The Prototype of the Integration between Low Cost Single Private LoRa Gateway and Public AIS NB-IOT

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Abstract

The prototype of the low cost single private LoRa gateway and LoRa node with GPS was developed as the alternative communication channel for IOT work. The AIS NB-IOT was applied as a public communication for sending data (latitude and longitude) from the private LoRa gateway and the LoRa node with the GPS to the cloud. That data can be monitored in real time on smart phones and computers via web browser. Node-Red was applied as the cloud service to manage this data. The research studied the distance of the communication between the low cost single private LoRa gateway and the LoRa node with the GPS, RSSI (Received Signal Strength Indicator), received completed packages, incomplete packages and lost packages. The EGAT, Mae Mao Coal Mining, Lampang Thailand was the location for testing the prototype. The result of the study was satisfied. The maximum distance of the communication between those devices was 5 kilometers and the percentage of received complete packages was 89 and the lost package was 1.

Keywords: LoRa gateway, AIS Nb-IOT, IOT, Node-Red

1 Introduction

1.1 Background

The Thai government would like to promote Thailand 4.0 to use a new technology for the smart living such as smart city, smart health, smart agriculture and etc. Hence, an IOT was one of the technologies to imply. Previous research was done on an IOT for smart mining, agriculture and solar energy [1-4]. However, the communications used for those researches were wire (LAN cable) and unwired (WIFI) communication.

The LoRa and NB-IOT were recently developed in Thailand for support an IOT as the alternative communication channel. The LoRa frequency used was allowed recently by Thai government [5] and NB-IOT was developed early and tested by 2 telecommunication companies, AIS-Advanced Info Service and True Corporation [6-7].

In this research, the integration between Low Cost Single Private LoRa Gateway and Public AIS NB-IOT were prototyped, as the alternative communication channel for IOT works.

1.2 Research Objective

This research aimed to develop the prototype of the integration of the low cost single private LoRa gateway and the public AIS NB-IOT. The prototype system consisted of 2 parts, first, the GPS (Global Positioning System) LoRa node. It was used to send the data (latitude and longitude). Second, the low cost single private LoRa gateway and the public AIS NB-IOT were used to receive the data from the GPS LoRa node, and AIS NB-IOT was used to send the data from the low cost single private LoRa gateway to the cloud. The data (latitude and longitude) can be monitored in real time online on computers and the smartphones.

This prototype was developed for the improvement of the alternative communication channel for the previous work [1-4].

2 Literature

LoRa (Long Range) is a patented digital wireless data communication IOT technology developed by Cycleo of Grenoble, France, and acquired by Semtech in 2012 [8]. LoRa uses license-free sub-gigahertz radio frequency bands like 169 MHz, 433 MHz, 868 MHz (Europe) and 915 MHz (North America). LoRa enables very-long- range transmissions with low power consumption [9]. In Thailand, 920-925 MHz is allowed.

WeMos Di Mimi is a small arduino (ESP8266), it is an open-source microcontroller compatible with the developed platform. The controller is not expensive and uses low electrical power. C++ was employed for the development of this research. WeMos Di Mini can connect to a computer via the Universal Serial Bus (USB) and perform with compatible accessories in

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both analog and digital signal. The WeMos Di Mini [10] is a microcontroller platform, mounted on a board that easily plugs into most computers. It allows the developer to program the onboard Mega Chip to do various things with the programming language.

NB-IOT (Narrowband internet of things) is a low power wide area network radio technology standard developed by 3GPP to enable a wide range of cellular devices. NB-IOT focusses on indoor coverage, low cost, long battery, and high connection density. It uses a subset of the LTE standard, but limited bandwidth to a single narrow-band of 200 KHz. It uses OFDM modulation for downlink communication and SC-FDMA for uplink communication [11].

2.1 Previous Research

Previous research, the researcher [1-4] applied using the IOT for a mining logistic management, the IOT for a small Lingzhi mushroom farm, and the IOT for smart solar energy. For the communication to send data from sensors to the cloud, the IOT for a logistic management used wire communication (LAN UTP cable). The IOT for the small Lingzhi mushroom farm and IOT for the smart solar energy used WIFI communication.

The IOT with RFID was applied to find the best practice of logistic management for the Electricity Generation Authority of Thailand (EGAT) Mae Mao Mining, Lampang. Their research applied the use of RFID for lignite coal trucks and data from the RFID process automatically through a server and was stored into a private cloud computer. The equipment and tools used in their research were an RFID reader, UHF passive RFID tags, Arduino Mega 2560 + Ethernet Shield, PHP, Jason, Node.JS, and Maria DB as a database system. The protocol used was MQTT. The results of the research showed that officers who worked for related systems were satisfied. The system enhanced the best practice of lignite coal mining logistics in terms of information checking [1].

