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Presentation on

"AI-Powered IoT System for Early Detection and Forecasting of Urban Water Contamination"

Department of Information Technology (2025-26)

JES's

SND College of Engg. & Research Center, Yeola

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Introduction

Urban water is the main source of drinking and daily use for millions of people. But in many cities the water can get polluted by sewage leaks, industrial waste, chemicals, or heavy rainfall . If contamination is not detected quickly, it can lead to serious health problems such as water diseases and can also damage the environment.

Our project aims to build an AI-Powered Internet of Things (IoT) system that can continuously watch the quality of urban water in real time and predict future changes .This means the system will not only tell us when the water is unsafe right now, but will also forecast when contamination might happen in the coming hours or days.

Literature Survey

Sr. No	Title (IEEE Format)	Authors	Methodology Used	Research Gap	Future Scope
1	Smart Bio-Sensor Based Water Contamination Alert System Using IoT(2022)	H. Sawant, R. Jadhav	Bio-sensing layer + ESP32 IoT transmission	No AI for early forecasting	Integrate ML prediction + anomaly detection
2	Reinforcement Learning Enabled Smart Water Purification Control Unit (2022)	S. Nair, V. Desai	RL-agent-based automated purification tuning	High training time	Use hybrid RL + expert control models
3	Blockchain-Based Secure Water Quality Data Logging (2023)	P. Gupta, T. Kaur	IoT sensors + blockchain ledger	System is slow for large-scale data streams	Implement lightweight blockchain framework

Sr. No	Title (IEEE Format)	Authors	Methodology Used	Research Gap	Future Scope
4	UAV Assisted Water Pollution Monitoring for Remote Regions (2021)	R. Kumar, P. Shah	Drone imaging + remote sensing + ML	Limited continuous long-term monitoring	Combine UAV with fixed IoT stations
5	Hybrid LSTM Transformer Model for Water Quality Forecasting (2022)	K. Malhotra, D. Bose	Hybrid DL timeseries model	Requires high GPU computation	Convert to quantized edgeefficient model
6	AI-Based Real-Time Water Contamination Monitoring Using IoT Sensors (2022)	R. Kumar, P. Shah	pH, TDS sensors + microcontroller + threshold detection	No predictive analytics used	Add ML-based forecasting models
7	Wireless Sensor Network Framework for Water Quality Surveillance (2022)	S. Dutta, K. Banerjee	ZigBee-based sensing network	Limited to small geographical regions	Extend to cloud + large-scale deployment

Sr. No	Title (IEEE Format)	Authors	Methodology Used	Research Gap	Future Scope
8	Smart Water Pollutant Detection Using Embedded IoT Devices (2023)	A. Thomas, R. Torres	NodeMCU + water probes + GSM communication	Manual calibration required frequently	Develop autocalibration mechanism
9	Machine Learning Assisted Water Purity Classification(2021)	K. Roy, T. Ahmed	SVM classifier on water quality dataset	Dataset was small and regionspecific	Create large multi-regional dataset
10	Real-Time River Monitoring System Using IoT and Cloud Dashboards (2022)	L. Smith, H. Patel	IoT sensors + Firebase + dashboards	No prediction; only monitoring	Integrate forecasting analytics

Problem Statement

When city water gets dirty, it is a big danger to our health and the environment. The main issue is that the old ways of checking water quality are just too slow and are often done by hand. Because of this delay, we usually find out about contamination after it has already caused serious health problems. Most current systems can only tell us if the water is bad right now; they can't predict when it's about to get bad. This means officials are always one step behind, forced to react to problems instead of being able to stop them before they happen.

Aim & Objectives

Aim :-

- To design and develop an AI-powered IoT system capable of detecting and forecasting urban water contamination in real-time.

Objectives :-

- To collect real-time water quality parameters using IoT sensors.
- To store and analyze sensor data in the cloud.
- To use AI/ML algorithms for detecting contamination and predicting future trends.
- To enable authorities to take preventive action before water quality deteriorates.

