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Tracking device system using LoraWan for motorized and non-motorized Banca in Catanduanes

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Abstract

LoRa (Long Range) technology is suggested as an effective way to ensure the safety of fisher folks in Catanduanes. The paper proposes a tracking device system for boats there, using low-power wireless tech to transmit data between the device and a network of gateways. This technology can send small data amounts over long distances, enabling real-time location tracking even in areas with weak network signals. When paired with GPS, LoRa can boost tracking accuracy. The system includes a GPS module, water level sensor, and emergency button. Test results confirm the Neo 6M GPS module provides precise boat location coordinates. The water sensor triggers an emergency signal to authorities if levels get critical. Additionally, a webpage displays real-time locations of LoRa devices, helping personnel track their movement.

Keywords: Microcontroller; Real-Time Tracking; Global Positioning System; Long Range (LoRa); Save Our Ship (SOS)

1. Introduction

Catanduanes is an island province located in the central part of the eastern Philippines, positioned at the far eastern edge of the Bicol Region. It stands as the initial landmass in the Philippine archipelago that touches the Pacific Ocean. The province comprises 11 municipalities: Bagamanoc, Bato, Baras, Caramoran, Gigmoto, Pandan, Panganiban, San Andres, San Miguel, Viga, and Virac. Due to its surrounded nature by water bodies, fishing has become a predominant occupation on the island.

Banca boats, both motorized and non-motorized, have been a vital part of coastal living in the Philippines, especially for fishing, transportation, and island tours. These boats, primarily constructed with wood, trace their development back to the pre-Hispanic era. In various regions, such as Surigao, motorized Bancas are favored for transport due to their accessibility and docking capabilities. However, in Catanduanes Island, Bancas are mainly used for fishing, constructed traditionally with lightweight materials, making them vulnerable to damage during maritime disasters. The island's exposure to strong winds and frequent typhoons poses challenges to its residents, particularly fishermen whose livelihoods are at risk. Lacking location-tracking technology for Bancas amplifies the difficulty for local authorities during maritime accidents or missing fishermen incidents, hindering effective search and rescue operations at sea.

Advancements in GPS tracking have led to the global positioning system (GPS), employing satellites transmitting signals to devices worldwide. Additionally, LoRa (Long Range) technology facilitates location tracking using low-power wireless communication between a device and gateways, transmitting data over extensive distances, even in areas with weak network coverage. When paired with GPS, LoRa further improves location tracking accuracy and reliability. Researchers aim to deploy a tracking system for fisherfolk in select Catanduanes areas.

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The main goals of this study are to develop a real-time tracking system that can be used to direct rescuers in the event that fishing boats go missing, to give fishermen a way to contact local authorities in an emergency, to develop a database for tracking boat locations, and to develop a webpage that can be used to show output or location.

2. Literature Review

2.1. Local *Fisherman*

According to Lopez, G. P. R. (2018) study site in Palumbanes Island, Caramoran, Catanduanes, Philippines. The findings of the study revealed that fishing is the major source of livelihood in the area. Fishermen, dominated by males, started fishing at a very early age.

2.2. Non–motorized and Motorized Banca

As per Aguilar, G. D. (2006), traditional twin outrigger banca boats in the Philippines vary widely in size, ranging from small 4-meter paddle boats to large 50-meter fishing and passenger ferry vessels. Irrespective of size, indigenous boat builders use consistent construction techniques and primarily wood as the main building material. Concerns arise regarding wood supply, sea safety, and performance issues resulting from scaling up hull designs, especially in significant fishing vessels. Similarly, Motor Banca serves as a vital marine transportation means in the Philippines, requiring continuous monitoring for passenger and crew safety, particularly during emergencies. Our study aims to develop a specialized tracking and monitoring system for motorized bancas, automatically alerting the Philippine Coast Guard in emergencies and providing precise location information for the banca.

2.3. Tracking and Monitoring System

In today's vehicle management systems, both fleet managers and individual car owners rely on vehicle tracking systems, a well-established and highly reliable technology. This paper proposes a real-time tracking system that utilizes the Global Positioning System (GPS) and Global System for Mobile Communication (GSM) to locate and track vehicles. The system comprises embedded software designed to continuously track and update the status of a moving vehicle. Utilizing components like Arduino Uno R3, SIM800A module, and NEO 6M GPS module, this tracking device is employed for real-time vehicle tracking (Khin & Oo, 2018).

