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Analysis of Listen Before Talk Protocol Implementation in Terrestrial Network Using Multi-Node LoRa Communication

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Abstract. This research implements wireless communication technology using Listen Before Talk (LBT) method and Long Range (LoRa) technology that enables efficient long-distance communication. The LBT protocol allows devices to listen to the communication channel before sending data, while the LoRa technology provides long-range communication capabilities with low power consumption. Both of these have significant implications in addressing transmission quality and distance challenges in wireless communications, especially in complex terrestrial environments. Test results show that LBT effectively reduces collisions at distances of 10 to 50 meters, Data transmission efficiency is also improved by using the LBT method with 90% efficiency from the previous 82% without LBT. This shows that LBT helps maximize data transmission by reducing data packet loss, so that the data received is closer to the amount of data sent, thus showing the positive potential of the LBT protocol in maintaining data transmission integrity in terrestrial environments.

Keywords: Listen Before Talk, LoRa, Wireless, Delay, Collision Data

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1. Introduction

Rapid advancements in communication technology have driven the development of increasingly complex and sophisticated wireless networks. In this context, terrestrial connectivity has become a crucial aspect to support data exchange between devices in vast and diverse environments. LoRa (Long Range) technology has emerged as a promising solution to address connectivity challenges in terrestrial regions involving long distances and diverse topologies[1]. While LoRa enables efficient long-range communication with low power consumption, issues of frequency overlap and collisions need to be tackled. The "Listen Before Talk" (LBT) protocol has emerged as a common solution with the principle of listening before transmitting[2]. Listen Before Talk (LBT) is a mechanism for fair channel usage, requiring other users to wait until the channel is available. Listen Before Talk (LBT) is a communication protocol to avoid collisions on the LoRa multinode communication channel[3].

LoRa (Long Range) is a wireless communication technology designed specifically for long-range connectivity. Chirp Spread Spectrum (CSS) modulation is used by LoRa to transmit signals. In CSS, the signal frequency changes sequentially, creating a recognizable pattern for the receiver. This enables LoRa to communicate over long distances with low power usage[4].The use of Pure ALOHA by LoRa becomes relevant as Pure ALOHA allows devices to transmit data without needing to coordinate with other devices. Although there is a risk of data collisions, this approach is simple and allows devices to immediately send data when the channel is available. In the case of LoRa, the use of Pure ALOHA aligns with the long-range transmission and low-power consumption characteristics of LoRa[5].

Previous research has developed LoRa connectivity through various methods. The use of the CSMA/CA protocol helps avoid data collisions[6], while the TDMA protocol eliminates collision risks and improves packet delivery ratio[7]. In tackling these challenges, in the study "A Slotted Transmission with Collision Avoidance for LoRa Networks," the receiver only demodulates the strongest signal. Each node is allowed to transmit data in specific time slots and applies LBT to avoid collisions. LBT proves effective and reliable in addressing varying traffic loads[8].A recent study implemented the LBT protocol while considering collision rates and delivery delays. While LBT reduces collisions, packet delivery time increases as each node waits for an available channel. Devices continuously monitor the channel before data transmission through Clear Channel Assessment (CCA)[9].

The LBT protocol has proven effective in avoiding collisions and enhancing communication quality under varying traffic loads. Therefore, in this study, the "Listen Before Talk" protocol is implemented in a terrestrial network using LoRa technology. By combining the LBT mechanism and the Pure ALOHA approach, LoRa can optimize channel efficiency and maintain communication quality, especially in terrestrial environments prone to interference and disturbances.

2. Methods

2.1. Device Design

In this research, the method carried out has a design stage which is divided into two main parts, namely hardware and software design. Hardware design begins with developing an overall system block diagram. In designing a device, making a block diagram is a very important component. Through the block diagram, the workflow of the entire circuit can be understood. Therefore, the overall block diagram of the circuit will form the basis of a system that can operate effectively, as shown in Figure 1.

