LoRa Technology for Communication in Blankspot Areas

L. Ahmad S.Irfan Akbar
Electrical Engineering Department
University of Mataram
Mataram, Indonesia
irfan@unram.ac.id

Misbahuddin
Electrical Engineering Department
University of Mataram
Mataram, Indonesia
misbahuddin@unram.ac.id

Muhamad Syamsu Iqbal
Electrical Engineering Department
University of Mataram
Mataram, Indonesia
msiqbal@unram.ac.id

A. Sjamsjiar Rachman
Electrical Engineering Department
University of Mataram
Mataram, Indonesia
asrachman@unram.ac.id

Djul Fikry Budiman
Electrical Engineering Department
University of Mataram
Mataram, Indonesia
djulfikry@unram.ac.id

Giri Wahyu Wiriasto
Electrical Engineering Department
University of Mataram
Mataram, Indonesia
giriwahyuwiriasto@unram.ac.id

***Abstract*—By 2020, the number of devices connected to the internet has reached 50 billion. By 2030, Cisco estimates that 500 billion devices are connected to the Internet. This increase in number is due to the rapid development of Internet of Things or IoT technology. IoT devices have the advantage of being able to transmit data over long distances but require low consumption of electrical energy sourced from batteries. This study utilizes the ability of the LoRa SX1276 IoT device to send messages in the blank spot area. On the island of Lombok, there are still areas that are still not covered by communication signals, both GSM signals and internet signals, due to geographical conditions located in hilly or forest areas. This study also uses ESP32 which can interact with the LoRa SX1276 device. The smart phone connects to the ESP32 through the web server it provides, through the HTML page the user sends a message which LoRa will forward to the receiving device. The test results in the field show that the LoRa and ESP32 communication devices are able to send messages up to a distance of 1.1 km in the blankspot area of hills and forests along the road.**

Keywords—IoT, LoRa SX1276, Blank spot, ESP32, Message

I. Introduction

Communication plays an important role in everyone's life to interact with the surrounding environment. As technology advances, the use of digital communication is increasing rapidly. Transfer of information has become easier to do. For example, information about volcanic activity can be quickly passed on to the appropriate authorities. But there are still places that are still not reached by communication signals called blank spots, where we cannot transmit information. So the question is how to transmit information from that place, such as in the forest or in remote areas. There are several technologies to build a means of communication such as Wi-Fi, GSM or Bluetooth. But based on [1] one of the main problems in building communication facilities in rural areas is the lack of availability of reliable and cost effective. On the other hand, LPWAN offers wireless communication technology which is low cost, long coverage in license-free frequency band and consumes less power [2] LoRa is a recently developed LPWAN technology based on the spread spectrum technique. LoRa uses the entire channel bandwidth to broadcast a signal which makes it resistant to channel interference, long-range relative frequency, Doppler effects, and fading. LoRa characteristics are based on three transmission parameters: Code Rate (CR), Spreading Factor (SF) and Bandwidth (BW) [3]. This technology is bidirectional, and consumes less power used by sensors when sending or receiving data. LoRa can cover almost 15-20 km and work for years on battery [4]. But LoRa also has the disadvantage of a small data rate to cover long distances. LoRa has a maximum data rate of 50 kbps [5], therefore LoRa cannot transmit video or audio data, LoRa devices can only transmit text data [6].

In this study, the ESP32 MCU Node modem and LoRa Transceiver SX1276 are used, these devices will be used to send messages to blankspot areas that have not been reached by GSM infrastructure and internet signals. Smartphones that are always carried by everyone will be used as an interface to send messages. The ESP32 MCU node is responsible for connecting the smartphone with the LoRa SX1276 device. ESP32 also provides a web server that can be accessed via a web browser on a smartphone so that messages typed via a smartphone can be sent via LoRa Devices. This research will also measure the range that can be taken by the LoRa device when sending text messages in the blankspot area, because sending messages will be carried out along the road through winding hills with forests on both sides of the road.

The SX1276 provides long range spread spectrum communication and high interference immunity while carrying current consumption. Using Semtech's patented LoRa modulation technique, the SX1276 can achieve a sensitivity of over -148dBm. The high sensitivity combined with the integrated +20 dBm power booster is optimally suited for any application that requires range or endurance [7]. LoRa has the capabilities required by LPWAN technology, so LoRa is very suitable to be applied to wireless sensor networks that can integrate real-time environmental conditions such as temperature, humidity, rainfall, wind, pollution, and others. LoRa technology is suitable for use in urban and rural environments [8]. LoRa technology supports variable and adaptive speeds, enabling trade-offs between throughput for long distances with good durability and low energy consumption, while keeping bandwidth constant [9]. One receiver on a LoRa network can handle multiple hubs in an area. Its performance is much better when compared to Wi-Fi networks which require many access points to cover a wide range. Although LoRa performance is better when compared to Wi-Fi, there are inconveniences in transmission speed and size of the payload [10].

