Building a Peer to Peer Channel Using LoRa

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Abstract— **This paper presents a comprehensive guide to building a peer-to-peer communication channel using LoRa technology. Here forest fire detection system is used as an application. The system integrates flame sensor and temperature sensor with LoRa for real-time data transmission. It offers a cost-effective solution for monitoring remote areas. The paper discusses system architecture, sensor selection, and LoRa configurations. It emphasizes reliability and robustness through redundancy. Field tests illustrate the system's effectiveness in real-world scenarios. This research provides a practical solution for early forest fire detection using LoRa, contributing to IoT in environmental monitoring and emergency response.**

Keywords—Flame sensor, temperature sensor (LM35), LoRa module (SX1276), sensor-based forest fire detection system using LoRa, peer to peer LoRa channel, STM32 F4 series(nucleo64) Interfaced.

I. Introduction

In recent years, the advancement of Internet of Things (IoT) technologies has opened new avenues for addressing critical environmental and safety concerns. Among these concerns, the early detection and mitigation of forest fires stand as a pressing challenge, particularly in remote and environmentally sensitive areas. This paper explores a novel approach to tackle this issue by presenting a comprehensive guide to building a peer-to-peer communication channel using LoRa (Long Range) technology for forest fire detection.

The combination of LoRa technology with the imperative task of forest fire detection addresses a crucial need in environmental monitoring and emergency response. Traditional fire detection systems often rely on centralized network infrastructure or cellular communication, which can be unreliable or even non-existent in remote forested regions. LoRa technology, known for its long-range coverage and low-power characteristics, offers an ideal solution for communicating vital data from fire sensors in these challenging environments.

The LoRa spread spectrum is a patented modulation developed by Semtech [1] based on the chirp spread spectrum (CSS) modulation. Chirp spread spectrum (CSS) modulation maintains the same low-power characteristics as FSK modulation. It is a spread spectrum technique that uses wideband linear frequency-modulated chirp pulses to encode information. CSS was developed for radar applications in the 1940s. It has been used in military and space communications for decades because of its long communication distances, low transmission power requirements, and less interference.

LoraWAN network is responsible for the communication protocol of the LoRa system which includes ensuring the security and integrity of the data being communicated via the LoRa technology. The LoRaWAN' has a network architecture of a star topological connection structure. LoRaWAN corresponds to Media Access protocol for the communication network while LoRa corresponds to the Physical layer.

LoRa (short for "long range") provides long-range and low-power consumption, a low data rate, and secure data transmission. LoRa can be used with public, private, or hybrid networks to achieve a greater range than cellular networks. LoRa technology can easily integrate with existing networks and enables low-cost, battery-operated Internet of Things (IoT) applications.

II. Literature Survey

[2] Wireless sensor networks (WSNs) have been widely employed in forest fire detection systems to enhance early warning, monitoring, and response efforts. In this proposed detection system WSNs are deployed according to cellular architecture to cover the entire area with sensors to monitor temperature, humidity, CO levels using a microcontroller, transceiver module and power components. Sensor nodes are dispersed throughout the forest at strategic locations. Common sensors used include temperature sensors, humidity sensors, smoke detectors, and sometimes cameras for visual monitoring. The sensor nodes continuously collect environmental data such as temperature, humidity, and smoke levels. This data is then transmitted wirelessly to a central control unit or a base station for processing and analysis. The collected data is processed and analyzed to identify abnormal patterns or conditions that may indicate the presence of a fire. When the system detects a potential forest fire, it triggers an alarm or alert.

[3] Satellite-based Forest fire detection systems play a crucial role in monitoring and mitigating forest fires. Earth-observing satellites equipped with various sensors are used to monitor the Earth's surface. These sensors can capture data in different wavelengths, including visible, infrared, and thermal infrared, which are essential for detecting and tracking fires. Advanced algorithms are employed to process satellite data and identify potential fire hotspots. Thermal infrared sensors on satellites are particularly effective at detecting fires. Satellite-based fire detection systems often integrate with ground-based weather stations, remote cameras, and other sensor networks to improve the accuracy of fire detection and provide additional context. Once a potential fire is detected or an existing fire is monitored, automated alerts are generated and sent to relevant authorities, such as firefighting agencies. These alerts include information about the fire's location, size, and potential growth.

[4] Optical sensors and digital cameras are commonly used in forest fire detection systems to visually monitor and detect fires. These sensors and cameras capture images or video footage of the environment and can be integrated into a broader monitoring and alert system. These sensors, such as

digital cameras, are used to capture images and video footage of the forested area. These devices continuously monitor the environment and capture visual data at specified intervals. They can identify smoke, flames, or other visible indicators of a fire in the images. Algorithms analyze the images to identify and track the presence of smoke, which is an early indicator of a potential fire. To enhance the accuracy of fire detection, data from optical sensors and cameras can be integrated with weather information, including wind speed and direction, humidity levels, and temperature. When a potential fire is detected, the system can generate alerts and notifications that are sent to relevant authorities.

