Air quality monitoring system based on low power wide area network technology at public transport stops

TEAM MEMBERS

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INTRODUCTION

Air pollution poses a significant threat to public health and sustainable development, particularly in urban areas with high vehicle density and industrial activity. The proposed project, **"Air Quality Monitoring System Based on Low Power Wide Area Network Technology at Public Transport Stops,"** focuses on addressing this issue in Kilinochchi. Leveraging IoT technologies and low-power wide-area network (LPWAN) communication, the system will monitor air quality in real-time at public transport stops. This initiative aims to measure pollutant levels, such as particulate matter (PM2.5/PM10), CO, and NO2, using low-cost sensors and LoRaWAN technology for data transmission. The data will be visualized through an interactive web platform, enabling informed decision-making to mitigate pollution and improve public health in the region. This project not only contributes to environmental monitoring but also establishes a scalable solution for air quality management in other urban and rural areas.

PROBLEM STATEMENT

- **Air Pollution at Public Transport Stops:** Public transport stops are hotspots for air pollution due to emissions from vehicles and high human activity, posing health risks to commuters and nearby residents.

- **Lack of Real-Time Monitoring:** There is no real-time air quality monitoring system in Kilinochchi to track pollutant levels, making it difficult to identify and address pollution effectively.

SOLUTION

- **IoT-based air quality monitoring:** Deploy IoT-enabled sensor nodes to measure pollutants like CO, NO2, PM2.5, and PM10, as well as temperature and humidity, in real-time.
- **LoRaWAN technology:** Use low-power, wide-area network (LoRaWAN) technology to ensure cost-effective and energy-efficient data transmission over long distances.
- **Real time monitoring dashboard:** Develop a user-friendly application to visualize real-time and historical air quality data for stakeholders, including government authorities and the public.
- **Scalability and affordability:** Design a low-cost and scalable system tailored to the resource constraints of Kilinochchi, enabling future expansion to other locations.
- **Informed decision-making:** Provide actionable insights to policymakers and environmental agencies for developing strategies to mitigate pollution at public transport stops.

HIGH-LEVEL ARCHITECTURE

Sensor Nodes

- Collect air quality data, such as concentrations of pollutants (e.g., CO, NO_2) and environmental parameters (e.g., temperature).
- Use electrochemical sensors (e.g., MiCS 4514 for CO and NO_2) and temperature sensors (e.g., LM35).
- Convert analog data into digital format for transmission.

Gateway

- Sensor nodes send collected data wirelessly to the gateway using LoRa technology.
- Acts as a central hub to receive data packets from sensor nodes.
- Integrated GSM/GPRS module for internet connectivity.
- Relays processed data to a remote database via HTTP POST requests.

Backend System

- Centralized storage for all air quality data collected from sensor nodes.
- MySQL database structure includes tables for sensor data, user management, and API token validation.
- Gateway node establishes a GPRS connection.
- Secure data transfer to the database using HTTP POST requests with API token authentication.

Web Application

Frontend

- Interactive web interface for users to view real-time air quality data.
- Built using HTML, CSS, and JavaScript for dynamic interaction.

Backend

- PHP and JavaScript handle data requests and logic for the web application.
- Hosts API endpoints for data input and output.

Monitoring and Visualization

- Web interface displays pollution levels, temperature, and trends.
- Enables identification of pollution patterns and hotspots over time.

REASON FOR CHOOSING THESE TECHNOLOGIES

TABLE - 01

Technology	Reason for Choice
LoRa WAN	Low power, long-range communication ideal for urban areas with minimal energy consumption.
GSM/GPRS Module	Reliable and widely available technology for connecting the gateway to the internet and transferring data to a remote database.
ESP32 Platform	Cost-effective, widely supported microcontroller platform with extensive libraries for sensor interfacing and LoRa communication.
LM35 Sensor	High precision and ease of integration for measuring temperature with a low error margin.
Database (MySQL)	Relational database with robust performance and support for large-scale data management, essential for handling long-term environmental monitoring data.
Web Technologies (HTML, CSS, JS)	Provide a simple, accessible, and responsive web interface for visualizing air quality data in real time.
Alternative Gas Sensor	Replace the MiCS 4514 sensor with another sensor that measures CO and NO_2 levels accurately, ensuring similar functionality with a comparable cost.