Hardware, Software & Other Requirements

Hardware :-

- pH Sensor
- TDS Sensor
- Turbidity Sensor
- Temperature Sensor
- Arduino UNO
- ESP-32

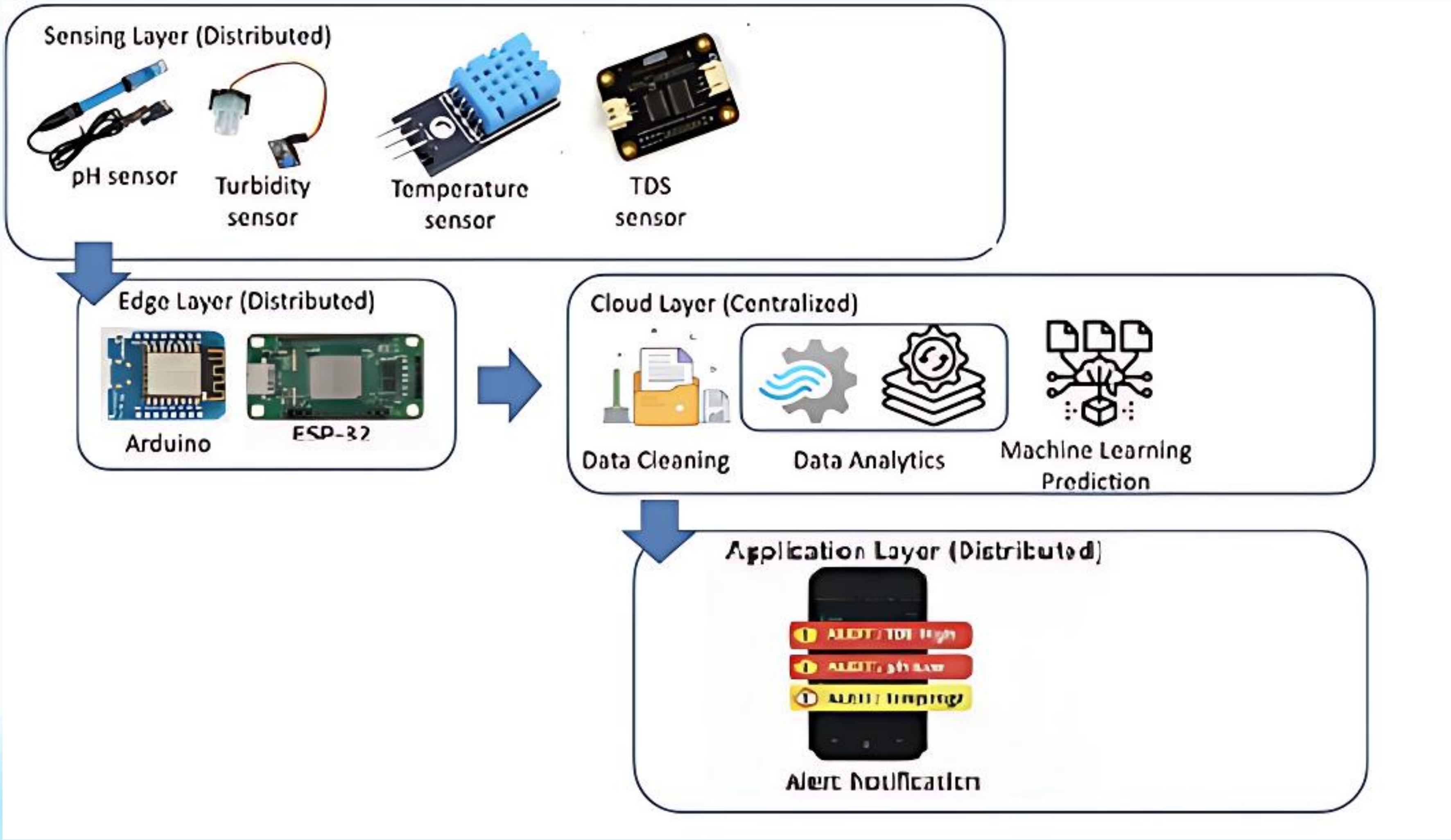
Software :-

- Arduino IDE
- FireBase (Cloud)
- ML-Libraries (Tensorflow , Scikit-learn)