The prototype of a smart Lingzhi mushroom farm [2-3] their research applied the use of IOT with a sensor to measure and monitor the humidity in the Lingzhi mushroom farm. The humidity data is processed through NETPIE which was developed and provided by NECTEC as a free service for IOT. Humidity data was stored into a NET FEED (a sub service from NETPIE) and displayed on mobile devices and computers through NET FREEBOARD (another sub service of NETPIE). This research also controlled sprinkler and fog pumps automatically and the functional status (switching on and off for periods of time) and pushes notifications through the LINE API on the LINE Application. The equipment and tools used in this research were NodeMCU, humidity sensor, RTC (real time clock), relay module, sprinkler and fog pumps. C++ and Node.JS were used as programming. The services and protocol used were NETPIE (Network Platform for internet of everything) with subservices such as NETPIE FEED, NETPIE FREEBOARD, and NETPIE REST API. The results of their research show that using IOT with the sensor enhanced the prototype of smart farming.

In addition, another previous research expended the use of the solar system for the smart agricultural greenhouse as an alternative and green energy resource. The IOT with voltage and current module sensors were applied to measure and monitor the status of solar energy. The status of the solar system consisted of the solar system current charging from solar panels to the battery and the loading from battery to water systems. All the data from the solar system status were preceded into a Blynk as an IOT cloud service. All data could be monitored in real time on mobile devices [4]

In this research, the researchers would like to improve the previous work mentioned above. Wire (LAN cable) and WIFI communication were replaced with a low cost single private LoRa gateway that connects with the public AIS NB-IOT.

3 Research Methodology

This research followed the waterfall model of the system development life cycle (SDLC) as a research methodology. There are 5 steps in this research [12]. These steps are the requirement and feasibility study, system analysis and design, implementation, system validation, and maintenance.

3.1 Requirement and Feasibility

The requirement of this research was to prototype the alternative communication system for an IOT, by using the low cost single private LoRa gateway and the public AIS NB-IOT.

LoRa node with GPS was used to study the data (latitude and longitude). This research focused on the distance of LoRa node with GPS and a low cost single private LoRa gateway. RSSI (Received Signal Strength Indicator), complete packages, incomplete packages and package loss were also studied. Coverage area and speed of the GPS were not included in this study. Hardware, software and protocol used in this research were shown in Table 1, Table 2, Table 3 and Table 4.

3.2 System Analysis and Design

The research aimed to prototype an alternative communication channel for IOT, based on previous works from researchers [1-4]. The low cost single private LoRa gateway was applied to integrate with the public NB-IOT communication. The GPS was used to study data such as distance of communication, package lost, RSSI (Received Signal Strength Indicator). The frequency of LoRa communication was 920-925 MHz, allowed by office of NBTC (Office of The National Broadcasting and Telecommunications Commission, Thailand) [5].

Table 1. The GPS LoRa node (Sender)

Hardware	Purpose of the use
Ubox GPS Module	GPS module
ESP 8266 WeMos D1 Mini	Main Controller
Sx1267 WeMos D1 Mini Shield	LoRa Transceiver (send data to gateway)
Oled WeMos D1 Minu Shield	Screen Display
5dbi Omni Antenna	Outdoor Omni Antenna
18650 Lion Battery	Dc Power

Table 2. Gateway (Reveiver) and purposes of the use

Hardware	Purpose of the use
SparkFun RedBoard-Arduino UNO Compatible	Main Controller
Sx1276 Shield	LoRa Transceiver (receive data from GPS node)
Oled Shield	Screen Display
AIS NB-IOT (Quectel Bc95)	Transceiver (send data from Sx1276 to cloud)
6Ah 6V Lead Acid battery	DC Power
5dBi Omni Antenna	Outdoor Omni Antenna

Table 3. Software and purposes of the use

Software	Purposes of use
C++ on Arduino IDE	Programming language on WeMos D1 Mini and Arduino (SparkFun RedBoard-Arduino UNO Compatible)
NodeRed (Flow based programming)	Cloud Service (UDP server) Receive data (Lat and Long) from gateway and store into CSV file
Web Brower (Chrome)	Real time data monitoring
Distance Calculator (free mobile application)	Use for distance calculating from GPS node and gateway

