Early Warning System Integrated with Automatic Identification System for Ship Safety

Supria[1], Depandi Enda[2], M. Nur Faizi[3], Romadhoni[4], Hardiyanto[5], M Afridon[6]

{phiya@polbeng.ac.id[1], depandienda@polbeng.ac.id[2], faizi@polbeng.ac.id[3], romadhoni@polbeng.ac.id[4], hardiyanto@polbeng.ac.id[5], mafridon@polbeng.ac.id[6]}

Politeknik Negeri Bengkalis, Street. Bathin Alam Bengkalis Riau, Indonesia[1,2,3,4,5,6]

Abstract. The island of Bengkalis is located between the Bengkalis Strait and the Melaka Strait. Every year there are 80,000 ships passing through the Bengkalis strait and the Melaka strait. Every ship passing through the strait will be detected by the AIS base station or AIS-Polbeng. AIS devices can only transmit AIS data. In this research, an Early warning system integrated with AIS is proposed for ship safety. This system uses a Lora device that is integrated with AIS so that it can transmit data other than AIS data. The system installed on the ship is an AIS transponder, Lora module, environmental sensor, accelerometer sensor, vibration sensor, and anemometer sensor. The results of the experiment show that the system can send data from the AIS transponder and sensor data through the Lora device.

Keywords: Bengkalis strait, melaka strait, automatic identification system, lorawan integrated AIS, ship safety.

1 Introduction

Referring to the Minister of Transportation Regulation Number PM 7 of 2019 and IMO regulations on the use of AIS devices, it states that AIS devices must be installed for passenger ships, cargo ships with a size of at least 35GT and fishing vessels of at least 60GT (1). However, fishing vessels smaller than 60GT are also strongly recommended to have AIS equipment to improve shipping safety and security, especially when conducting fishing activities at night. In addition, AIS devices can also function as a tool to monitor the presence of ships that are sailing and anchored in the port channel and other strategic channels such as the ALKI route which has international maritime law conventions, supporting the implementation of TSS stipulations in the Sunda Strait and Lombok Strait which are closely related to foreign ship traffic passing through, especially for NON SOLAS ships or safety of life at sea (2), then the use of AIS can also facilitate supervision of illegal acts such as smuggling, illegal fishing, or facilitate SAR activities and investigations in the event of a ship accident because with AIS, SAR can easily remember the location and movement of ships, monitor the movement of ships.

The main function of AIS devices installed on ships is to facilitate access and share the same information between devices. So that it can prevent as early as possible potential dangers at sea

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such as ship accidents at sea caused by ship collisions. Therefore, AIS devices are highly required to be installed on ships that are active at sea, especially traditional fishing boats that net or catch fish at sea. According to data from Destructive Fishing Watch (DFW) Indonesia, there were 42 accidents at sea in the period December 2020 to June 2021 which resulted in 83 fishermen missing. Of the 42 incidents, 142 victims were recorded with details of 83 missing, 14 dead and 42 survived (4). An average of seven incidents a month are experienced by fishermen and definitely take victims. The number of incidents experienced by fishing boats indicates the high level of vulnerability of fishermen when earning a living. This is because they work without personal protection, lacking safety facilities such as navigation equipment and AIS. In addition, according to the National Transportation Safety Committee (KNKT), 31 percent of the total ship accidents from 2018 to 2020 were dominated and experienced by fishing vessels. The KNKT also noted that the number of fishing vessels that experienced accidents was higher than general cargo ships and passenger ships. The eight KNKT findings related to fishing vessel accidents cover issues of construction, safety equipment, navigation equipment, communication equipment, manning, management, supervision, and regulations (5).

The unavailability of AIS devices can cause accidents at sea, such as the case that occurred on a fishing pompong boat in Teluk Papal Village, Bengkalis District, Bengkalis Regency which was hit by a tankers while spreading fishing nets which resulted in 3 fatalities, two survived and one died (6). This collision could have been avoided if there was an early warning system given to ship owners to sail on a safe route because there were other ships on the route. Another marine accident case occurred in North Rupat sub-district, Bengkalis Regency, where a fishing boat carrying three fishermen looking for fish capsized in the waters of Tanjung Senepis, North Rupat, Bengkalis Regency (7).