CIRCUIT DESIGN AND PROTOCOLS

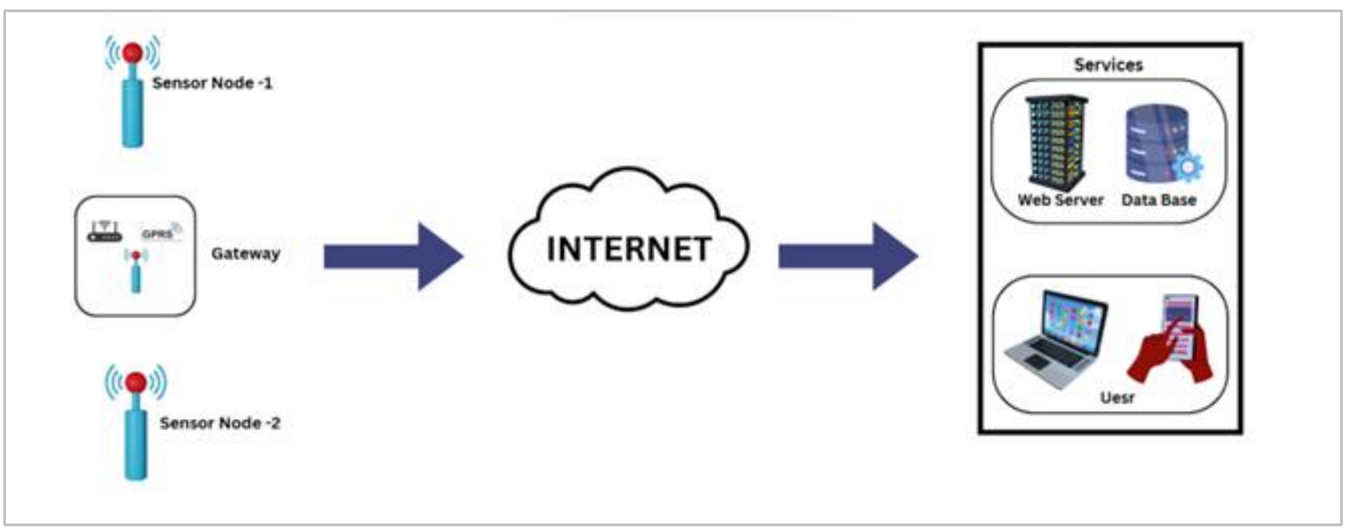

FIGURE-01

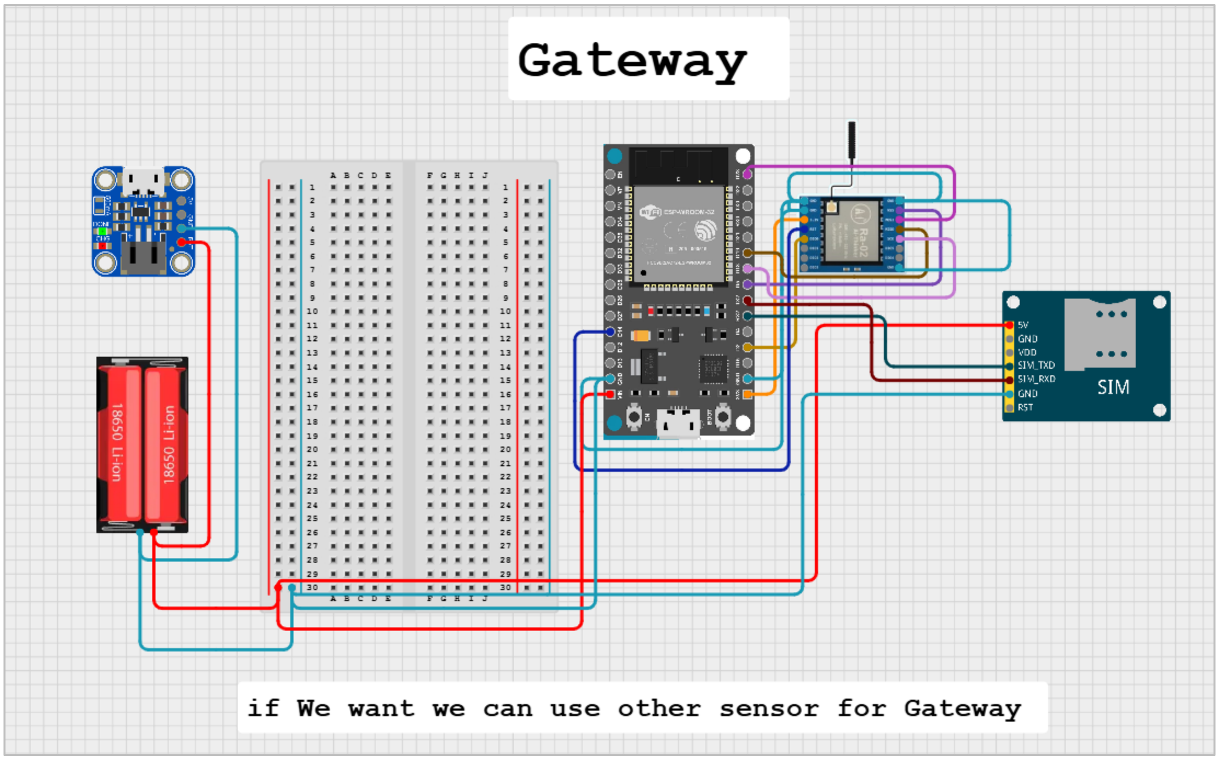

FIGURE-02

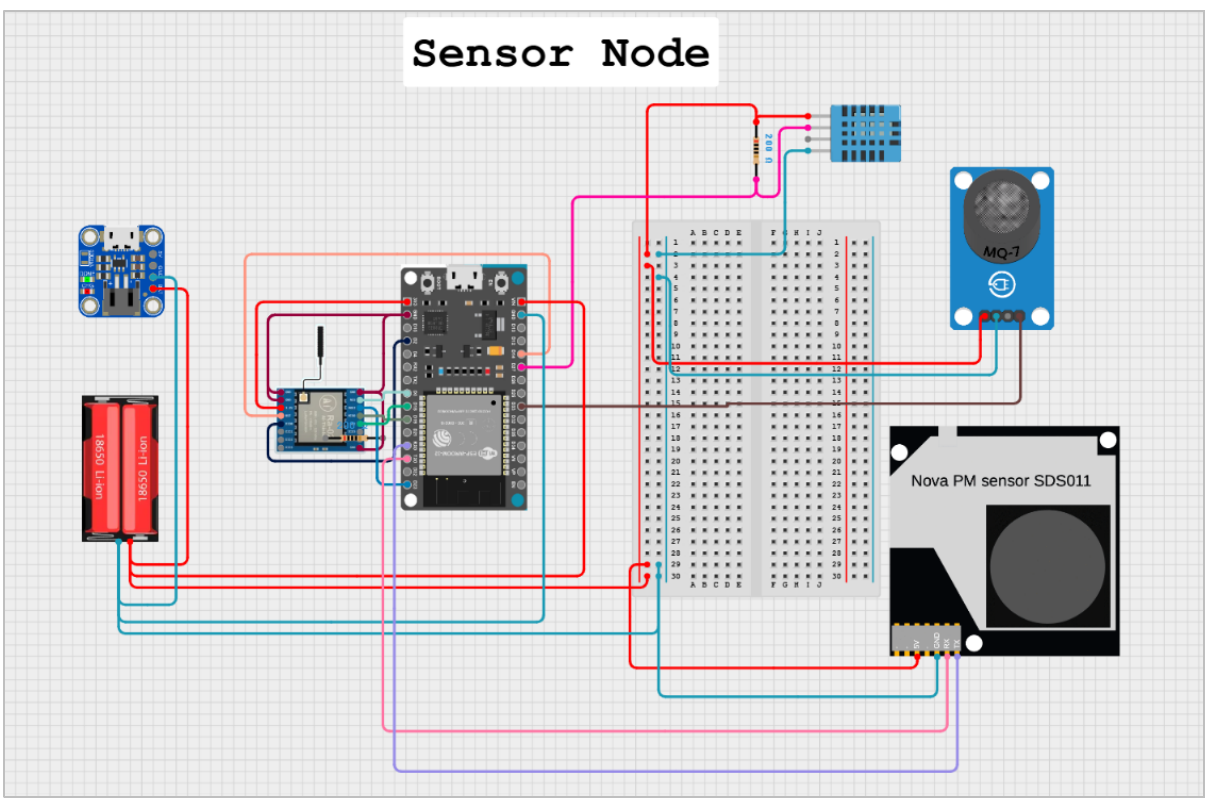

FIGURE-03

GITHUB REPO LINK WITH UPDATED ReadMe FILE

- **Github Repo link - Air Quality Monitoring System**

BUDGET

TABLE - 02

Components	Quantity	Price (LKR)
MQ-7 Carbon Monoxide CO Gas Sensor Module Type 1	1	430.00
ESP32-WROOM-32U Wi-Fi Bluetooth	2	1,270.00
Temperature Sensor Module	1	170.00
Jumper wire	3	160.00
Lithium Battery Charging Module	2	60.00
Li-ion Rechargeable Battery	4	350.00
Battery Holder Case for	2	70.00
Project Board Breadboard	2	210.00
GSM Antenna with IPEX to SMA Cable	3	300.00
Mini SIM800C GSM GPRS Bluetooth Module	1	1,450.00
LoRa Ra-02 SX1278 Module 433MHz 10km Transceiver	2	1,500.00
TOTAL		**10,050.00**

TIMELINE

TABLE - 03

Activity	Weeks									
	5	6	7	8	9	10	11	12	13	14
Research and component procurement										
System design and initial testing										
Hardware assembly										
firmware development										
Web application development and database setup										
System testing and user interface refinement										
Final integration and system debugging										
Project documentation and preparation for presentation										
Final review and project submission										