Table 4. Protocol and Communication of the use

Protocol and Communication	Purposes of use
SPI (Serial Peripheral Interface)	- The communication between SX1267 WeMos DI Mini Shield and WeMos DiMi (GPS LoRa Node) - The communication between SX1267 with OLED shield and RedBoard Arduino UNO compatible (private single chanel LoRa gateway)
Serial Communication	The communication between UBlox GPS module and WeMos Di Mini
I2C (Inter Integrate Circuit Bus (IIC))	The communication between OLED display and RedBoard Arduino UNO compatible (private single channel LoRa gateway)
Serial UART (Universal Asynchronous Receiver/Transmitter)	The communication between Red Board Arduino UNO compatible and AIS NB-IOT
UDP (User Datagram Protocol)	The communication between AIS NB-IOT and cloud

At the first step, the low cost single private LoRa gateway designed in this research was the single channel, communicating with a single GPS LoRa node (with GPS). The communication between the low cost single private LoRa gateway and GPS LoRa node was used as a class C [13]. It means that the low cost single private gateway was in the status of standing by at all time, waiting for receiving packages from the LoRa node. Hence, energy saving was not concerned in this research.

3.3 Concept Diagram

In this research, a prototype of a Private LoRa communication integrating with a NB-IOT as public communication channel was applied as an alternative communication system for and IOT (in Figure 1).

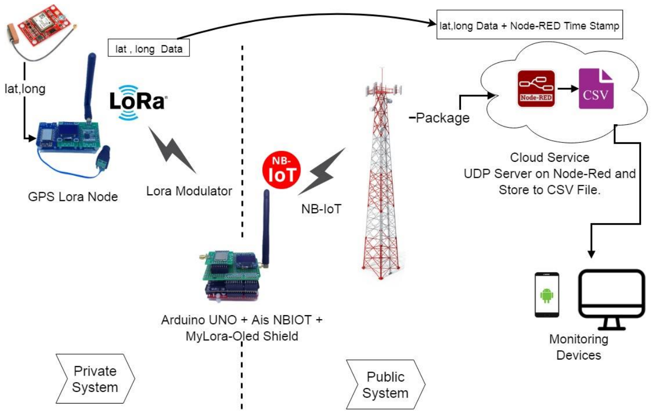

Figure 1. A Concept diagram of the prototype of the integration between the low cost single private LoRa gateway and public NB-IOT

A private LoRa communication system consisted of (1) a GPS connecting with a LoRa node and (2) a private single channel LoRa gateway. GPS connecting with LoRa node was used to send data (Latitude and Longitude), to the single channel LoRa gateway. The data of latitude and longitude can be monitored in real time on a screen on the single LoRa gateway privately.

A public communication system consisted of (1) the private single channel LoRa gateway connecting with, (2) NB-IOT. The data of latitude and longitude from GPS can be real time monitored on the internet by using computers or smartphones via web browser.

In addition, the data of latitude and longitude were stored on cloud. Node-Red was applied as the data management tool on the cloud, and for displaying data on web browser. The Node-Red was also used to convert and record GPS data to a TEXT file as CSV format (Comma-Separated Value). The historical data from CSV file can be displayed on the Google map as Geographic information.

The data of GPS (latitude and longitude) was studied for the distance of communication between GPS LoRa node and Private LoRa gateway. Number of sending data packages, number of receive completed and uncompleted package and number of data package lost were examined in this research.

For more information on GPS LoRa node (sender node), WeMos D1 Mini was applied as a main controller. C++ language on Arduino IDE was written on the controller. Three hardware modules were used to connect with WeMos D1 Mini (in Figure 2).

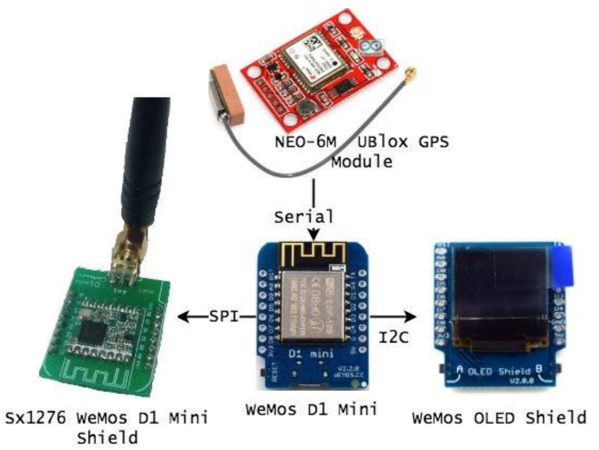

Figure 2. A detail diagram of sender node (GPS LoRa node)

First, GPS module, NEO-6M Ublox GPS module with antenna was used as a GPS. It should be noted that, hardware connection between Wemos D1 Mini and NEO-6M Ublox GPS module with antenna was serial communication.

