International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified ⁂ Impact Factor 8.102 ⁂ Vol. 12, Issue 4, April 2023
DOI: 10.17148/IJARCCE.2023.12478

Smart Environmental Monitoring via LoRa-Enabled IoT Solutions

Sakshi Ganvir[1], Pranay Madavi[2], Nikita Sawarkar[3], Kajal Chahande[4], R.B. Khule[5]

Department of Electronics Engineering, K.D.K. College of Engineering, Nagpur, India[1-5]

Abstract: The objective of this paper is to introduce an environmental monitoring system that employs LoRa technology for wireless communication in IoT-based applications. The system is specifically designed to gather environmental data such as temperature and humidity from rural areas and transmit it to a central server for analysis and visualization. The system comprises three major components, namely, sensor nodes, a LoRa gateway, and a cloud-based server. Sensor nodes are installed at specific locations and equipped with sensors to collect environmental data. The data is transmitted wirelessly to the LoRa gateway through LoRa technology. Acting as an intermediary between the sensor nodes and the cloud-based server, the LoRa gateway receives and forwards the collected data to the server over the internet. Once the data reaches the cloud-based server, it is processed and analyzed. The proposed system offers several advantages, such as low power consumption, long-range wireless communication, and support for a large number of devices, and it can be used in various applications.

Keywords: Battery, TP4056, Solar Panel, ESP8266, DHT11, LoRa SX1278, OLED Display, IoT.

I. INTRODUCTION

The Internet of Things (IoT) has revolutionized how we interact with the world, particularly in the context of environmental monitoring. However, internet dependency limits the utility of IoT-based technologies when network infrastructure such as GSM, CDMA, or LTE is unavailable. To address this issue, we propose a wireless sensor network architecture that operates without internet connectivity. The architecture includes sensor nodes and a gateway and enables efficient transmission of sensor data over a wide range without relying on the internet.

This paper presents a detailed study of an IoT-based environmental monitoring system that utilizes LoRa (Long Range) technology. LoRa technology is a low-power, long-range wireless communication technology that is well-suited for IoT-based environmental monitoring systems. Our proposed system employs a network of wireless sensor nodes capable of measuring various environmental parameters, such as temperature and humidity. The wireless sensor network includes a LoRa module that serves as the backbone of the system. This module, along with a microcontroller (ESP8266), transceiver, sensors (DHT11), and power source, makes the system suitable for remote data access in locations such as rural areas, forests, highways, and surveillance and monitoring applications. The system's low power consumption is an additional feature. The sensor nodes transmit the collected data to a central gateway using the LoRaWAN (LoRa Wide Area Network) protocol, and the gateway then processes and sends the data to the cloud for further analysis.

This paper outlines the design and implementation of an IoT-based environmental monitoring system that employs LoRa technology. We comprehensively evaluate the system's performance, including its accuracy, reliability, and power consumption. Our findings demonstrate that the proposed system is a viable solution for real-time environmental monitoring applications, with potential applications in domains such as agriculture, smart cities, and industrial monitoring.

II. RELATED WORKS

Olakunle Elijah, Sharul Kamal Abdul Rahim, Vitawat Sittakul, Ahmed m. al-Samman, Michael Cheffena, Jafri Bin Din, and Abdul Rahman Tharek **"Effect of Weather Condition on LoRa IoT Communication Technology in a Tropical Region: Malaysia"** In IEEE Access, Volume.9 ,2021 [1]

The research paper titled "Effect of Weather Condition on LoRa IoT Communication Technology in a Tropical Region: Malaysia" was published in IEEE Access on May 6, 2021. The paper's authors, including Olakunle Elijah, Sharul Kamal Abdul Rahim, Vitawat Sittakul, Ahmed M. Al-Samman, Michael Cheffena, Jafri Bin Din, and Abdul Rahman Tharek, investigate how weather conditions in tropical regions impact the LoRa link in a LoRaWAN setup. The study examines the influence of several environmental factors, such as onboard and atmospheric temperature, relative humidity, and solar radiation, on the LoRa communication link. Furthermore, the paper includes an analysis of how rainfall conditions affect the LoRa link.

