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DESIGN AND IMPLEMENTATION OF AN AUTOMATED AND SCATTERED POLLUTION TRACKING SYSTEM WITH LORAWAN

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Abstract:

This study addresses a decentralized IoT-based system for automated air and water quality measurement, storage, and monitoring in contexts which including ponds, hills, cities, and industries. Similar government methods allow human input to extract data, or demand a great deal of power or equipment, or are built on centralized structures. On one side, the suggested pollution monitoring system uses LoRa to handle IoT standards high power dissipation and long-range transmission problems. Assertions on multiple sensing devices for monitoring potential hydrogen (PH), turbidity, carbon monoxide (CO), and carbon dioxide (CO2) demonstrated a high precision with the estimated time of measurements, quasi calculated data obtained, which could be used as factual information of pollution existence.

Key Words: LoRaWAN, Automation, PMS, TTN.

Introduction:

The exponentially growing global population [1] has exacerbated key environmental issues, which including global warming and the loss of natural habitat. Drinking waters, pure air, rich wildlife, and humanity are all harmed by modernization, and also industrial and commercial activities. While several worldwide authorities, as well as private and autonomous groups, have made substantial efforts to protect our earth's atmosphere from human-caused ecological issues, human-independent solutions that simplify the process of air and water quality monitoring remain necessary. Modern pollution monitoring and measuring systems are based on applications that require direct human interaction. Previous techniques had concerns with cost of installation, excessive space limits, mobility, human-interaction requirements, centralization, power dissipation, complete lack of suitable access, and low sensor transmission range. IoT-based technologies are evolving as we move to 5G, enabling for the creation of less sophisticated systems that can communicate over greater distances without requiring human interaction to access data collected by sensors. IoT Cloud-based technology is practically ubiquitous in a wide range of research fields, including agriculture, healthcare, the socio cultural environment, smart cities, smart manufacturing, and so on. Thousands of academics and entrepreneurs, particularly startup companies, have invested in research ideas to incorporate newer technology into current solutions in order to profit or benefit society.

Related Work:

In the field of pollution monitoring, there has been a lot of theoretical study and solutions offered using various methodologies. In addition, contemporary pollution monitoring facilities gather data utilizing sensors located near/in the inspected region. This location may be a long distance from the laboratories, and frequent sensor maintenance and access to the sensors to read data may not always be possible. Including the range between the sensors and data centers, data accuracy, sensor energy usage, sensor node size, a need for interaction to access the information recorded by sensors, protocols used to connect sensors and server software, and following a centralized architecture are all significant problems in improving such a Pollution Monitoring System (PMS). Due to various creative solutions or product improvements, sustainable urban studies and solutions have advanced in recent years. In the recent past, solutions such as supplying enough bandwidth via 5G, various performance metrics in numerous sectors, such as mobility and efficient waste management, managing air/water levels of pollution, warning services, etc have grown in multiple dimensions. Furthermore, city rankings and other prominent programmes, such as India's Swatchh Bharath[13], have encouraged city authorities to establish effective measurements and policies to combat bad practices; a few indexing methods, like as Air Quality Indexing, exist for rating nations.

Controlling air pollution levels takes place in the outdoor, indoor, and industrial sectors. For example, Kadri et al presented a networked machine-2-machine system to monitoring air quality indicators. A cloud-assisted air quality monitoring system has also been developed by Yash et al. Siemens has created software that reveals city air quality levels. Sensor modules with Wi-Fi or Ethernet adapters can be used for small-area communications, but due to its high energy consumption, these communication techniques are not suitable for long-distance communications. There are several approaches for reducing sensor node energy consumption, such as utilizing DARAL [2] to charge sensor batteries via a Wi-Fi network, although DARAL limits sensor node communication range.

Design:

This research provides a unique architecture for tackling the requirements and obstacles in constructing a PMS by concocting a low power consumption communication protocol that facilitates high range communication. A layered architecture is used in the suggested PMS. To keep data private and untampered, data is sent straight from IoT sensors to Web servers over the LoRa [3] network (TTN). Wi-Fi may also be used to link the sensors to the Internet, allowing data from the sensors to be accessed. Sensor modules are just as significant as data transmission in terms of energy usage. The battery use increases as the module size grows. Changing the battery and monitoring the battery state is not an option if the sensors are positioned across large distances. LoRa technology allows for long-range communication. However, it only allows extremely modest data rates, allowing the sensors' battery life to be extended.

