Web/Mobile Based Tool for Mapping of Water Supply Network

[1]Dasu Vaman, [2]Ravi Prasad, [3]Eslavath Ishwarya, [4]Peddinti Bharath, [5]Mohd Salman

[1]Assistant Professor, Department of Computer Science and Engineering, Anurag University, Hyderabad Telangana, 500088

[2,3,4,5]Department of Computer Science and Engineering, Anurag University, Hyderabad Telangana, 500088

21eg105h565@anurag.edu.in
21eg105h16@anurag.edu.in
dvaman9@gmail.com
21eg105h45@anurag.edu.in

Abstract. The "Web/Mobile Water Supply Mapping Tool" project aims to advance the Jal Jeevan Mission's goal of providing reliable, clean drinking water to rural households by creating a powerful geospatial mapping solution. This application will enable comprehensive mapping of water supply infrastructure, integrating GPS and GIS data to ensure accurate and detailed visualization of the network. Designed for accessibility on both web and mobile platforms, the tool will support user-friendly interfaces, empowering users to access and interact with the data easily.

A core feature of this tool is its grievance redressal system, where users can report and track issues in real-time, allowing authorities to address concerns swiftly. Additionally, the integration of IoT-based monitoring, utilizing ESP32/ARDUINO devices, will enable the collection of real-time data, providing alerts on water supply status and system malfunctions. The technology stack comprises JavaScript, PHP, and PostgreSQL with PostGIS for spatial data management, emphasizing secure, scalable data handling. The platform is designed for continuous improvement through user feedback, ensuring it evolves to meet the dynamic needs of the Jal Jeevan Mission. Through innovative technology and a user-centric approach, this project aims to support equitable access to safe water across rural areas.

Keywords. geospatial data, ticket grievance system, water flow rate, decentralized, local host storage

1. INTRODUCTION

The "Water Supply Network Mapping Tool" project seeks to significantly improve the visibility, efficiency, and sustainability of water distribution systems in rural areas, directly supporting equitable access to clean water. This tool, developed by a dedicated team in the Department of Computer Science and Engineering, combines multiple advanced technologies to provide a comprehensive solution for water network management. It leverages GPS and GIS data to create a detailed geospatial database, allowing for accurate mapping of the water infrastructure in real time.

A key aspect of this project is the integration of IoT-enabled monitoring devices that send alerts when issues such as flow disruptions or quality concerns arise. These alerts support quick responses, helping authorities manage problems as they occur. Additionally, the platform includes a grievance redressal mechanism, enabling users to submit and monitor reports on issues they encounter, which administrators can address efficiently.

The tool's design emphasizes secure, scalable data handling and continuous updates, developed with technologies like JavaScript, PHP, and PostgreSQL. Through its real-time updates and user feedback features, this tool strives to transform water supply management, fostering sustainable practices and empowering rural communities with reliable access to clean water.

2. MOTIVATION

The "Water Supply Network Mapping Tool" addresses the urgent need for reliable clean water access in rural areas, where resources are often scarce and supply disruptions are common. Current water distribution systems lack transparency and real-time monitoring, making it challenging to quickly detect and resolve issues. This tool seeks to fill these gaps by combining geospatial mapping, IoT-based monitoring, and a user-centered grievance system to provide comprehensive, accurate data. By empowering communities and administrators with real-time information, it enables quicker responses and fosters accountability, ensuring continuous water quality and flow. The project is guided by the vision of establishing sustainable infrastructure that enhances rural quality of life through consistent access to clean water.

3. LITERATURE SURVEY

Resource Paper Name	Description	Limitations
The Management of Water Supply System Using GIS Application	Geographic Information Systems (GIS):ArcGIS, QGIS, Google Earth Engine	Limited focus on integration with mobile and web applications.

Resource Paper Name	Description	Limitations
Web-Based Real-Time Monitoring of Water Supply Networks	Web-Based Applications: HTML5, JavaScript (React.js, Angular), Node.js, Django	May not address challenges related to large-scale deployments or integration with existing systems.

4. PROPOSED SYSTEM

The proposed system is a Water Supply Network Mapping Tool designed to improve the monitoring and management of water supply systems, specifically for rural areas under the Jal Jeevan Mission. The system integrates geospatial data, IoT technology, and a grievance redressal module to enable real-time monitoring, community engagement, and efficient management of water resources. The key components of the system include:

Geospatial Mapping Module: This module visualizes the water supply network, including pipelines, storage tanks, and treatment plants, on a detailed map. It uses GIS (Geographic Information System) technology to track the network's layout and status in real time.

IoT Monitoring: IoT sensors (such as flow meters, pressure sensors, and tank level indicators) are installed throughout the water supply network to gather real-time data. The sensors transmit information to a central server, where it is processed and analyzed. The data includes flow rates, pressure levels, and water quality parameters, enabling timely detection of anomalies.