Other Requirements :-

- Sample water dataset for ML training

Architecture :-



Working of the Architecture

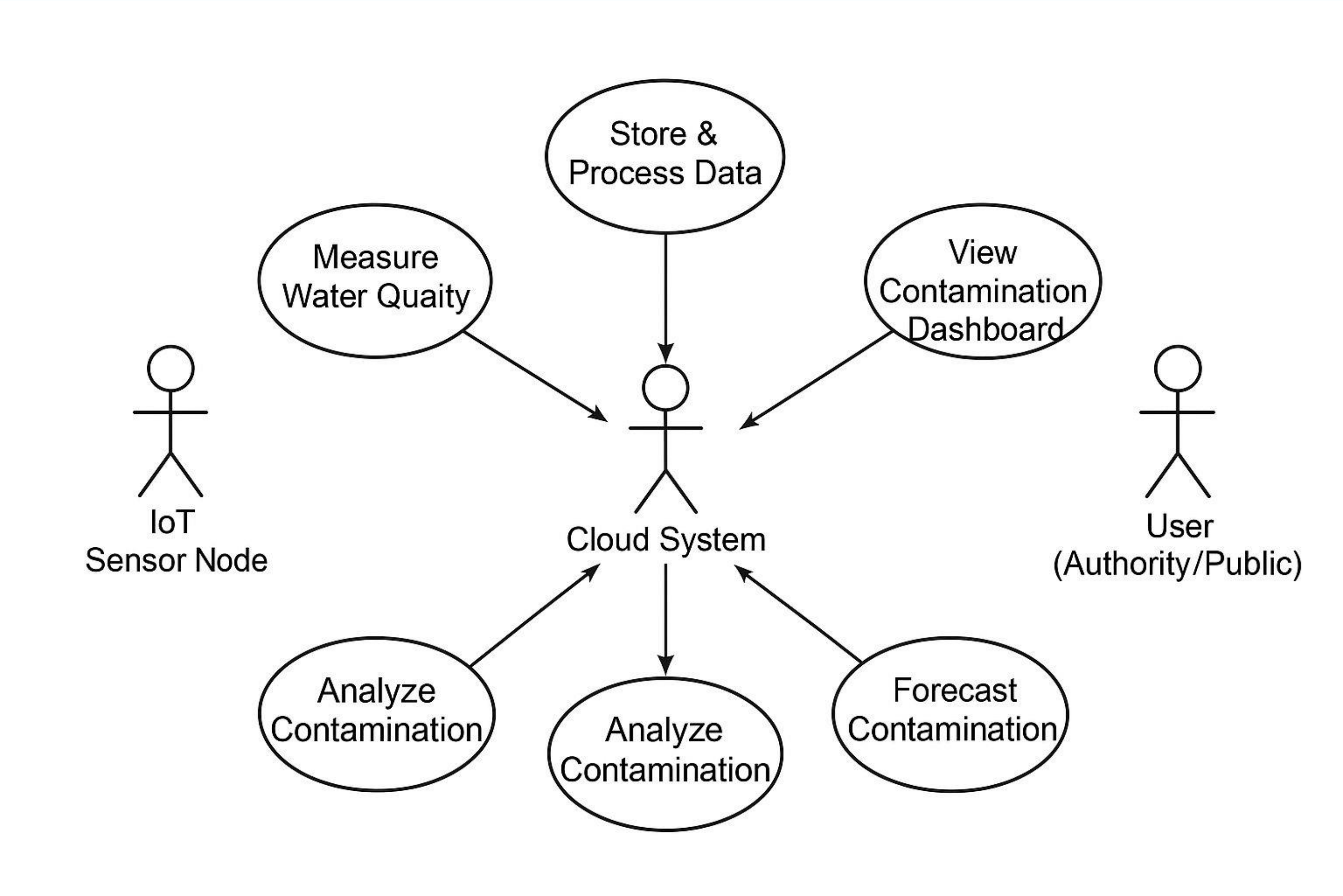
- **Sensor Layer:**
  Collects real-time water quality data using pH, TDS, Turbidity, and Temperature sensors, continuously monitoring and sending readings to the edge layer.

- **Edge Layer:**
  Arduino Uno gathers sensor data and sends it via ESP32 (Wi-Fi) to the cloud after basic filtering and preprocessing.