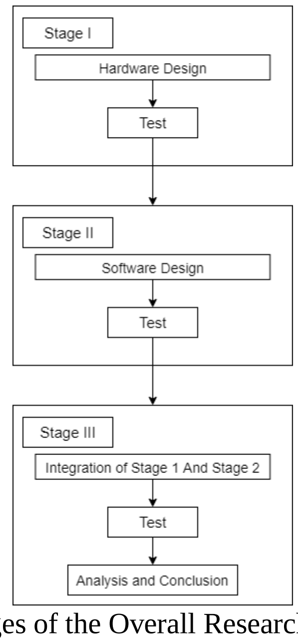


Figure 1. Stages of the Overall Research Methodology

The hardware design process involves planning and manufacturing the physical components that will be used. Hardware systems consist of several key components that interact with each other to form a functioning LoRa network. In this context, there are two crucial entities that become important points in the LoRa network, namely Node A and Node B. These two nodes act as data receivers in the network. These two nodes act as data receivers in the network. Not only that, the LoRa Gateway is also present as a communication center that connects and manages the data flow between Node A, Node B, and the Cloud Server device.

Arduino has a role in regulating the switching of data transmission modes from nodes to the gateway, by setting the transmission mode alternately between Node A and Node B. The LoRa component serves as a means to transmit data to the gateway. The LoRa operating frequency used is 915MHz. The application of the LBT (Listen Before Talk) protocol ensures that both LoRa nodes will send data at the same frequency in turn, so that the data sent is maintained in integrity. The final part of the circuit is the power supply which ensures there is enough power to carry out the LoRa transmission. Node A and Node B have a similar structure, with LoRa A sending data to "..." and LoRa B sending data to "..." continuously. The hardware block diagram is shown in Figure 2.

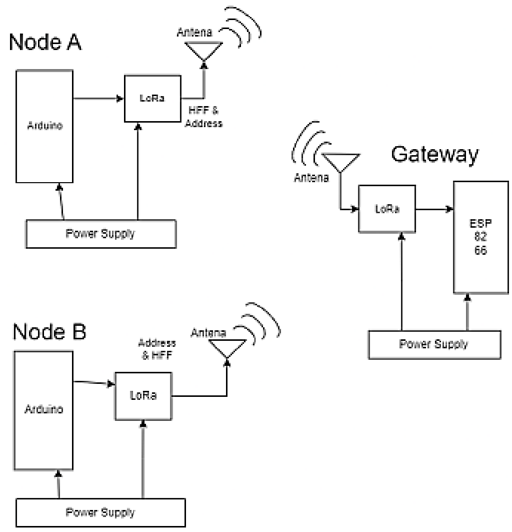
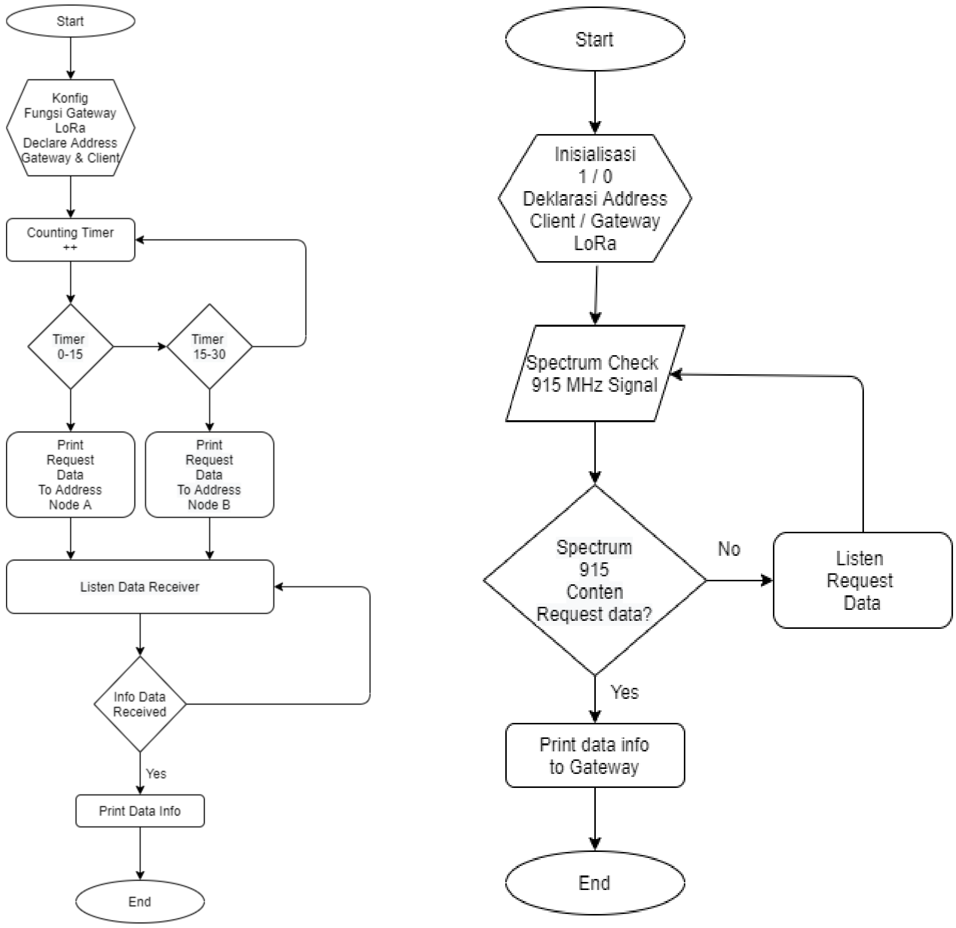


