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Image Transmission Using LoRa Technology with Various Spreading Factors

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Abstract—**With the development of technology, today's Internet of Things (IoT) is not only to read the value of the sensor to monitor the system. The demand for image monitoring is also important. In this paper, we use LoRa (Long Range) technology to transmit the images. LoRa technology is defined on Low Power Wide Area Networks technology (LPWAN) of the IoT. In general, LoRa supports the transmission of small data coming from the sensors. Since it has these features with low power, long distance, low cost and low data rate, transmitting images will spend more time for LoRa. If LoRa transmission can decrease the time to transmit pictures, it will produce a wide range of applications in IoT system. In this paper, we focus on transmitting the image simultaneously with both different SF (Spreading Factor) parameters and antennas for LoRa. In other words, using various SF as the multiplexing method may improve the image transmission time. Through experiments, this method does have less time than that with a single SF. The results show that effective LoRa image transmission is possible.**

Keywords-IoT; LoRa; image; SF (Spreading Factor)

I. Introduction

Today, the technology of the IoT is developing rapidly, and many applications can be found everywhere, including smart homes, logistics management systems, and medical systems, etc. [1-3]. Most applications in IoT use sensors to read physical values, and use wireless communication technologies such as RFID, Bluetooth, Zigbee, WiFi, etc. [4-6] to transmit data. Then, the IoT monitoring systems is established. For the application of large data transmission such as image, only WiFi technology is suitable for its wide bandwidth. However, the high power consumption and short transmission distance make it limited in image transmission.

LoRa technology defined on the LPWAN is characterized by excellent transmission distance and low power consumption. Based on spread spectrum, it is designed using Chirp Spread Spectrum (CSS) modulation technology. Thus, LoRa transmission does not interfere with each other under different SF (Spreading Factor), and low power consumption is achieved. In addition, compared with NB-IoT (Narrow Band IoT) technology, LoRa operates in the ISM radio band, which allows LoRa to save costs in setting up nodes. Therefore, LoRa devices offer the long-distance, low-power and low-cost data transmission advantages for IoT applications [7-8].

So far, the research on the image transmission using LPWAN technology is not common in the IoT because longer time is required for the image transmission. In this paper, we propose a method to improve the development of LoRa image transmission based on simultaneous transmission using various SF parameters. In this design, the image pixel packets are distributed to various sender nodes with different SF nodes for multiplexing transmission to improve the image transmission efficiency. Section II describes LoRa parameter configuration, system design and architecture. Experiments and results are discussed in section III. Finally, the conclusion is shown in section IV.

II. System Design

A. LoRa Parameters

When using LoRa transmission, you need to configure several important basic parameters. Selecting different spreading factors, bandwidth, coding rate and transmission power transmission parameters has an impact on communication performance [9]. Some of the important parameters of LoRa are:

- SF (Spreading Factor): LoRa spreads each symbol using several chips (Spreading Factor: 7~12) to increase the receiver sensitivity. Hence, it determines the transmission distance. A larger SF will improve the sensitivity and increase the transmission distance. However, the longer packets will increase the transmission time. It is a critical challenge for image transmission using LoRa. In addition, the signals with different SF are orthogonal.
- BW (Bandwidth): This parameter determines the packet transmission data rate. Higher BW allows for

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higher data rate, but it also reduce the sensitivity and transmission range.

- CR (Coding Rate): LoRa uses the Forward Error Correction (FEC) to improve the anti-interference ability. The adjustable value is 4/5, 4/6, 4/7 or 4/8. When CR is large, the anti-interference is better, but the packets and transmission time are longer.
- TP (Transmission Power): The basic setting range is adjusted from -4 dBm to 20 dBm. When TP is large, it consumes energy quickly.
- RSSI (Received Signal Strength Indicator): The index describes the received signal power in dBm. For higher RSSI, the received signal is stronger.