II. METHODOLOGY

A. LoRa Modul

LoRa (Long Range) is a spread spectrum modulation technique derived from chip spread spectrum (CSS) technology. LoRa is a long-range low-power wireless platform that has become the Internet of Things (IoT) de facto wireless platform. LoRa works under the unlicensed frequency of 1 GHz, is a unique modulator created by Semtech [11]. LoRa uses a type of frequency modulator (FM) with transmission methods in the form of Phase Shift Keying (PSK), or Frequency Shift Keying (FSK). LoRa uses six spreading factors (SF7 to SF12) to adjust the data rate and tradeoff range. Higher spreading factors allow longer coverage at the expense of lower data rates, and vice versa. LoRa data rates are between 300 bps and 50 kbps depending on spreading factors and bandwidth. Messages transmitted using different spreading factors can be received simultaneously by LoRa BTS. The maximum payload length for each message is 243 bytes [12]. If we refer to the OSI standard, there is a difference between LoRa and LoRaWAN. LoRa represents the physical layer, while LoRaWAN is the MAC layer. LoRaWAN added to standardize and improve LoRa physical communication. LoRaWAN has been designed to respond to use cases where sensors communicate small amounts of data over several times a day. But it is not designed to support applications that require high data rates such as audio or video [13].

Fig. 1. LoRa Module SX1276

TABLE I. DEVICE COMPONENTS OF LORA

Device	Model
LoRa	SX1276
Node MCU	ESP32 W ROOM
Antenna	Omnidirectional 3 dBi
Screen	SSD1306 0.96 inch I2C OLED
Interface	Android Smartphone

LoRa supports the use of multiple carrier frequencies. Carrier frequency in MHz, allowed values range from 137.0 MHz to 1020.0 MHz. We use the 920MHz frequency in accordance with the LoRa frequency usage rules that apply in Indonesia. On both sides of the sender and receiver in order to communicate well, it is necessary to adjust the suitability of the test parameters on both the sending and receiving sides. Table II shows some other parameters used, we use a compromise of several parameters based on [8] to get the best results

TABLE II. PARAMETERS SETTING

Device	Model
Frequency	920MHz
Power Transmission	17 dBm
Coding rate	4/5
Payload size	32 byte
Bandwidth	250 kHz
Spreading Factor	8

B. ESP32

The ESP32 is a dual-core system with two Harvard Xtensa LX6 architecture CPUs. All embedded memory, external memory, and peripherals are located on the data bus and the CPU instruction bus or on both. Each of the two Harvard Architecture Xtensa LX6 CPUs has 4 GB of 32-bit address space. Both Address spaces are symmetrical between two CPUs With their little use, the address map of both CPUs is symmetric, meaning the same to access the same memory. Several peripherals in the system can access the embedded memory via DMA. Both CPUs are named PRO_CPU and APP_CPU is used for Protocols and Applications. But to achieve a certain goal the two CPUs are interchangeable [14].

Fig. 2. ESP32 WROOM 32

To send and receive LoRa messages with ESP32, we use the RFM96 transceiver module (SX1276). All LoRa modules are transceivers so LoRa can send and receive messages/information. The RFM96 LoRa transceiver module communicates with the ESP32 using the SPI communication protocol, so the default SPI pin on the ESP32 will be used. RFM96 transceiver module has 3 GND pins and only 1 pin is used Mapping Pin SX1276 and ESP32 can be seen in table III.

TABLE III. PIN MAPPING SX1276 AND ESP32

Pin	SX1276 Pins	ESP32 Pins
1	GND	GND
2	3.3V	3.3V
3	DIO 0	GPIO 2
4	Reset	GPIO 14
5	NSS	GPIO 5
6	SCK	GPIO18
7	MOSI	GPIO 23
8	MISO	GPIO 19

The MISO and MOSI pins are important to note because they are the communication path between the two modules. MISO (Master In Slave Out) and MOSI (Master Out Slave In) are data lines for communication between the SX1276 chip (USBAsp) and Slave (Node MCU). MISO is the path used by ESP32 to receive data, while MOSI is the path used by ESP32 to send data to the microcontroller IC. These two lines are the main lines used by SX1276 and the microcontroller in this case ESP32 to communicate. To avoid errors in communication, synchronization is needed. The synchronization is done with using the SCK pathway. Data (MISO and or MOSI) will be considered valid only when SCK is high.