An accurate and dependable real-time tracking system employing GPS and GSM services is presented by Dafallah, H. A. A. (2014). The system was successfully developed and put into use in the labs of the University of Khartoum. The portable tracked device, which is attached to a person, vehicle, or other assets, and the tracking center, where the location of the portable device should be tracked, make up the GPS tracking system. The tracking center, which is just a personal computer with numerous interface programs to display the location on Google Maps using the free version of Google Maps APIs (application programming interfaces), receives the GPS coordinates from the mobile tracked device and sends them as SMS via GSM modem to the tracking center. Testing demonstrates that the system.

Tang, (2016) describes the planning and execution of a system that offers real-time locating and tracking services. A tracking gadget, a backend server, and a mobile app make up the system. Our tracking gadget combines a GPS module, GSM/GPRS module, and TCP/IP stack, making it able to send and receive SMS messages as well as generate location data. The device sends location information over a TCP connection to our backend server. The server is in charge of gathering and conserving data.

This study aimed to create a tracking device using regular hardware, allowing remote control via text messages and a basic computer monitoring service. Testing on both land and water vehicles showed the device worked well, delivering tracking data perfectly and with minimal errors in distance measurements. It performed similarly to a standard GPS data logger even on sea routes. This device could be useful for vehicle security, managing inland fleets, monitoring tourist boats, and field surveys, as long as GPS and GSM signals are accessible (Omar, 2021).

According to Sanchez et al. (2018), due to the poor transmission conditions and lack of a built-in infrastructure to support long-range connectivity with the land, maritime communications are difficult. Typically, satellite links—which are expensive and cause high power consumption by the terminals—cover communications on high seas.

Families and authorities had been extremely concerned about real-time boat tracking. The products on the market are either too expensive or don't offer real-time tracking. The background location tracking capabilities of IoS and Android mobile phones are severely constrained, making them untrustworthy for continuous real-time tracking. a low-cost, embedded, real-time position tracking system that uses a GPS sensor aboard and a Raspberry Pi computer to connect to a server on land utilizing long-range WiFi backhaul.

2.4. Radio Frequency Communication

LoRa (Long Range) is a newly discovered technology that is advancing quickly. It is a brand-new wireless protocol created especially for long-range, low-power communication.

The capability of LoRa is still questioned knowing that it is a newly discovered technology but according to a study, with a single gateway, we can achieve a range of 7 km, giving us a coverage of 154 km2. However, these are ideal circumstances that cannot be met in a city (Daniłowski, 2021). This shows that LoRa has a lot more to offer that a 7km module can exceed up to 154 km^2 but can only be achieved in a non-urban area our 10 km LoRa module will be tested or will be used on the ocean surface where nothing will block its signal.

Hundreds of square kilometers or entire cities can be covered by a single base station or gateway. The environment or impediments in a particular area have a significant impact on range. This statement from a study also shows how far can a LoRa reach. Furthermore, there is also a study of the usage of LoRa on tracking ships. In the port of Vigo (Spain), a genuine LoRa-based network has been set up. The obtained results demonstrated the viability of using LoRa to follow ship motions and keep an eye on some port-related metrics (Sanchez et al., 2018, p. 15).

3. Method

The tracking device system for motorized and non-motorized bancas was designed and developed using the developmental research method. Developmental research is thought to be especially important in the field of instructional technology. Developmental research is defined as the systematic study of designing, developing, and evaluating instructional programs, processes, and products that must meet criteria of internal consistency and effectiveness (Seels & Richey, 1994).

