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IOT-BASED WATER SUPPLY SYSTEM WITH CLOUD INTEGRATION

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ABSTRACT

The efficient and equitable distribution of water in rural areas has long been a challenge due to manual operations, irregular supply schedules, and lack of real-time monitoring. This paper presents an IoT-based smart water supply system integrated with cloud computing to automate and optimize rural water distribution. The proposed system uses sensors to monitor water level, flow rate, pH, and turbidity, while the ESP32 microcontroller serves as the control unit. The collected data is transmitted via MQTT protocol to AWS IoT Core for real-time storage, processing, and alert generation. A web-based dashboard allows authorities and users to view system performance, receive alerts, and manage operations remotely. The system enables automation of water pumps, efficient usage tracking, and ensures water quality, thereby providing a sustainable, cost-effective, and scalable solution for rural water management.

Keywords: IoT, Smart Water Management, Cloud Integration, AWS IoT Core, Water Quality Monitoring.

I. INTRODUCTION

Access to clean and reliable water is a fundamental necessity, yet rural areas often face challenges in managing water distribution efficiently. Traditional water supply systems in villages are largely manual, leading to issues such as overflows, leakages, and inequitable distribution. These systems lack real-time monitoring, making it difficult to identify system failures, manage resources effectively, or ensure water quality compliance. With the emergence of the Internet of Things (IoT), automation and real-time monitoring have become accessible even for rural infrastructure. IoT-based solutions enable the integration of sensors, controllers, and cloud platforms to continuously monitor water levels, detect flow rates, and assess water quality parameters like pH and turbidity. These solutions can drastically reduce human dependency, enhance transparency, and enable data-driven decision-making. Cloud computing plays a vital role in managing the vast amount of data collected from IoT devices. By using platforms such as AWS IoT Core, the system ensures secure data transmission, scalable storage, real-time processing, and instant alert generation. When combined with web dashboards, the system offers a transparent and user-friendly interface for authorities and end-users. This research proposes a smart water supply system leveraging IoT and cloud integration to address rural water distribution problems. By automating tank monitoring, pump operation, and quality checks, the system ensures an efficient, sustainable, and cost-effective solution for water supply management.

II. PROPOSED METHODOLOGY

The methodology is centred on integrating hardware components (sensors and ESP32) with software-based automation and cloud integration. The process is structured into key phases:

- **Sensor Deployment:** Sensors like ultrasonic, flow, pH, and turbidity are installed in water tanks or pipelines to monitor critical parameters in real time.
- **Data Collection:** ESP32 collects analogue and digital signals from these sensors and formats the data.
- **Data Transmission:** The ESP32 uses Wi-Fi to transmit data using MQTT protocol to AWS IoT Core.
- **Cloud Processing:** AWS Lambda functions process incoming data, apply logic (like threshold checks), and store results in DynamoDB.
- **Control Signals:** When specific conditions are met (e.g., tank full), commands are sent back to control the relay module to turn the pump ON/OFF.
- **Alert Generation:** Alerts are triggered using AWS SNS when parameters exceed safe limits.
- **Dashboard Interface:** A web-based dashboard displays real-time sensor data and pump status to users for monitoring and control.

This modular methodology ensures scalability and reliability even in environments with limited infrastructure.

III. SYSTEM DESIGN AND ARCHITECTURE

Overview of the IoT-Based System

The system includes sensors for data acquisition, an ESP32 microcontroller for processing and communication, and AWS cloud for backend processing and data storage.

Components of the Architecture

- **Sensing Unit:** Captures water level, quality, and flow.
- **Control Unit (ESP32):** Receives data and controls relay output for automation.
- **Communication Protocol:** MQTT for lightweight message transmission to the cloud.
- **Cloud Platform:** AWS IoT Core, Lambda, DynamoDB, SNS.
- **Visualization Layer:** Dashboard built using Node-RED or other frameworks.

IV. HARDWARE AND SOFTWARE DETAILS

Hardware Components

- **ESP32 Microcontroller:** Core unit for communication and control.
- **Ultrasonic Sensor (HC-SR04):** Measures tank water levels accurately.
- **Flow Sensor (YF-S201):** Measures volume of water flowing through pipe.
- **pH Sensor:** Assesses water acidity or alkalinity.
- **Turbidity Sensor:** Checks for water clarity.
- **Relay Module:** Controls pump operation based on logic.
- **Pump:** Small water motor pump to simulate supply.
- **Power Supply & Breadboard:** Supplies voltage and connects components.

Software Components

- **Arduino IDE:** Code and upload logic to ESP32.
- **MQTT Protocol:** Efficient communication between ESP32 and AWS.
- **AWS IoT Core:** Device connectivity and message handling.
- **AWS Lambda:** Serverless computation to process sensor data.
- **DynamoDB:** Stores data for history and monitoring.
- **Node-RED/HTML+JS:** Front-end dashboard for users.
- **AWS SNS:** Sends notifications via SMS/email.

V. CLOUD INTEGRATION

Cloud connectivity is at the heart of this system, enabling scalability and remote access. The steps involved include:

1. **Device Registration:** ESP32 is registered on AWS IoT Core.
2. **Secure MQTT Communication:** Certificates and topics are configured for secure transmission.
3. **Data Ingestion:** ESP32 publishes sensor data to AWS topics.
4. **Processing (AWS Lambda):** Executes logic when new data arrives (e.g., check if tank is full).
5. **Data Storage:** DynamoDB stores timestamped sensor values.
6. **Visualization & Alerts:** Dashboards are updated in real-time and SNS sends alerts to users.

VI. RESULTS AND DISCUSSION

Simulated tests showed:

- **Water Level Accuracy:** ±2 cm with ultrasonic sensor.
- **Flow Rate Detection:** 95% accurate at standard flow conditions.
- **pH & Turbidity:** pH averaged 7.2; turbidity under 5 NTU.
- **Pump Automation:** Relays responded within 1.5 seconds of cloud command.
- **Cloud Latency:** Under 2 seconds for full data cycle.
- **Dashboard:** Updated every 5 seconds with real-time values.
- **Alert System:** Triggered SMS alert when tank was low or quality dropped.

VII. CONCLUSION

This project successfully demonstrates a low-cost, scalable solution for automating and monitoring rural water supply using IoT and cloud computing. By integrating real-time data collection, cloud processing, and automation, it reduces manual errors, enhances water conservation, and increases transparency.

Future Enhancements:

- **AI/ML Algorithms:** Predict demand patterns and optimize supply.
- **Solar Power:** To ensure energy independence in rural areas.
- **Mobile App:** For user-level control and notifications.
- **Multi-Tank Management:** Extend the system to handle multiple tanks across locations.

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