Second, LoRa SX1267 module on Wemos Di Mini shield was used to connect with WeMos D1 Mini. It should be noted that, they were connected via SPI communication (Serial Peripheral Interface). In addition, the 5dbi Omni Antenna was used for LoRa (LoRa Sx1267 with Wemos Di Mini shield)

Third, OLED screen (organic light-emitting diode) on Wemos OLED shield was used to connect with WeMos D1 Mini. To be noted that, they were connected with I2C communication.

All electronic devices (GPS LoRa node) were put in a waterproof control box and the battery used was a DC 2 battery of 6Ah 6V Lead Acid battery (in Figure 3).

Figure 3. All electronic devices (GPS LoRa node) were put in a waterproof control box

According to Figure 4, package of data from LoRa node consisted of latitude and longitude (not including speed). The counter of sending package was set from 1 to 100 and the package was sent every 3 seconds. If the counter of the package was 100 and it turned into 1 for the next loop. The counter was used for the purpose of monitoring package (numbers of received and lost packages).

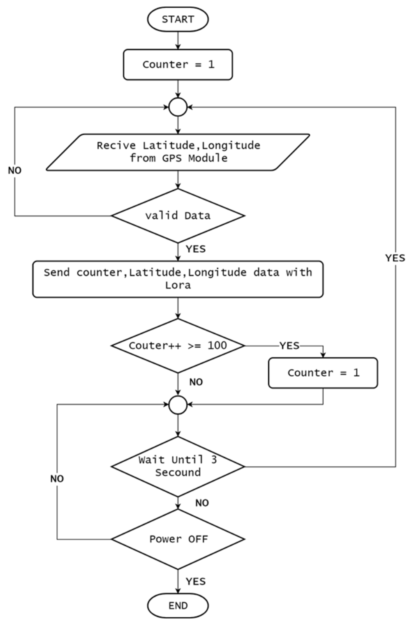

Figure 4. The flow chart of sending GPS data from GPS LoRa node to the single private gateway

For more details of the low cost single private LoRa gateway and the public AIS NB-IOT, the SparkFun RedBoard Arduino UNO Compatible was applied as a main controller. C++ language on Arduino IDE was written on the controller. Two hardware modules were used to connect with SparkFun RedBoard Arduino UNO Compatible (in Figure 5).

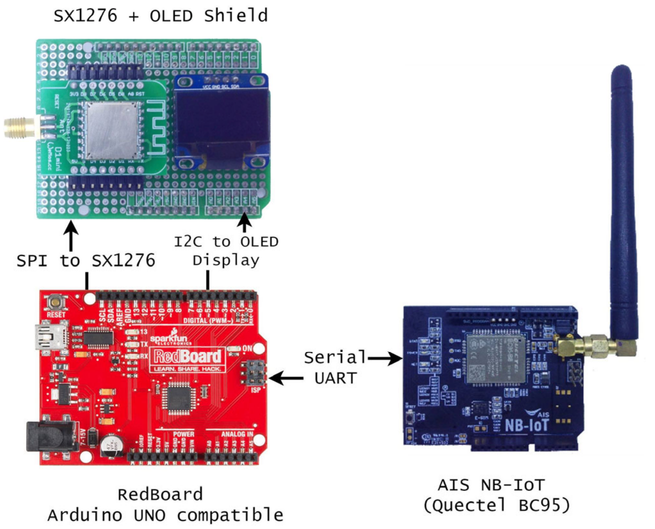

Figure 5. A detail diagram of detail diagram of the low cost single private LoRa gateway connecting with the public AIS NB-IOT

First, LoRa Sx1276 with OLED shield was used to connect with the SparkFun RedBoard Arduino UNO Compatible. It should be noted that, hardware connection between the LoRa SX1267 chip and the SparkFun RedBoard Arduino UNO Compatible was SPI communication. And OLED display was connected with the SparkFun RedBoard Arduino UNO Compatible by I2C communication channel. It was considered as a private single channel LoRa gateway, receiving GPS data from GPS LoRa node. GPS data (latitude and longitude) can be monitored on OLED screen.

Second, the AIS NB-IOT (Quectel BC95 chip) from AIS Telecommunication Company in Thailand was used to connect with the SparkFun RedBoard Arduino UNO Compatible. It should be noted that, they were connected via UART (Universal Asynchronous Receiver/Transmitter). The connection was a serial communication with a full duplex, since there were two-ways that data can be transmitted via pin TX and RX. It was considered as a public gateway, forwarding data from a private single channel gateway to a public system. This data can be monitored in real time on the internet by computers and smartphones.

All electronic devices were put in a waterproof control box as well as the 18650 lion battery. The portable stand was designed to be easily moved (in Figure 6 and Figure 7).

