Location Tracking, Messaging, and Monitoring System for Lightweight Boats Using LoRa Technology 'Safe Ride'

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ABSTRACT

The facilitation of maritime communications has been a challenging endeavor from the beginning of history. Coverage for maritime communications is limited due to the limited availability of various communication solutions. They rely on intercontinental telecommunications satellites. Typically, ships have reliable communication options because of satellite technology. Since these systems are both costly and drain substantial amounts of power from the terminals, only lightweight boats do not utilize them. Lightweight boat sailors typically encounter numerous challenges due to a failure to effectively communicate. Therefore, individuals face numerous risks in unexpected situations. Although radio transmission technologies such as Wi-Fi, 4G, WiMAX, etc. have advanced rapidly in recent times, seaside communications remain challenging due to poor transmission conditions, coastal interference, and a lack of pre-installed machinery to facilitate long-range interconnection with the land. Fortunately, this problem has a highly efficient answer: the Low Power—Wide Area Network (LP-WAN). This approach is well-liked for Internet of Things (IoT) uses since it allows for extended transmissions of more than 15 km (10 miles) in empty space while only requiring a small amount of power. LoRa (Long Range) is a popular example of a low-power wide-area network. This study's ultimate goal is to use LoRa mesh networking technology for the development of a network in a coastal environment. So, we might be able to keep good connections to land while reducing the number of accidents involving light boats.

Keywords– Communication, Wi-Fi, WiMAX, LoRa, Boat

I. INTRODUCTION

Since the commencement of maritime operations such as shipping and fishing, it has become significantly more difficult to hold a conversation next to the ocean [1]. Marine communications make it possible for ships to communicate with one another as well as with land and other ships. As a result of this, the utilization of semaphores and flags for maritime communication became prevalent in the past. The use of flags and lights allowed for transmissions to take place over extremely wide distances. However, throughout the years, there has been a significant shift in the way that sailors converse with one another. That is one of the most important things in the fishing industry.

The use of pricey satellite links has become the normal mode of communication for large boats such as ships. In addition to this, they take a significant amount of juice from the terminals. Cellular communications and wireless sensor networks have been implemented as modes of communication in inland regions that are closer to the coast [2].

However, each of them has problems with the system's coverage and its ability to efficiently use energy. To add insult to injury, the majority of lightweight boats that go out to sea for fishing stay near the coast. There, they do not have the resources to upgrade to more expensive types of communication, such as satellite communications. This is another way insults are added to the pain. When a boat exits the territorial waters of a country, it is impossible to ascertain who is responsible because there is no method to do so. When sailing light-weight boats like fishing or pleasure boats, there is no way to tell how safe the boat is or how to get in touch with land in case of an emergency.

When shipping goods or fishing, it has always been difficult to effectively converse with other people out on the water. Through the use of marine communication, it is possible to have conversations not only with other ships but also with individuals on seaside [3]. Historically, the primary means of communication amongst sailors was through the use of semaphores and flags. Flags and lights were utilized in or detonate communication across extended distances. The way people exchange information, on the other hand, has changed dramatically since the advent of boats. Large boats, such as ships, often rely on

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-12, Issue-6, (December 2022)
https://doi.org/10.31033/ijemr.12.6.8

pricey satellite hookups in order to maintain ineffective lines of communication. In addition to this, they draw a significant amount of power from the outlets. People who live closer to the coast have mostly met their communication needs through cell phones and wireless sensor networks.

The vast majority of them, on the other hand, have limitations that reduce the system's effectiveness and scope. In addition, lightweight boats frequently fish in coastal waters, and as a result, their owners typically do not have the financial resources to update to more advanced kinds of communication, such as satellite communications, lighting communication, and Mos codes.

A country also has a maritime boundary and legal regulations, which is the point at which it becomes hard to identify who is at fault in a departure from its territory and sailing into international waters. When sailing light vessels such as fishing boats or pleasure boats, there is no way to determine the safety of the boat, and there is also no way to get in touch with the dashboard in the event of an emergency. After all, this is a new era of shipping boat communication, and it is important for safety and good productivity for the sailors' workload. And this is cost efficient than the other technologies that are currently used in the fishing industry.

