A Wireless Emergency Signaling with LoRa Network for Elderly Persons

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Abstract: Using LoRa technology, a push-button wireless remote emergency assistance system has been created that can communicate with aged care providers using warning sound and light on the receiver. The experimental results can assure that this system can be processed with 100% accuracy inside a 6 km coverage area of suburban and a 12 km by adding a repeater node. Especially, another transmitter can do the duty of a repeater. The benefit of this work is that staff can correctly respond to alerts and get patients promptly.

***Keywords* — LoRa, Wireless Emergency Signaling, Elderly People**

I. INTRODUCTION

CURRENTLY, there is a lot of research being conducted in the field of wireless long-distance communication. One key issue is safety communication, particularly in ensuring that responsible organizations can respond promptly to critical incidents affecting the safety of those involved. According to [1], [2], [3], [4], various approaches for managing crises in today's smart cities have been explored, and systems focusing on emergencies have been categorized based on the employed technology and the provided services. Furthermore, [5], [6], [7], [8] have developed an emergency information transmission system via mobile communication devices, aimed at achieving the fastest possible response time, closely matching the actual time of incidents. This enables responsible personnel to address the situation promptly and minimize potential losses. Sometimes there is a significant number of patients requiring treatment and hospital beds, [9], [10], [11], [12] have simplified detection and alarm device operations and analytical processes in patient rooms. This allows hospital staff to respond more quickly and effectively to the high volume of patients. Most research tends to focus on systems in large cities with advanced technology and comprehensive wireless internet services. However, in underserved communities lacking extensive internet coverage, these emergency alert or help signal systems cannot be utilized. Therefore, LoRa (Long Range) technology plays a crucial role in addressing this issue, as it can transmit signals over long distances from sender to receiver devices without relying on wireless internet. However, this comes at the cost of reduced data volume and complexity, as well as slower response times of the receiving devices. In response, [13] has proposed strategies for deploying LoRa networks to cover wide areas and achieve faster response times closer to real-time. The node connection structure in this system is star topology, requiring a central device to relay data. To cover wide areas efficiently, more central devices need to be distributed across the area. [14], [15] have enhanced the signal transmission efficiency of LoRa systems by using mesh topology node connections, which improves signal transmission efficiency without the need for additional central devices as required by star topology.

Thailand, which is entering an aging society, should emphasize distant assistance systems. Because of sometimes, elderly people cannot help themselves, especially those living alone. When accidents or emergencies occur, it is necessary to have assistants or service agencies providing timely care, as delays in assistance could result in danger or death. Therefore, the design of a wireless emergency assistance system for elderly people utilizing LoRa technology has been proposed in this paper.

II. SYSTEMS DESIGN

LoRa (Long Range) is a long-range communication technology employed in unlicensed radio frequencies such as 433 MHz, 868 MHz, and 915 MHz [16]. In the experiment on suburban, LoRa can support long-range communication in more than 10 km based on transmitted power. Communication is focused on point-to-point between active nodes, which can receive signal power intensity as low as -140 dBm.

The manuscript received Sept. 9, 2024; revised Nov. 29, 2024; accepted Dec. 20, 2024; Date of publication Dec. 30, 2024

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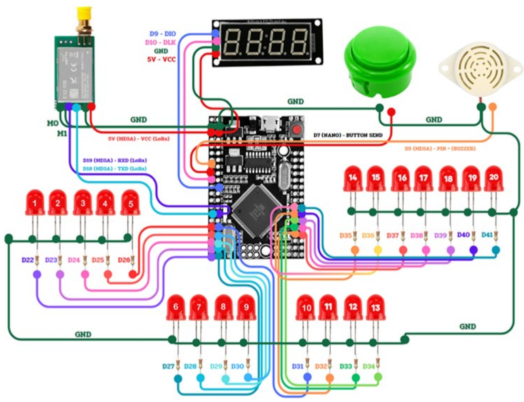

Fig. 1. Receiver device structure.

