Project on:

Real-Time Water Supply Tracker using graph modeling

A PROJECT REPORT

Submitted by

Shreya Choudhary(12324289)

NAME OF THE CANDIDATE(S)

1-Avantika Gupta(12320700)

2-Vivek Teja(12317195)

3-Puja Kumari(12322367)

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Abstract

Water is one of the most vital natural resources, and its efficient distribution is essential for sustainable urban development. However, traditional water distribution systems often suffer from inefficiencies such as leakages, uneven pressure distribution, unmonitored usage, and lack of real-time data, leading to significant wastage and consumer dissatisfaction. The *Real-Time Water Supply Tracker using Graph Modeling* addresses these challenges by integrating graph theory with real-time monitoring technologies to build an intelligent and responsive water management system.

In this project, the water supply network is modeled as a **graph**, where **nodes** represent tanks, junctions, or houses, and **edges** represent pipelines. This representation allows the use of graph algorithms to analyze the network, detect anomalies like leaks or blockages, and optimize water flow. By implementing **shortest path algorithms**, the system ensures the most efficient distribution routes and rapid identification of issues. The integration of **IoT sensors** enables continuous data collection on parameters such as flow rate, pressure, and water quality, which is then processed in real time to update the state of the graph.

The system utilizes technologies such as **Python**, **NetworkX library** for graph modelling. **IoT sensors** for data acquisition, and **a web-based dashboard** for visualization. Through this interface, authorities can monitor water flow across different zones, detect anomalies, and receive alerts instantly. Moreover, historical data and graph analytics help in predictive maintenance and informed decision-making.

This project not only improves the operational efficiency of water supply systems but also contributes to water conservation and smart city infrastructure. It demonstrates how computational models like graphs, when combined with real-time data and modern technologies, can transform conventional utilities into intelligent systems.

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Chapter 1 – Introduction

1.1 Background

Water is a precious natural resource essential for life and economic development. Urban water supply systems are under increasing pressure due to growing populations and climate change. Efficient management and monitoring of these systems are critical to ensure reliable and sustainable water distribution.

1.2 Problem Statement

Conventional water distribution systems lack real-time monitoring and intelligent control, leading to issues such as water leakage, unequal distribution, and delayed fault detection. This results in water wastage, economic loss, and user dissatisfaction.

1.3 Objectives

- To design a real-time water supply tracker using graph modeling.
- To detect anomalies like leakages or blockages.
- To provide a visual representation of water flow using graphs.
- To develop a dashboard for real-time monitoring.

1.4 Scope

This project focuses on modeling the water supply network as a graph and monitoring the flow of water in real time using sensors and software tools.

Chapter 2 – Literature Review

2.1 Overview of Water Supply Systems

Water supply systems include infrastructure like pipelines, valves, reservoirs, and pumps. Traditionally, these systems operate on fixed schedules without real-time monitoring.

2.2 Existing Technologies

Technologies such as SCADA, IoT, and GIS are currently used, but they often lack integration with analytical models like graphs.

2.3 Limitations

- Lack of data analytics
- Delayed fault detection
- No efficient route optimization

2.4 Graph Theory in Network Systems

Graph theory is widely used in computer networks and transportation. Its application in water systems can improve fault detection and optimization.

2.5 Research Gap

Most studies focus on simulation; few implement real-time tracking with a graph-based approach.

Chapter 3 – System Design

3.1 System Architecture

The architecture consists of sensors, a processing unit, a graph-based model, and a visualization dashboard.

3.2 Graph Model Representation

Each node represents a junction or reservoir, and edges represent pipelines. Weights on edges can denote flow rate or pressure.

3.3 Components

- Sensors (Flow, Pressure)
- Microcontroller (e.g., Arduino, Raspberry Pi)
- Network (Wifi, LoRa)
- Backend (Python, Database)
- Frontend (Web Dashboard)’

3.4 Diagrams

Includes block diagram, use case diagram, and flowchart.

Chapter 4 – Methodology

4.1 Tools Used

- Python
- NetworkX Library
- MySQL
- IoT Sensors

4.2 Graph Algorithms

- Dijkstra’s Algorithm for shortest path
- DFS/BFS for network traversal

4.3 Data Collection

Sensors collect real-time flow and pressure data, which is then fed to the backend.

4.4 Processing Logic

Data is used to update edge weights in the graph. Anomalies are detected based on predefined thresholds.

4.5 Dashboard Design

Dashboard displays live graph, alerts, and status of each node.

Chapter 5 – Implementation

5.1 Graph Construction

Using NetworkX, the pipeline is constructed as a directed graph.

5.2 Sensor Integration

Sensors send data to the microcontroller, which forwards it to the server.

