Study of Lora Module Ra-02 For Long Range, Low Power, Low Rate Picture Transfer Applications

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Abstract. LoRa is a long-range, low-power, low-bitrate communication technology that is a major component of the Internet of Things (IoT). In realizing smart cities, many environmental parameters are observed in decision making that supports sustainable development. LoRa is an alternative to wireless communication from wifi and GSM networks which are more power-consuming. The use of many sensor nodes that are distributed in areas with difficult access to electricity requires low power usage. The use of low-power LoRa has the disadvantage of slow transmission speeds. Although environmental monitoring based on specific parameters such as temperature, humidity, gas, pH, etc. has been widely applied, visual environmental monitoring is necessary. In monitoring volcanoes, visual field inspections are needed to support decision making. Monitoring can be done periodically based on time. The LoRa Ra-02 module is a Lora module that is cheap and widely available in the market. In this research, a study on the potential use of the Lora Ra-02 Module for low-speed image transfer applications was conducted.

1. Introduction

LoRa is a long-range, low power, low bitrate communication technology that is one of the main supporters of the Internet of Things (IoT) [1]. In realizing a smart city, there are many environmental parameters that are observed in making decisions that support sustainable development [2]. In previous researches, the use of Wireless Sensor Network communication devices using low power XBee for monitoring in volcanoes has a range limitation[3][4]. LoRa is an alternative wireless communication from the use of wifi networks and cell phones which are more power intensive. The use of many distributed sensor nodes and areas with difficult access to electricity requires low power usage. The use of low-power LoRa has the disadvantage of slow transmission speeds.

Environmental monitoring based on specific parameters such as temperature, humidity, gas, pH etc. has been widely applied but visual environmental monitoring is also very necessary. In monitoring volcanoes, field inspections and visual monitoring are needed to support decision making. Visual recording and image processing are also used in observing volcanic activity [5]. cameras and image processing are used to monitor forest fires [6][7][8][9]. Monitoring of deforestation using satellite imagery data with complex technology [10]. Previous researchers also conducted monitoring of plant conditions based on image processing [11]. Researchers monitored volcanic activity using a thermal camera connected to an Ethernet network and transmitted using wifi with a pointing antenna [12]. The use of long-range Ethernet and wifi networks generates realtime data using high power consumption and complex installations. This is not effective for many monitoring point locations. LoRa is used by researchers for image data transfer in several monitoring applications [13][14]. In this research, the controller device used was insufficient to be able to perform further image processing.
In some cases such as monitoring forests, volcanoes, gas pipelines, and oil, it does not require real
time data. Monitoring can be done regularly. In certain conditions that require the system to send data
on time, the system must be able to respond properly. Therefore, a simple image processing device is
needed that can detect specific conditions, such as forest fires, fire movements and so on. The system
must also be power efficient and reliable if used continuously. In this study, a remote image data
transmission device using LoRa was designed for periodic visual monitoring applications.

2. Research Method

2.1. Research Step
To achieve the research objectives, it is necessary to arrange the stages of research that will be
carried out. In general, the main stages of the research carried out are as follows:
   a. Study of literature,
   b. System design and determination of equipment specifications,
   c. Circuit system design,
   d. System implementation,
   e. Testing and analysis.

2.2. Research Location
The research was conducted at the Computer Control Engineering Laboratory, Department of
Engineering, Politeknik Negeri Madiun. Field testing was carried out in settlements with variations in
distance.

2.3. Observed Variables
   a. Data transfer rate (Throughput), Data Latency, Percentage Packet Received (PRR), RSSI and
      range based on variations of the LoRa parameter,
   b. Appliance power consumption.

2.4. Research Model
The model used in this research is field experimental as shown in Figure 1. The research begins
with determining the specifications of the tools that suit your needs. Making prototypes and
programming tools. Testing and evaluation is carried out after the prototype is ready. If there is a
discrepancy with the specifications, then the software is corrected to get optimal results.

Fig. 1 Flowchart of Research
2.5. Research Design

The block diagram of the research system and research tools is shown in Figure 2. This device consists of a node and a gateway. The node consists of a camera, Raspberry Pi as a data processor, ATMEGA328 as power management and supervisory devices, LoRa Ra-02 as a wireless communication device and RTC as a determinant of data retrieval and delivery time according to schedule. The gateway consists of the LoRa Ra-02 module, raspberry pi as a data processor, and a display as a data viewer. The specifications in this experiment are shown in Table 1.