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified ⁜ Impact Factor 8.102 ⁜ Vol. 12, Issue 4, April 2023
DOI: 10.17148/IJARCCE.2023.12478

Syazwan Essa, Rafidah Petra, M. Rakib Uddin, Wida Susanty Haji Suhaili, Nur Ikram Ilmi **"IoT-Based Environmental Monitoring System for Brunei Peat Swamp Forest"** In International Conference on Computer Science and Its Application in Agriculture (ICOSICA),2020 [2]

The research paper mentioned above focuses on the development of an IoT-based environmental monitoring system for the Brunei Peat Swamp Forest. The forest is highly vulnerable to forest fires, especially during the hot and dry seasons, which can spread rapidly and pose a significant threat to the ecosystem. To mitigate the impact of forest fires, an IoT-based monitoring system is proposed, which comprises sensor nodes that gather data on critical parameters such as temperature, water level, and soil moisture. The data collected is then transmitted via a gateway and can be monitored in real-time on a dashboard. To ensure data accuracy, the water level sensor underwent several software tests before deployment, and in-house testing confirmed that each sensor node could collect and transmit data to the dashboard, which can be viewed remotely by the public. By implementing this monitoring system, it is possible to achieve better data collection, coordination, and decision- making, which can help to reduce the consequences of forest fires. The collected data can be used to detect changes in temperature, water level, and soil moisture in real time, which can help forest managers take timely and effective measures to minimize the risk of forest fires and protect the ecosystem. The proposed technology thus has the potential to play a significant role in forest fire prevention and control.

V.Raju, Mrs.T.Surya Kavitha**, "An Environmental Pollution Monitoring System using LoRa"** Published in International Journal Of Technical & Scientific Research -Vol.6, Issue II, 2017 [7]

The paper discusses the inadequacies of present automated environmental pollution monitoring systems and presents a newly proposed system that addresses those shortcomings. While conventional systems are expensive, complex, and stationary, the new system is more accurate, cost-effective, compact, and portable. Its design is optimized for monitoring toxic gases in remote or challenging locations, which makes it ideal for farmers and site operators in such areas. A key advantage of the proposed system is that it provides real-time toxic gas values, which can be monitored continuously on a personal computer. This enables professionals to supervise and monitor environmental pollution in remote locations and provides a feasible solution for those struggling to gather data from their required remote areas. Overall, the proposed environmental pollution monitoring system is a smarter, more efficient, and cost-effective solution to the limitations of traditional systems. Its portability, compactness, and real-time monitoring features make it a highly desirable option for individuals who need accurate and continuous monitoring of toxic gases in remote locations.

Zhi-Yang Su, Yi-Nang Lin, Victor R. L. Shen **"Intelligent Environmental Monitoring System based on LoRa Long Range Technology"** Published in IEEE Eurasia Conference in 2019. [6]

The research paper titled "Intelligent Environmental Monitoring System based on LoRa Long Range Technology" was published in the IEEE Eurasia Conference in 2019. The authors of the paper are Zhi-Yang Su, Yi-Nang Lin, and Victor R. L. Shen. The main aim of the research is to develop an effective environmental monitoring system using Long Range (LoRa) transmission technology that consumes less power. The system will be implemented in a densely populated large-scale campus and will use sensors placed at different locations to collect data on various environmental parameters such as temperature, humidity, suspended particles, carbon monoxide, carbon dioxide, wind speed, apparent temperature, and ultraviolet light in both indoor and outdoor environments. The transmission technology used will be LoRa 915 MHz, which will utilize the transmission module LRM001 developed by Liyatech. An industrial computer will serve as the Gateway, and the data from different detection points will be analyzed through C# Windows Forms. Hourly data will be uploaded to Microsoft Azure SQL Server, and the Server end will use ASP.NET technology to publish the website with the assistance of Google Map API to display the different detection stations' locations. This will enable users to investigate the environmental quality trend and carry out further analysis using Big Data.

III. METHODOLOGY

In this research we have developed an IoT based model for Environmental monitoring system.