The researcher initiated this study after addressing a significant concern in their Barangay (neighborhood) in Baras, specifically the incidents involving missing fishing boats and their crew. Initial data collection involved studying the sailing distances of fishing boats and analyzing past cases of missing vessels. Additionally, interviews were conducted with administrative field offices such as the Coast Guard Station Catanduanes to understand their search and rescue methods and protocols. Interviews with local fishermen provided insights into their typical sailing distances. To evaluate the prototype's effectiveness and accuracy, tests were conducted from the Barangay Rawis Bay area, using it as the base station. The prototype, utilizing the Global Positioning System (GPS) for coordinates, employed LoRa for transmitting data to the coastal area's server

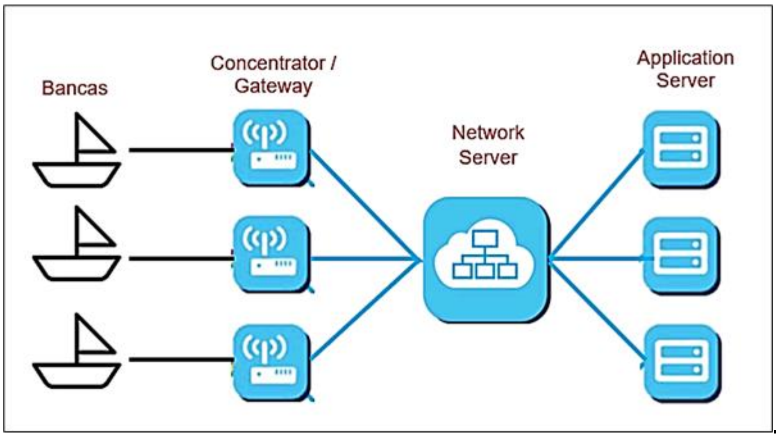

Figure 1 Systems Architecture

Figure 1 displays the system architecture of the tracking device. The banca transmits signals to the concentrator or gateway, which forwards them to the network server and application server. The application server manages data transmission and reception. It interacts with the GSM Modem, which in turn communicates with the GSM module. The GSM module receives data from the microcontroller. The microcontroller obtains data from the GPS Module (LoRa) and processes it. The data initially comes from the GPS Receiver (LoRa).

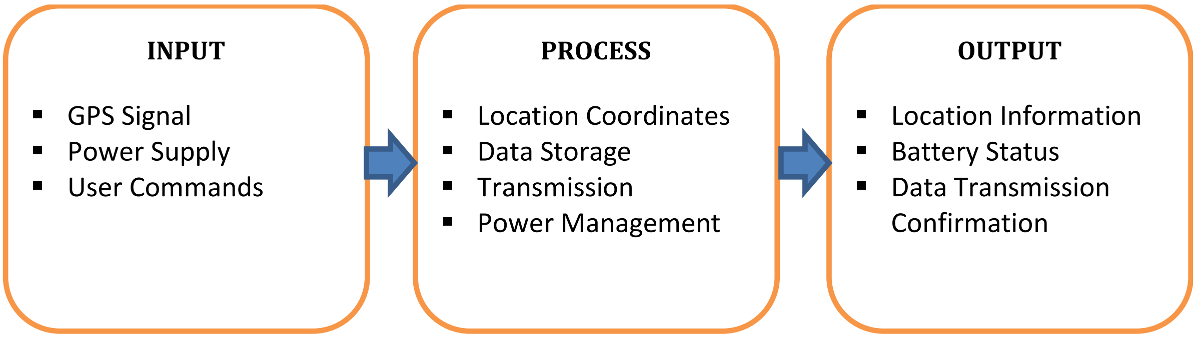

Figure 2 IPO Diagram of Tracking Device

Figure 2 illustrates the IPO diagram of the Tracking Device. GPS signals are crucial inputs providing location data, and continuous power supply is needed for device operation. User commands, if used, may include instructions to activate features. Data processing interprets GPS signals for accurate location determination. Calculated location information is stored in memory. During transmission, it sends location data via a network for tracking. Power management optimizes consumption for sustained functionality. Outputs include Location Information, Battery Status, and Data Transmission Confirmation for users or systems to track coordinates, battery charge, and transmission success.

4. Experimental method

4.1. Tracking System

The Internet of Things (IoT) has gotten a lot of attention because of its ability to connect disparate devices and facilitate efficient data transfer. Long Range (LoRa) and other low-power wide-area network (LPWAN) technologies have grown in popularity, making low-cost and energy-efficient tracking devices more feasible. Our project aims to develop a tracking system using LoRa, one of the most recent emerging wireless communication technologies.

