# LoRa Communication for Image Transmission and Reception

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March 5, 2025

## Introduction

This paper presents a system for transmitting and receiving images using LoRa (Long Range) communication with Raspberry Pi Zero devices equipped with SX1276 LoRa modules. LoRa is a low-power, long-range communication technology that is suitable for applications requiring efficient data transmission over significant distances. In this system, Raspberry Pi devices serve as LoRa nodes, where the transmitter sends image data, and the receivers reconstruct the image from received packets.

The process involves converting an image into smaller packets, transmitting them over LoRa, and reconstructing the image on the receiver side. This system is optimized for low-power and long-range communication, making it suitable for remote and IoT applications. The first transmission method uses a single frequency for communication, while the second method employs two receivers, reducing transmission time by operating on two frequencies simultaneously.

## Single Frequency Transmission (SFT)

In Single Frequency Transmission (SFT), the system consists of a single transmitter and a single receiver. The transmitter splits the image into smaller packets, which are then transmitted sequentially using LoRa. The receiver listens for incoming packets, reconstructs the image, and saves or displays it. Each packet is sent in sequence, and the final packet includes an "ABC" end marker to signal the end of the image data.

The following algorithms describe the process for both the transmitter and the receiver:

### Transmitter Algorithm for SFT

**Algorithm 1** Image Transmitter Algorithm (SFT)

**Initialize** LoRa module with frequency 915 MHz
**Load** image from file "Image_xx.jpg"
**Compress** the image using JPEG with quality 85
**Convert** the image to byte stream
**Set packet size** to 240 bytes
**for** each packet in the byte stream **do**
    **Send** the packet over LoRa
    **Wait** for 1 second to allow receiver processing
**end for**
**Send** final packet with identifier "ABC"
**Exit** transmission loop

### Receiver Algorithm for SFT

**Algorithm 2** Image Receiver Algorithm (SFT)

```
Initialize LoRa module at 915 MHz
Set LoRa mode to receive (RX)
Initialize variable final_data
while True do
    Wait for packets
    Store received data
    Record RSSI values
    if final_data contains "ABC" then
        Reconstruct and save image
        Calculate performance metrics
        Exit receiver loop
    end if
end while
```

## Interleaved Frequency Transmission (IFT)

In Interleaved Frequency Transmission (IFT), the system consists of one transmitter and two receivers operating at different frequencies. The transmitter alternates between two frequencies, 915 MHz for the master receiver and 914.5 MHz for the slave receiver. This allows the master and slave receivers to process different parts of the image data concurrently, reducing the total transmission time.

### Transmitter Algorithm for IFT

**Algorithm 3** Image Transmitter Algorithm (IFT)

```
Initialize LoRa module at 915 MHz
Load image from file "Image_xx.jpg"
Compress the image using JPEG with quality 85
Convert the image to byte stream
Set packet size to 240 bytes
for each packet in the byte stream do
    if packet index is even then
        Set frequency to 915 MHz
    else
        Set frequency to 914.5 MHz
    end if
    Send packet over LoRa
    Wait for 0.5 seconds
end for
Send end marker "ABC" on both frequencies
Exit transmission loop
```

### Master Receiver Algorithm for IFT

**Algorithm 4** Master Receiver Algorithm (IFT)

```
Initialize LoRa module at 915 MHz
Set LoRa mode to receive (RX)
Initialize final_data
while True do
    Wait for packets
    Store received data
    if final_data contains "ABC" then
        Wait for slave data
        Combine received data
        Reconstruct and save image
        Calculate performance metrics
        Exit receiver loop
    end if
end while
```

### Slave Receiver Algorithm for IFT

**Algorithm 5** Slave Receiver Algorithm (IFT)

```
Initialize LoRa module at 914.5 MHz
Set LoRa mode to receive (RX)
Initialize final_data
while True do
    Wait for packets
    Store received data
    if final_data contains "ABC" then
        Send data over UART to master
        Exit receiver loop
    end if
end while
```

## Conclusion

This paper demonstrated two different transmission methods for image transmission using LoRa. The Single Frequency Transmission (SFT) method uses one transmitter and one receiver, while the Interleaved Frequency Transmission (IFT) method employs two receivers working in parallel on different frequencies to reduce transmission time.

IFT significantly improves transmission efficiency by utilizing multiple receivers. Additionally, the introduction of Ready to Receive (RTR) logic ensures reliable data transfer, preventing UART buffer overflow. These optimizations make LoRa-based image transmission more effective for remote sensing and IoT applications.