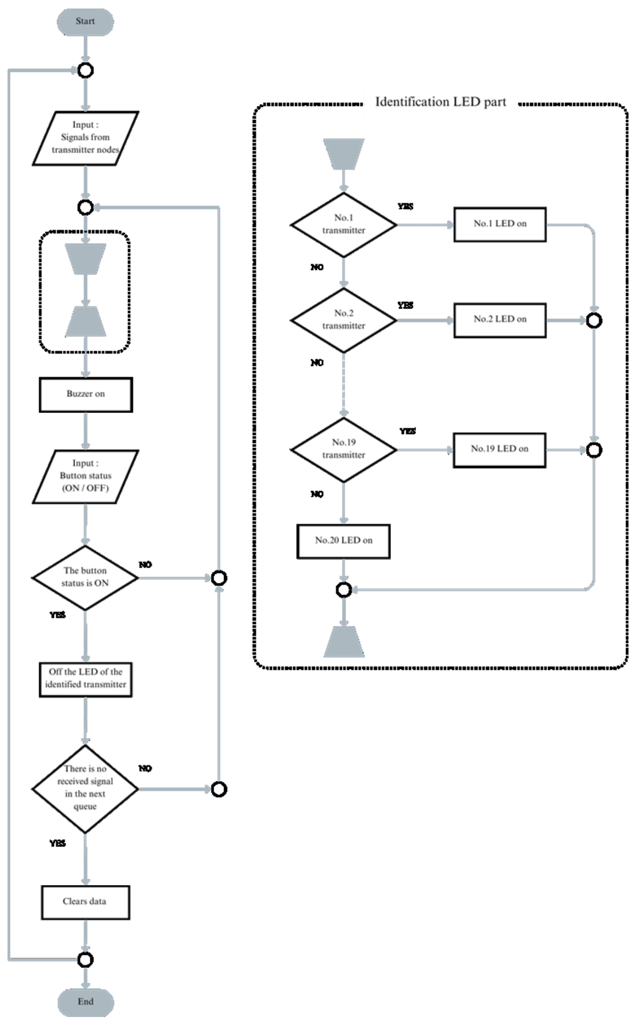

Fig. 2. Receiver flowchart.

A. Receiver

From Fig.1 and Fig.2, the receiver device can receive signals from transmitters up to 20 nodes. When there is a signal from any transmitter, the device will sound an alarm and light up a red light to identify that transmitter. If the receiver user hears the signal and wants to respond, they must press the "acknowledge" button on the device, then the receiver will silence the alarm, and the red status light will turn off. While pressing the button, the status will be sent to the transmitter device and light up a green light to notify the transmitter user that it has been acknowledged. Finally, they can send help immediately.

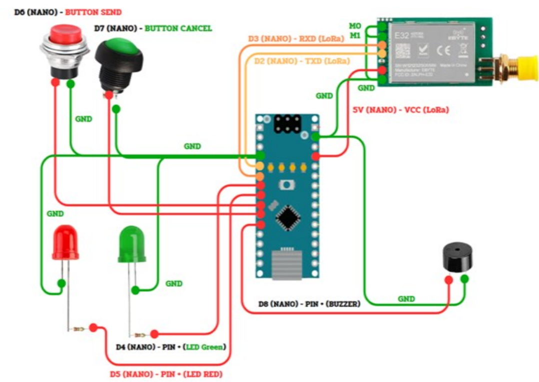

Fig. 3. Transmitter device structure.