The incident occurred on Friday, April 29, 2022 at 20.00 WIB and the SAR team was only able to evacuate and rescue the victims about three hours later at 23.05 WIB, because SAR officers only received information on the coordinate point of the ship accident at 21.10 WIB. This evacuation and rescue process can certainly be done faster if SAR officers get information on the coordinate point of the ship accident at a faster time. The importance of the role of the AIS device for the safety of fishermen in activities at sea is very large, especially functioning as a device for ship navigation and communication. Therefore, every fisherman who wants to go to sea should have this AIS device to improve the safety of their voyage. However, the facts on the ground are very different, based on the results of interviews with 10 fishermen in Bengkalis, only 1 fisherman has AIS equipment. This shows that the risk of fishermen going to sea is very high. There are at least two main reasons presented by fishermen, namely, first, the expensive price of AIS devices and second, they do not know how AIS devices work.

Based on the problems described, in this study the research team developed an affordable AIS device that can be owned by fishermen at a lower cost with the same functionality as the AIS standard in general. The communication module used as an alternative to sending and receiving data is the Lorawan module, which has been experimentally tested to have a range of up to 22 km or 13.67 miles in clear Line-of-Sight (LOS) conditions or without any obstacles (8). In addition, the use of Lorawan modules is believed to increase the efficiency of battery power so as to extend battery life (9).

The use of lorawan communication technology is more reliable in terms of energy efficiency when compared to using VHF radio communication technology with almost the same transmission range. The developed AIS device is also integrated with the existing AIS Base Station system at Politeknik Negeri Bengkalis which is capable of capturing AIS Class A and Class B signals with a signal reception range of about 180 km (11).

It is expected that the developed AIS device can be an alternative solution for traditional fishermen to have more affordable AIS equipment with a target estimated cost of making the device under three million rupiah. In addition, the development of this device can also help stakeholders such as syahbandar officers in carrying out their duties as an effort to improve monitoring and supervision of ship traffic, especially fishing boats that are at sea.

2 Research Methods

In the proposed system, there are several parts, namely the AIS base station Polbeng, Lorawan, sensor devices, and AIS transponders. The design of the early warning system integrated with AIS can be shown in Figure 1.

Figure 1 shows the design of the proposed system consists of several integrated system units, the remote base station unit is useful for capturing data from ships that have AIS equipment, both AIS Class A and AIS Class B. Meanwhile, data from ships using AIS devices based on the Lorawan module will be captured by the Lorawan Gateway unit. The captured data will then be forwarded to the web server through a web service (Restful API). The data sent to the web server is then stored in the database storage media (PostgreSQL Database) to ensure the availability of data in real time and can be easily accessed by end users. While on the end user side there is a web application as a user interface to access the ship monitoring application. The application creation stage includes creating a system database, creating a backend web service (Restful API) and creating a frontend web application on the web server side. While the application update stage includes adding the http request post AIS data feature from the Lorawan module device in the backend application, updating the frontend web application and database server.