Figure 2. Hardware Design

The software design is described through flowcharts displayed on the gateway and the client. In the gateway flowchart, the process starts with the "Start" step to initialize the program. Then, the configuration of the LoRa gateway function is done by setting the LoRa device address for each node and the LoRa gateway. After that, the timing stage is performed to set the timer interval that controls the turn of the data transmission request cycle from the node to the gateway. In the timer range of 0-15, the gateway will request data delivery from node A. While in the 15-30 timer range, the gateway will request data transmission from node B. The gateway, as the center in the LoRa network, listens to the information data received from the gateway. If the data is interrupted or unsuccessfully received, the process will be repeated to try listening to the data again. Successfully received data will be displayed as success information, and this process will be terminated.

Furthermore, in the Client Flowchart, the process starts with "Start" to initiate the program. The next step is the preparation of input and output initialization, as well as address declaration for each client and gateway. The node will then check the 915 Mhz spectrum to look for data transmission requests from the gateway. If there is no data request, the system will repeat to continue listening for requests. However, if there is a request for data transmission, the node will send data information about the count to the gateway, and the process will end with "Done". The gateway and client flowcharts are shown in Figure 3.



(a) (b)

Figure 3. (a) Hardware Flowchart (b) Software Flowchart

2.2. Listen Before Talk Design

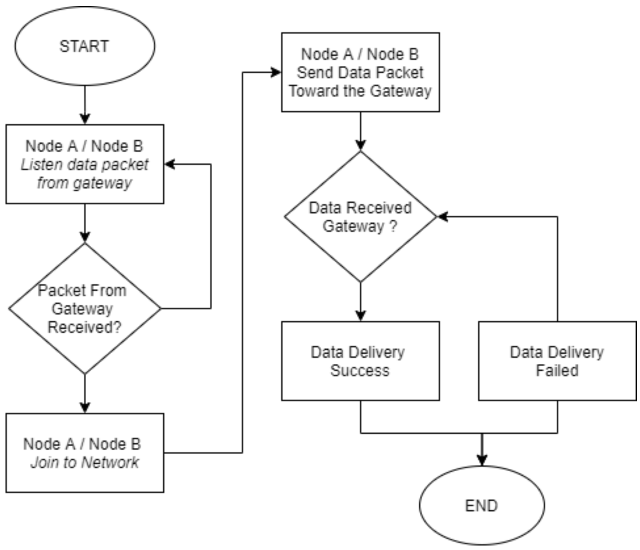


Figure 4. Listen Before Talk Process

Figure 4 illustrates the workflow or communication process in the LoRa network between Node A, Node B, and the Gateway. The process starts with Node A and Node B listening for data packets from the Gateway, ready to receive data sent by the Gateway. They wait to receive data packets from the Gateway and can join the network at the same time. After that, if there is data that needs to be sent to the Gateway, Node A and Node B will send data packets towards the Gateway. The Gateway then receives and processes the data sent by Node A or Node B, checking whether the data was successfully received. If the data is successfully received, it indicates that the communication between Node A/Node B and the Gateway is running smoothly, and the communication process ends, but if the data fails to be received, it will be taken back to the data sent from the gateway until the data is successfully sent. This diagram provides an overview of how communication in a LoRa network occurs, illustrating the important steps in the process.

