Comparison of LoRa 915 MHz and 433 MHz on Distance Coverage in Thailand Area

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Abstract—**We have conducted an experiment to study and determine the longest possible communication distance between Long Range (LoRa) sensor nodes with different network topologies. The aim is to develop and incorporate IoTs in a smart farm and smart city in the future. In this experiment, we started out by transmitting and receiving between 2 nodes by using half-duplex communication, one is a master unit and another one is a slave unit. We start the experiment by 100 meters transceiving, and then step up the distance by 100 meters until reaching 500 meters because the area is limited at 500 meters. According to the results we obtained, LoRa ST development board 915 MHz gives liner relationship between signal strength and distance. In other words, RSSI and SNR decrease when the distance is increased linearly; however, it is important to note that LoRa 433 MHz module cannot operate if the distance is longer than 200 meters. As a result, we can conclude that LoRa 915 MHz is more suitable than LoRa 433 MHz in performing in area with high density of obstacles**.

Keyword—LoRa, Smart farm, Smart city, Thailand, IoT.

I. Introduction

Nowadays, Wireless Sensor Networks (WSNs) play a central role to many things in our daily lives in everywhere with various applications; for example, smart farm, indoor localization [3], vehicle to vehicle communication, or even wild fire tracking systems. Those mentioned above are all applications of WSNs. We are now living in Internet of Things (IoT) and wireless age where everything is to be connected and is to communicate, exchange information or even video stream around the world in milliseconds without transmission lines. It is the merit of connected world that drives WSN researches.

For our research, the communication distance between nodes, power consumption and remote control via the internet are considered. We have done a literature review about IoT and WSNs and found that Low Power Wide Area Network (LPWAN) is suitable with those needed properties. There are many existing LPWAN solutions that we can deploy into this research such as Sigfox network, NB-IoT, LoRa and so on. However, LoRa is adopted in this research because it is flexible to design a private network.

The goal of this study is to combine WSNs to smart farming, so we need a good point of LoRa to be implemented for our system. For this reason, we can custom and design any topology based on user's requirements. This paper is composed of 5 parts. Section I is an introduction. Section II describes related works and literature review. Section III illustrates the problem formulation. Section IV provides the experiment setup and Section VI discusses the experiment results. Finally, section V concludes the results of the study.

II. Related works

As of now, LoRa is more widely used since there are many advantages such as:
- Safety of the system because it is bi-directional communica- tion.
- Simple star topology, no need to implement or includeany complicated systems or componentssuch as a mesh network or a repeater.
- Low data rate in transmission leading to low power consumption at the nodes.
- Low cost of installation
- Long range transmission

For these reasons, LoRa is widely used in research. From our literature review activity, we found that LoRa is deployed in various applications as in the following.

- Biomedical engineering [4]
The patient is attached by bio sensor to monitor their condition. It makes a comfortable to patient and the doctor that they do not need to go to the hospital frequently.

- Smart grid [5]
The system monitors power consumption in the household and sends and receives data between a home and a power grid to adjust and control the load accordingly.

- Smart farm [6]
The wide and discrete area of a farm is one of the problems that can be solved by LoRa because it can send the data in longer range without approaching the area.

In this paper, we study and compare the operations of two LoRa frequency ranges between 433 MHz and 915 MHz in the Non Line Of Sight (NLOS) area. The purpose is to study a performance and how different functional of both systems when implementing in the real environment. Because we need to realize how much attenuation of the Receive Signal Strength (RSSI) produces, and the robustness of Signal to Noise Ratio (SNR) if we increase the distance amongst nodes. After obtaining all of the data, we will analyze them for implementing in the real system which is targeted for smart farming and smart city. The experimental result will be the conclusion of using the proper setup for our future system.

III. Problem Formulation

From section II, we have mentioned about researches which are related LoRa topic. In this section, we are going to discuss about all equations which are needed in the experiment. We need to compare the RSSI and SNR of each system in the difference distance between LoRa 433 MHz and 915 MHz.