B. System Design and Architecture

JPG is an image compression technology and is also a widely used file format. It is characterized by its ability to support full color, grayscale, etc., and the compressed file size is small. The method is destructive compression, and the pixel ratio is compressed to about 1/10. Because the distortion resulting from the method can not be recognized by the human eye, the image quality can still meet the requirements [10].

The basic design of the system uses image with 200×150 pixels and JPG format. The transmission module includes Semtech sx1276 LoRa chip with 5 dBi antenna and Raspberry pi 3 B + used for controlling LoRa transceiver. As shown in Fig. 1, each node is configured with a transceiver module and Raspberry pi 3 B+. The power part is powered by 5V mobile power [11-12].

In order to improve the image transmission time, the image is compressed to JPG format before the transmission. Furthermore, to reduce the transmission load, N to N transceiver structure with N antennas and SFs are proposed. The image packets are allocated to N sender nodes. Then, the N sender nodes simultaneously transmit the allocated packets, and the related N receiver nodes receive the corresponding transmitted packets. The systems with N=1~3 are designed and tested. For example, the system architecture with N=3 is shown in Fig. 1. The left sides are senders node 1, node 3 and node 5. The right sides are receivers node 2, node 4 and node 6. Node 1 corresponds to node 2 with SF=7, node 3 corresponds to node 4 with SF=8, and node 5 corresponds to node 6 with SF=9. First, node 1 compresses the image and then divides it into three parts according to the SF characteristics.

MQTT is a simple internal TCP/IP transmission communication protocol with low data. It is designed for use in IoT applications of regional network with low-bandwidth, low-level hardware and poor network connectivity. The message is delivered to Publish/Subscribe mode, which provides a one-to-many transmission method. The sender can forward the data to all or specific users in Publish mode, and the user can select the received data through subscription [13].

Then, through the MQTT publish/subscribe function, node 1 will individually transmits the pixel packets of the second and third parts to node 3 and node 5. As soon as they receive it, they will directly transmit it to the corresponding receiver. Node 1 will also start to transmit the first part of the pixel packets. In the process of transmission, each LoRa has its own assigned work. Regarding the confirmation mechanism, if the packet is lost, the receiver will request the transmitting end to resend the lost pixels packet. As long as the receiver node 2, node 4 and node 6 complete their receiving. The node 2 will enable the MQTT subscribe function, and the pixel packets received by the receiver node 4 and node 6 will be delivered to node 2. Finally, after the collection of all the image pixel packets by node 2, the entire pixel packets are decoded and restored to the original image.

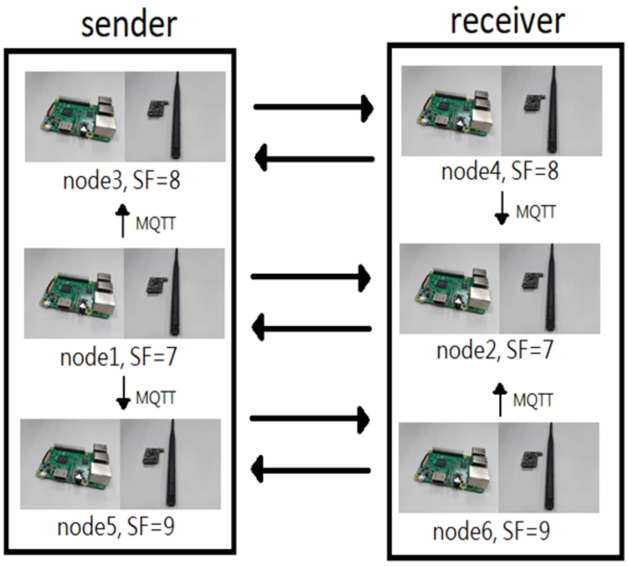


Figure 1. The 3 to 3 LoRa transmission system is shown.