[5] Unmanned Aerial Vehicles (UAVs), commonly known as drones, are increasingly being used for forest fire detection and management. These remotely piloted aircraft can provide real-time data and imagery that is invaluable for early fire detection, monitoring, and response. They are equipped with cameras and other sensors that provide an aerial view of the forested area. In addition to fire detection, they can also monitor air quality by measuring particulate matter and other pollutants. This data can be useful for assessing the impact of the fire on the environment and public health. UAVs often use GPS for precise positioning and can be integrated with Geographic Information Systems (GIS) to provide accurate location data. This helps in mapping the fire's location and predicting its potential path. Advanced computer vision and image analysis algorithms can be applied to the data captured by UAVs to detect and track fire hotspots, smoke patterns, and changes in the fire's behavior. After the fire is contained, UAVs can be used to assess the damage, evaluate the impact on the ecosystem, and plan post-fire recovery efforts.

[6] The system architecture consists of embedded systems and soil sensors on Soil Monitoring Nodes that provide data to the Cluster Head (CH) using Wi-Fi. Using Wi-Fi and LoRa, the CH acts as a relay point for data, expanding the reach of data beyond 100 meters. Environmental data is gathered by the Environment Monitoring Aggregator Node and sent to the Gateway, which may entail a number of LoRa gateways. In order to control irrigation, the Aggregator Node also interacts with Actuator Nodes. Data is sent over Ethernet to the Data Center for analysis and storage. Comprehensive garden condition monitoring in a variety of urban and green settings is made possible by this architecture.

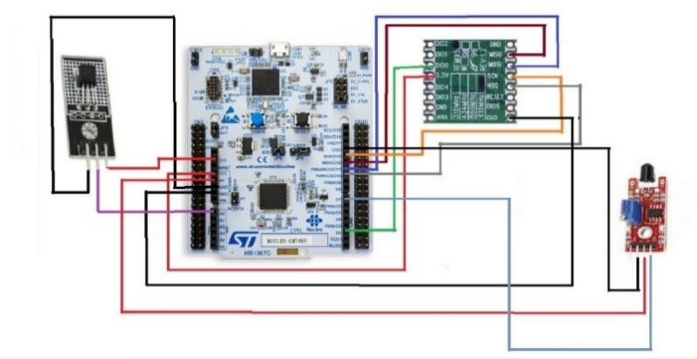
[7] In this system there are three main sensors that have been selected as detection methods for this research which are IR beam detection and geophone seismic sensor detection and microwave Radar sensors. These three detection methods are designed in such a way that they specifically detect elephants from other animals and moving objects such as vehicles and transmit those signals using lora communication (sx1278 module). They have also proposed an improved electric fencing system.

III. METHODOLAGY

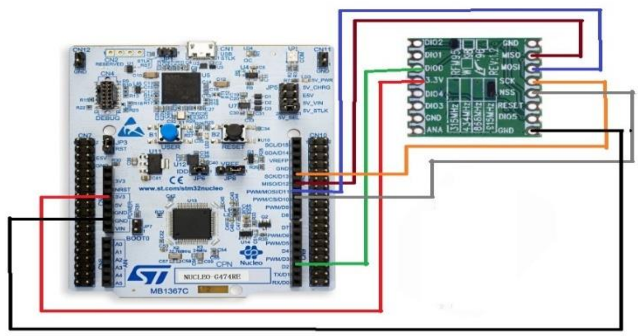
A. Components Required

- LoRa Module (SX1276) x2
- STM32 F4 series board (nucleo64) x2
- Flame Sensor
- Temperature Sensor (LM35)
- Connecting Wires

B. Setting up Hardware



TRANSMITTER SIDE (LORA SENDER)



RECEIVER SIDE (LORA RECEIVER)

The SX1276 LoRa module typically includes a particular set of pins with the following purposes:

An external antenna (ANT) is connected to this pin to provide effective signal transmission and reception. Vcc is the power supply pin, which is typically connected to 3.3V, while Ground is the ground reference. SPI Communication Interface (SCK, MISO, MOSI, NSS/SEL, DIOx): The SX1276 module and a microcontroller communicate using these pins as part of the Serial Peripheral Interface (SPI). The clock signal is known as SCK, while the master out/slave in and master in/slave out pins are known as MISO, MOSI, NSS/SEL, and DIOx pins, respectively. RESET: This pin is used to reset the module. TX and RX: These pins are used for transmitting (TX) and receiving (RX) data. DIOx (Digital Input/Output): These pins are often used for various digital I/O functions. Other I/O pins: There may be more I/O pins for a variety of uses, depending on the module and application.

