

Position Monitoring Fishing Boat at Boddia Wharf

Nuraeni Umar^{1,*a}, Ichsan Mahjud², Yedi George Yefri Lely³, Ahmad Syukut⁴, Muh Yusuf Aditama⁵

^{1,2,3,4,5} Department of Electrical Engineering, State Polytechnic of Ujung Pandang, Jl. Perintis Kemerdekaan Km.10, Makassar, 90245, Indonesia

^a, nuraeni_umar@poliupg.ac.id, ^bichsan_mahjud@poliupg.ac.id, ^cyedigeorge40@gmail.com,
^dahmadsyukur1970@gmail.com, ^emuh Yusufaditama270@gmail.com



Abstract—Real-time monitoring of the boat's position, with a GPS-based monitoring system and LoRa communication that is power efficient and easy to operate. Design of a fishing boat position monitoring system using GPS and LoRa modules using components, such as ESP32, GPS NEO-6M, and LoRa SX1278 module. This system sends boat location data from the transmitter to the receiver every 10 seconds, and displays it via a digital map application using Processing software. In the design of this system, GPS functions as location input, the data is processed by a microcontroller, then sent via LoRa to the receiver. The data is then displayed in real-time on the monitoring side. Test results show that the system is capable of working position monitoring with a range of up to 1.8 km, RSSI -94 dBm, SNR -2 dB in clear weather conditions, with the percentage of data reception decreasing as the distance increases. This system is considered feasible and efficient for use by traditional fishermen and can be further developed with additional modules such as RedBlock for accuracy.

Keywords—Positioning, GPS NEO-6M, ESP32, LoRa

I. Introduction

Fishing activities are carried out by small fishermen who live in coastal areas and still rely on simple fishing gear and shipping facilities. Most of them use traditional ships, namely small wooden boats driven by simple engines, without modern navigation equipment, long-distance communication systems, or position tracking devices. Reliance on intuition and experience without the support of modern technology often results in accidents that result in the loss of ships and loss of life. One solution that can be implemented to improve fishermen's safety is the use of a GPS-based ship position monitoring system (Global Positioning System) and gyroscope with TTGOT-Beam module [1]. However, real-time tracking systems generally rely on cellular or satellite networks which are not always available in open ocean areas, and their costs are relatively high. LoRa based telemetry

system, Web and mobile applications [2], As an alternative, LoRa (Long Range) technology is used, which is a low-power wireless communication system with a range of up to 5-7 kilometers in open areas, and can even be further depending on terrain and antenna conditions. LoRa is able to transmit GPS position data without requiring cellular infrastructure, and is more energy and cost efficient. This research offers a more efficient solution compared to previous approaches by designing a traditional ship position monitoring system based on GPS and LoRa communication. One of the supporting microcontrollers [3] is the GPS and LoRa system [4]. This system is aimed at small fishermen in order to increase safety when at sea, facilitate position monitoring by families and authorities, and encourage the use of affordable and appropriate technology in the traditional fisheries sector.

II. Research Methodology

Monitoring the position of fishing vessels with GPS, using satellite technology to monitor objects in remote or difficult to reach locations such as fishing vessels at sea, vehicles on the road, industry in remote locations. This GPS system is installed on a fishing boat, then its position is sent via satellite modem to the monitoring center. Monitoring centers can access this information, monitoring the location of fishing vessels. Internet of Things is a concept where certain objects have the ability to transfer data via the internet network without requiring interaction from human to human or from human to computer device. Its capabilities vary, for example in sharing data, remote control, food processing, electronics, interaction between machines that are connected automatically without human intervention and without distance limitations.

A microcontroller or single-chip microcomputer is a computer system in which all components including the processor (CPU), memory (RAM and ROM), and input/output interface are consolidated on one single chip. The internal components of a microcontroller include a processing unit for executing instructions (arithmetic and logic), memory for storing programs and data, and I/O ports for connecting sensors, actuators and other external devices [5].