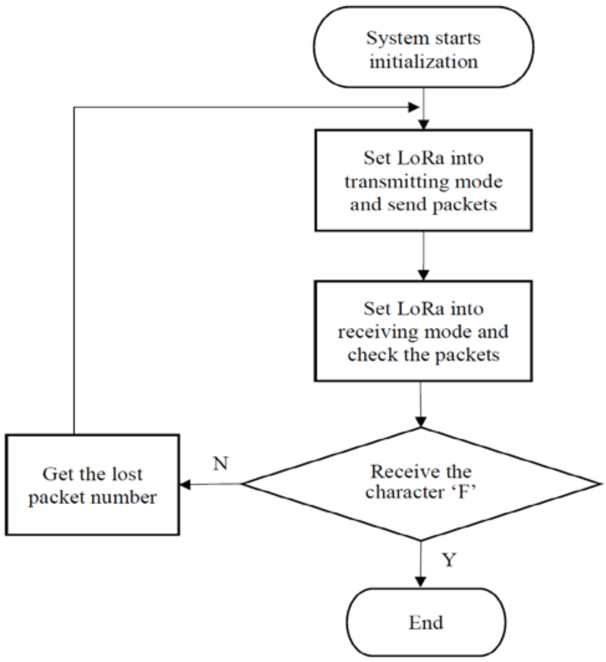


Figure 2. The LoRa transmitting flow chart.

The LoRa transmitting and receiving flow charts are respectively shown in Fig. 2 and Fig. 3. Firstly, the system starts initialization in Fig. 2. Then, set LoRa into transmitting mode and transmit the packets. After the transmission is completed, set into the receiving mode to receive the signal back from the receiver in order to check whether the packets are completely received at receiver. If the sender received the character 'F', that represents the complete reception, and then the system ends. Otherwise, set into trainsmit mode to transfer the lost packet until the character 'F' is received. The receiving mechanism flowchart is shown in Fig. 3. The system starts initialization, sets LoRa into receive mode and receives the packet. After receiving, it is set into transmitting mode to inform the sender whether the packet was lost. If there is loss, the lost packet number will be transmitted, otherwise the transmitted character 'F' representing the complete reception will be sent. The system then exits.

Regarding the quality of the transmitted image, PSNR (Peak Signal-to-Noise Ratio) is widely used as an indicator for image evaluation. In general, if PSNR is closer to infinity, the transmitted image shows the higher similarity and the smaller distortion [14].

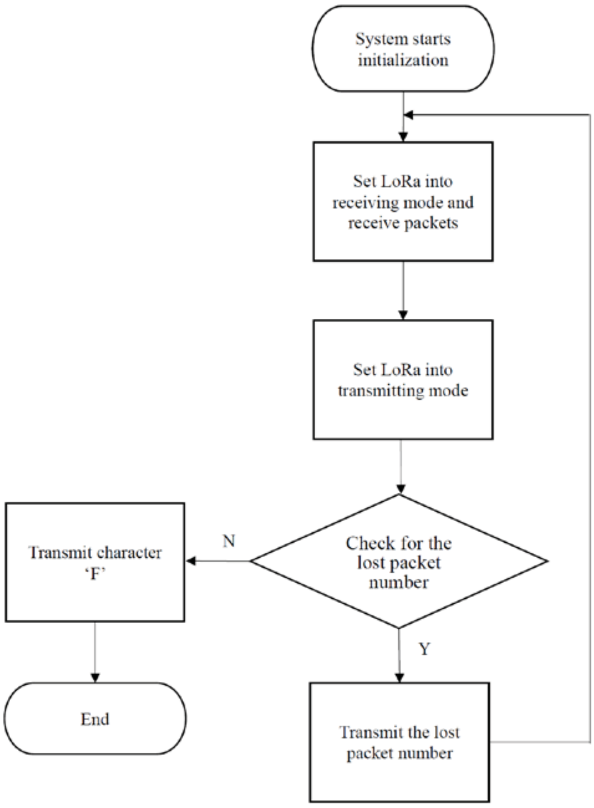


Figure 3. The LoRa receiving flow chart.