The monitoring parameters are as follows:

1. Temperature Monitoring
2. Humidity Monitoring

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

ISO 3297:2007 Certified ⁜ Impact Factor 8.102 ⁜ Vol. 12, Issue 4, April 2023

DOI: 10.17148/IJARCCE.2023.12478

BLOCK DIAGRAM:

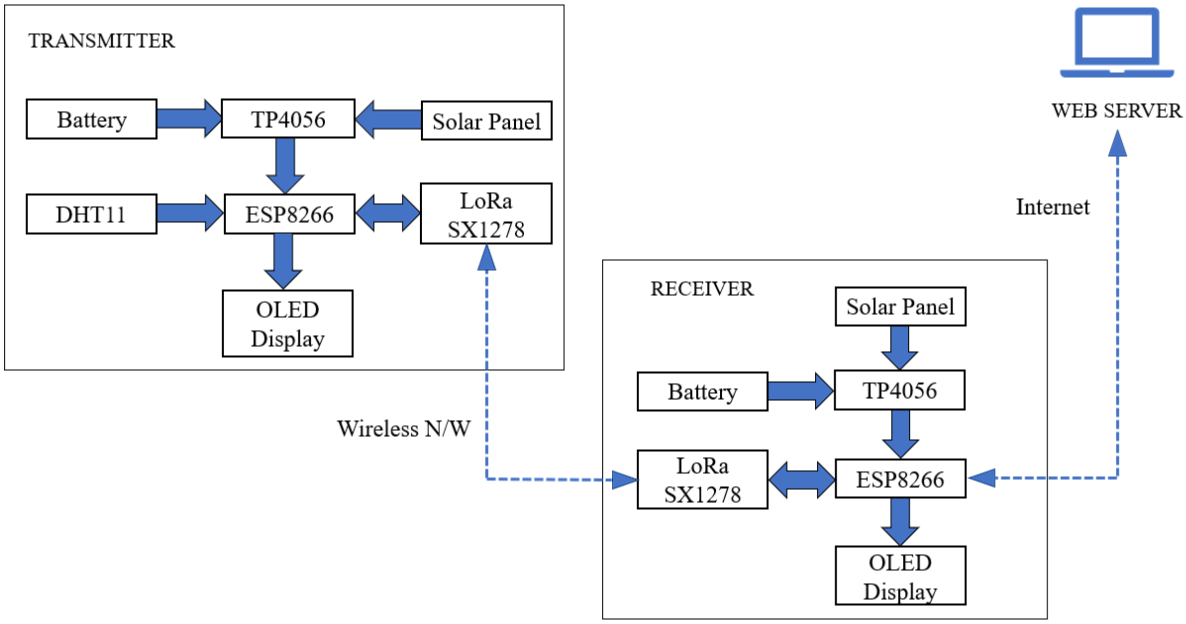

Fig.1 Block Diagram of the System

The following block diagram provides a detailed explanation of the intricate process involved in transmitting data from a sensor deployed in the environment to a cloud or web server through a LoRa (Long Range) communication system. The transmission process commences with the deployment of a sensor in the environment to collect relevant data. The sensor (DHT11) is specifically designed to detect temperature and humidity levels, and it does this by continuously monitoring changes in the surrounding environment and converting them into electrical signals that are then channeled into a microcontroller, in this case, the ESP8266.

The microcontroller, which can be described as a small computer capable of processing data and controlling other devices, then receives the data from the sensor and prepares it for transmission. The next stage in the data transmission process involves the use of a transmitter, which is typically a LoRa transmitter in this case. LoRa technology is a wireless communication protocol that is uniquely designed to enable long-range transmissions with low power consumption. Thus, the transmitter takes the data from the microcontroller and sends it to the LoRa network, a collection of gateways responsible for receiving the data from the transmitter and relaying it to the cloud or web server.

LoRa technology is an ideal communication system for transmitting data over long distances, and it is especially useful in environments where traditional wireless technologies may not work. Once the cloud or web server receives the transmitted data, it is processed, analyzed, and stored for future reference. The data can be used for various purposes, such as monitoring the environment, tracking assets, and analyzing user behavior patterns, among others. Therefore, the transmission process described above is a crucial aspect of modern-day data collection and management, enabling organizations to make informed decisions based on accurate and real-time data.