ESP32 is an embedded system-on-chip (SoC) microcontroller developed by Espressif Systems, designed to support Internet of Things applications, automation systems, and embedded computing devices. The device has a dual-core Tensilica LX6 processor architecture with a maximum operating frequency of 240 MHz, which allows data processing with high efficiency. In addition, the ESP32 is equipped with 520 KB of SRAM memory as well as support for external flash memory, which functions for data storage and execution of more complex programs.

One of the main features of the ESP32 is the wireless communications capabilities that have been integrated into the chip, including Wi-Fi 802.11 b/g/n at a frequency of 2.4 GHz as well as Bluetooth 4.2, which supports Bluetooth Classic and Bluetooth Low Energy (BLE) modes. With this combination, the ESP32 can be used as a communication module in an IoT system without requiring additional external modules [6]. This device is also equipped with various digital and analog interfaces, including 34 General-Purpose Input/Output (GPIO) pins, 18 Analog-to-Digital Converter (ADC) channels with 12-bit resolution, 2 Digital-to-Analog Converter (DAC) channels with 8-bit resolution, as well as support for various communication protocols such as SPI, I²C, UART, and PWM. In addition to computing and communications aspects, the ESP32 also has advanced security features, including AES, SHA, and RSA encryption hardware, as well as a secure boot system that ensures protection against unauthorized access. These features make the ESP32 a safe and reliable choice for industrial and commercial applications, including automation systems, smart equipment control, and sensor-based monitoring systems.

The Neo-6M GPS module operates by receiving signals from several satellites that are part of the global positioning system network. These satellites continuously broadcast their position and time data. This module captures these signals and calculates their distance from these satellites by analyzing the time it takes for the signals to reach them [7]. Using data from satellites, the Neo-6M can determine its precise geographic coordinates (latitude and longitude). The LoRa SX1278 is a wireless communications module, LoRa in operation. After the module processes satellite data, it outputs this information using the NMEA (National Marine Electronics Association) protocol. NMEA is a standard format that organizes GPS data into readable sentences, including details about location, time, and more. This data is then sent via the module's TX pin to a microcontroller, such as an Arduino. At low radio frequencies, such as 433 MHz, 868 MHz, or 915 MHz, depending on the spectrum regulations in each region, chirp spread spectrum (CSS) modulation. This module has a low data rate, ranging from 0.3 kbps to 37.5 kbps, making it more suitable for transmitting small data, such as GPS coordinates, environmental sensor data, or other monitoring system parameters. The module is designed to support long-range communications, resistance to interference with minimal power consumption, making it ideal for IoT applications that require broad connectivity without dependence on cellular infrastructure or Wi-Fi.

A good antenna, namely strong signal reinforcement, will improve the quality of the signal sent and received by the LoRa device. So the antenna used will affect how well the signal can be transmitted and received, so choosing the right antenna increases the communication range. Good signal quality is critical in avoiding data loss or communications failure, especially when devices are connected to widespread networks or in areas with many obstructions [8].

To obtain a stable voltage, the common step-down types LM2596 and MP1584 are used, which are able to provide high efficiency and voltage stability. The use of a step-down converter not only keeps components safe, but also extends the life of the device by maintaining a stable voltage.

IDE (Integrated Development Environment) is software used to program on Arduino, Arduino IDE as a medium for programming Arduino boards, useful as a text editor for creating, editing and validating program code, also used to upload to Arduino boards. The program code used on Arduino is called Arduino "sketch" or also called Arduino source code, with the source code file extension .ino. There are 3 Arduino IDEs, namely: Editor, Compiler, Uploader.

Processing is programming designed for the visual arts to make it easier to create graphics and animations with simple syntax. Computing is data that is input into a computer to produce the desired output. Ptoles convert data into useful information such as images, sounds, videos.

The NEO-6M GPS module functions to receive satellite signals and determine position in the form of latitude, longitude, altitude, and time information, which is then sent in the form of serial data (NMEA sentence). The coordinate data is read by the ESP32 via serial communication (UART), then processed to retrieve important information such as latitude and longitude before being forwarded to the LoRa module. The SX1278 LoRa module acts as a transmitter that sends position data from the ESP32 via radio waves at the LoRa frequency. So that the signal can be transmitted properly and received by receiving devices on the ground, an antenna is used which functions to strengthen and transmit the LoRa signal into the air according to the needs of the communication system.