Figure 6. All electronic devices are put in a waterproof control box

Figure 7. The low cost single private LoRa gateway connecting with the public AIS NB-IOT with the stand and the Omni antenna

The concept of GPS LoRa gateway (in Figure 8) can be explained as the private single LoRa gateway received GPS data from GPS node (latitude and longitude) and it reported the quality of signal status such as RSSI (Received Signal Strength Indicator) and SNR (signal to noise ratio). However, SNR was not studied in this research as the testing area was open near the dam so we are not concerned about interference.

It should be noted that, the package from the private single gateway was encoded with BASE64 and sent to the public AIS NB-IOT with serial communication. The reason to encoded with BASE64 was that if the package from the private single gateway was sent but did not encode to the public AIS NB-IOT, the public AIS NB-IOT was frozen or unresponsive. It was assumed that some characters could be similar to AT command of AIS NB-IOT.

After that, AIS NB-IOT forwards packages to the internet (public network) with UDP protocol. The data from the package can be monitored on computers and smartphones (by Node-Red service) with an internet browser.

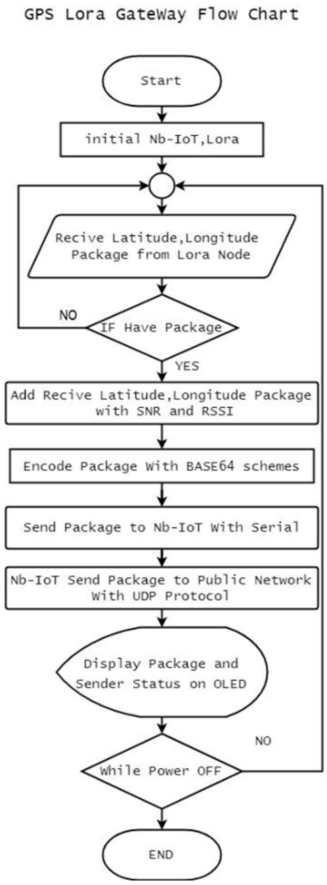

Figure 8. The flow chart the low cost single private LoRa gateway connecting with the public AIS NB-IOT

3.4 Implementation

The location of the low cost single private LoRa gateway was placed in the tower. The hight was around 6 floors (approximately 18 meters). In addition, the tower was on a small hill (in Figure 10).

The location of the GPS LoRa node was placed on the vehicle (in Figure 9). The distance for driving was approximately 5 kilometers and the vehicle would be stopped every 1 kilometers. (From the Figure 11, there were 5 zones in this study A, B, C, D, E and each zone was 1-2 kilometers. The last zone (E) was not included in this study (in Figure 11).

Figure 9. The LoRa node with the GPS was place in the vehicle for testing the distance of the communication

Figure 10. The low cost single private LoRa gateway and the public AIS NB-IOT was located at the tower

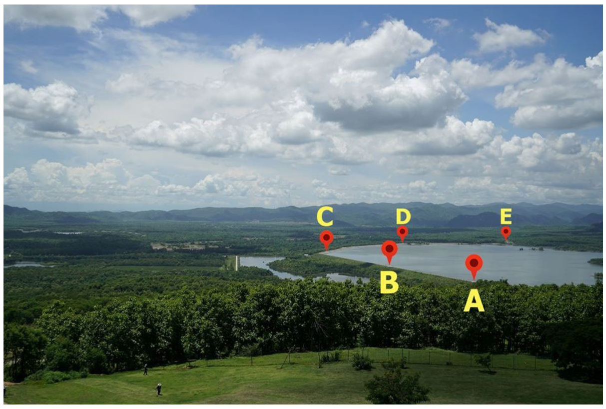

Figure 11. The testing distance for the communication between the low cost single private LoRa gateway and the LoRa node with GPS

3.4 System Validation (System Testing)

The pilot system was done before implementing the LoRa GPS node and the private low cost LoRa gateway with the public AIS NB-IOT.

LoRa node (without GPS) and Gateway was implemented. The gateway sent the sequential number (counter) to the LoRa node for testing the distance of the communication between those two devices. RSSI was included. The location for the pilot system testing was in the EGAT, Mae Mao Coal Mining, Lampang Thailand (tourist zone). It can be seen in the Figure 12 and Figure 13).