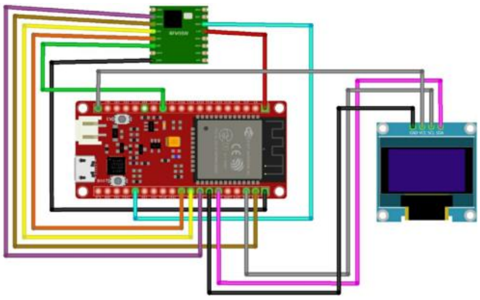

Fig. 3. Circuit diagram SX1276 to ESP32

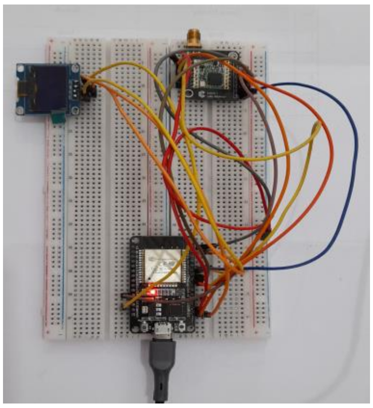

Fig. 4. Connecting SX1276 and ESP32

C. SSD1306 0.96 inch I2C OLED

The organic light-emitting diode or OLED is a light emitting diode (LED) in which the emissive electroluminescent layer is a film of organic compounds that emit light in response to an electric current. OLED screens do not require a backlight and the pixels only consume energy when they are on, so OLED requires less power compared to other screens

D. Communications Model

ESP32 is used as a Wi-Fi access point and as a web server. Smart phone users and ESP32 Web server are connected to the same network provided by EPS32 Wi-Fi. The web server provides an HTML page that serves as a form for typing messages. Messages sent via a web browser are then forwarded to the LoRa SX1276 device. The sending LoRa then forwards the message to the receiving LoRa (Fig. 5).

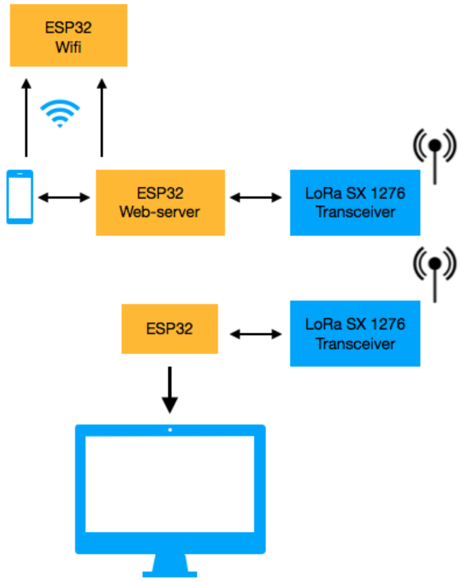

Fig. 5. LoRa Transceiver

E. Blankspot Location

The blankspot location used to test message delivery and the range of LoRa devices is on the route to Mount Rinjani National Park. The route chosen is through Aikmel Village because it crosses the forest area which is a blankspot area. Fig. 6 shows the route along the blank spot area, in addition to the winding path and changing heights, the blank spot path is also blocked by dense tree vegetation.

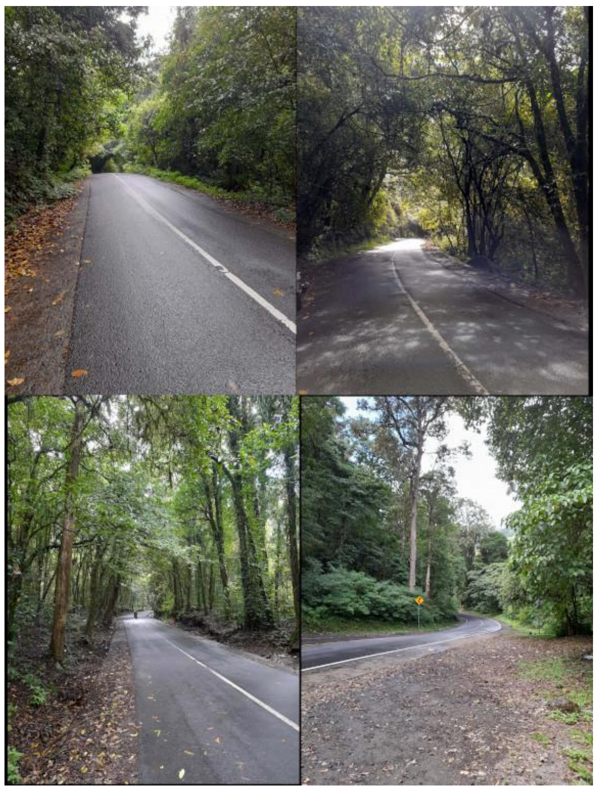

Fig. 6. Blank spot area

III. Results And Discussion

In this study, a mechanism was created to send messages in the blankspot area and measure the range achieved by the LoRa SX1276 device. Measurements were made at 10 different points with different ground elevations. The LoRa sender sends a message at a lower ground level to a receiver at a higher ground level and vice versa. The messaging location also has lush trees on both sides of the road.