III. EXPERIMENT AND RESULT

The sender nodes are placed at the 9th floor of the building in Chaoyang University of Technology, and the receiver nodes are placed near Meiqun Bridge and Zhongxing Road in Dali District, Taichung City, Taiwan. The communication path is the line-of-sight. According to the distance measured by google map, it is about 1.5 kilometers from the sender to the receiver, as shown in Fig. 4.

Some parameters are fixed as BW=500 k (Hz), CR=5 and frequency band is 868 MHz. Since LoRa signals with different SFs are orthogonal, the related receiver nodes will not interfere with each other. Therefore, we set different SFs for LoRa image transmission and evaluation the performance. The original test image is shown in Fig. 5. Fig. 6 shows the practical deployment of the 3 to 3 sender and receiver devices.

A. One-to-One Transmission (1 to 1)

One LoRa transceiver constitutes the sender node, and the other constitutes the receiver node. Both nodes were set with SF=7. Then, the sender transmits 81 packets to the receiver. After the test, the received image is shown in Fig. 7(a), of which RSSI is -97 dBm, PSR (Packet reception Success Rate) = 98%, PSNR=33.84 dB, and transmission time is 48s. The data is shown in TABLE I.

Figure 4. Experimental equipment deployment map.

Figure 5. The original test image.

Figure 6. The practical deployment of the 3 to 3 sender and receiver.

B. Two-to-Two Transmission (2 to 2)

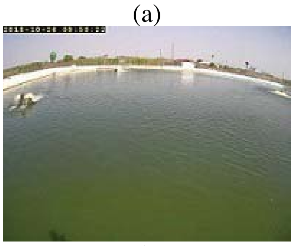
Two LoRa transceiver respectively with SF=7 and 8 constitutes the sender node, and the other two respectively with SF=7 and 8 constitutes the receiver node. The received image is shown in Fig. 7(b). RSSI is respectively -96 and -91 dBm, PSR=95%, 94%, PSNR=Inf dB, and the transmission time is 31s, as shown in Table I.

C. Three-to-Three Transmission (3 to 3)

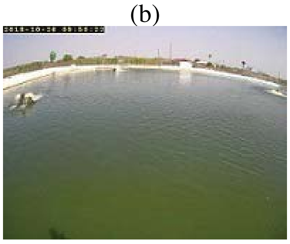
Three LoRa transceiver respectively with SF=7, 8 and 9 constitutes the sender node, and the other three respectively with SF=7, 8 and 9 constitutes the receiver node. The received image is shown in Fig. 7(c). RSSI is respectively -84, -89 and -94 dBm, PSR=93%, 92% and 73%, PSNR=Inf dB, and the transmission time is 26s, as shown in Table I.

Regarding the experimental results shown in Table I, we found that image transmission time using multiplexing methods to simultaneously transmit the image packets with different SF parameters can really reduce the transmission time. In addition, PSR and PSNR is also high enough.

(a)



(b)



(c)

Figure 7. The transmitted images: (a) 1 to 1 (b) 2 to 2 (c) 3 to 3.

TABLE I. EXPERIMENT RESULTS

	1 to 1	**2 to 2**		**3 to 3**		
SF	7	7	8	7	8	9
RSSI (dBm)	-97	-96	-91	-84	-89	-94
Total packet number	81	36	45	31	40	10
PSR(%)	98	95	94	93	92	73
PSNR (dB)	33.84	Inf		Inf		
time	48s	31s		26s		

IV. CONCLUSION

We propose the method that LoRa transmit the image in a multiplexing mode with different SFs. Through experiments, we can confirm that using this method does have less time to transmit the image than that for single-point transmission. Therefore, after decreasing the transmission time, the image transmission by LoRa technology will be feasible, and the results can thus accelerate the LoRa application.

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