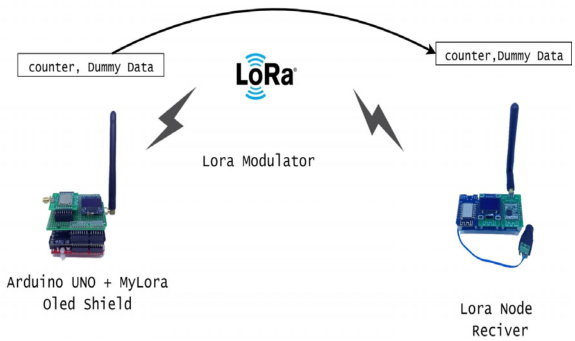

Figure 12. The concept diagram of the communication between (sender) and (receiver)

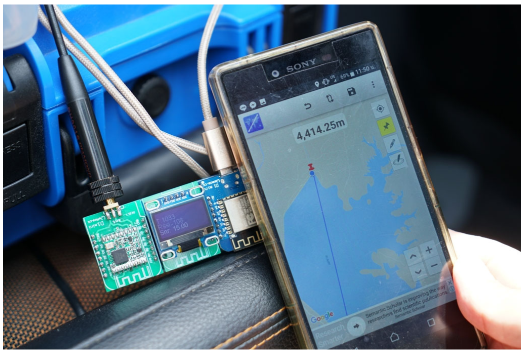

Figure 13. The sequential number, RSSI were shown on the OLED screen and the distance of communication was shown the screen of mobile phone

Table 5. The results of distances and numbers of packages sent by the private LoRa gateway to LoRa node (receiver), and RSSI

Zone	Distance	Number of receive package	RSSI (-dBm)
A	1-2 km	21	-115
B	2-3 km	25	-105
C	3-4 km	30	-103
D	4-5 km	25	-101

From the results (Table 5), the first 1-2 kilometers was far down the slope in the dense forest; the RSSI was approximately -115 dBm and received 21 packages. In between location 3 and 4 there was an open road on the dam andthe RSSI was approximately -103 dBm and 30 packages were received.

The second implementation was done by adding a GPS to the LoRa node. The gateway GPS LoRa node then sent the data to the gateway (the low cost single private LoRa gateway with the public AIS NB-IOT).

4 Results

The results of the study (Figure 14) concerned the distances of the communication between the GPS LoRa node to the private LoRa gateway, it was measured in kilometers (line of sight). Packages sending, receiving (complete, incomplete, lost) were concerned. Package included the data of latitude and longitude. RSSI in receiving packages was also reported.

The results from the Table 6 showed that the first 1 to 2 kilometers, the private LoRa gateways received the highest incomplete packages (10 packages), because the first 1 to 2 kilometers was the way down the hill and full of dense trees. For 3 to 4 kilometers, there were the highest numbers of LoRa node sending packages and also were the highest numbers of receiving complete packages by the private LoRa gateway. The lowest packaged lost was at 4-5 kilometers (one package lost). For the last zone E, was not include in the study (on the Figure 17, zone E was out of line of sight and full with dense trees).

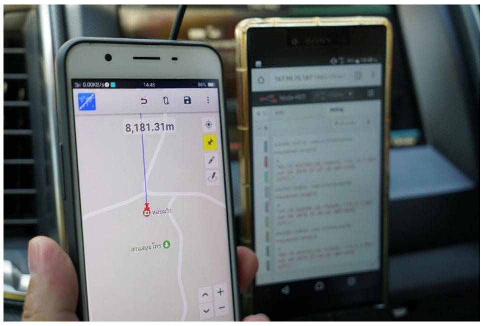

Figure 14. The result of the communication was shown real time on line on a mobile phone and the distance of communication was shown another mobile phone

Table 6. The results of distances and numbers of packages sent by GPS LoRa node to the private LoRa gateway, and results of received packages by the private LoRa gateway (numbers of complete, incomplete, and lost packages)

Zone	Distance	Number of sending packages	Number of receive complete package	Number of receive incomplete package	Number of package lost
A	1-2 km	24	11	10	3
B	2-3 km	27	25	0	2
C	3-4 km	105	100	0	5
D	4-5 km	90	89	0	1

If looked at RSSI (Figure 15), the distance 3 to 4 kilometers, the RSSI was -104 dBm and the highest counters (received packages 26 packages). The distance 4-5 kilometers, the RSSI was -103 dBm and the highest counters (received23 packages). It should be noted that RSSI was a term used to measure the relative quality of a received signal from the gateway to the client device, but has no absolute value. The closer to 0 dBm, the better the signal was [14].

