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Long Range Communication Technology for Weather Buoy

Nilo M. Arago[1], Edgar A. Galido[2], Maria Victoria C. Padilla[3], Lavern M. Tulin[4], Glenn C. Virrey[5], Jessica S. Velasco[6]
[123456]Department of Electronics Engineering, Technological University of the Philippines, Manila,
Email address: nilo_arago@tup.edu.ph, edgar_galido@tup.edu.ph, mariavictoria_padilla@tup.edu.ph, lavern.tulin@tup.edu.ph, glenn_virrey@tup.edu.ph, jessica_velasco@tup.edu.ph

ABSTRACT

Coverage is one of the most critical performance metrics for Long Range Wide Area Networks (LoRaWAN) besides long battery life and low cost. In this research we study the coverage using real-life measurements of the recently developed LoRaWAN technology. The experiments were carried out using the commercially available equipment in the ocean bodies. Three Arduino MEGA and three RN2483 LoRa motes were distributed in the ocean bodies with a LoRaWAN Gateway in the shore that serves as a base station. The LoRaWAN Gateway consists of a core board and a Radio daughter card. The observed maximum contact range is more than 15 km on the suburban ground and close to 1.4 km on water, for a node operating in 868 MHz ISM band using 14 dBm transmitting power. We also present the network architecture of the wireless sensor network of LoRa motes.

Key words: Arduino MEGA, Long Range Wide Area Network (LoRaWAN), LoRa Motes, LoRaWAN Gateway, Wireless Sensor Network

1. INTRODUCTION

In predicting weather conditions, deploying weather buoy can now be deployed together with Wireless Sensor Networks (WSNs). Wireless Sensor Networks (WSNs) are used in different areas of technology involving environment monitoring, medicine fields, logistics, etc. New Internet of Things (IoT) technologies such as Long Range (LoRa) are emerging which allow very long distances of power-efficient wireless communication [1].

Long Range (LoRa) is a technology that is rapidly turning up and is being used in different parts of the world because of its technical advantages such as the lifetime of battery, long range, security and more [2]. Studies has been made for LoRa and Augustin. et al. presented a paper that gives a comprehensive analysis of the LoRa modulation, receiver sensitivity, data rate, etc., which resulted in proving that the LoRa has a good resistance to interference and gives sufficient network coverage up to 3km in a suburban area [3].

LoRa and LoRaWAN were extensively used in different implementations and applications. They were used in healthcare applications which can easily help to supervise the vital signs monitoring of the patient especially in far-flung areas [4], [5]. They were also applied as successful transmission modes in precision aquaculture whether intensive or extensive in form [6], [7], [8] and in hydroponics [9] for easy and faster checking and verification of plant, water, and fish parameters.

The main objective of this project is to create a network and collect data from different monitoring sensors wirelessly. The data collected will be organized and available in the main server. The sensors that will be placed inside the buoy are monitoring meteorological and hydrological parameters in the open sea. One objective of the proponents is to construct three (3) buoys that consist of eight (8) different monitoring sensors and deploy it in an open sea. The buoy is also called Weather Buoy as it has the capability to collect data that are vitals in weather prediction.

The proponents shall create a communication network for the three weather buoys to collect the data from the sensors. One of the challenges they faced is the distance of the weather buoys to the base station. In order to achieve accurate data for weather prediction, the weather buoys must be deployed in different parts of the sea (certain location). The approximate distance is not less than 750 meters away from the shore. It is a problem because we have inadequate communication technology that can cover that much range wirelessly.

After they conducted an extensive research they came up with a solution to this challenge. The communication technology they used is the Long Range (LoRa) Communication Technology which is now gaining popularity in the industry of Wireless Sensor Network.

2. RELATED WORKS

The Wireless Sensor Network (WSN) has been one of the leading wireless network research fields particularly in the last year. The Wireless Sensor Network (WSN) has been one of the leading wireless network research fields particularly in the last year. Sensors are located randomly in the area, each node senses the surroundings and sends the data collected to the head of the cluster (CH), which aggregates and transmits information obtained to the Base Station (BS) [10].