II. LITERATURE REVIEW

Previous studies in this field include "GPS & Lab view Based System for Detection and Control of Maritime Boundary Intruding Boats," written by N. Jayapal, B. Aadhithyaa Vishwanath, and their colleagues [4]. This is how the system treats the two primary factors. As a result, they are completely oblivious. No such system exists to issue a warning to fishermen before they cross the maritime boundary. Because of this, not only are lives but also money and resources lost. Problems with crossing maritime boundaries can also be caused by a lack of security measures or a failure to issue a security notice by the coast guard. Marine patrols are responsible for rescuing fishermen in perilous situations. All operations are managed by a PIC microcontroller. Two sections make up the entirety of this endeavor (boat unit, border unit). Border GPS coordinates are entered through keypad on board. The boat's rain and wind sensors measure the intensity of precipitation and wind, respectively. That's why the command center has access to every piece of information about the ship. Vehicle data such as GPS coordinates, precipitation, and wind speed are transmitted to the coast and shown on an LCD screen (Server with help of RF module).

In 2017, Dr. R. Azhagumurugan and Vignesh Kumar published a research paper titled "Guiding and Control of Fishermen Boat Using GPS" under the auspices of the Institution of Electrical Engineers (IEE) [5]. This existing paper makes use of the technology that is provided by the Global Positioning Satellite System (GPS) to track the position of the boat in the form of latitude and longitude. The signal that is received from the position of the boat is compared with the current value at regular intervals. As a consequence of the comparison, the boat's motor may now be controlled in three distinct modes, including normal, slow, and reverse respectively. The fishermen were able to get sufficient knowledge about their position, which allowed them to move into a zone where they were safer as a result of using this method.

Another research article that was written and published by Kishore Kumar Reddy is titled "Ensuring Fishermen Safety with a Range-Based System by Trizonal Localization Using Low Power RSSI." N.G, Ramakrishnan [6]. Within the framework of this proposed approach, a remedy is provided for the issue concerning fishermen. Keeping tabs on their position in the ocean. In order to facilitate this, the marine environment has been sectioned off into three distinct zones: safe, intermediate, and hazardous. Within the confines of the safety zone, the boat is free to travel wherever it pleases. In the event that the vessel enters the intermediate zone, the fisherman will receive a buzzer warning. If the boat enters the danger zone, the fisherman receives notification that he is expected to enter the intermediate zone within the allotted amount of time. In that case, the engine will shut off on its own, and the operation of the boat will be transferred to the control room. The boat won't be released until the coast guard has either completed its examination or provided assistance to those in need. Received Signal Strength Indicator is utilized in order to differentiate between the various Ranges (RSSI).

III. RESEARCH OBJECTIVES

The main objective of this research is to provide a unique solution for the current sea side communication between sailors.

Maritime and terrestrial wireless communications have different settings. Poor transmission conditions, interferences, and absence of pre-installed equipment make beach communications challenging. In places closer to beach, alternative communication options are used for boat tracking and telemetry, data collecting from moored monitoring systems, etc. In these cases, cell phones or wireless sensor networks have been used.

In the ocean, IoT is challenging to use because to communication coverage, power supply, and maintenance. The relevance of lightweight boat communication has grown due to a lack of a viable approach. Lightweight boat sailors often have trouble owing to poor communication. In an emergency, they face many threats.

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
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A. *Create and setup a mesh network for seaside communication:* There are just a few of viable methods for ensuring maritime communication coverage. They rely on intercontinental and international communications satellites. Usually, ships have reliable communication capabilities thanks to satellite communication systems. The high cost and significant power requirements from the terminals mean that lightweight boats cannot benefit from these innovations. The solution to this problem is the Low Power—Wide Area Network (LP-WAN). This approach is well-liked for Internet of Things (IoT) uses since it permits extended transmissions of more than 15 km (10 miles) in empty space while only requiring a small amount of power. Using LP-WAN users can satisfy following conditions.

- Long-distance transmission is required.
- Reduced bandwidth consumption per message.
- A maximum of one message per node every day
- A large number of end devices that are linked at the same time.
- End-devices with low costs.

As one of the most well-known LP-WANs, LoRa (Long Range) is rapidly growing in popularity. Therefore, the goal of this study is to deploy a LoRa-based mesh network in a coastal setting. An accompanying web app uses this technique to track information arriving over mesh networks.