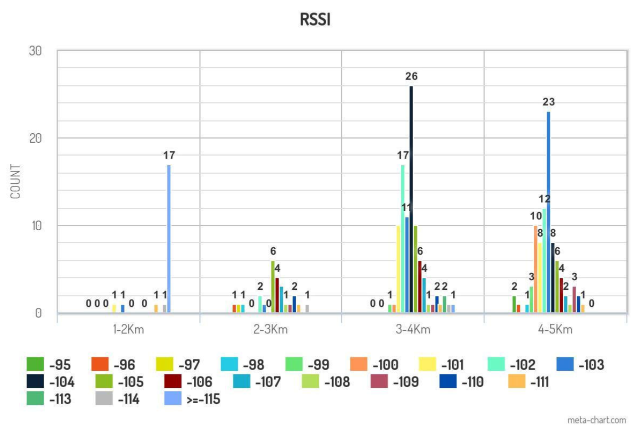

Figure 15. The average of RSSI (Received Signal Strength Indicator) by the distance and packages received (both complete and incomplete)

According to Figure 16, Node-Red service on the cloud showed the real time online information via web browser. Counter number (counter from 1 to 100), Latitude and Longitude data were from LoRa node with GPS to the low cost single private LoRa gateway. The low cost single private LoRa gateway added RSSI into the package. Then, AIS NB-IOT sent that data to the cloud. On the cloud with Node-Red, this data was added with time and date.

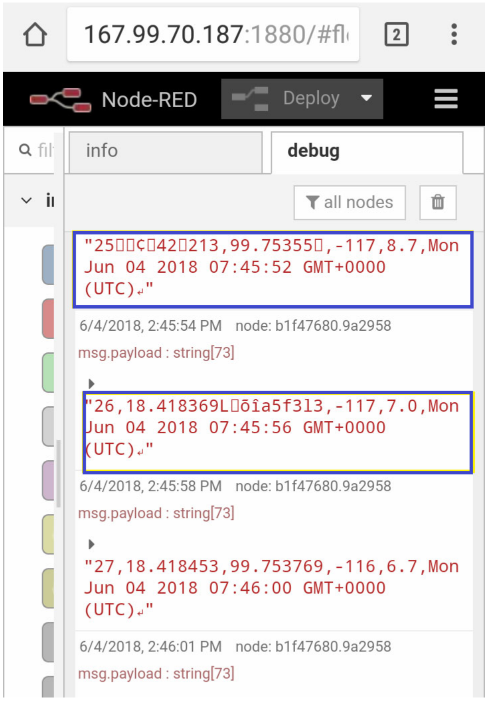

Figure 16. The Node-Red showed complete and incomplete package

The time in cloud server was GMT/UTC format, for example, it was 07:46:00 o'clock and it was 14:46:00 o'clock in Thailand time (UTC + 7 was needed to be added).

It should be noted that in Figure 16, there were two highlights on incomplete packages (unreadable letters or figures were appeared). The researchers noticed that this was happening when the LoRa node with GPS and the low cost single private LoRa gateway were out of line of sight (dense trees).

In addition, the historical data counter number, latitude, longitude, RSSI, date-month-year, and time were stored as a CSV file on the cloud. CSV file can be plotted on Google Maps. In Figure 17, Google Maps showed the distance between the LoRa node with GPS and the low cost single private LoRa gateway. The number showed on the Google map was the counter (from 1 to 100).

5 Discussion

There were two points to discuss in this research. One was on the economic perspective of using the low cost single private LoRa gateway, and AIS NB-IOT as an alternative communication channel for the IOT woks, particularly previous works [1-4]. The second

Figure 17. A CSV file was plotted on the Google map, it was shown the location with the counter

one was the protocol and format of data used in this research.

Firstly, from an economic perspective, the newly developed low cost single private LoRa gateway and AIS NB-IOT is considered worth the investment. Especially when applied in isolated areas where there is no WIFI or 3G cellular.

The cost of the GPS node (sender) was 2,500 baht (excluding the battery). The most expensive part was an Omni antenna worth 1,000 baht. The WeMoS Di Mini (controller) was 125 baht and the GPS was 380 baht.

For the low cost single private LoRa gateway with AIS NB-IOT, was 5,860 baht (including the stand and battery). The low cost single private LoRa gateway, was 3,870 baht and the AIS NB-IOT was 1,990. In addition, the AIS NB-IOT service for sending the data from the low cost single private gateway to the cloud was 350 baht per year.

If we do not use a low cost single private LoRa gateway, and we would like to send data directly to the cloud, we would need 5 public AIS NB-IOT devices.

It would cost (for hardware 1,990 × 5= 9,950 baht). The service cost (350 × 5 = 1,750 baht). Extra costs such as 5 water proof boxes, 5 OELD screens, WeMoS Di Mini (controller) would cost 1,100 x 5 = 5,500 baht. The total cost was 9,950 + 5,500 = 15,450 baht. In 5 years, the on air service (1750 × 5 = 8,750) 15,450 + 8,750 = 24,200 baht (Table 7).

On the other hand, if we applied a low cost single private LoRa gateway, we would need 5 LoRa nodes with GPS. Only one AIS NB-IOT was needed for the internet connection to send data to the cloud.