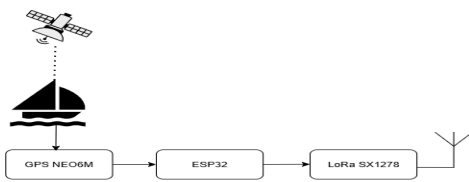


Figure 1. Transmitter System Block Diagram

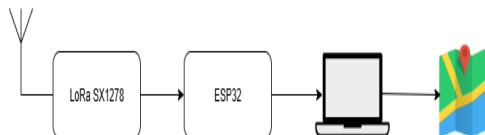


Figure 2. Block Diagram of the Receiver System

The antenna captures the LoRa signal from the sender and then receives it by the SX1278 LoRa module.

The data is forwarded to the ESP32 for processing, for example latitude and longitude coordinates, then sent to the computer via USB. The computer runs applications such as Processing to read and display data to Google Maps, so that the position of objects can be monitored in real-time.

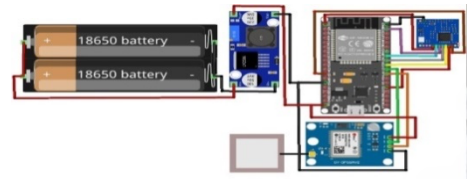


Figure 3. Transmitter System Circuit

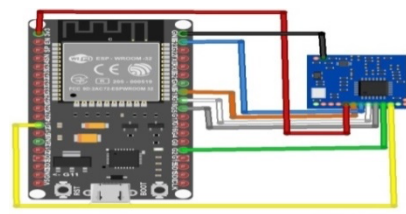


Figure 4 Receiver System Circuit

The system involving the ESP32, GPS NEO-6M, and LoRa SX1278 functions to transmit real-time boat position data, which is very in boat tracking or boat monitoring-based applications at sea. The NEO-6M GPS module functions to receive signals from satellites and determine the geographic position of the boat, which includes latitude and longitude information. This position data is then sent by the GPS module via serial communication (usually UART) to the ESP32, which acts as the main controller in this system. The ESP32 not only receives data from the GPS, but also processes the information and prepares it for transmission via the SX1278's LoRa module.

The SX1278 LoRa module plays an important role as a data transmitter in this system. After the ESP32 receives and processes position data from GPS, the data is forwarded to the SX1278 LoRa module to be sent to LoRa receivers located in other locations, such as on shore or other ships that are also equipped with LoRa modules. LoRa SX1278 uses low-power, low-frequency-based communication technology, enabling data transmission over long distances, even several kilometers, with high energy efficiency. It is ideal for use in applications that require sending data in open areas such

as the sea, where cellular networks or Wi-Fi may not be able to reach.

The combination of these three components makes it possible to send boat position data accurately and efficiently even though it is far from land. This system is very useful in various applications, such as ship tracking, fishing boat monitoring, or even safety systems for shipping. By using the ESP32 as a central controller that connects GPS and LoRa, data can be transmitted over long distances, providing the boat owner or supervisor with real-time positioning information that is critical for the safety and management of the boat at sea.

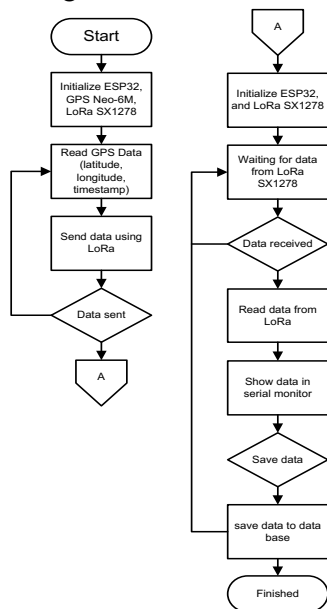


Figure 5. Flowchart system

System design the system starts from the initialization process of the ESP32 device and the NEO-6M GPS module. After successful initialization, the system will read GPS data in the form of longitude and latitude coordinates. If the location data has not been read, the process will repeat the reading again until the data is available. When the location data is successfully read, the system will continue to send the data via the LoRa module. If the data sending process fails, the system will try again until the data is successfully sent. If the data has been successfully sent, the process is considered complete and the system stops according to the specified flow.