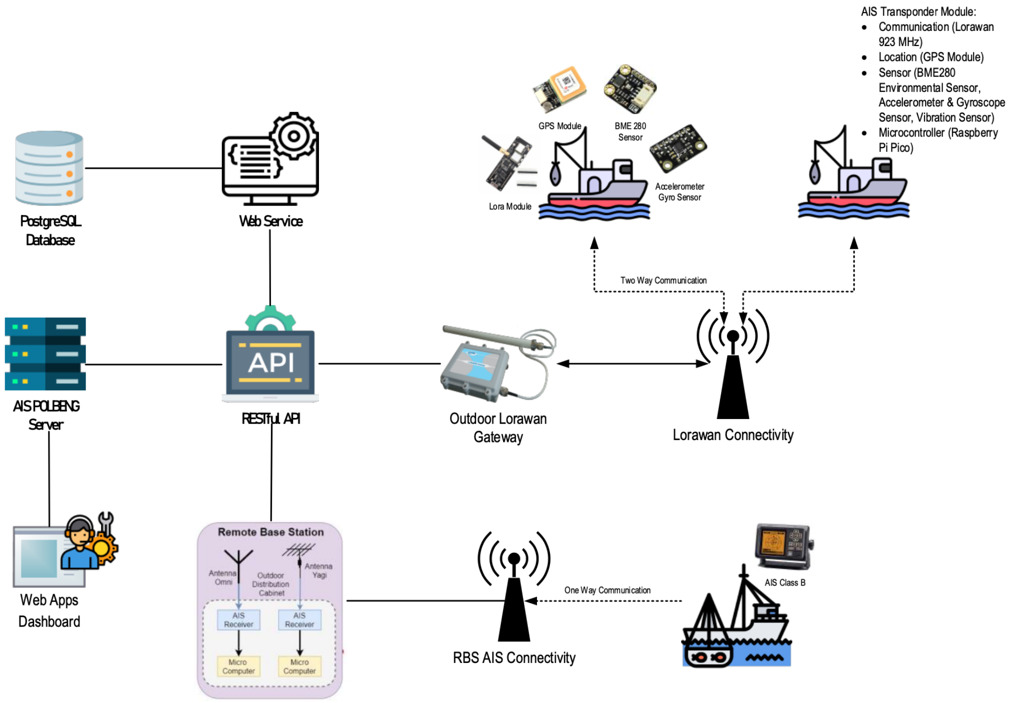

Fig. 1. The design of the Lorawan EWS system integrated with AIS.

The specifications of the designed AIS Transponder device include several module parts: The communication module used is the Lorawan module with a working frequency of 920 MHz - 923 MHz. This frequency selection is based on the regulation of the Minister of Communication and Information (Kominfo) No.1 of 2019 concerning the use of radio frequency spectrum based on class licenses and PERDIRJEN SDPPI No. 3 of 2019: LPWA Specification, which stipulates that the permitted frequency of lorawan devices is in the range of 920-923 MHz.

The location module or location tracking module used is the Matek System SAM M8Q GPS Ublox GPS Module which has a good level of accuracy with a tracking and navigation sensitivity of 165 dbm.

Sensor modules are several sensor modules used such as environmental sensors (BME 280) which can measure temperature, humidity and air pressure data. Accelerometer and gyroscope sensors that can be used to determine the stability of the ship, vibration sensors that can be used to determine the level of vibration of the ship, and finally anemometer sensors used to measure wind speed.

The Alarm Module is a module that is used as a sign or alarm to the ship's driver to be careful if there is a message from the system or base station officer about a possible danger that occurs on the ship. To turn on and off the alarm, a relay module is used as a trigger module.

Microcontroller Module is a module as the main controller of all modules in the AIS Transponder. The microcontroller module used is the Raspberry Pi Pico which supports several sensors used in the AIS Transponder device.

The Powersupply Module is the main source of power for the AIS-Transponder device is the battery. In addition, there are also solar panel modules and power inverters that are used to provide additional power when the battery is low. In order for the microcontroller, sensor and GPS devices to get a 5 volt power supply, a step down module is needed to reduce power. Then the casing is the outside or cover of the assembled AIS Transponder device.

The advantages of the proposed system have a cheaper and affordable price, capable of 2-way communication between the end device lora module and lorawan gateway. This two-way communication is needed to provide information from the base station to the ship, especially when in danger conditions that may occur. Able to integrate with existing AIS systems (able to capture AIS Class A and AIS Class B devices). Integration with existing systems is necessary, because with the integration of data on AIS Class A, Class B devices and the designed Lorawan-based AIS Transponder device, port officials are easier to monitor shipping activities.

3. Result and Discussion

The results of the designed and tested system implementation can be shown in Figure 2.
To measure the success of the proposed system, a system test was conducted. The test was carried out in several stages, namely testing the functionality of each device used and testing the entire system that has been designed.