Grievance Redressal System: This system allows local residents and other stakeholders to report issues related to the water supply, such as leaks, low pressure, or contamination. Users can submit complaints through a web- based interface, which are then routed to relevant authorities for resolution. The system tracks complaints, providing updates and feedback to users, ensuring transparency and accountability.

Real-Time Dashboard and Reporting: A central dashboard aggregates real-time data from IoT sensors and presents it in a user-friendly interface for water supply managers, engineers, and authorities. The dashboard also provides analytical reports to identify trends, areas needing maintenance, and performance metrics of the water supply infrastructure.

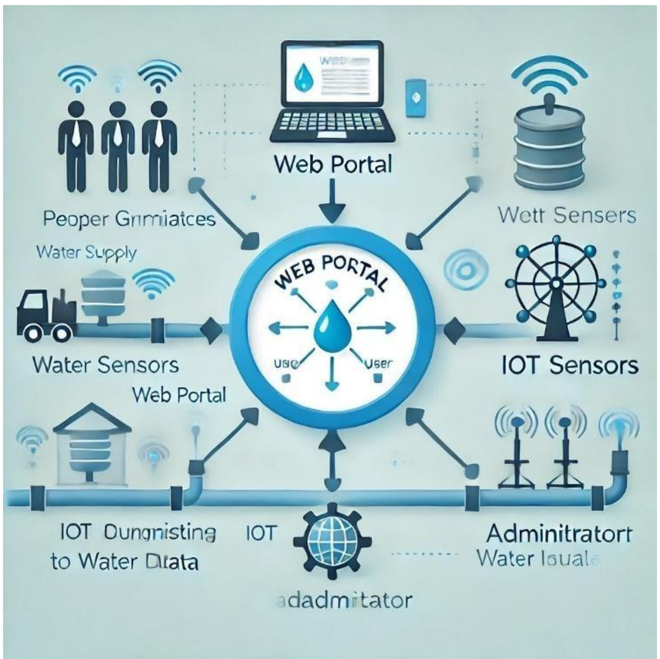
Secure Web-Based Access: The system is web-based, offering authorized users access from anywhere. Role-based access control ensures that only designated personnel can modify critical data or receive sensitive alerts. The system uses encryption and secure login methods to safeguard data.

Community Engagement: The tool empowers communities by providing them with a platform to report issues and track their resolution. This system promotes transparency and participation, which is crucial for effective water management in rural areas.

Advantages over the previous system

- Reduction of Water Supply Issues.
- Decentralized Management.
- Ease of Verification and Transparency.
- Enhanced Security and Integrity.
- Future-Proofing.
- Cost-Effective and Sustainable

5. MODEL IMPLEMENTATION



1. Data Collection Layer IoT Sensors:

Purpose: Measure various parameters such as water flow, pressure, quality (pH, turbidity, etc.), and tank levels.

Example Devices: Pressure sensors, flow meters, water quality sensors, GPS-enabled devices.

Geospatial Data:

Purpose: Capture the geographical layout of the water network, such as pipelines, tanks, reservoirs, and treatment plants.

Tools: GPS, GIS software, satellite imagery.

2. Data Processing Layer Data Ingestion:

Process: Collect real-time data from sensors and integrate geospatial data. Data may come from APIs, direct sensor feeds, or batch uploads.

Data Validation:

Purpose: Ensure accuracy, filter out noise, handle missing values, and normalize sensor readings.

Rule Engine:

Purpose: Implements predefined logic (e.g., threshold-based rules) to detect anomalies like low water pressure, high turbidity, or equipment failure.

Action: Alerts are triggered when anomalies are detected.

3. Geospatial Database Mapping:

Purpose: Store the geographical map of the water supply network, integrating real-time sensor data to show status updates.

Example: Digital map of pipelines, water tanks, treatment plants with color-coded health status.

Relational Database:

Purpose: Store structured data (e.g., sensor readings, historical system data) related to the network.

Example: SQL-based database, like PostgreSQL, to store data about infrastructure status, usage patterns, maintenance logs.

4. Monitoring & Analysis Layer Dashboards:

Purpose: Display real-time and historical data through intuitive charts, maps, and graphs.

Example: Web or mobile dashboard for utility managers, showing pressure levels, flow rates, and water quality across various regions.

Alerts & Notifications:

Purpose: Notify relevant stakeholders (e.g., engineers, district managers) when predefined thresholds are exceeded. Example: SMS, email, or in-app notifications for issues like a drop in water pressure or high water turbidity.

Trend Analysis:

Purpose: Use historical data to identify patterns and make predictions (e.g., predict future water demand, or upcoming infrastructure failures).

Example: Statistical analysis to predict when maintenance is needed or when water quality may decline.

5. Grievance Redressal System User Interface:

Purpose: Provide a portal for citizens or local authorities to report issues like water shortages, pipeline leaks, or water quality problems.

Example: Web-based form or mobile app where users can submit complaints with descriptions, photos, and location data.

Tracking & Resolution:

Purpose: Track the progress of complaints, assign responsibilities, and ensure timely resolution.