Wireless Sensor Networks are targeted for data monitoring which have various expectations, such as data monitoring traffic patterns, limiting packet epochs and network steadiness, not only are average loss rates significant, but also deliveries relevant, because high loss rates on temporary wireless associations could have it impossible to guarantee dependable administration of the targeted application. So novel evaluation metrics are required to determine the reliability of those networks. They address the WSN 's data monitoring stability, develop a system to advance the "equitability of the routes to the central node as the advanced local route reselection procedure, and evaluate the proposed mechanism through a wireless failure conditional data delivery ratio" [11]. The most significant parameters in WSN concerned for cluster head selection are energy, delay and distance [12].

The study, A Long-Range Low-Power Wireless Sensor Network Based on U-LoRa Technology for Tactical Troops Tracking System by San-Um et al., proposed a technology for Internet-of – Things called Universal and Ubiquitous (U-LoRa) and utilized it in tactical troop tracking systems. The said technology is connected through Wi-Fi for a communication with the server and can be combined with different types of sensors. The LoRa module used in the system is connected to the Arduino Pro-Mini which processes the input and output data gathered [13].

Moreover, the U-LoRA End-Nodes applied in the system are used to transmit data through LoRa Gateway to the network switch which is under the IoT and web server. The gathered data transmitted to the network will be visualized real-time through the graphic user interface [13].

To determine the applicability of wireless industrial networks, the LoRa radios built by Semtech Corporation and the LoRaWAN technology were assessed. The paper also said that given both, it seems they are built for IoT, the LoRa and LoRaWAN scenarios can meet the requirements of the industrial environments [14].

This research [15] claims that they proposed a wireless communication system to identify a fishery buoy. The device is implemented using LoRa communication technology. Experimental results showed that the buoy 's GPS position could be moved to a fishing boat at an approximate distance of 15 km. In addition, if the lithium-ion battery is used, the device can be run continuously for one year. "Fishermen can locate a buoy faster with this approach if the device is applied to fishing work than searching with the naked eye, thus greatly improving the efficiency of fishing operations."

Reference [16] shows that due to advances in electronics and wireless communication, small-scale sensor nodes had developed that include data processing, sensing, and communication components. Wireless Sensor Network (WSN) can therefore be deployed which can be regarded as a notable improvement compared to conventional wired sensor networks. In the most part, sensor nodes are deployed in a potential unfavorable or even aggressive state. It is a small-scale device that has sensing and wireless capabilities. It has a lot of applications such as military, environmentally, safety, home, and commercially.

One of the limitations of using Wireless Sensor Networks or WSN is the energy restriction and therefore numerous studies have been done to further make the energy consumption efficient. Analyzing routing methods and getting rid of the identical data from the node is done to reduce the consumption of energy and enhance the life of the WSN, proving it using the NS2 simulation [17].

Drawbacks of Wireless Sensor Networks are the importance of constructing a base station, its static character and centralized route. They depend on a stable connection for communication. This is why Ad Hoc Networks is introduced. It does not need a base station and does not work in centralized routing which makes it great as it equally distributed routing. It gives the nodes the freedom to move around and the topology can be easily changed. This effective quality of Ad Hoc Networks fits perfectly for demanding applications [18].

3. SYSTEM ARCHITECTURE

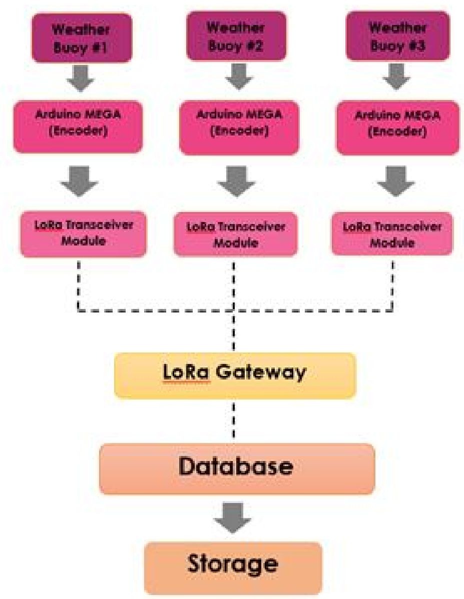

Figure 1: Block Diagram of Long-Range Communication System for Weather Buoy

Implementation of Figure 1 will be needed to attain the communication between the wireless sensor networks. As shown above, each weather buoy consists of an Arduino Mega, Lora Transceiver Module (LoRa mote), and multi-sensor such as Wind Speed Direction, Air Pressure, Liquid Precipitation, Salinity Liquids, Moisture in the Air, Solar Irradiance, Water Temperature, and Air Temperature that is interconnected by an algorithm. The gathered data by the sensors will then be recognized by the Arduino Mega as inputs and will be processed. The LoRa Transceiver Module (LoRa mote) will transmit the gathered data through LoRa Gateway to the database. The database will process the gathered data and will be stored to the Hard Disk Drive. Once the gathered data is stored it will be ready for real time interpretation.