HARDWARE DISCRIPTION:

ESP8266 – NodeMCU :

Fig.2 ESP8266

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

ISO 3297:2007 Certified ⧖ Impact Factor 8.102 ⧖ Vol. 12, Issue 4, April 2023

DOI: 10.17148/IJARCCE.2023.12478

The ESP8266-NodeMCU is an affordable microchip manufactured by Espressif Systems in Shanghai, China, which enables microcontrollers to connect to Wi-Fi networks and establish basic Transmission Control Protocol/Internet Protocol connections. This compact module is designed with a 64 KiB boot ROM, 80 KiB of user data RAM, and 32 KiB of instruction RAM pre-installed for optimal performance.. It supports Wi-Fi 802.11 b/g/n operating around 2.4 GHz, along with 16 GPIO, Inter-Integrated Circuit (I²C), Serial Peripheral Interface (SPI), 10-bit ADC, and I²S interfaces with DMA. This module has the capability to access external QSPI flash memory through SPI, which supports up to 16 MiB for enhanced storage. Additionally, the module is equipped with a 512 KiB to 4 MiB of built-in memory to further enhance its performance.

LoRa Module Ra-02 SX1278 :

Fig.3 LoRa Module

The Ra-02 is a transmission module that utilizes SEMTECH's SX1278 wireless transceiver to establish wireless connections. It uses advanced LoRa spread spectrum technology and can communicate up to a distance of 10,000 meters (10 km). The module is resistant to jamming and features air wake-up consumption. The SX1278 RF module is designed primarily for long-range spread spectrum communication, and it can minimize current consumption.

DHT11 Sensor :

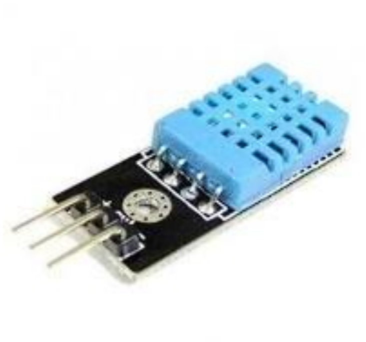

Fig.4 DHT11 Sensor

The DHT11 is an affordable, basic digital sensor that measures both temperature and humidity. It relies on a capacitive humidity sensor and a thermistor to detect the temperature and humidity of the surrounding air, and provides a digital output on the data pin, thereby eliminating the need for analog input pins. Although it is straightforward to use, accurate timing is necessary to obtain data.

The sensor is outfitted with a top-of-the-line resistive-type humidity measurement component, as well as an NTC temperature measurement component. It seamlessly interfaces with a high-performance 8-bit microcontroller, ensuring exceptional quality and rapid response times., anti-interference capabilities, and cost-effectiveness. Each DHT11 component undergoes strict laboratory calibration to guarantee highly precise humidity measurements.

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified ⁜ Impact Factor 8.102 ⁜ Vol. 12, Issue 4, April 2023
DOI: 10.17148/IJARCCE.2023.12478

OLED Display :

Fig.5 OLED Display

These displays are small, measuring only around 1 inch diagonally, but they are highly legible thanks to the high contrast of OLED technology. The display features a high-resolution 128x64 array of individual white OLED pixels, with each pixel controllable by the integrated controller chip. With its self-illuminating technology, the display eliminates the need for a backlight.. This reduces the power consumption of the OLED and explains why the display has such high contrast. The breakout is compatible with both SPI and I2C interfaces, with the interface selected by soldering two jumpers on the back. The design is fully 5V-ready, complete with an onboard regulator and built-in boost converter. Connecting directly to your 3V or 5V microcontroller has never been easier.

Lithium-Ion Battery :

Fig.6 Lithium-Ion Battery

The 18650 Battery is a reliable and rechargeable lithium-ion cell, widely utilized in a broad range of portable power devices such as laptop battery packs, flashlights, cordless tools, and electric vehicles. Its model number denotes the battery's physical dimensions, with the fifth digit indicating that it is a cylindrical cell, ensuring optimal compatibility with a variety of devices..