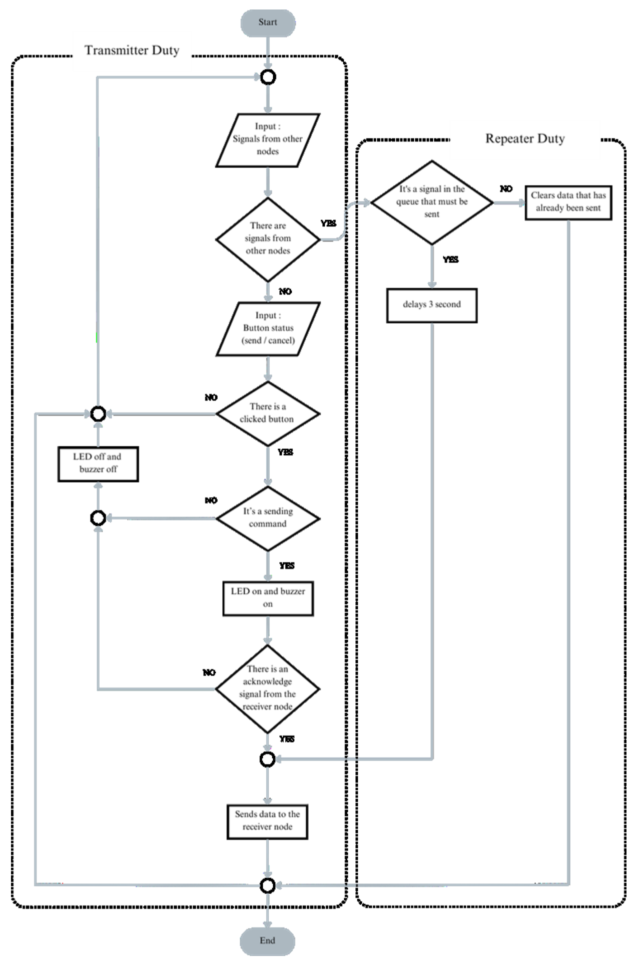

Fig. 4. Transmitter flowchart.

B. Transmitter

From Fig.3 and Fig.4, if the transmitter device has normal operating status, it will be active when the user presses the device button, a warning sound will sound and a red light will light up. There is a delay of approximately 30 seconds in case of a wrong pressing. Then the user presses the cancel button in time and the alarm sound and red light will be turned off. If the cancel button is not pressed, the signal will be sent to the receiver. When the receiver user presses the acknowledgment button, a green light will appear on the receiver. The cancel button can be pressed then the green light of the receiver will be turned off. Then the device will back to standby mode. In addition, it can also receive signals from other devices that are far away to help replicate the signal to the receiving device. The transmitter device can transmit a signal with approximately -28.7 dBm as shown in Fig.5.

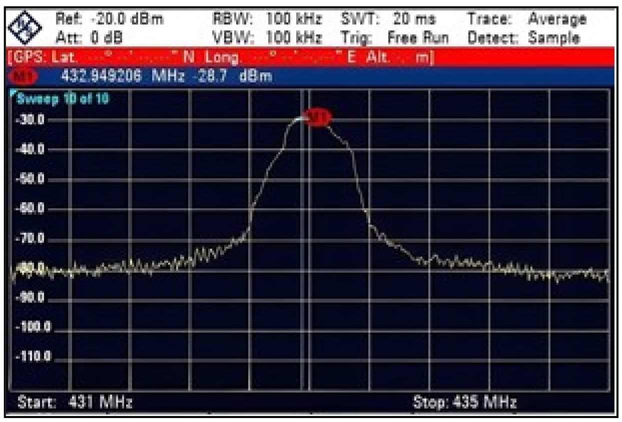

Fig. 5. Transmitted power.

III. Results and Discussion

Start by experimenting in a suburban area. The buildings are not dense as shown in Fig.6 to see the communication coverage distance between transmitter and receiver. Keep changing the position of the transmitter away from the receiver until the receiver has no response to the transmitter. Then the results of the received power and the % rebounding of the receiver will be recorded.

Fig. 6. Performance experiment on the suburban area.

Fig.7 (a) shows the receiver power level changing related to the distance of the transmitter without any amplifying or regenerating new signals. The experiment has been carried out until the % rebounding of a receiver is 0% as shown in Fig.7 (b). It can be seen that the average received power level measured is approximately -135.14 dBm, which is close to the minimum received signal power of -140 dBm according to LoRa theory. In actual operation, it will be affected by the environment, causing the limit at which the receiver can respond to a signal from the transmitter to be lower than the theoretical value.