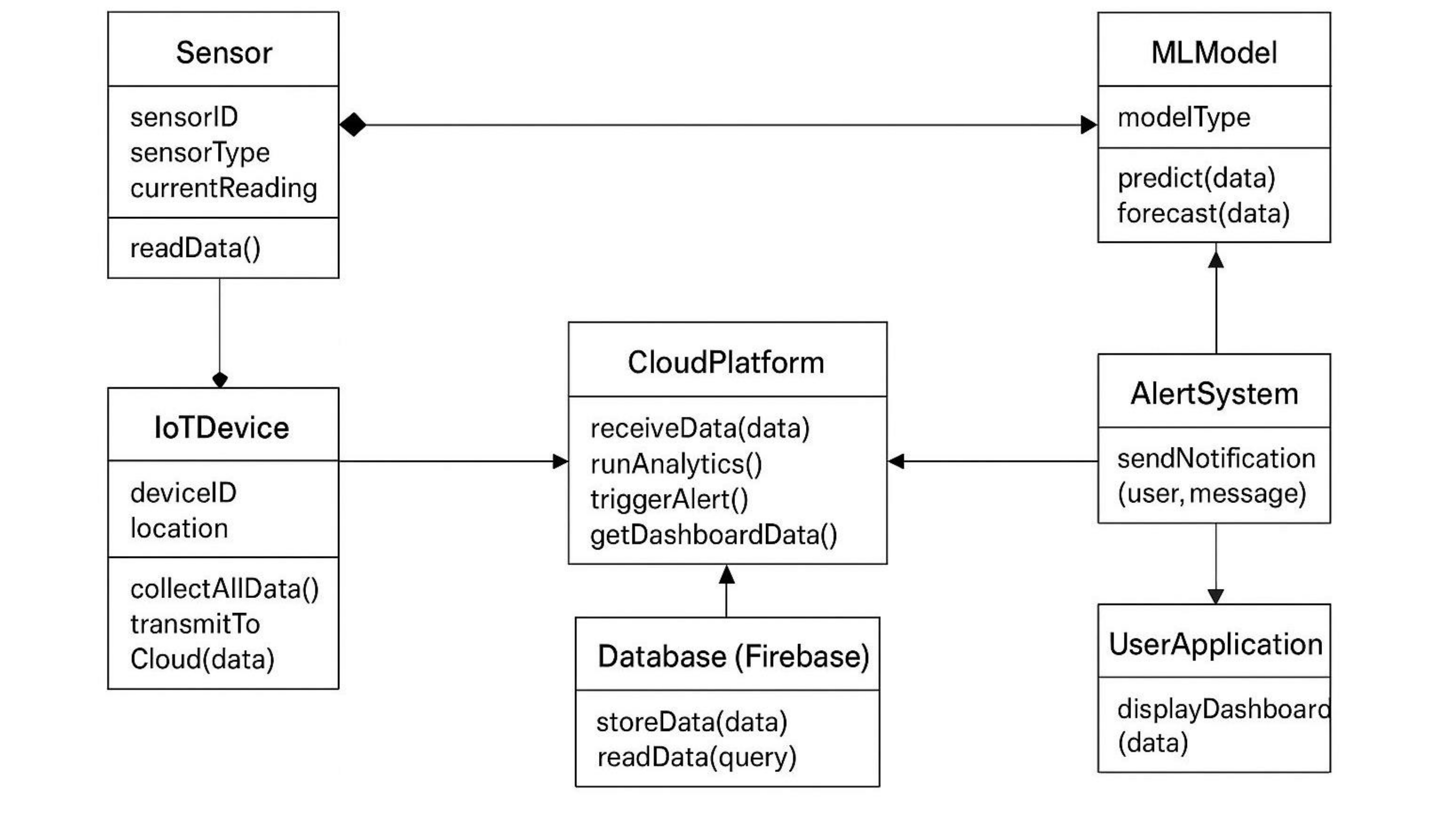
- **Cloud Layer:**
  Firebase Realtime Database stores the incoming data, while Cloud Functions and the KNN algorithm analyze it to detect and LSTM algorithm predict contamination.

- **Application Layer:**
  Displays real-time results on the user dashboard and sends instant alert notifications highlighting detected and predicted contaminations.