Receive Strength Signal

We perform this function into our experiment to find the robustness of the signal, and it will lead us to find the constraint of communication range of the system, so we can correctly adopt the proper topology into our system by the communication range. We can calculate RSSI as following equation. [1]

$$dBm \quad -10 * n * log_{10}(d) + P \tag{1}$$

Where:
d is the distance between nodes.
n is the propagation constant or path loss exponent. (n = 2 in free space)
P is power in reception mode. (dBm)

Signal to Noise Ratio

High SNR means that the communication of the system is stable. We can obtain SNR of the system by following equation, [2]

$$SNR = 10log_{10}\left(\frac{S}{N}\right) \tag{2}$$

Where:
S is Data signal of the system.
N is Noise of the system.

Linear least square
We perform linear least square into our experiment data plot to find the trend of the system. We can calculate and estimate linear least square by using the following equation. [7]

From linear equation

$$y = \beta_1 + \beta_2 x \tag{3}$$

We can find the best approximate value of the system by

$$y = \beta_1 + \sum_{j=2}^{n+1} \beta_j x_j - 1 \tag{4}$$

Where n is number of data points.

Experiment Setup

For the experiment setup part, we have divided this into 4 parts which is composed of experiment procedure, experiment design, equipment for the experiment and experiment area respectively.

A. *Experimental procedure*

The procedure for system communication is designed as in the following sequence diagram.

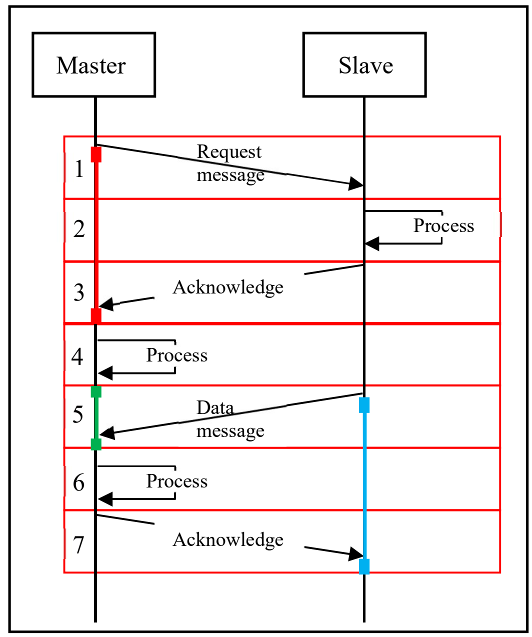
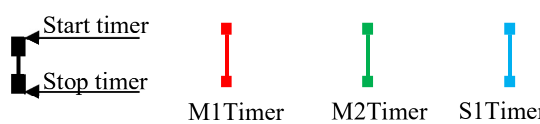


Fig. 1 Sequence diagram between master and slave unit



1. Master sends request message to Slave and starts M1 timer to wait for acknowledge from slave.
2. Slave receives message and operates processing.
3. Slave sends acknowledge to master in time. Otherwise, the communication must be denied and master must send the new request message again.
4. Master receives acknowledge and operates processing.
5. Master starts M2 timer after processing and slave must send back data to master in time. Otherwise, the communication will be denied and the master must send the new request message to slave again. When slave sends data message to master, S1 timer must be started simultaneously.
6. Master receives message from slave and operates processing.
7. Master sends acknowledge to slave.

B. Experimental Setup

The experiment setup is consisted of ST development board and our custom development board.

- ST development board at 915 MHz.
  The further information is expressed in [8]

Fig. 2 ST development board at 915 MHz

- Custom-designed development 433-MHz LoRa board
  This development board is invented by our research team. It composes of LoRa module [9], and Node MCU [11] which communicate to each other via Serial Peripheral Interface (SPI). [12]

Fig. 3 Our custom development board at 433 MHz

C. Experimental area

The experiment was performed on the narrow road in front of faculty of engineering, King Mongkut's Institute of Technology Ladkrabang at 5PM to 6PM.

Fig. 4 Experiment area

IV. EXPERIMENT RESULT

After implementing the setup from the previous section, we have obtained the results as in the table I.