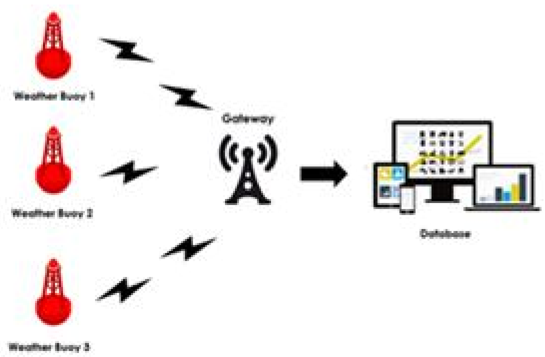

Figure 2: Network Architecture (Star Topology)

Implementation of Figure 2 will be needed to attain the communication between the wireless sensor networks. As shown above, each weather buoy has a LoRa Transceiver Module (LoRa mote) and Arduino MEGA that is connected to the LoRa Gateway.

4. RESULTS AND DISCUSSION

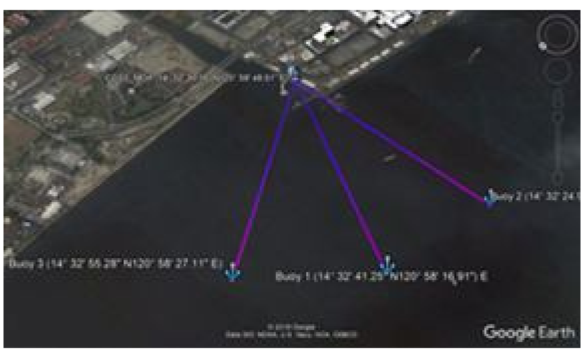

Figure 3: Network Topology

Figure 3 shows the actual designed network topology used for the communication of the three (3) weather buoys deployed in Manila Bay. The design is based on Star Topology, in which the LoRa communication technology works best. The exact location of the weather buoys are as follows:

1 Longitude: 14°32'41.25"N

Latitude: 120°58'16.91"E

Range: 1000 m

Heading: 0.000000°

Tilt: 45.000000°

2 Longitude: 14°32'24.94"N

Latitude: 120°58'15.78"E

Range: 1000 m

Heading: 0.000000°

Tilt: 45.000000°

3 Longitude: 14°32'55.28"N

Latitude: 120°58'27.11"E

Range: 1000 m

Heading: 0.000000°

Tilt: 45.000000°

Base Station

Longitude: 14°32'30.10"N

Latitude: 120°58'48.51"E

Range: 0 m

Heading: 0.000000°

Tilt: 45.000000°

Figures 4 to 11 below shows the graphical representations of data from the monitoring sensors of the weather buoy that collects the following meteorological and hydrological parameters:

- Air Temperature
- Air Pressure
- Liquid Precipitation
- Moisture in the Air
- Salinity of Liquids
- Solar Irradiance
- Water Temperature
- Wind Speed and Direction

There are twenty (20) collected data of each sensor that are used in these graphical representations.