A. Message Interface

The message sender interface is accessed by the user via a smart phone web browser. The user is connected to the Wi-Fi access point and web server provided by the ESP32 mcu node (Fig. 7). But this LoRa transmitter device is still one-way, meaning that the LoRa transmitter can only send messages and cannot receive messages on the same device.

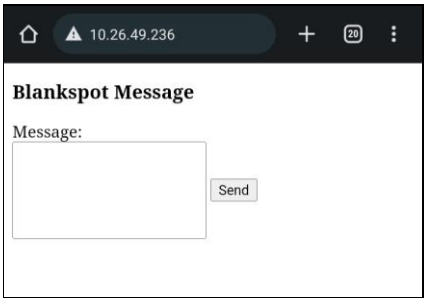

Fig. 7. Message Interface

B. SX1276 Range in Blankspot

Testing of sending messages using LoRa was carried out at 10 points. Table IV shows the distance of sending messages at blankspot locations. The farthest distance obtained is 1.1 km (Fig. 8) and the closest distance is 454 m (Fig. 9).

TABLE IV. LoRa Distance in Blackspot Locations

Point	Distance (m)	Starting Point (masl)	end Point (masl)	Packet Lost
1	806	1038	1065	7
2	507	1085	1145	6
3	542	1148	1192	28
4	546	1201	1242	16
5	1.110	1476	1630	6
6	763	1628	1498	17
7	702	1510	1442	27
8	541	1443	1365	27
9	478	1356	1323	21
10	454	1323	1290	10

At points 1 to 5, the sender's LoRa is at a lower altitude than the receiver's LoRa, while points 6 to 10 of the sender's LoRa are at a higher altitude. The height difference between the sender and the receiver can be seen in the table. From the test results, it can be seen that the range achieved by LoRa is further when the receiving device is at a higher ground level.

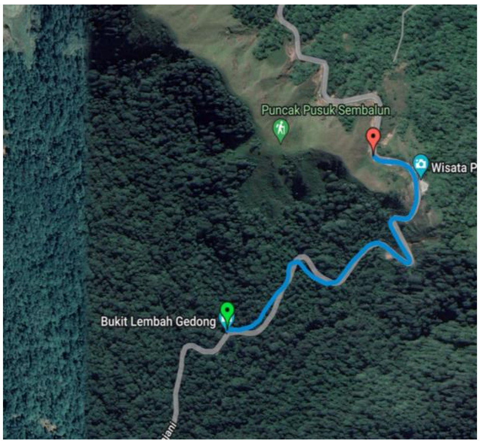

Fig. 8. Blankspot location at a distance of 1.1km

Fig. 9. Blankspot location at the closest distance 454m

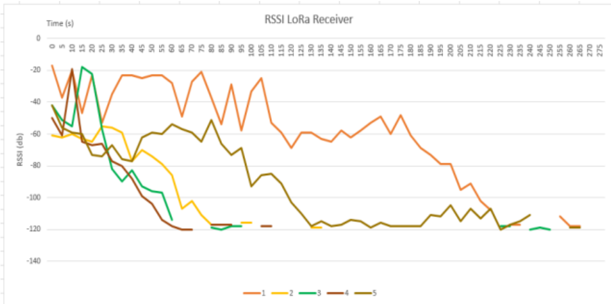

Fig. 10. RSSI LoRa Receiver 1-5

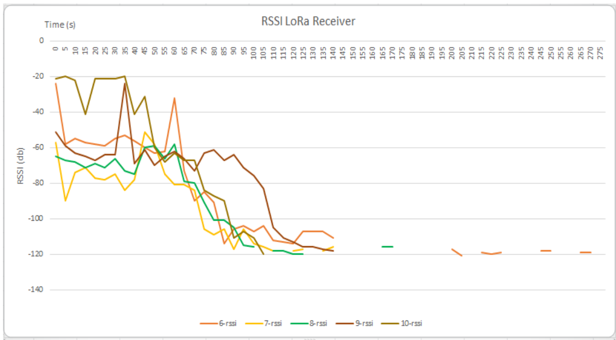

Fig. 11. RSSI LoRa Receiver 6-10

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Fig. 10 shows the RSSI value, by observing the RSSI value received by the receiving LoRa device. The pattern of lost data can be analogized to a broken RSSI curve. It can be seen that at point 3 data collection has the most lost data.

In Fig. 11 it can be seen that the RSSI at points 6 to 10 shows a better quality of data reception although in general the range achieved is shorter than the 5 points in Fig. 8.

IV. Conclusion

LoRa devices can be used to send messages at blank spot locations by utilizing the ESP32 MCU Node as an intermediary between Android smartphones and LoRa transmitter devices. The LoRa transmitter device is capable of sending messages from a distance of 450 m to 1100 m at the blankspot location although there is still data loss at some measurement points.

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