2.3 Data Test

In this stage of Data Testing, the main attention will be focused on testing parameters that have a critical impact, namely the collusion rate and the delay. The collusion rate parameter measures the frequency of data collisions in the context of a wireless communication network. Data collisions occur when two or more devices attempt to transmit information simultaneously, resulting in data interference or "collisions" in the air medium. This causes the data to be received incorrectly by the receiver. The collusion rate formula can be calculated with the following equation :

$$\mathit{Collusion\ Rate}\ (\%) = \frac{\mathit{Transmission\ Count}}{\mathit{Number\ of\ Collisions}} \times 100\% \tag{1}$$

Meanwhile, the concept of delay in the framework of network communication refers to the time interval required from when data is transmitted from the source until it is finally received by the receiver. It reflects the time required for data to pass through a communication channel or network, and reach its final destination. The delay formula can be calculated with the following equation :

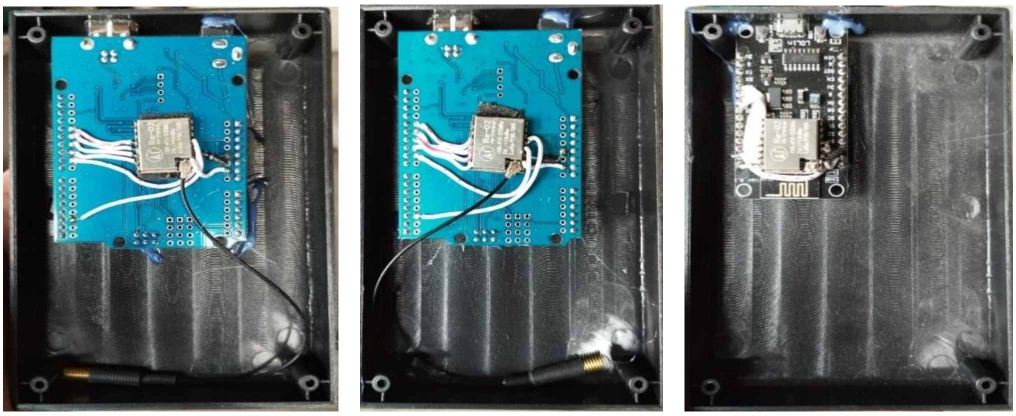
$$\mathit{Delay} = \mathit{Time\ Received} - \mathit{Time\ Sent} \tag{2}$$

3. Results and Discussion

This implementation stage will present the hardware design results in detail. These results include concrete implementations of a previously prepared design consisting of two Node devices, namely Node A and Node B, and one Gateway. Node A and Node B will function as entities in the multi-node LoRa network to be tested. At the same time, Gateway will serve as a communication center to connect and manage communication between these nodes.

Carefully assembled devices will be placed in a specially designed case. This casing protects the device from external environmental conditions and ensures long-term operational safety and reliability. In addition, the casing can also help arrange the placement of the device in formations that match the proposed network topology design.

Through this process, the hardware will become more responsive to the tested environment and enable further implementation of the Listen Before Talk protocol on terrestrial networks through multi-node LoRa communication. With all the hardware components installed in the appropriate casing, this implementation stage is a key step in bringing theoretical design into the real world. The results of making this research device are shown in Figure 5.