B. *Creating a maritime boundary tracking:* Oceans hold around 96.5 percent of earth's water. Many individuals who live by the coast depend on the ocean. When fishing, it's vital to alert and watch fishing vessels to prevent them from crossing maritime boundaries. Boat riders who breach the maritime border unintentionally or purposely can be severely punished by the neighboring country's coast guards. An effective strategy is devised to overcome this threat with Global Positioning System (GPS) which offers dynamic location of fishing vessel in water and microcontroller which competes on GPS and predetermined boundary positions to determine if the boat has crossed the border or not. Existing marine boundary tracking systems have issues. Existing systems do not alert before reaching the border. They notify when the boat sits on the maritime border. And they don't inform when a boat takes a long time to reach a safe zone after crossing a maritime border purposely.

Our technique, primarily for fishermen, detects the marine borders between the two countries. This happens when fishermen cross the maritime border of a neighboring country accidentally. This solution uses LoRa technology to achieve reliable connection at sea. The system has a separate login for boat owners. So, people can see their own boats on the dashboard and check all alert messages, live sensor details, current GPS location, and boat history. And they can generate a report of boat details as a pdf and a report of attention-required boats using the frequency a boat breached the boundary in a month. By existing systems, boat owners can't track their own boats.

C. *Send emergency messages:* Since the ocean surrounds the entire island of Sri Lanka, many of the locals who make their homes near the coast rely on it for their livelihood. Lightweight boats are the norm for sailors here. The use of radio signals for communication is commonplace in boats of this type. Sri Lanka also uses cellular and satellite communication systems as additional maritime methods of contact. The cellular approach is simple, quick, and easy to implement. Unfortunately, it has a very low effective range. Therefore, long-range fishing vessels cannot utilize this cellular approach. The use of satellites for communication is extremely costly and draining on terminal batteries. As a result, radio frequencies are widely used for communication among sailors in lightweight boats. But when the weather is severe, they can't use that strategy because radio transmissions fail. Consequently, even in an emergency, sailors will be unable to make contact with land masses along the coast. Therefore, they should hold off until the weather returns to normal. As a result, sailors are in for a tough time.

D. *Prevent boat accidents to keep the boats and the sailors safe:* Due to a lack of resources and technology, the sailors are restricted in their ability to maintain contact with the mainland. Most sailors are in trouble because they lack the tools for long-distance contact with the shore and protection from the constant danger of collisions. However, ship collisions account for 26% of all accidents at sea. With LoRa technology's position tracking, messaging, and monitoring system, mishaps involving lightweight boats can be reduced while still maintaining high-quality connections to shore. Users who aren't logged into the system will receive an SMS message alerting them of the situation. If the lightweight boat is ever in danger, the mobile messaging system can notify the coast guard and the owners. The suggested system uses LoRa technology to construct a location tracking, messaging, and monitoring system for lightweight boats, thereby minimizing accidents involving such vessels while preserving high-quality land-based communication.

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-12, Issue-6, (December 2022)
https://doi.org/10.31033/ijemr.12.6.8

IV. METHODOLOGY

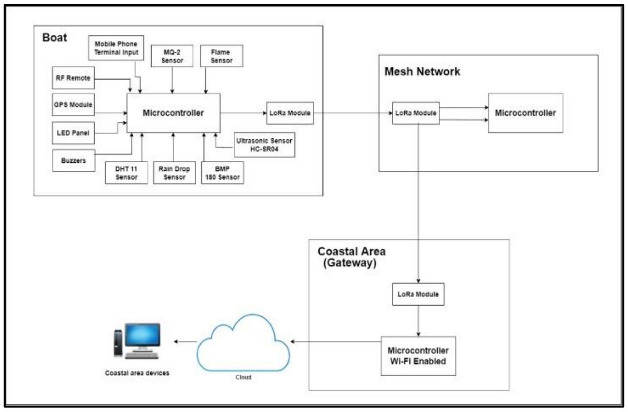

Figure 1: Overall hardware system

High-level architecture

In this section, we will discuss the solution's background and development. The theoretical underpinnings of the system, as well as its abilities, are explored. The next step is to show the audience the solution's technical creation, technical specification, and overall system architecture.