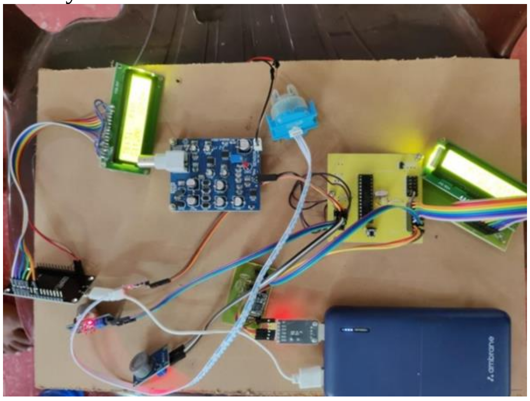

Figure 1: Prototype

The fast advancement of network and web - based technologies has aided the global expansion of the Iot technology. Each sensor and actuator will be connected to an object as part of the Internet of Things, allowing information out of each object to be sent to third parties using internet network technologies. In the future, the Internet of Things' (IoT) performance will be determined by the device's power efficiency as well as the maximum distance between the transmitter and the receiver. This prompted a lot of study into leveraging IoT capable of monitoring air quality and makes the observed air intensity value accessible to many parties.This study focuses on the setup of a wireless network, which includes two key considerations: energy and cost. Because we use LoRa transmission technology, the system has minimal power, a wide range of coverage, and a long battery life. In both indoor and outdoor situations, we present a method for data collection and air pollution analysis. Through connecting to a dedicated site, pollution monitoring data may be acquired from various areas.

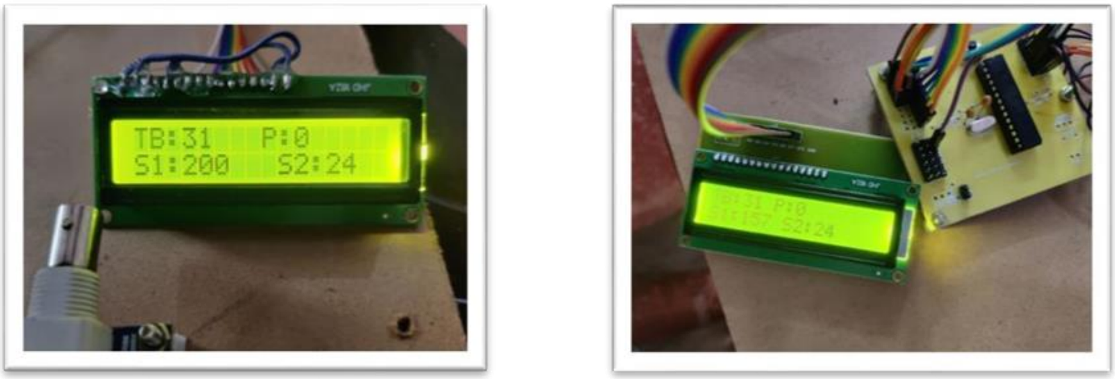

Figure 2: Output Values

Implementation:

This work offers a LoRa-based wireless sensor for air pollution monitoring and pollution detection that is resilient, low-power, and scalable. The gateway and the endpoint nodes, which contain the sensors, make up the physical structure of this sensor network. Furthermore, the network stores data from the sensors on a cloud server, and the data is processed or visualized using a local network, a Computer, or a Smartphone that accesses a front- end application. The following is how the network was set up: An indoor LoRa gateway was installed in a location that allowed it to connect to the Internet through a Wi-Fi connection. The gateway was ready to forward uplink and downlink messages delivered from the nodes to the server and vice versa after it was linked to The Things Network (TTN) cloud server. At the end of each sample period, nodes take measurements, encode the information, and communicate the data before going into deep sleep mode.