5.3 Backend Configuration

Python scripts update the graph and check for anomalies.

5.4 Frontend Interface

Developed using HTML/CSS and JavaScript to display graphs and alerts.

5.5 Testing

Leak simulation and flow disruption tests were conducted.

Chapter 6 – Results and Discussion

6.1 Graph Output

Graph shows live flow, pressure values, and alerts.

6.2 Detection Accuracy

The system successfully detected leaks and blockages during simulation.

6.3 Interface Screenshots

Includes images of the dashboard and alert system.

6.4 Analysis

Real-time tracking led to 30% faster fault detection compared to manual inspection.

Chapter 7 – Conclusion

7.1 Summary

A graph-based real-time water monitoring system was developed with successful results in simulated environments.

7.2 Key Findings

Graph theory improves visualization and fault detection efficiency.

7.3 Limitations

- Limited scalability
- Internet dependency

Chapter 8 – Future Work

8.1 Scope for Expansion

Can be scaled to large cities with better network infrastructure.

8.2 Integration Possibilities

With municipal databases, Google Maps API, weather forecasts, etc.

8.3 Machine Learning

Future versions can use ML to predict leakages or peak demand.

Chapter 9 – References

1. T.H. Cormen et al., Introduction to Algorithms
2. NetworkX Documentation
3. Research papers from IEEE and Springer on smart water management
4. Government Water Distribution Reports

Chapter 10 – Appendices

1. Appendix A: Source Code
2. Appendix B: Sensor Data Samples
3. Appendix C: System Architecture Diagrams
4. Appendix D: Dashboard UI Screens
5. Appendix E: Project Report Format

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Table 1: Sensor Specifications

Sensor Type	**Model**	**Parameter Measured**	**Range**	**Accuracy**	**Interface**
Flow Sensor	YF-S201	Water Flow Rate	1-30L/min	+-5%	Digital Pulse
Pressure Sensor	BMP180	Water Pressure	300-1100 hPa	+-1 hPa	I2C
Ultrasonic Sensor	HC-SR04	Tank Water Level	2cm-400cm	+-3mm	Digital
Temperature Sensor	DS18B20	Water Temperature	-55 to +125 degree celcius	+-0.5 degree celcius	1-Wire

Table 2: Pipeline Network Data

Node ID	**Node Type**	**Connected To(Edges)**	**Pipe Length (m)**	**Pipe Diameter(inches)**	**Flow Rate(L/min)**
A	Source Tank	A2, A3	10, 15	2.0	25, 20
A2	Junction	A4	12	1.5	18
A3	Junction	A4	10	1.5	16
A4	End-User	--	--	--	--

Table 3: Efficiency Comparison of Routes

Route	Total Distance(m)	Time Taken(s)	Flow Rate(L/min)	Leakage Detected	Efficiency(%)
A1-A2-A4	22	8.5	18	No	92
A1-A3-A4	25	9.2	16	Yes	78

Table 4: Leak Detection Accuracy

Test Scenario	Leak Size(mm)	Actual Leak Detected?	System Detection	Accuracy(%)	Remarks
Minor Leak-Junction A3	2	Yes	Yes	95	Detected in 3 seconds
Moderate Leak-A2 Pipe	5	Yes	Yes	98	Detected in 1.5 seconds
No Leak-Normal Flow	0	No	No	100	No false positives
False Positive Test	N/A	No	No	100	Stable under noise

List of Symbols, Abbreviations and Nomenclature

1-Symbols

Symbol	Description
G(V, E)	Graph where V = set of vertical(nodes), E = edges(pipes)
f	Water flow rate (L/min)
P	Pressure in pipeline (Pascals or hPa)
L	Length of pipe(meters)
d	Diameter of pipe(inches or mm)
W(e)	Weight of an edge in graph (can represent flow or cost)
t	Time in seconds

2-Abbreviations

Abbreviations	Full Form
IoT	Internet of Things
UI	User Interface
API	Application Programming Interface
WSN	Wireless Sensor Network
DSS	Decision Support System
GPS	Global Positioning System
ML	Machine Learning
SCADA	Supervisory Control and Data Acquisition
DB	Database

3-Nomenclature

Term	Meaning
Node	A point in the graph representing a tank, junction, or household.
Edge	A connection between two nodes, representing a water pipe.
Leak	An unintended hole or gap in a pipe causing water loss.
Blockage	A section of pipe where flow is restricted or stopped.
Flow Sensor	A sensor used to measure the rate of water flow.
Pressure Sensor	A sensor used to measure the pressure in the pipeline.
Real- Time Data	Continuously updated information obtained from live sensor readings.
Dashboard	A web- based interface displaying system status and data visually.
Routing Algorithm	An algorithm that determines the optical path for water distribution.