The research project "Location Tracking, Messaging, and Monitoring System for Lightweight Boats using LoRa Technology: 'Safe Ride' " aims to develop a novel, secure, and more effective communication system for lightweight boats. The answer consists mostly of four distinct elements.

A. Create a mesh network. (Emergency communication).
B. Maritime boundary detection.
C. Manual communication system for breakdowns and mitigation system.
D. Facilitate emergency alerts through SMS service.

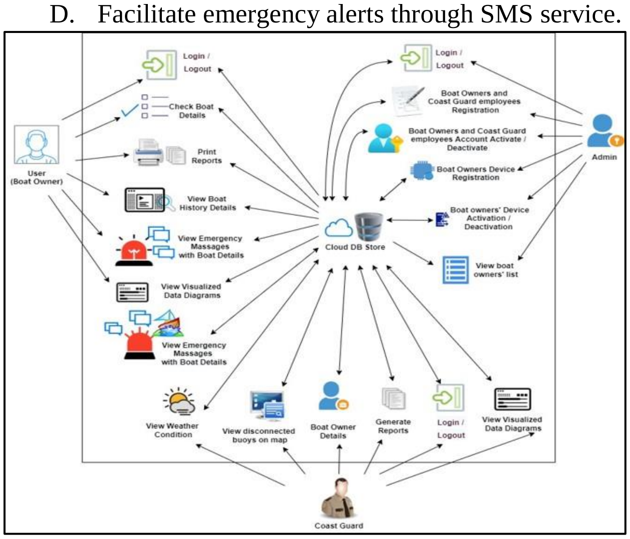

Figure 2: Overall System diagram

System Design: This 'Safe ride system" has developed for 4 components for fulfill the hole system. It is generated as follows;

The primary purpose is to relay information to smaller vessels. Here, we're offering a web app and hardware components that have a lot of flexibility. The majority of modern boats are equipped with radio communication equipment for usage during conversations. Climate and other technical and environmental issues might cause temporary drops. To do so, we must establish a means of **communication via the LoRa module**. That's why we're installing LoRa modules at 15-kilometer intervals (in the sea). From there, we plan to upload the gathered information to the cloud and refresh the website in an effort to establish a connection between that module and the rest of the network. With the 'Arduino Mega board, we are developing a marine-specific hardware component. That consists of LoRa modules, sensors, and emergency-detection sensors (smoke, flame, mealtime boundary). Our LED screen and buzzers will help the sailors make sense of the scenario at hand. In this case, the lightweight's LoRa module is talking to the top LoRa module at sea. The information will then be sent to a website via communication with land. An additional remote for land-based communication is being made available to boats. In an urgent scenario, the sailors can offer a special massaging system. Depending on the gravity of the scenario, you can press one of four buttons. The sailors can **communicate (emergency SMS system)** with the module's Arduino terminal via their cell phones. We've built in an object detection system that uses ultrasonic sensors, and the dashboard helps the sailors assess the danger. An additional feature of this technology is an automated technique of communicating an emergency situation on the boat. The status of weather sensors is continuously monitored, and they can be used in case of an emergency. Every 10 seconds, refresh the data. Our situation is displayed in LED format on the ship's penal, and the crew must undergo LED illumination training. Every piece of gear in this system is powered by Solar panels and is protected from moisture to its construction. The website has all the essentials. They consist of administrators, sailors, and the Coast Guard. **The website serves multiple purposes** for the sailor, including providing reports and allowing them to sort through the findings based on their preferences. As a result, they may learn about the ocean's currents and find safe harbors for their ships, among the many other advantages of this approach. The following technology uses LoRa boards installed in floating buoys to monitor the whereabouts of small boats at sea. The tracking system functions by having the boat's LoRa device talk to each raft of bouys over the most efficient available network connection. Ship identifiers are stored in the cloud, and

e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-12, Issue-6, (December 2022)
https://doi.org/10.31033/ijemr.12.6.8

the corresponding **maps are generated online**. After collecting enough data, administrators can use it to verify the bouy's connection to the internet and update the ship's road map accordingly. Some bouys are not maintained if they are not functioning properly they can track it from that. The coast guard and administrators can use filters to collect data about the LoRa boards, which will be useful for planning maintenance and other operations.