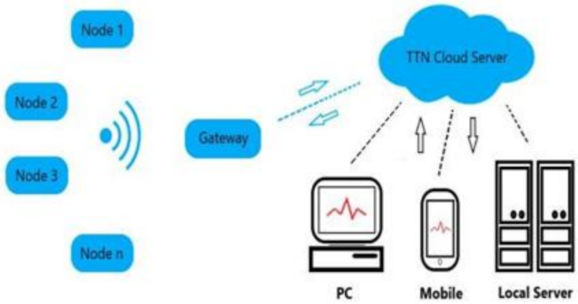

Figure 3: Visualization

The data is processed and saved on the cloud server for subsequent visualization. To access and see the data stored on the cloud server, front-end web and desktop applications were created. The data is processed and saved on the cloud server for subsequent visualization. To access and visualize the data, front-end web and desktop applications were built. Data from the IoT modules is collected using four sensors coupled to an Arduino Uno board. This module provides data to LoRa gateways, which then upload it to the internet of things. In this technology, sensors collect data and communicate it directly to the Web server. Alternative technologies, such as WLAN/Wi-Fi, can be utilized instead of LoRaWAN in this strategy. Even in this case, the protocol's capability of long-range communication and low-power consumption properties are appealing. Data from gateways is collected and monitored on the monitoring website for further analysis. The web server saves all sensor data, not only the violated data (data that is outside of the usual range). This choice was taken to create further trust, as well as to improve the application's functioning by having all of the data needed to monitor every country and city in the globe based on pollution generation and standard levels. We designed a web page to display the pollution statistics in order to visualize the data. The data was stored on a local server and made available for use in on-site and mobile apps. The system displays the pollutant rates together with a risk assessment. They will also be aware of the relative amounts of various gases in the atmosphere. This system gives precise information that has been tested in both the interior and outdoor environment in order to detect the quality of gases in the air that create pollution and, as a result, to take measures to eliminate those sources. The system will offer data at the lowest possible cost. The user interface is easy to use and comprehend. The data will be updated every minute by the system from various locations.

By building a wireless sensor network to deliver information, this system can detect and categorize pollutants. It needs eliminating the shortcomings of earlier measurement systems in terms of employing technology between network components. This sort of network may be created in the past, but due to the limitations of wireless transmission, many gateways are required. To assess pollution in real time, all nodes were placed at varied distances. Data is gathered once per minute from the gateway's public and collected nodes. The data was gathered and saved in a text file that represented the database on the hard disc before being sent to end-users through a local server.

Result and Discussion:

On the basis of security, reliability, scalability, and accessibility, the suggested PMS must be evaluated on three separate elements of the employing communication protocol and overall functioning. Cost effectiveness and dependability are offered with data transfer security in this solution, which includes the LoRa gateway. The data received by the gateways from sensors was lower in this scenario than in previous systems. As a consequence, the data made available in the public domain maintains its integrity and correctness. The reliability of this strategy, in which the web server logs all of the data flowing from sensor nodes in order to provide a more comprehensive analysis on the web server. The suggested PMS's scalability may be separated into three categories: back-end (LoRa scalability), front-end (Web Server scalability), and sensors (e.g., number of sensors). By changing the amount of data fields in the existing model, the number of sensors in/and sensor nodes may be simply modified depending on the requirements without impacting the logic of the current arrangement.

In terms of the proposed PMS's power usage, the entire sensor node system employs four sensors and is powered by an 18 V battery to start up and transmit data over the LoRa network. The total power consumption of the sensor nodes must be separated into data transmission and sensing (collecting) power consumption.

Figure 4: Field Charts

In terms of data transfer, LoRaWAN allows for energy-efficient communication. The majority of power consumption is directly related to the number of sensors and their power consumption, which narrows down the key power consuming portions of the PMS as Sensors and Arduino Uno. By building a wireless sensor network to deliver information, this system is capable of detecting and categorizing pollutants. It needs eliminating the shortcomings of earlier measurement systems in terms of employing wireless communication technologies between network components. This sort of network may be created in the past, but due to the limitations of wireless transmission, many gateways are required. To assess pollution in real time, all nodes were placed at varied distances. Data is gathered once per minute from the gateway's public and collected nodes. The data was gathered and saved in a text file that represented the database on the hard disc before being sent to end-users through a local server.

Conclusion:

This paper introduces a low-power, long-range communication enabled, automated, and decentralized IoT pollution monitoring system that uses the LoRaWAN communication protocol for long-range and low-power communication. This facilitates communication with IoT sensors in remote locations. This paper describes the creation of a LoRa-based, scalable, low-cost, and low-power sensor network for real-time air quality monitoring and detection of gas leakage incidents. By simply registering nodes on the cloud server application, the network of hot-plugging nodes allows for continuous operation and easy growth. This technique solves the requirement for IoT sensor nodes to install web server applications, which is typically not achievable due to the limited space, compute power, and energy resources available. The suggested PMS provides a technique in which all information from sensor nodes is received by the LoRa sensor network as well as the Web server. The methods used in this PMS allow users to access data collected automatically by IoT devices. This information can be used as proof of contamination in the monitored region. According to the TTN network's coverage, this PMS may be utilized in a variety of nations. On this PMS, evaluations of different aspects show that using the LoRaWAN has advantages. This study proposes a LoRa-based pollution monitoring system that is integrated with IoT-enabled air quality monitoring equipment. Using air quality monitoring devices and publicly available information, the method was tested.

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