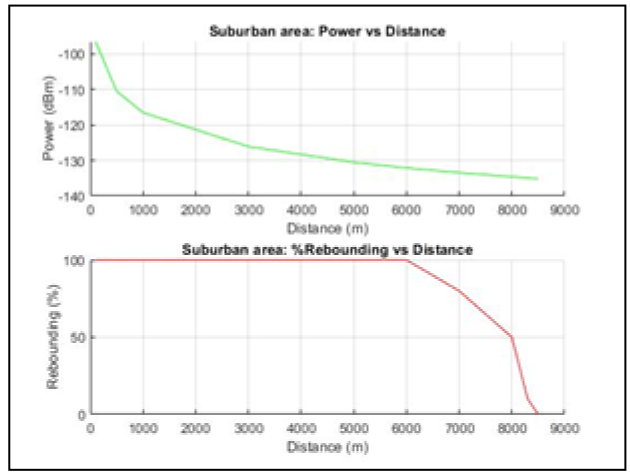

Fig. 7. Results of the received power versus communication distance value (a) and the % rebounding versus communication distance (b) in a suburban area.

Fig. 8. Repeater performance experiment on the suburban area.

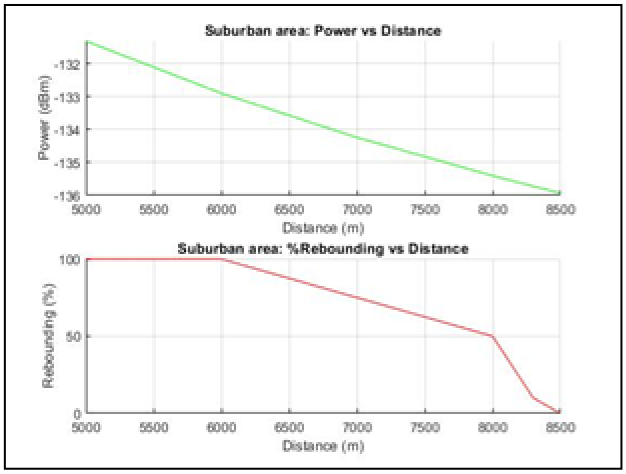

Fig. 9. Results of the received power versus the increased communication distance from the repeater (a) and the % rebounding versus the increased communication distance from the repeater (b).

Next, another transmitter node acting as a signal repeater has been added to the experiment. This experiment has been set the repeater distance of 6000 m from the transmitter, a distance where the % rebounding of the receiver is still 100% as shown in Fig.7. Keep changing the positions of the transmitter and repeater away from the receiver until the receiver has no response to the transmitter. Then the results of the received power and the % rebounding of the receiver will be recorded as shown in Fig.8.

Fig.9 shows the increased distance from the repeater. The additional distance also has the % rebounding of the receiver of 100% which is 6000 m. This is because the signal repeating is like creating a new signal before transmitting it to the receiver. Therefore, the communication distance between the transmitter and receiver can be as high as 12000 m if a repeater is employed.

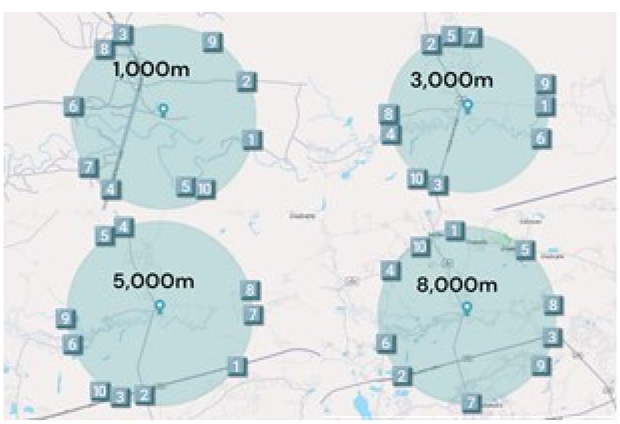

Fig. 10. Coordinates for testing locations of the system devices in community areas.