Usage in LoRa Communication:

MISO, MOSI, and NSS pins are frequently used in LoRa applications for SPI communication between a microcontroller (the master) and a LoRa module (the slave).

To enable setup and the transmission and receipt of LoRa packets, MISO and MOSI enable data interchange between the microcontroller and the LoRa module.

The SPI bus's other devices are kept idle until the LoRa module is chosen for communication via NSS.

The microcontroller can effectively manage LoRa packet transfers and receptions by using the DIO0 pin to handle interrupt-driven communication and LoRa-specific events.

For LoRa communication between a microcontroller and a LoRa module to be implemented properly, it is crucial to comprehend the functions and settings of these pins.

C. *Setting up Software IDE*

INSTALLATION OF STM32 SOFTWARE IN ARDUINO IDE:

The Arduino-STM32 platform package may be used to install STM32 software support in the Arduino IDE, enabling you to interact with and program STM32 microcontrollers. The steps to add STM32 software functionality to the Arduino IDE are as follows:

1. Browse for" **github.com/stm32duino"** >select BoardManagerFiles repository >select and open package_stmmicroelectronics_indexjson.

2.click raw option and then copy the URL.

3. launch Arduino IDE select File ->Preferences -> Additional Boards Manager URLs -> paste the copied link -> ok

4. Tools -> Board -> Boards Manager -> search **STM32** -> Install the STM32 MCU based Boards

You have successfully added STM32 software compatibility to the Arduino IDE. As a result, you can now use the well-known Arduino IDE environment to program and interact with STM32 microcontrollers. Any extra settings or specifications particular to your STM32 board should be found in the documentation for that board.

INSTALLATION OF LORA SOFTWARE IN ARDUINO IDE:

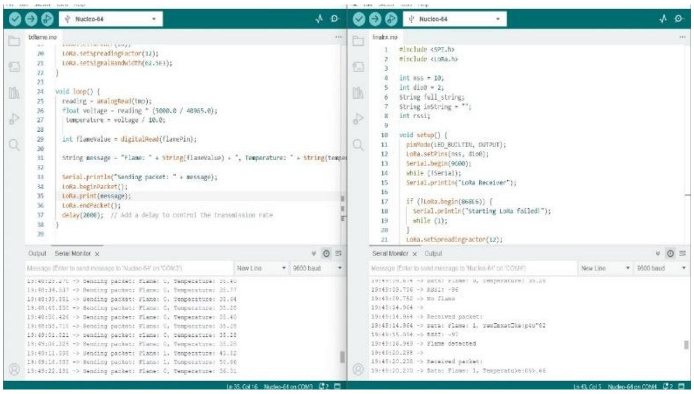
You normally need to include the pertinent library for your LoRa module to install LoRa software functionality in the Arduino IDE. The typical procedures to install LoRa software on an Arduino board are listed below:

1.Launch the Arduino IDE:

2.go to tools>manage libraries and search for lora library by Sandeep Mistry and download the latest version of it.

It is required to access the lora sx1276 module with inbuilt functions.

IV.RESULTS



The result of our proposed system is, it continuously reads the temperature value and when it crosses the threshold it takes the reading of flame sensor. Only if the flame sensor value is high, then the transmitter sends the "Flame detected!" message to the receiver side along with the temperature reading at that moment. We have got rssi in the range of –80 to –90 which is ok. However, we did not get a pretty good range as we haven't installed antenna. We got range only up to a room area I.e., around 200m to 300m.

V.CONCLUSION

In conclusion, our project focused on the development and implementation of a forest fire detection system using the SX1276 LoRa module in conjunction with flame and temperature sensors.

The integration of the SX1276 LoRa module allowed for seamless communication over extended distances, enabling real-time data transmission and alert generation. The flame and temperature sensors played a crucial role in accurately identifying potential fire incidents by monitoring key environmental parameters.

Our results show how this approach is successful at detecting and alerting forest fires early—a necessity for quick action and mitigation measures. The LoRa module is a sustainable option for long-term deployment in remote places because of its low power consumption.

As we move forward, there is potential for further enhancements and scalability of this system, such as incorporating additional environmental sensors and integrating it with existing wildfire management infrastructure. This project serves as a foundation for the development of more advanced forest fire detection systems, ultimately contributing to the preservation of our precious natural resources and the safety of our communities.

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