![Figure 2. System Block Diagram](image)

### Table 1. Tool Specifications

| No. | Description                  | Receiver       | Node     |
|-----|------------------------------|----------------|----------|
| 1   | Main Controller              | Raspberry Pi 3 | Raspberry Pi 3 |
| 2   | Transmitter Power (dB)       | 20             | 20       |
| 3   | Antenna Gain (dBi)           | 2              | 2        |
| 4   | Spreading Factor             | 7/12           | 7/12     |

The working principle of the nodes is shown in Figure 3. If the node detects the image according to the set time, the image will be retrieved and sent. However, if the time does not match, the system will detect whether any events have occurred based on image processing. If not, the process will repeat. In this process, sampling is also carried out during certain intervals to save battery usage.

![Fig. 3. Flowchart of node working principle](image)

2.6. Data Collection and Analysis Techniques

Next do some Tests including:

a. Lora's Time On Air Test
Testing is done using the following equation 1:

\[ T_s = \frac{2^{SF}}{BW} \]  

(1)

b. Time On Air Lora for image data

c. RSSI and range based on variation of LoRa parameters

The relationship between distance and RSSI is obtained from equation 2. Where \( d \) is the distance (m), \( \text{TxPower} \) is the RSSI measured at a distance of 1 m, and \( N \) is a constant according to environmental conditions.

\[ d = 10^{\left(\frac{\text{TxPower} - \text{RSSI}}{10N}\right)} \]  

(2)

3. Results and Discussion

3.1. LoRa Range Distance Testing

Distance testing is done by testing in the field to predict the maximum range based on the RSSI value and the sensitivity of the tool. Field testing was carried out in two different areas, namely residential areas and rice fields. The relationship between RSSI values and distance is as shown in equation 3.3. The LoRa sensitivity values based on SF and BW settings are shown in Table 2.

| BW/SF | 7  | 8  | 9  | 10 | 11 | 12 |
|-------|----|----|----|----|----|----|
| 125   | -123 | -126 | -129 | -132 | -133 | -136 |
| 250   | -120 | -123 | -125 | -128 | -130 | -133 |
| 500   | -116 | -119 | -122 | -125 | -128 | -130 |

Field testing produces two test data from different areas. Table 3 shows the test results in rice fields while Table 4 shows the test results in residential areas.

| Range (m) | RSSI (dbm) | Test 1 | n | PLE | RSSI (dbm) | Test 2 | n | PLE |
|-----------|------------|--------|---|-----|------------|--------|---|-----|
| 1         | -53        | 1      | 0 | -57 | 1          | 0      |   |     |
| 44        | -90        | 44,10  | 2,25 | -94 | 44,1         | 2,25   |   |     |
| 165       | -102       | 150,58 | 2,21 | -107 | 166,81      | 2,25   |   |     |
| 244       | -107       | 251,19 | 2,26 | -111 | 251,19      | 2,26   |   |     |
| 362       | -111       | 380,75 | 2,27 | -115 | 378,25      | 2,27   |   |     |
| Mean      | 2,25       | Mean   | 2,26 |     |            |        |   |     |

| Range (m) | RSSI (dbm) | Test 1 | n | PLE | RSSI (dbm) | Test 2 | n | PLE |
|-----------|------------|--------|---|-----|------------|--------|---|-----|
| 1         | -65        | 1      | 0 | -63 | 1          | 0      |   |     |
| 10        | -89        | 10,50  | 2,4 | -88 | 10,48       | 2,5    |   |     |
| 20        | -95        | 18,91  | 2,31 | -93 | 16,77       | 2,31   |   |     |
| 41        | -103       | 41,40  | 2,36 | -103 | 42,92       | 2,48   |   |     |
| 146       | -116       | 147,98 | 2,36 | -116 | 145,6      | 2,45   |   |     |
| Mean      | 2,36       | Mean   | 2,44 |     |            |        |   |     |
The values obtained from the test (n-PLE factor, tool sensitivity value and the RSSI equation) were used to predict the maximum range of LoRa. Combining the experimental results and the equation produces the maximum range as shown in Figure 4. The result is a prediction for the maximum coverage distance in the two environmental conditions and BW-SF variation. From the prediction results, it can be concluded that with the largest SF and the smallest BW will get the farthest range. In the rice fields it produces a distance of 5 km, while in the residential area it is 1 km.