(a) (b) (c)

Figure 5. (a) Node A (b) Node B (c) Gateway

3.1. Collusion Rate Testing Data

Table 1 shows the collusion rate data test results from the measurements taken and the results are calculated through the delay formula in equation (1).

Table 1. Collusion Rate Testing Data

No	Distance (meter)	Protocol LBT	Transmission Count	Number of Collisions	Collusion Rate (%)
1.	10	No LBT	100	8	8
		With LBT	100	0	0
2.	20	No LBT	100	12	12
		With LBT	100	0	0
3.	30	No LBT	100	16	16
		With LBT	100	0	0
4.	40	No LBT	100	20	20
		With LBT	100	0	0
5.	50	No LBT	100	24	24
		With LBT	100	0	0

The Collusion Rate test results in table 1 above provide an important understanding of the role of the Listen Before Talk (LBT) protocol in dealing with data collision challenges in LoRa Multi Node networks. This research includes a series of tests at various distances, ranging from 10 to 50 meters, by implementing two types of protocols, namely Without LBT and With LBT. The test results show that at each test distance, the use of the LBT protocol successfully prevents data collisions, as evidenced by the zero percent (0%) collision rate. Meanwhile, in tests without LBT, there is a clear relationship between the number of collisions and the number of transmissions performed. For example, at a distance of 10 meters, using the protocol without LBT resulted in a collusion rate of 8%, while using LBT reduced it to 0%. The same applies to other distances, where the use of LBT always successfully eliminates the risk of data collisions. In contrast, in tests without LBT, the data collision rate can reach 24% at a distance of 50 meters.

3.2. Delay Testing Data

Table 2 shows the test results of the delay data from the measurements taken and the results are calculated through the delay formula in equation (2).

Table 2. Delay Testing Data

No	Distance (meter)	Protocol LBT	Time Posted(s)	Time Accepted(s)	Delay(s)
1.	10	No LBT	30	42	12
		With LBT	30	48	18
2.	20	No LBT	30	48	18
		With LBT	30	55	25
3.	30	No LBT	30	54	24
		With LBT	30	62	32
4.	40	No LBT	30	60	30
		With LBT	30	68	38
5.	50	No LBT	30	65	35
		With LBT	30	72	42

Table 2 illustrates the results of delay testing in LoRa Multi Node networks with and without the Listen Before Talk (LBT) protocol at various distances. The data in the table identifies the impact of using LBT on delay parameters. At a distance of 10 meters, it can be seen that the use of LBT causes an increase in delay compared to the use without LBT, with the difference reaching 6 seconds. This indicates that with LBT, each node has to wait longer before it can transmit data, in accordance with the main purpose of LBT to avoid data collisions that can affect data transmission time. A similar trend is seen at other distances, namely 20, 30, 40, and 50 meters, where the use of LBT also results in an increase in delay. This time difference indicates that the LBT protocol provides additional time for each node to monitor the communication channel before performing data transmission. Despite causing an increase in delay in data transmission, the use of LBT is expected to reduce the risk of data collisions and improve the overall communication quality.

3.3. Efficiency Level Testing

Table 3. Efficiency Testing

No	Distance (meters)	No LBT			With LBT		
		Data Sent	Data Received	Efficiency (%)	Data Sent	Data Received	Efficiency (%)
1.	10	100	90	90	100	97	97
2.	20	100	88	88	100	94	94
3.	30	100	82	82	100	90	90
4.	40	100	76	76	100	88	88
5.	50	100	70	70	100	84	84

In table 3 above, this data efficiency level analysis compares the efficiency of data transmission with and without the Listen Before Talk (LBT) protocol in the LoRa Multi Node network. Efficiency is measured by comparing the amount of data that is successfully sent with the amount of data that should be sent. The analysis focuses on the efficiency of using LBT at various distances. The test results from the previous table were used to calculate the efficiency under each condition, giving an idea of the advantages of using the LBT protocol in improving data delivery. At each test distance, the efficiency of data delivery with LBT (With LBT) is always higher than without LBT (Without LBT). For example, at a distance of 10 meters, the data efficiency without LBT is 90%, while with LBT it increases to 97%. This shows that LBT successfully increases the efficiency of data transmission. The same pattern is seen at other distances. At a distance of 20 meters, the data efficiency with LBT reaches 94%, higher than without LBT which is only 88%. The same applies at longer distances such as 30, 40, and 50 meters, where the data efficiency with LBT is always higher than without LBT.