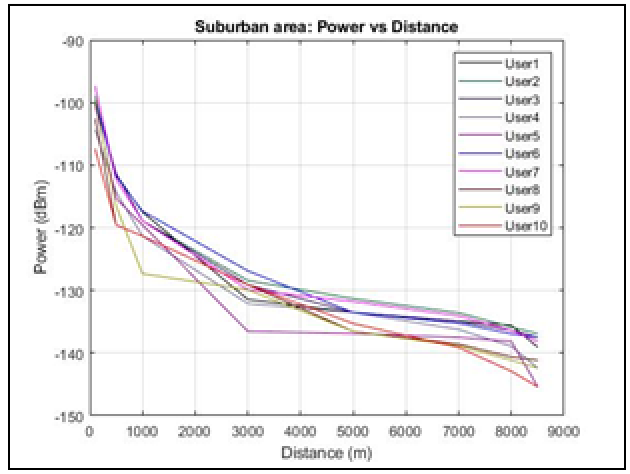

Fig. 11. Comparison results of the received power versus the communication radius on the urban area.

Next, a communication distance experiment around a circular radius in an urban area has been conducted to see the impact of surrounding buildings. By positioning 10 transmitters around the receiver in various radius distances. Then the results of the received power and the % rebounding of the receiver will be recorded as shown in Fig.10.

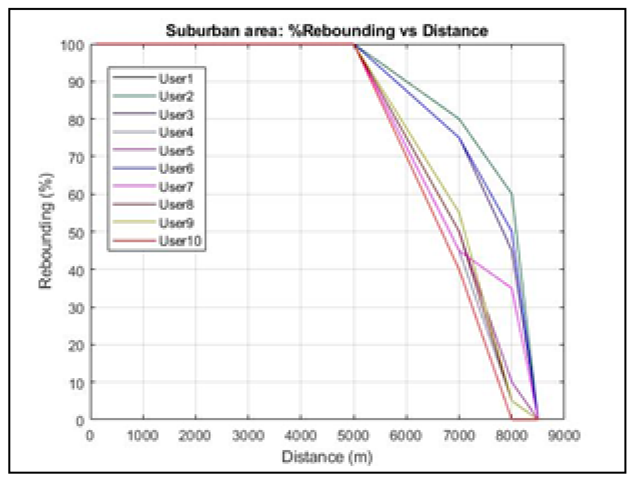

Fig. 12. Comparison results of the % rebounding versus the communication radius on the urban area.

From Fig.12, the receiver can respond to all 10 transmitters 100% in an urban area where the distance from the transmitter is not more than 5000 m, which is shorter than in a suburban area. Due to the density of buildings, the result can be clearly seen from the significantly lower average received power values as shown in Fig.11 at the corresponding distances of the two cases.

Fig. 13. Operation principles description of the equipment to relevant personnel in Talad Sai Subdistrict.

IV. Utilization

For utilization as Fig.13, our team described the operation principles of the equipment to relevant personnel in Talad Sai Subdistrict.

From Fig.14, we went to Ban Prathai Tambon health promoting hospital for receiver equipment installation. The receiver device has been supervised by the hospital officers.

Fig. 14. Receiver equipment installation.

From Fig.15, the transmitter devices were installed allocating to each house of the elderly population in Talad Sai Subdistrict.

Fig. 15. Transmitter equipment installation.

V. Conclusions

From point-to-point signal reception and transmission testing. The system can receive and transmit signals with 100% accuracy over a distance of approximately 5 km. But, the distance can also be extended by using another device that acts as a repeater on its own. Proper positioning of the equipment will allow for longer distances and greater coverage of the service area.

Acknowledgment

The authors are thankful to a group of elderly volunteers in Talad Sai Subdistrict, Talad Sai Subdistrict Administrative Organization, Talad Sai Subdistrict Health Promoting Hospital, and all those involved, including the TSRI who supported funding for this research.

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