3.2. Lora’s Time on Air
LoRa has several main settings related to data transfer speed and range. These settings include Spread Factor and Bandwidth. Based on equation 3.1, the time to send data for one byte of data can be calculated.

| BW(kHz)/SF | 7   | 8   | 9   | 10  | 11  | 12  |
|------------|-----|-----|-----|-----|-----|-----|
| 125        | 1.024 | 2.048 | 4.096 | 8.192 | 16.384 | 32.768 |
| 250        | 0.512 | 1.024 | 2.048 | 4.096 | 8.192 | 16.384 |
| 500        | 0.256 | 0.512 | 1.024 | 2.048 | 4.096 | 8.192 |

Based on the calculation results, it is found that the greater the Spread Factor value, the longer the transfer time. Meanwhile, the higher the bandwidth, the longer it takes LoRa to send one byte of data. Image sending applications require a very large number of sending Bytes depending on the image...
quality. LoRa is unable to send the data in one transmission. Therefore, in this study, data transmission was determined once per 50 Bytes of data. The data transmission specifications are shown in Table 6.

### Table 6. Data transmission specifications

| Application payload size | 50 bytes |
|--------------------------|----------|
| Header size              | 13 bytes |
| Coding rate              | 4 / 5    |
| Preamble symbols         | 8        |

\[ n_s = 8 + \max\left(\left[\frac{BPL - ASF + B + CRC + H}{4(SF - DE)}\right] \times \frac{4}{CR}, 0\right) \]  

(3)

In one data transmission 50 Bytes, a total packet delivery is required which can be calculated according to equation 4.1, where PL is the data / payload size in bytes, CRC is 16 when activated and 0 when not activated, H is 20 when activated and 0 when not activated and DE is 2 when low data rate optimization is activated and 0 if it is not activated.

### Table 7. Time on Air with various settings for 50 bytes of data

| SF | ns 125 | ns 250 | ns 500 |
|----|--------|--------|--------|
| 7  | 103    | 18.12726 | 9.063629 |
| 8  | 93     | 33.10879 | 53.888  |
| 9  | 83     | 107.776  | 97.536  |
| 10 | 73     | 195.072  | 174.592 |
| 11 | 78     | 349.184  | 369.664 |
| 12 | 73     | 739.328  | 698.368 |

**Fig. 6.** Time on Air graph for 50 Bytes of data

In the process of sending a VGA-quality image data with a resolution of 640x320 RGB 8 bits, it requires 614,400 Bytes of data. From the calculation of the previous equation, it is obtained the relationship between data transmission time and the variation of SF-BW settings as in Table 8.

### Table 8. Time on Air LoRa for VGA quality image data (minutes)

| BW\SF | 7     | 8     | 9      | 10     | 11     | 12     |
|-------|-------|-------|--------|--------|--------|--------|
| 125   | 36.25452 | 66.21757 | 119.8522 | 214.5386 | 454.2431 | 858.1546 |
| 250   | 18.12726 | 33.10879 | 59.92612 | 107.2693 | 227.1216 | 429.0773 |
| 500   | 9.063629 | 16.55439 | 29.96306 | 53.63466 | 113.5608 | 214.5386 |
Based on Table 8 and Figure 7, it can be concluded that the maximum range setting will result in the fastest transmission time of 858 minutes for one image. This time value is not appropriate for image submission except for special applications that only need to send one image per day.

Fig. 7. Time on Air graphics for VGA quality imagery

4. Conclusion and Suggestion
4.1. Conclusion
Conclusions that can be drawn:
  a. Determination of the Spread Factor (SF) and BandWidth (BW) settings can determine the range distance and data transmission time (Time on Air)
  b. Time on Air will affect image transmission time and power usage.
  c. It is necessary to determine the proper SF and BW according to the conditions.
  d. Image sending using LoRa can be done for special and limited purposes.

4.2. Suggestion
Suggestions that can be used for further research:
  a. Need to conduct field trials of image capture devices
  b. Use of other communication devices for maximum results
  c. Image compression is necessary to reduce the size of raw data

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