The Tracking System is made up of a 433 MHz LoRa transmitter and receiver, as well as a Neo 6M GPS module, all of which work together to provide an accurate and dependable location-tracking system. The LoRa transceiver employs a low-power, long-range wireless communication protocol, allowing our device to transmit and receive locations while consuming little power. The Neo 6M GPS module provides precise location data (longitude and latitude) for locating the fishing boat.

Table 1 Test Results of Sender and Receiver Transmission

Date	**Time**	**Latitude**		**Longitude**		**Distance**	**Received Signal Strength**	**Status**
		Sender	Receiver	Sender	Receiver			
03/08/23	4:46 pm	13.587793	13.590267	124.242126	124.246768	567.83m	-101 to -110 RSSI	Stable Transmission
03/10/23	10:25 am	13.581090	13.593377	124.238433	124.257610	2.54km		Failed
03/10/23	11:08 am	13.581090	13.590612	124.238433	124.247455	1.47 km	-99 to -109 RSSI	Stable Transmission
03/11/23	6:20 pm	13.580172	13.593545	124.238163	124.259670	2.72 km	-105 to -108 RSSI	Stable Transmission
03/26/23	6:57 pm	13.580704		124.238226		2.72km	-99 to -103 RSSI	Stable transmission
03/28/23	7:55 pm	13.57955	13.595632	124.2381	124.267955	3.67 km	-99 to -105 RSSI	Stable transmission

04/26/23	5:03 pm	13.566424		124.31781		8.18 km	-118 RSSI	Unstable transmission
04/26/23	6:45 pm		13.592853		124.282166	5 km	-94 RSSI	Unstable transmission

The data shows the sender and receiver's locations, the date and time, the Received Signal Strength Indicator (RSSI), and the transmission status. During the test, the location of the transmitter and receiver is displayed using latitude and longitude, which is the same data we use to determine the location of the missing boat.

The RSSI (Received Signal Strength Indicator) is useful in wireless communication because it indicates the strength of the signal received by a wireless receiver from a wireless transmitter. This is the most important data in the table because it helps to determine the quality and reliability of the received signal because it indicates if the received signal from a certain distance is still a strong signal, indicating that you can still extend your range until the signal weakens.

So far, we have been able to achieve a stable transmission of the transmitter and receiver within a range of almost 4 kilometers, but there are still a lot of factors that we haven't considered doing during the testing, such as the placement of our LoRa receiver, which should be positioned higher to avoid any interferences and to achieve a much better line of sight to the transmitter.

4.2. Sending Emergency Signals

To enable fishermen to send an emergency signal directly to the coast guard or other local authorities. The first is that we added an emergency button to the device. When activated, the button sends an emergency signal to the receiver. This signal will be picked up by local authorities who are authorized to receive and respond to emergency signals, allowing them to take immediate action and provide assistance during an emergency.

In the second scenario, the device has a water level sensor that activates when it comes into contact with water. The sensor detects the water level and, when it reaches a critical level, the device automatically sends an emergency signal to the local authorities. This alerts them to the fact that someone is in distress and requires immediate assistance.