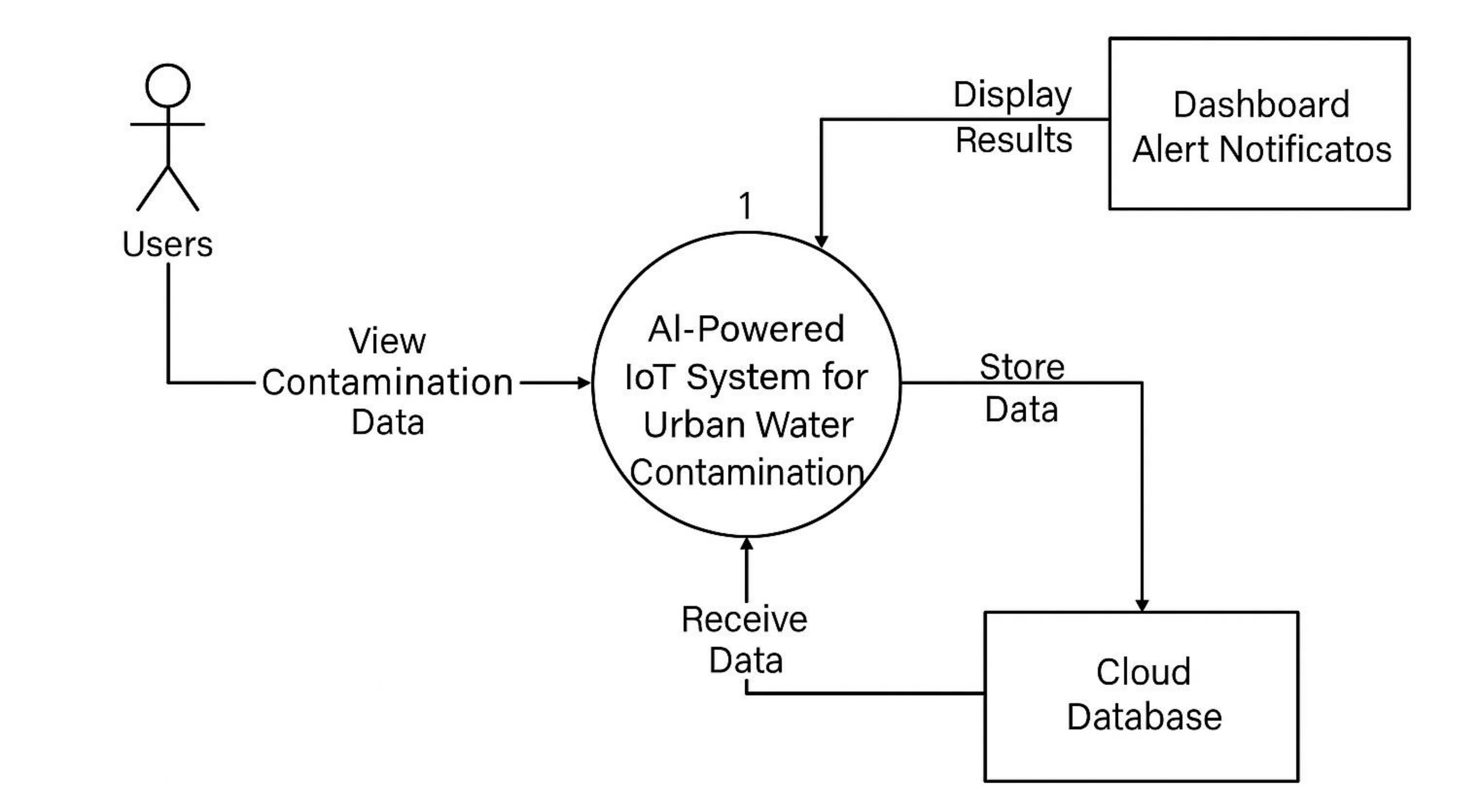
Use Case Diagram



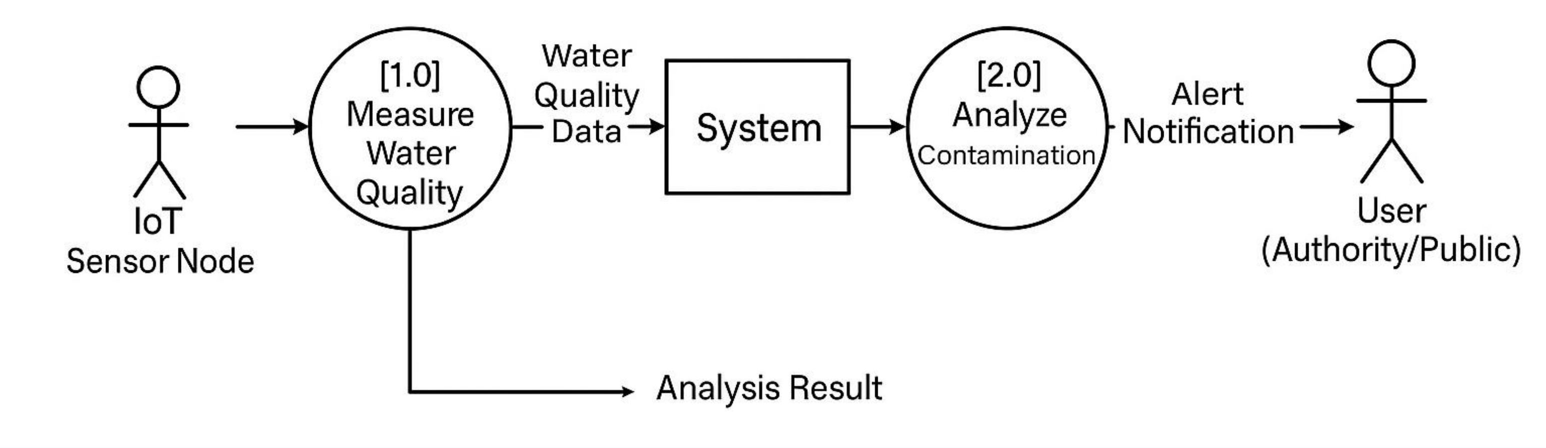
UML Class Diagram



DFD Level 0 diagram



DFD Level 1 diagram



Algorithms

Data Preprocessing:-

- Cleaning and normalization of sensor data

ML Algorithms :-

- kNN for classification of contamination levels.
- LSTM (Long Short-Term Memory) networks for time-series forecasting of future contamination.

Alert Generation :-

- Threshold-based and predictive alerts using AI model outputs.

Working of Algorithm

Algorithm 1: kNN (for Real-Time Detection)

- **Purpose:** To analyze the current sensor data and instantly classify the water quality.
- **Question it Answers:** "Is the water contaminated right now?“

How it Works:

- **Input:** A new, live sensor reading (pH, TDS, etc.) arrives from the cloud.
- **Analysis:** The kNN model immediately compares this new data point to its "memory" of pre-labeled training data (e.g., "Clean," "Contaminated").
- **Output:** It finds the 'k' closest "neighbors" and "votes" on the most likely category.
- **Result:** If the vote is "Contaminated," it triggers an immediate Detection Alert

Working of Algorithm

Algorithm 2: LSTM (for Future Forecasting)

- **Purpose:** To analyze trends over time to predict future contamination events.
- **Question it Answers:** "Will the water become contaminated in the next few hours?“

How it Works:

- **Input:** The model analyzes a sequence of recent data (e.g., all readings from the last 12 hours).
- **Analysis:** The LSTM network's "memory" identifies subtle, long-term patterns (like a slow, steady rise in TDS) that signal a developing problem.
- **Output:** It generates a forecast of the water quality for the near future.
- **Result:** It triggers a Preventive Alert before the water becomes unsafe, giving authorities time to act.

Applications

- Municipal water supply monitoring.
- Industrial wastewater management.
- Real-time pollution tracking in lakes and rivers.
- Integration in smart city infrastructure.

Conclusion

The proposed AI-powered IoT system ensures efficient and intelligent monitoring of urban water quality. By leveraging AI algorithms and IoT connectivity, the system provides early detection and forecasting of contamination, helping authorities act before critical damage occurs. The combination of data analytics, automation, and cloud computing can make urban water systems safer and more sustainable.

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Thank You !!!