Furthermore, the flowchart below describes the workflow of the ESP32 and LoRa SX1278 based data receiving system. The process begins with initializing the

ESP32 device as well as the SX1278 LoRa module. After that, the system enters the waiting stage for data sent via LoRa SX1278. If the data has not been received, the process will continue to repeat until the data is successfully entered. If the data has been received, the next step is to read the GPS data that is forwarded from the LoRa SX1278 module. The reading data is then displayed on the Serial Monitor and visualized on Google Maps to make location monitoring easier. Furthermore, the data is stored so that it can be used for further analysis. After all stages have been completed, the process is declared finished. This system Antenna captures the LoRa signal from the sender which is then received by the SX1278 LoRa module. This data is passed to the ESP32 for processing, for example latitude coordinates.



Figure 6. Transmitter system device



Figure 7. Receiver system device

III. Results and Discussion

The results of the research are tool testing: Distance measurement using the Haversene formula, and using radian units to convert degrees to radians. System performance in displaying positions directly on digital maps. Shows the results of receiving coordinate data, displayed on Google Maps.

The location point is shown with a red marker on the map, which corresponds to the coordinates of the GPS reading, namely Latitude -5.315797° and Longitude 119.347775° .

The display proves that the receiver (RX) has successfully processed the data sent by the sender (TX) and displayed it directly in the digital map application.

Table 1. Location of Latitude and Longitude

Point	Latitude ($^\circ$)	Longitude ($^\circ$)
Starting location	-5.325167	119.353806
End Location	-5.315797	119.347775

The data obtained by the system in table 1 is calculated as follows

$$\phi_1 = -5.325386^\circ = -0.092963 \text{ rad} \quad (1)$$

$$\phi_2 = -5.315797^\circ = -0.092787 \text{ rad}$$

$$\lambda_1 = 119.353733^\circ = 2.083352 \text{ rad} \quad (2)$$

$$\lambda_2 = 119.347775^\circ = 2.083246 \text{ rad}$$

To produce the difference between latitude and longitude is as follows.

$$\Delta\phi = \phi_2 - \phi_1 = 0.000176 \text{ rad} \quad (3)$$

$$\Delta\lambda = \lambda_2 - \lambda_1 = -0.000106 \text{ rad}$$

Haversine Formula

$$a = \sin^2\left(\frac{\Delta\phi}{2}\right) + \cos(\phi_1) \cdot \cos(\phi_2) \cdot \sin^2\left(\frac{\Delta\lambda}{2}\right) \quad (4)$$

$$a \approx 9.6825 \times 10^{-9}$$

Calculate Central Angle

$$c = 2 \cdot \arcsin(\sqrt{a}) \approx 0.000197 \text{ rad}$$

Distance Between Points

$$d = R \cdot c = 6371000 \cdot 0.000197 \approx 1253.81 \text{ meter}$$

Based on the distance calculation results at the point $5^\circ 18' 56.87''\text{S}$ $119^\circ 20' 51.99''\text{E}$ and $5^\circ 19' 31.39''\text{S}$ $119^\circ 21' 13.44''\text{E}$, the result was 1253.81 meters, and this is very close to the results displayed by Google Earth, which is around 1.25 km.

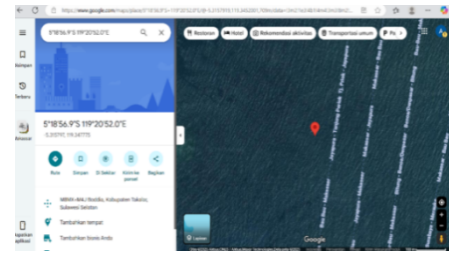


Figure 8. Display of the receiver module



Figure 9. Display of each distance in Google Earth

The initial location is at a point with latitude coordinates -5.325167° and longitude 119.353806° , while the final location is at latitude coordinates -5.315797° and each point indicates a certain distance from the initial location, namely 0.5 km, 0.9 km, 1.2 km, 1.6 km, up to 1.8 km. With this marker, movement from the starting location to the ending point can be observed clearly and systematically. This visualization not only helps in monitoring track direction, but also provides a more real picture of the distance traveled in the field based on the GPS coordinates obtained.