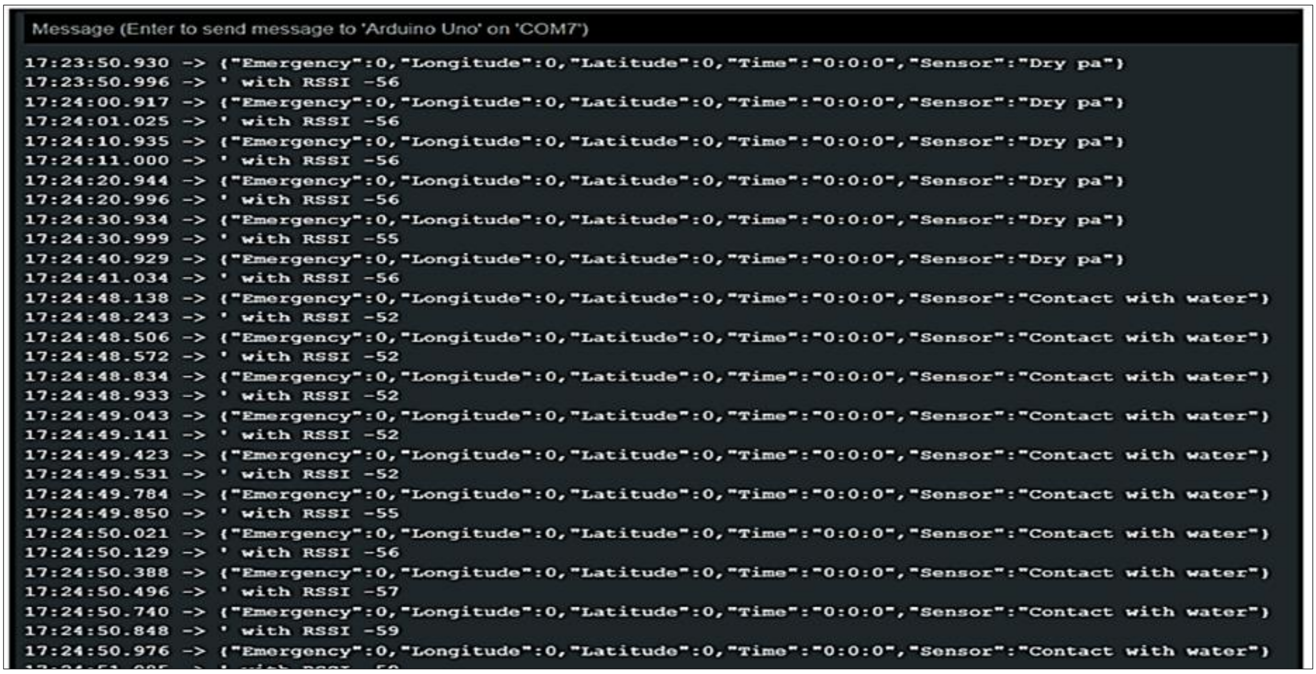

Figure 3 Data Captured

Figure 1 depicts some of the data obtained while testing our water level sensor. During the test, we programmed the device to send regular data with a 20-second delay every time it sends data, which is why the first three data have a 20-second interval, and as soon as we put water on our water level sensor, it immediately sends data with its locations and a message indicating that the device is already in contact with water. As soon as water reaches the water level sensor, the device will send a barrage of emergency signals to alert the server that a boat is in distress.

4.3. For recording boat locations

When a device equipped with LoRa technology is purchased or activated, the device address is automatically registered in our database and given a unique name, such as LoRa Device 1, LoRa Device 2, and so on. Users can view all registered LoRa devices via our webpage map. The database will record and store every piece of data received as the device transmits data to the receiver. Any data that must be accessed, read, or analyzed will be retrieved directly from the database.

To elaborate, all data transmitted by LoRa devices will be received and stored directly in our database, including RSSI (Received Signal Strength Indication), longitude, and latitude. This ensures data security and that all data is captured and accessible to authorized personnel at all times. The webpage will also show the current location and coordinates of all active and registered LoRa devices. This feature allows users to track the location of each device using the website map.

The database's primary function is to capture and record data transmitted by LoRa devices, such as their RSSI, longitude, and latitude. This will help secure and store data and will only be accessible to authorized personnel, who will also be able to access and analyze the data via our website. The webpage will also display each LoRa device's current location and coordinates, allowing personnel to track their movement.