Table 7. The estimation cost of using the 5 public AIS NB-IOT directly to send data to the cloud

Hardware	Cost (baht)	Total (baht)
AIS NB-IOT + controller (WeMos Di Mini), etc	1,990 + 1,100 = 3,090 × 5	15,450
AIS NB-IOT 5 years public on air service (baht)	350 × 5 × 5	8,750
		24,200

It would cost 2,500 × 5 = 12,500 baht. And one low cost single private LoRa gateway was 3,850 baht and if we only use one AIS NB-IOT to send data to the public, it would only cost350 baht. The total cost was 12,500 + 3,870 + 350 = 16,742 baht. After one year, the one air service would cost (350 × 5 = 1,750 baht) = 16,742 + 1,750 = 18,492 baht (Table 8).

Table 8. The estimation cost of using the 1 public AIS NB-IOT to send data to the cloud and use 5 LoRa node with the private LoRa single gateway

Hardware	Cost (baht)	Total (baht)
5 LoRa Nodes + GPS	2,500 × 5 = 12,500	12,500
1 Gateway	3,870	3,870
AIS NB-IOT 5 years public on air service (baht)	350 × 5 = 1750	1,750
		18,492

The second point to discuss from Table 9, is the communication protocols in physical layers and communication protocols in transportation layers used in this research. Therefore, we were concerned with the data format in each protocol. The summary of the protocol and the data format is in Table 9. It should be noted thatthe data format from the low cost single private LoRa gateway to data format of AIS NB-IOT was needed. IC2 was not included in this table, as it was only used for the OLED display, not used for the data processed. Base 64 was applied as binary to text encoding. For example index 1 can be indexed as B char in the Base 64 index [15]. In this research, counter, latitude and longitude were recorded as

1, 18.2330545, 99.4962788 (counter + CSV format) from single private LoRa gateway can be Base64 decoded as

MSwxOC4yMzMwNTQ1LDk5LjQ5NjI3ODg=

and sent to the public AIS NB-IOT. Node-Red service on cloud encoded the data as 1, 18.2330545, 99.4962788 and plus current server time and date as Mon Jun 04 2018 06:41:00 GMT+0000 (UTC). The reason for decoding and encoding was some index number can be similar index character as command in AIS NB-IOT and it could be frozen or out of order.

Table 9. The conclusion of the protocol used and data format in each protocol

Hardware	Communi cation port	Data format	Example of data
GPS Module to NodeMcu	UART	GPS - NMEA	$GPRMC,081836, A, 3751.65, S, 14507.36, E, 000.0, 360.0, 130998, 011.3, E*62
NodeMcu to Sx1276 LoRa Send	SPI	Counter + CSV lat, lon	1,18.2330545,99.4962788
Sx1276 LoRa Recive to ReadBoard UNO	SPI	Counter + CSV lat, lon	1,18.2330545,99.4962788
ReadBoard UNO to Ais NB-IoT	UART	Counter + CSV lat, lon Encoder to Base 64	MSwxOC4yMzMwNTQ1LDk5LjQ5NjI3ODg=
Ais NB-IoT to UDP Node-Red Cloud Server	NB-IoT	Base 64	MSwxOC4yMzMwNTQ1LDk5LjQ5NjI3ODg=
UDP Node-Red Cloud Server Recive	Internet	Base 64	MSwxOC4yMzMwNTQ1LDk5LjQ5NjI3ODg=
Node-Red to CSV File		Decoder From Base 64 + Current Server DateTime	1,18.2330545,99.4962788, Mon Jun 04 2018 06:41:00 GMT+0000 (UTC)

6 Conclusion

The development of the prototype of the integration of the low cost single private LoRa gateway and the public AIS NB-IOT was an alternative for the IOT. The system consists of the GPS LoRa node as the sender. The receiver was the low cost single private LoRa gateway. In addition, AIS NB-IOT was applied as a public gateway to send data from the GPS LoRa node and the low cost single private LoRa gateway to the cloud. Node-red was used to manage the data on the cloud and the data can be monitored in real time online on smart phones. The distance of the communication, RSSI, received completed packages, incomplete packages and lost packages are studied. The location for testing the system is the EGAT, Mae Mao Coal Mining, Lampang Thailand.

7 Future Research

Future research could be done for the improvement of the low cost single private LoRa gateway with AIS-NB-IOT system, multi channels and multi nodes should be applied, in case, if the requirement of the work needs multi node (senders). Furthermore, coverage areas (in this study, only the range or distance was studied) and battery life time should be studied. Moreover, the low cost single private LoRa gateway with AS-NB-IOT system should be applied to replace WIFI and wire communication for the previous work, IOT with RFID, smart farm and smart solar system with an IOT [1-4]. In addition, a security threat in the IOT is also concerned [16-17].

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