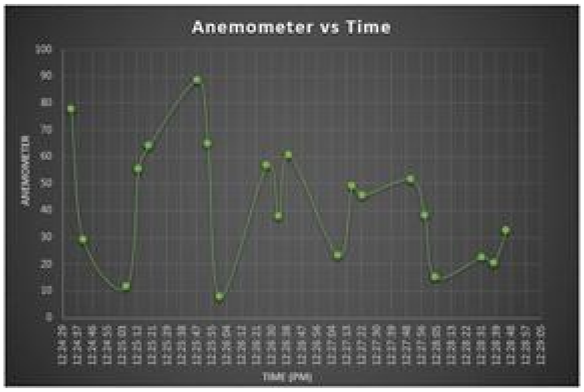

Figure 4: Anemometer Data

Figure 5: Barometer Data

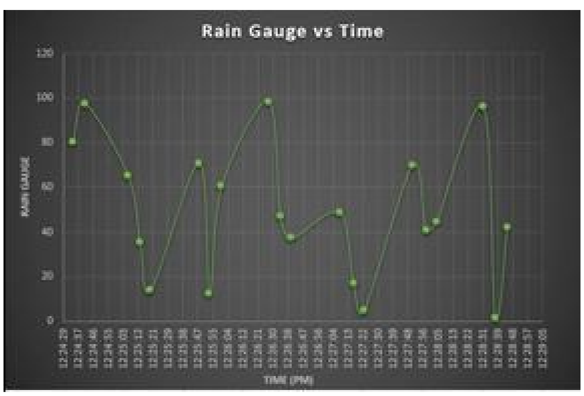

Figure 6: Rain Gauge Data

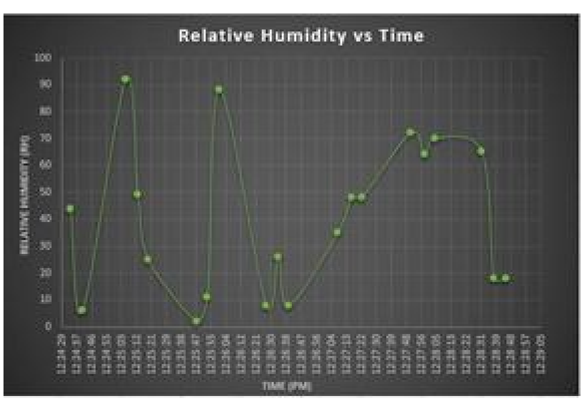

Figure 7: Relative humidity Data

Figure 8: Salinity Data

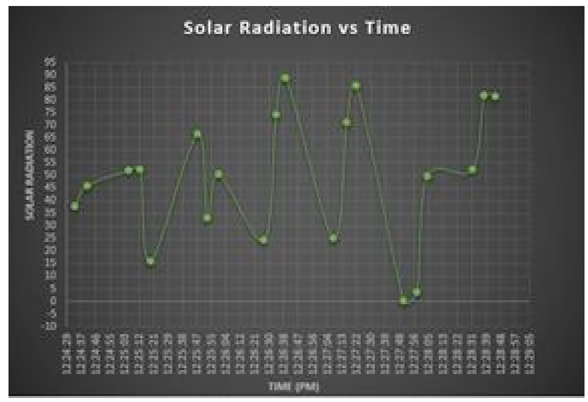

Figure 9: Solar radiation data

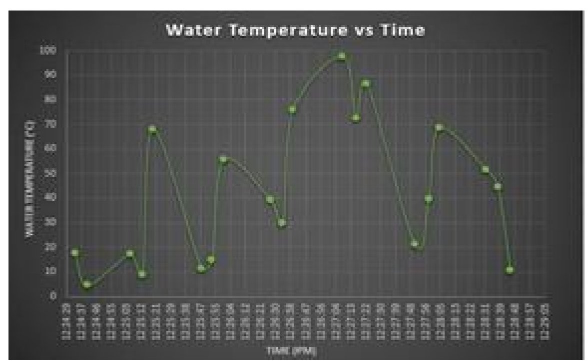

Figure 10: Water Temperature Data

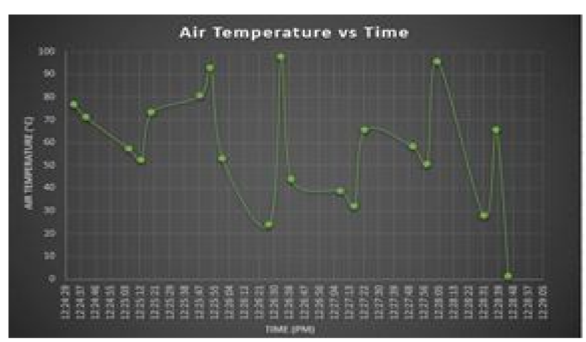

Figure 11: Air Temperature Data

5. CONCLUSION

The weather buoys are equipped with Long Range (LoRa) Communication Technology. Through this technology, the range capacity for the transmission of data is widened. It can now be deployed at least 1 kilometer away from the shore. The Long Range (LoRa) Communication Technology doesn't require internet connection because it has its own server. The data gathered from the weather buoys are transmitted to the organized database created by the proponents. The proponents were able to design a solution to create a Long-Range Communication Technology wirelessly for Weather Buoys. In this research, the proponents were able to create a solution for a Long-Range Communication Technology wirelessly for Weather Buoys. Upon some extensive research and a series of trial and errors of different methodologies present today, they were able to arrive at a successful system for the problem introduced in this research.

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