A. Create a mesh network. (Emergency communication)

As part of this study, we established a mesh network comprised of LoRa modules with the purpose of facilitating communication between coastline and seashore regions. We link the microcontroller on the LoRa module to the nodes of the mesh network. Solar panels are where we are putting our hopes to get the electricity for the microcontrollers. In order to get the rechargeable tiny lithium battery to work, we had to connect it to the solar panel.

If there is a flame or a dangerous gas leaking aboard the boat, the sensors will be able to identify the situation, and they will alert the sailor of it by using two different colors of LED indicators and two different buzzer beep patterns. Through the use of our mesh network, we are also able to notify the coast guard of the issue. Through the use of the mesh network, the weather information (air pressure, rainfall, humidity, and temperature) from the boat are transmitted to the Department of Coast Guard every 15 seconds by 15 seconds.

If there is a problem with a buoy, we will be able to determine what the problem is if we track buoys. The one-of-a-kind identifiers of the buoys are attached to each and every request that is processed by the mesh network.

B. Maritime boundary detection

The GPS module in this system is responsible for providing an up-to-date snapshot of the boat's dynamic location. The controller unit that evaluates the GPS position value ranges in relation to the predetermined border GPS location. If the fishing boat gets within one kilometer of the boundary, it will be tracked using GPS, and the riders on the boat will be informed of this fact using an LED indication and beep noises generated by a buzzer. As a result, they will be able to adjust their movement location. A notification, together with the location of the boat, will be sent to the Department of Coast Guard using a mesh network if passengers aboard the boat make the conscious decision to cross the border.

The suggested system makes use of a Global Positioning System (NEO 6M GPS Module) in order to receive signals from satellites and provide the boat's current location to the user. A border may be predefined, and the information on this may be saved in the memory of the microcontroller. After that, we will be able to compute the distance between the border and the place that the boat is currently in, and if that distance is less than one kilometer, then the specific action will be carried out instantly. We are going to use the following formula in order to calculate the distance from the origin point between any two points on the globe.

$$\Delta\varphi = \ln(\tan(lat_B / 2 + \pi / 4) / \tan(lat_A / 2 + \pi / 4))$$

$$\Delta lon = abs(lon_A - lon_B)$$

$$\text{bearing}: \theta = atan2(\Delta lon, \Delta\varphi)$$

Note:

1) Ln = natural log
2) If $\Delta lon > 180°$ then $\Delta lon = \Delta lon \pmod{180}$.
3) Operation <u>a mod n</u>
4) Function <u>atan2(y, x)</u>
5) The angles are in radians

If the distance is less than one kilometer, the controller unit will notify the people riding the boats about their location on the indication panel. Using this technique, we are able to determine how long the boat will take to get to the safe zone after crossing the border, and if it takes a significant amount of time, that message will also communicate to the department of the coast guard.

C. Manual communication system for breakdowns and mitigation system

This research has the capacity to convey urgent messages over radio signals in the event of a radio signal crash. There are two different kinds of massages that sailors can send from this area. The first method is for sailors to type messages into an Arduino terminal by utilizing a pc terminal as input, and then transfer those messages across a mesh network. This massage is connected to the boat's id as well as its GPS coordinate. The second method is for sailors to use an RF remote controller to deliver pre-programmed massages to one another. Within the software component, the interface for the coast guard was mostly composed of a notification bar. It is loaded with all of the various emergency alert messages. There are three massagers that give out emergency alerts.

1. When sailors manually send massages.
2. When boat is near to maritime boundary.
3. When there is detection of boat sensors.

Those warnings are labeled with the dashboard. By clicking on that emergency alert, the Coast Guard will be able to access all of the live details of the boat, including the details of the boat owner and its GPS location. In addition, the Coast Guard is able to compile and download reports regarding the sensor data and GPS rotation of the vessel whenever it is necessary to do so. In addition, the coast guard is able to conduct an investigation on the conduct of the vessel by viewing the history details of the vessel.