Measuring 18mm in diameter and 65mm in length, this battery is equipped with an internal protection circuit and can reach a maximum voltage of 4.1V when fully charged. As the battery discharges, lithium ions travel from the negative electrode through the electrolyte to the positive electrode, and this process is reversed during charging, allowing for the battery to be recharged and used repeatedly.

These batteries use an intercalated lithium compound as the positive electrode material and typically graphite as the negative electrode material. Lithium-ion batteries boast a remarkably high energy density, exhibit minimal self-discharge, and are not susceptible to memory effect (with the exception of LFP cells), allowing them to retain their full capacity for longer periods of time.

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified ⪤ Impact Factor 8.102 ⪤ Vol. 12, Issue 4, April 2023
DOI: 10.17148/IJARCCE.2023.12478

Solar Panel :

Fig.7 Solar Panel

Instead of relying on an AC power supply, we are powering this hardware with a Lithium-ion battery. To charge the battery, we are using a 4V/1A solar panel along with the TP4056 charging module. We chose a solar panel with a small size to match the maximum charging current of the TP4056, which is 1Amp. It's important to note that the solar panel is not the primary power source for the hardware. Its sole purpose is to charge the battery.

TP4056 Charging module :

Fig.8 TP4056 Charging Module

The TP4056 is a highly efficient charging module specifically designed for 3.7V Lithium-ion cells. While it's possible to recharge any rechargeable battery by applying the right voltage and current, doing so without proper control can lead to overcharging and damage. To ensure better efficiency and durability, we opted to use the TP4056 charging module. This low- cost module is reliable and offers protection against overcharging. It features an automatic cut-off mechanism that stops charging the battery once it's fully charged, as well as a safety mechanism that disconnects charging if the battery temperature rises too high. This charging module is suitable for charging single-cell lithium batteries using the constant current/constant voltage charging method.

IV. WORKING

In our Proposed System we have to develop low powered IoT device to transfer data from non-network area like Rural Areas, Forests, etc. to Cloud. Here we will create a WSN to fulfill Problem Statement. There will be a total 2 Modules in our Project. Module 1 will be the sender who will sense information from respective sensors & processed by using Microcontroller using ESP8266. This sensor information will transmit using LoRa (Long Range) module to another LoRa (Receiver) which is also called as Gateway. The Microcontroller ESP8266 on receiver side will receive data through LoRa & then transmit over the Internet to Cloud using GSM Technology or WiFi Technology by providing Internet. Further we will analyze the stored data from the Database using Web Application.

On both Transmitter & Receiver side we have connected low power OLED Display to display real-time status. Due to non- availability of Power Source at Transmitter Side we will power up using Solar Panel, Charge Controller & Battery. Solar Panel will be Small Size 4V & Charge Controller will be TP4056. Battery Rating 2200mAh depends on the power consumption.

DOI: 10.17148/IJARCCE.2023.12478

ADVANTAGES:

There are some advantages to using Smart Environmental Monitoring via LoRa-Enabled IoT Solutions:

1. Long Range
2. Low Power
3. High Scalability
4. Real time data monitoring
5. Cost effective
6. Data analytics

V. CONCLUSION

In summary, the IoT-based environmental monitoring system utilizing LoRa technology offers numerous benefits, including long-range connectivity, low power consumption, high scalability, real-time data collection, and cost-effectiveness.

It has been demonstrated to be a reliable and effective solution for monitoring a variety of environmental factors, providing valuable insights that can inform decision-making and environmental management practices. However, as with any technology, there are also potential drawbacks, such as limited bandwidth, interference, limited security features, distance limitations, limited functionality, dependence on gateway infrastructure, and reliance on battery power.

Despite these limitations, the results of this research demonstrate that the advantages of using LoRa technology in IoT-based environmental monitoring systems outweigh the disadvantages. The system is well-suited for deployment in remote areas where traditional infrastructure is not available, and it offers the flexibility and scalability necessary to monitor large areas effectively. Furthermore, it can operate for long periods on a single battery charge, reducing the need for frequent maintenance or replacement.

