safe limits. Comparative analysis shows improved response time and lower cost compared to traditional systems.

V. CONCLUSION

The proposed IoT-based water quality monitoring system successfully delivers real-time, accurate, and cost-effective monitoring of critical water parameters. Integration of embedded sensing, wireless communication, and web-based visualization provides a scalable and practical solution for continuous monitoring. The system is suitable for smart city applications, industrial monitoring, and rural water management.

ACKNOWLEDGEMENTS

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