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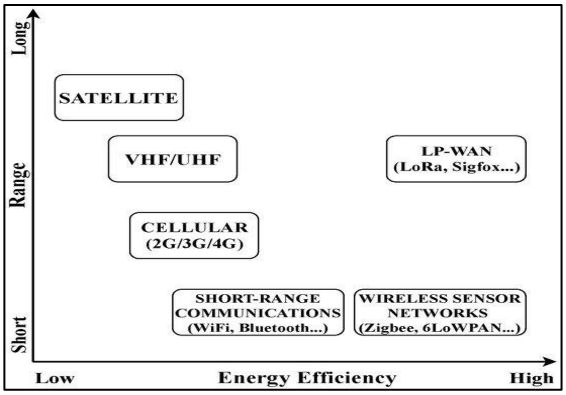

Figure 3: Different communication systems used in marine scenarios are compared for transmission range and energy economy

In the collision avoidance system, the system informs the fishing boats via emergency buzzers about the approaching ships or objects. Additionally, an accident detection system is included in the collision avoidance system. The HC-SR04 ultrasonic distance sensor is a component of the proposed system. This sensor may detect approaching ships or objects and sound an alarm to warn the passengers on the fishing boat.

D. Facilitate emergency alerts through SMS service

In the event of an emergency in which users are unable to log in to the system, the user can rapidly alert system administrators by using the SMS service. Through the web application's SMS mechanism, both the boat owner and the Coast Guard would be able to get SMS alerts on their respective mobile phones. The text message notifications, as well as the communication with the boat owner and the coast guard through the web application. The emergency scenario, the boat identification number, and the URL of the current GPS location are all included in the SMS alert. The recipient will be able to learn more about the yacht by going to the URL once they have connected with the link provided in the SMS alert.

V. RESULT AND DISCUSSION

This section provides the details of the results of the system.

Both physical and digital parts make up the suggested system. So many aspects of marine communication problems are explored in this study. Our system's many capabilities will be of great use to those who sail lightweight boats.

- Provide good connectivity between lightweight boats and costal area through a mesh network.
- Measure temperature, humidity, pressure of air and rainfall of the lightweight boat.
- Boundary tracking.
- Track buoys which are connected to mesh network.
- Detection of fire in the boat.
- Detection of toxic air and gas leak in the boat.
- Manual message system through lightweight boat Arduino terminal.
- Display details related to the emergencies on the coast guard and boat owners' dashboards.
- Coast guard employees and boat owners can generate the boat details reports.
- Messaging system available for coast guard employees and boat owners' mobile devices.

Basically, the suggested system is able to communicate mesh networks on the coastal region utilizing LoRa technology for each research component implementation, which in turn reduces the frequency of accidents involving lightweight boats. The following figure shows the tracking graphs of the lightweight boats. From graphs earn about coastal limits, potential dangers, and sensor warnings for optimum land-to-ship connectivity.

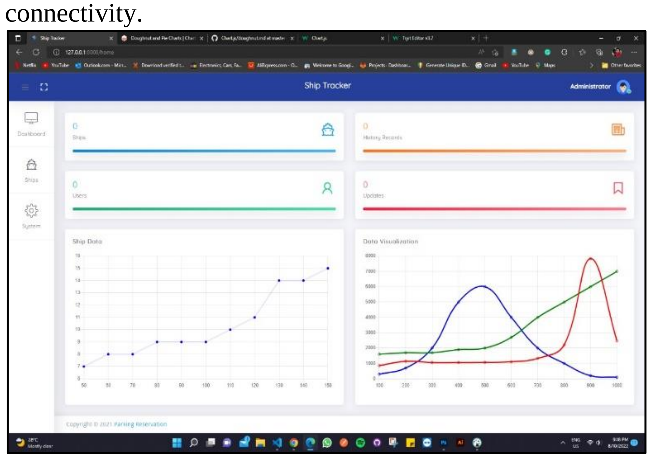

Figure 4: An administrative interface for keeping a check on the sailboats.

After all, this system is feed backed by the sailors. Sailors regarding the results of a number of other approaches. Based on the outputs and overall findings, it appears that the "location tracking, messaging, and monitoring system for lightweight boats employing LoRa technology" meets the needs of the vast majority of its users.