TABLE I
RSSI AND SNR VALUES FROM THE EXPERIMENT

	RSSI		SNR	
	915 Mhz	433 Mhz	915 Mhz	433 Mhz
100 m.	-79	-87	23	7.25
200 m.	-85	-99	19	7.25
300 m.	-97	-	4	-
400 m.	-104	-	-8	-
500 m.	-112	-	-17	-

From all of the obtained data, we made a plot for comparing linearity of both systems which we had applied linear least square algorithm. The results were shown in the following figure.

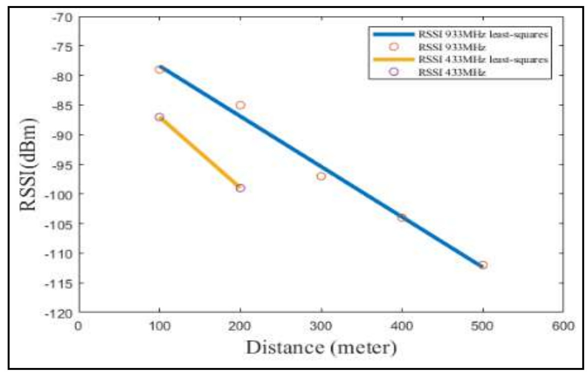


Fig. 5 SNR comparison graph

The SNR plot is illustrated the linearity of both systems whose SNR line of LoRa 915 MHz is less steep than LoRa 433 MHz. As a result, it means that LoRa 915 MHz is able to better work in the real noisy environment than LoRa 433 MHz. It is important to note that LoRa 433 MHz cannot communicate to each other when the distance is farther than 200 meters.

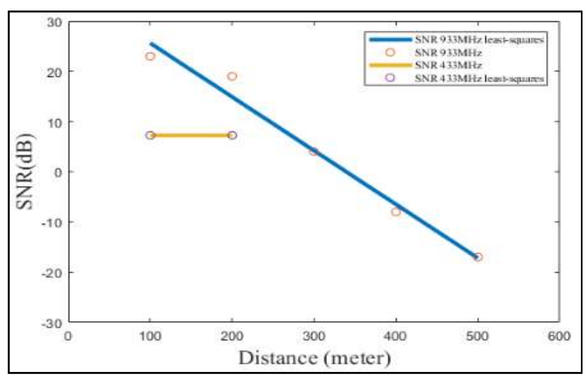


Fig. 6 RSSI comparison graph

In case of RSSI, the graph shows the result that is similar to the SNR graph. The signal strength is decreased when the distance is increased. However, LoRa 433 MHz cannot operate on a range that is greater than 200 meters. There might be various factors which are the root cause of this problem. Unfortunately, we have limited time and resources to complete the task. We are going to take it as a challenge in the future work.

V. CONCLUSIONS

We have compared linearity between LoRa 915 MHz and 433 MHz by using linear least square algorithm to estimate the trend of our system. From the experiment, we found that LoRa 915 MHz is able to operate as linear. The graph of LoRa 915 MHz has less steep than 433 MHz. Moreover, LoRa 433 MHz cannot operate when the communication distance is over than 200 meters. Hence, we can summarize our experiment that LPWAN communication by using LoRa solution in Thailand area. LoRa 915 MHz is more effective than 433 MHz.

FUTURE WORK

From this study, we have mentioned in the abstract section that we are going to deploy LoRa system in Thailand. However, we found that star topology is not effective when the system operates in high density of obstruction because it deteriorates communication range between sensor nodes. As a result, we are going to apply the new topology into our system for solving this problem such as a tree (expanded star) topology or a mesh topology to expand the communication range of the system.[3][10] Even though the sensor nodes cannot communicate with the gateway directly, we can still perform multi-hop technique to save cost of infrastructure installation. In additional, we have considered, concurrent transmission technique is needed to be applied into our future work.[14][15] We have realized that 18 bit per second (bps) is LoRa communication data rate which is unusable for any application to the real world scenario[13], so it is arduous to deploy other topologies onto the system, especially star topology because it needs quite high data rate transmission. So, this technique will be performed in our new implementation as well.

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