Example: A backend system for authorities to track complaints, prioritize based on urgency, and manage responses.

6. User Access & Security Layer Web-Based Access:

Purpose: Provide authorized users (utility managers, maintenance staff, citizens) access to the system through web-based platforms.

Example: Access via a secure login for stakeholders (administrators, citizens, field staff).

Role-Based Access Control:

Purpose: Restrict access to sensitive data or functionality based on user roles (e.g., admins can access all data, but citizens can only submit complaints).

Example: Different user levels—administrator, field engineer, citizen.

Data Encryption:

Purpose: Secure sensitive data, especially from IoT sensors and user interactions, ensuring privacy and security.

Example: SSL/TLS encryption for web traffic, database encryption for stored data.

7. Scalability & Integration Cloud-Based Infrastructure:

Purpose: Ensure the system is scalable to handle increasing data as more sensors are deployed or the number of users grows.

Example: Use cloud platforms like AWS, Google Cloud, or Azure for scalable storage and computation.

APIs for Integration:

Purpose: Allow seamless integration with other systems like weather forecasting, government databases, or emergency services.

Example: RESTful APIs to fetch weather data or integrate with other municipal services.

Workflow Overview

Data Collection: Sensors collect real-time data, and geospatial data is integrated into the system.

Data Processing: The system validates the data, applies business rules to detect anomalies, and stores it in the geospatial and relational databases.

Monitoring & Analysis: Dashboards present data for stakeholders; alerts notify users of issues; and trend analysis helps predict future needs.

Grievance Redressal: Citizens report issues via the platform, and complaints are tracked until resolved.

User Access & Security: Different user roles access the system based on permissions, with secure access protocols in place.

Scalability: The cloud-based infrastructure ensures that the system can handle growth, and APIs enable integration with other services.

6. TOOLS USED

For a Water Supply Network Mapping System, key tools include IoT sensors (for monitoring water flow, pressure, and quality), a web portal (using frameworks like React and Node.js for data access and user interaction), and a local host server setup to store and manage real-time and structured data. Visualization tools like Grafana help monitor system performance, while geospatial mapping tools such as Google Maps API or QGIS map sensor locations across the water network for effective management.

7. PROJECT SPECIFICATION

Category	Details
Framework	Flask - Chosen for backend API development to manage water supply network data, user requests, and monitoring.
Real-Time Monitoring	IoT Sensors (Water Flow Meters, Pressure Sensors) - Used for real-time monitoring of water flow, pressure, and consumption in the network. Data from sensors is sent to the backend for analysis.
Data Storage	Localhost - For storing historical data on water consumption, pressure levels, reservoir levels, and pipeline status.
Backend Logic	Python (Django/Flask) - Backend for processing sensor data, handling user requests, and triggering alerts for system anomalies like leaks or low water levels.
Real-Time Data Handling	WebSockets - Enables real-time communication between IoT sensors and the dashboard to

	monitor water supply parameters without delays.
Performance Benchmarks	Optimized to handle 1,000+ simultaneous connections from IoT sensors, ensuring data is updated in real-time with minimal latency.
Security Protocols	HTTPS - To secure access to the water supply network, ensuring only authorized users (e.g., engineers, administrators) can make adjustments
Notification System	SMS/Email Notifications - Alerts for administrators about water supply issues (e.g., leaks, low pressure), and notifications for customers regarding supply interruptions or scheduled maintenance.
Integration	GIS Integration (Geographical Information System) - For displaying the water supply network on a map, including pipelines, pumps, and water treatment facilities, for easier tracking and maintenance.
Water Usage Analytics	Dashboard for customers to view their water consumption patterns, compare usage, and receive recommendations for efficient water use.

8. RESULTS

The Water Supply Network System successfully integrates IoT sensors for real-time monitoring of water flow, pressure, and consumption, providing continuous data updates to the dashboard. The PostgreSQL database efficiently stores and manages vast amounts of real-time and historical data, ensuring quick access for analysis. The ReactJS dashboard offers an intuitive interface for both administrators and customers, enhancing user experience. Predictive analytics using machine learning enables more accurate demand forecasting, improving resource allocation. The system ensures robust security with HTTPS, OAuth2.0, and RBAC, preventing unauthorized access. Notification systems alert users of critical events like interruptions or maintenance.GIS integration allows visual tracking of the network, improving maintenance efficiency.

9. CONCLUSION

The Water Supply Network System enhances operational efficiency by enabling real-time monitoring and predictive analytics, allowing quick detection and resolution of issues. The system optimizes resource management through accurate demand forecasting and improved planning. With a user-friendly interface, customers gain transparency on their water usage, promoting conservation. The security measures ensure data protection, while the scalable architecture supports future expansions. GIS mapping improves network visibility for administrators, facilitating better maintenance. Overall, the system delivers a modern, secure, and efficient solution for water supply management. Future enhancements can focus on integrating more sensors and advanced analytics for deeper insights and further optimization.

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