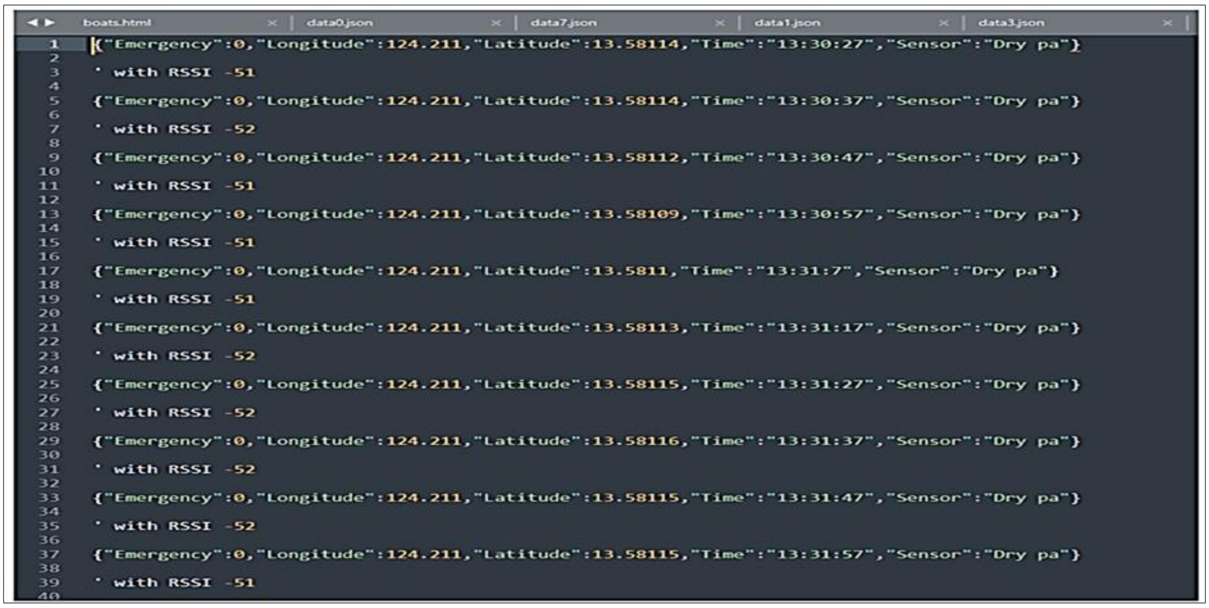

Figure 4 Data Recorded and Stored

Figure 2 presents the data recorded and stored into the database during emergency scenarios occurred in the ocean.

5. Results and analysis

The research aimed to create a tracking device using LoRa for wireless communication, GPS for precise location, and a microcontroller as the main system device. Interviews revealed that the local Coast Guard relies on regional data, not a single device, to locate missing fishing boats. Implementing our device in coastal areas could enhance preparedness for incidents like missing boats and their crews. Some factors weren't addressed in testing due to limited resources and locations, like elevating the receiver to prevent signal interference, but the desired results were achieved. The water level sensor provides precise data that yields consistent results. After testing, every emergency signal installed on our device is working correctly, and the data that the transmitter should relay is the exact data that we want to transmit, indicating that everything related to the emergency is correct and operational.

Storing data in a database and displaying it on a webpage linked to Google Maps has numerous benefits for a tracking device system. First, the database allows for the efficient storage and retrieval of large amounts of data, including real-time location information. Furthermore, the database can provide security and privacy measures to prevent unauthorized access to the data. Second, the webpage can provide a user-friendly and visually appealing interface that allows the data to be easily visualized.

6. Conclusion

Using tracking devices to monitor fishing boats is a practical and efficient solution for ensuring the safety and security of our fishermen, and given that our local coast guard lacks equipment, this tracking system would be a great help to them as a guide when conducting a search and rescue operation. The benefits of using tracking devices include real-time monitoring of the location and condition of the boat. Because fishing is a major source of income in most areas of Catanduanes, tracking devices can help ensure that boaters travel safely on the water.

Furthermore, because of its advantages such as long-range capability, low power consumption, flexibility, and affordability, using LoRa technology for tracking devices is a practical and efficient solution that requires real-time monitoring. The use of an emergency button and a water level sensor for sending emergency signals is an effective way of ensuring the safety of our fishermen because it provides a quick and easy way for the fishermen to call for help, while the water level sensor can automatically send an emergency signal as soon as the device hits the water, which means the boat is sinking. In addition, using GSM to directly notify selected individuals can be a big help in immediate emergency responses.

Finally, the use of a database is important because it secures and stores past data of a boat in order to determine their past activities before an accident occurs, as well as to avoid losing data and to have a method for data retrieval. Furthermore, the website has a user-friendly and simple interface.

Compliance with ethical standards

Acknowledgement

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Disclosure of conflict of interest

The authors declared that there is no conflict of interest.

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