Overall, the IoT-based environmental monitoring system using LoRa technology represents a significant step forward in our ability to monitor and manage the environment. It offers a powerful tool for environmental scientists, policymakers, and other stakeholders to collect and analyze real-time data, inform decision-making processes, and take action to protect our natural resources.

Future research can continue to explore and develop this technology, further enhancing its capabilities and potential impact on environmental management practices.

REFERENCES

[1] Olakunle Elijah, et al Effect of Weather Condition on LoRa loT Communication Technology in a Tropical Region Malaysia" Institute of Electrical And Electronics Engineers (IEEE), 2021
[2] Syazwan Essa, Rafidah Petra, M. Rakib Uddin, et al."loT-Based Environmental Monitoring System for Brunei Peat Swamp Forest International Conference on Computer Science and Its Appli cation in Agriculture (ICOSICA), 2020
[3] N. Jeftenic, M. Simic, and Z. Stamenkovic, "Impact of environmental parameters on SNR and RSS in LoRaWAN," in Proc. Int. Conf. Electr, Commun, Comput. Eng (ICECCE), Jun. 2020, pp. 1-6
[4] A. M. Al-Saman, M. Cheffena, M. Mohamed. M. H. Azmi, and Y At. "Statistical analysis of rain at millimeter waves in tropical area," IEEE Access, vol. 8, pp. 51044-51061, 2020
[5] Detecting Forest Fires using Wireless Sensor Networks with Waspmote | Libelium" [Online].Available:http://www.libelium.com/wireless semor_networks to detect for forest fires/ [Accessed: 15-Apr-2020]
[6] Zhi-Yang Su, et al. "Intelligent Environmental Monitoring Sys tem based on LoRa Long Range Technology" IEEE Eurasia Conference on 10T, Communication and Engineering, 2019
[7] V.Raju, Mrs. T.Surya Kavitha. "An Environmental Pollution Monitoring System Using LoRa" International Journal of Technical & Scientific Research (UTSR)VoL6, Issue II, 2017
[8] D. Hasan, U. Ratnayake, and S. Shams, 'Evaluation of rainfall and temperature trends in Brunei Darussalam, AIP Conf. Proc., vol. 1705, no. February, 2016
[9] DYaswanth. Dr Syed Kumar "A Study on Pollution Monitoring System in Wireless Semor Network" UCSET, Volume 3, Isnie-9, ISNN 324-328, 2013

International Journal of Advanced Research in Computer and Communication Engineering

ISO 3297:2007 Certified ⁜ Impact Factor 8.102 ⁜ Vol. 12, Issue 4, April 2023

DOI: 10.17148/IJARCCE.2023.12478

[10] Isha Gupta, Rashpinder Kaut "Design ans Development of Industrial Pollution Control System Using LABVIEW" 11ATCET, Volume 2, Issue 11, 2013

[11] HY Lam, L Luini, J Din, C Capsoni, and A. D. Panagopoulos, "Investigation of rain attenuation in equatorial kuala lumpur," IEEE Antennas Wireless Propag Lett vol. 11. pp 1002-1005, 2012

[12] L. S. Kumar, Y Hui Lee and J. Teong Ong. Truncated gamma drop size distribution models for rain attenuation in Singapore," IEEE Trans. Antennas Propag vol. 58, no. 4, pp. 1325-1335, Apr 2010.

[13] M Marzuki, T. Kozu, T. Shimomar, W L Randes, H. Hashiguchi, and Y Shibagaki, Diurnal variation of rain attenuation obtained from measurement of raindrop size distribution in equatorial Indonesia," IEEE Trans Antennas Propag., vol. 57, no. 4 pp. 1191-1196, Apr. 2009.

[14] O.A Postolache, IM Dias Pereira "Smart Semors Network for Air Quality Monitoring Applications" IEEE Transaction on Instrumentation and Measurement, 2006

[15] Son, Y Her, and J. Kim. A design and implementation of forestfires surveillance system based on wireless sensor networks for South Korea mountains, Int. 1. Comput. Sei. Netw Secur, vol. 6, no. 9, pp. 124-130, 2006.