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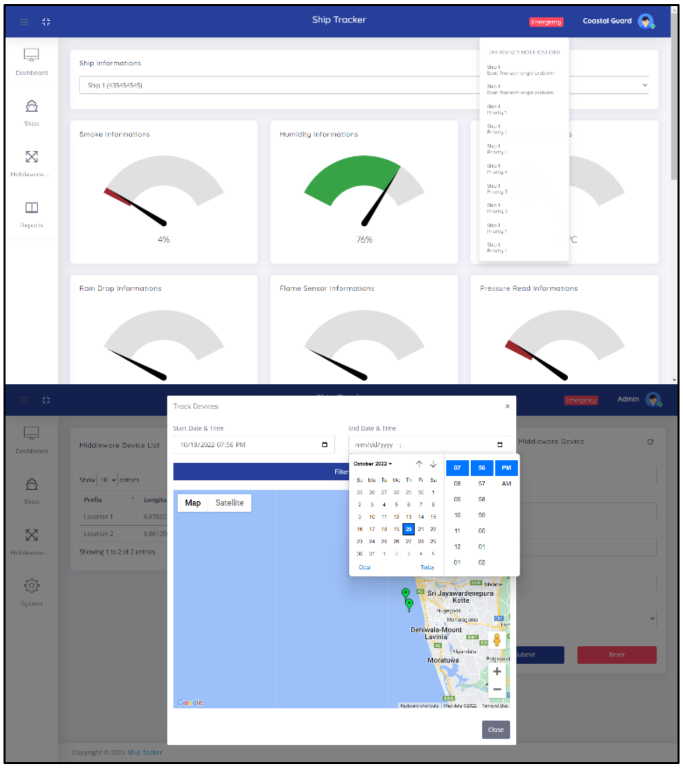

Figure 5: Ship information and Tracking boats outputs

Once all the parts were tested together, the system was able to successfully complete all the phases of project management. After extensive testing, it was determined that the system met or exceeded all of the aims of the study project regardless of which components were used. Given the facts, it's easy to see why the LoRa-based position tracking, messaging, and monitoring system for lightweight boats was such a brilliant idea.

VI. CONCLUSION AND FUTURE DEVELOPMENT

The project is a coastal communication line. This study setup three LoRa modules. One LoRa antenna is on a boat, one is on the water (the center device), and one is on the coast. Each LoRa module features a microcontroller for inter-module communication. The boat's LoRa module may send terminal messages and sensor data. The nearest LoRa mesh network module receives the data. A mesh network employs LoRa transceivers. They can get and send data to another LoRa module (middle devices are transceivers). The mesh network lets data reach land. LoRa module data is sent to the cloud via a Wi-Fi board and CPU. Processors decode and store data on the cloud.

This communication method can be upgraded with new tech. Most ocean communications use radio waves. Using satellite signals or sensitive signals with strong coverage, connection dependability, and low power consumption is safer for poor sailors and more effective for seaside communication.

Low-cost and low-power communications system. This communication method helps light boat sailors. This is a new communication line, so safety reasons increase sailing safety and minimize danger. The system's user guide is straightforward to comprehend and obtain, and output signs and symbols are basic. Sailors can simply spot warnings and advice and manage the problem. Installing this system will boost coastal jobs.

This LoRa mesh network may be enhanced by using block chain. Block chain improves mesh network privacy. Using advanced algorithms may make all sensor data more useful. Ultra-Wide Band can enhance tracking system.

REFERENCES

[1] F. Bekkadal. (2009). Future maritime communications Technologies. *OCEANS 2009-EUROPE*.

[2] P. B. Schroeder. (1967). *Contact at sea: a history of maritime radio communications*. Ardent Media.

[3] A. Chakrabarthy. (2022). *"marinesight"*. Available at: www.marinesight.com.

[4] *GPS & Labview Based System for Detection and Control of Maritime Boundary Intruding Boats*. (2018). Available at: https://www.ijert.org/gps-labview-based-system-for-detection-and-control-of-maritime-boundary-intruding-boats [Accessed 12 August 2022].

[5] *Guiding & Control Of Fishermen Boat Using Gps*. (2017). Available at: https://www.semanticscholar.org/paper/Guiding-%26-control-of-fishermen-boat-using-GPS-Azhagumurugan-Kumar/e9f2084ac7e7ca397494f2e0d6f4ee918c878e47. [Accessed 12 August 2022].

[6] Ieeexplore.ieee.org. (2022). *Ensuring fishermen safety through a range based system by trizonal localization using low power RSSI*. Available at: https://ieeexplore.ieee.org/document/8085707. [Accessed 12 August 2022].