4. Conclusion

Collusion rate test results highlight the significant benefits of using the Listen Before Talk (LBT) protocol in reducing data collisions. At a distance of 10 meters, the data collision rate with LBT is 3%, while without LBT it reaches 8%. Even at a distance of 50 meters, LBT managed to reduce the collision rate to 6%, while without LBT it reached 24%. This indicates a considerable reduction in data collision risk with LBT in a LoRa Multi Node network. Although the use of LBT increases the delay time in data transmission, this is proportional to its benefits in avoiding data collisions. At a distance of 20 meters, the delay time with LBT is 25 seconds, while without LBT is 18 seconds. The increase in delay time is acceptable considering the significant decrease in collision rate with the use of LBT. Data transmission efficiency also increases with LBT in a LoRa Multi Node network. At a distance of 30 meters, the data efficiency with LBT reaches 90%, while without LBT it is only 82%. This shows that LBT helps maximize data delivery by reducing data packet loss, so that the data received is closer to the amount of data sent.

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References

[1] Palinggi, Sandryones & Lande, Alfianto. (2021). Overview of Future Airspace Technology in Theory, Regulation and Application in Indonesia.

[2] S. Cosoli, “Implementation of the listen-before-talk mode for seasonde high-frequency ocean radars,” J. Mar. Sci. Eng., vol. 8, no. 1, Jan. 2020, doi: 10.3390/JMSE8010057.

[3] E. Didik Widianto, A. A. Faizal, D. Eridani, R. Dwi, O. Augustinus, and M. S. Pakpahan, "Simple LoRa Protocol: LoRa Communication Protocol for Multisensor Monitoring System Simple LoRa Protocol: LoRa Communication Protocol for Multisensor Monitoring Systems," TELKA, vol. 5, no. 2, pp. 83-92, 2019.

[4] M. I. Suga and H. Nurwarsito, "KWH Meter Monitoring System based on LoRa Communication Module," 2021. [Online]. Available: http://j-ptiik.ub.ac.id.

[5] L. Leonardi, L. Lo Lo Bello, G. Patti, A. Pirri, and M. Pirri, “Simulative Assessment of the Listen Before Talk Adaptive Frequency Agility Medium Access Control Protocol for LoRaWAN Networks in IoT Scenarios,” *Appl. Syst. Innov.*, vol. 6, no. 1, p. 16, Jan. 2023, doi: 10.3390/asi6010016.

[6] Nurhadi, A. A., Darlis, D., Murti, M. A. (2021). Implementation of RFM95W LoRa Communication Module in IoT-Based 3 Phase Electricity Monitoring System. Ultima Computing: Journal of Computer Systems, 13(1).

[7] Suga, M. I., & Nurwarsito, H. (2021). KWH Meter Monitoring System based on LoRa Communication Module. Journal of Information Technology and Computer Science

Development, 5(4), 1257-1266. [8] N. W. Zamani and S. S. M. Khairi, “A comparative study on data mining techniques for rainfall prediction in Subang,” in *AIP Conference Proceedings*, 2018, vol. 2013, no. 1, p. 20042.

[8] Yoshua, A., Primananda, R., & Budi, A. S. (2020). Implementation of Multi-Node Sensor Data Transmission Using the Master-slave Method in LoRa Communication. Journal of Information Technology and Computer Science Development 4(10), 3445-3454. https://j-ptiik.ub.ac.id/index.php/j- ptiik/article/view/7993.

[9] Leonardi, L., Lo Bello, L., Patti, G., Pirri, A., & Pirri, M. (2023). Penilaian Simulatif dari Listen Before Talk Adaptive Frequency Agility Medium Access Control Protocol untuk Jaringan LoRaWAN dalam Skenario IoT. Inovasi Sistem Terapan, 6(1), 16.