2. RSSI and SNR testing:

Received Signal Strength Indicator (RSSI) in the LoRa communication system, RSSI parameters and Signal-to-Noise Ratio (SNR) are the main references in assessing the quality of the received signal. The RSSI value shows the signal strength in dBm units, where the closer it is to zero, the stronger it is. LoRa is able to work in low RSSI conditions, with the general category being above -70 dBm which is classified as very good, between -70 dBm to -100 dBm is still suitable for use, while below -120 dBm the signal is already weak and approaching the

sensitivity threshold of the LoRa module, the SNR parameter shows the comparison between signal power and noise, LoRa has the advantage because it can still function even though the SNR is negative.

In general, SNR values above +7 dB are categorized as very good, between 0 and +7 dB are considered good, between -7 and 0 dB are still acceptable, while values below -10 dB indicate an unstable signal condition. Based on Semtech specifications, LoRa sensitivity can reach -137 dBm and is still capable of decoding signals with an SNR of up to -20 dB, especially at high spreading factors. This makes LoRa superior to other communication technologies in environmental conditions with very low interference and signal power.

Table 2. Measurement of distance, RSSI and SNR

Distance from Gateway (km)	RSSI (dBm)	SNR (dB)
0.5	-75	10.2
0.9	-80	8.5
1.2	-85	6.3
1.6	-90	4.1
1.8	-94	2.0

IV. Conclusion

From the data from the monitoring system for traditional fishing boats at Boddia wharf, it was concluded that:

1. GPS and LoRa based fishing boat position monitoring system. The system displays real-time location on a digital map with an effective communication range of up to 1.8 km in the open sea.
2. Test results show that RSSI -75 dBm to -94 dBm and SNR 10.2 dB to 2.0 dB still support data

communications in open areas. This system is efficiently used by fishermen in open sea areas with sunny weather conditions.

ACKNOWLEDGMENTS

We would like to thank the Research and Community Service Unit of Politeknik Negeri Ujung Pandang for providing support and access to this research.

References

- [1] Vinsensius Setiawan W, Eka Sugiarto, "Fishing Boat Safety Monitoring Prototype Using LoRa Module and Microsensors Based on Low-Power Wide Area Network (LPWAN)", *Jurnal Informatika dan Komputer*, vol. 8, 1, pp.1-9, 2023.
- [2] Siti Puspitorini, Febri Dwi Wahyuni, Tri Rahayu, "Implementation of a LoRa-Based Multihop Telemetry Communication System for Monitoring Fishing Vessels in Coastal Areas", *Jurnal Reka Cipta Elektronika dan Telekomunikasi*, vol. 10, 1, pp.25-34, 2023.
- [3] Dwi Feriyanto, Riko Rahmadian, "Design of a Fishing Vessel Monitoring System Using LoRa and GPS Based on the Internet of Things (IoT)", *Jurnal Teknologi dan Rekayasa*, vol.18,2, pp.12-18, 2023.
- [4] D.F,Sari,N., & Setiawan, R, " Identification and Selection of Microcontrollers for Internet of Things (IoT) Projects". *Aisyah Journal Of Informatics and Electrical Engineering*, vol.3,1,pp.1-7, 2023.
- [5] Boardor, "Microcontroller: An Overview of Single-Chip Microcomputers", 2023.
- [6] Hendra Setiawan Nugraha "Application of Internet of Things (IoT) for Microcontroller Based Environmental Monitoring" *Jurnal Ilmiah Teknik dan Komputer*, vol.6,2,pp.45-52,2023.
- [7] Arduino Indonesia, "NEO-6M GPS Module Review: LocationTrackingwithArduino", 2024
- [8] Huang and K. Boyle, "Antennas From Theory to Practice", 1st ed., Wiley, 2008.