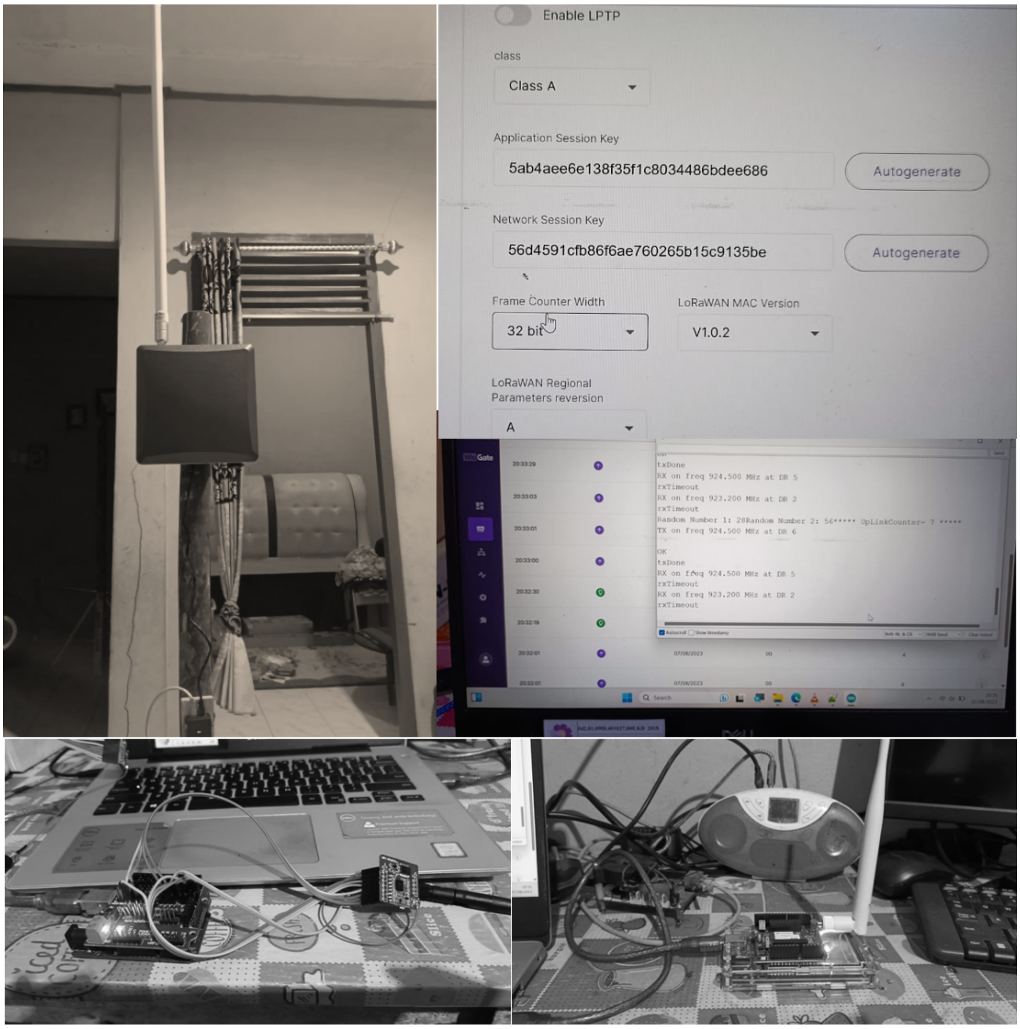

Fig. 2. Experimental results of the proposed system

Testing the functionality of the devices used is carried out to determine the success of the devices used. Each device used will be tested so that it does not cause problems when the system is finished. BMC sensor trials are carried out to determine the success of the sensor in issuing Temperature data, pressure, and humidity data. The results of the BMC sensor test can be shown in Figure 3.

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BMP280 test
Temperature = 26.98 *C
Pressure = 81945.41 Pa
Approx altitude = 1755.11 m

Temperature = 26.66 *C
Pressure = 100905.46 Pa
Approx altitude = 34.99 m
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Fig. 3. Experiment result of BME Sensor

The accelerometer sensor is used to measure the tilt of the ship. This sensor can output tilt data in the X, Y, and Z planes. The results of the accelerometer sensor test can be shown in Figure 4.

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X, Y, Z  :: 505, 505, 610
X, Y, Z  :: 505, 505, 610
X, Y, Z  :: 505, 505, 609
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Fig. 4. Accelerometer Sensor experiment results

The vibration sensor is used to measure the vibration level of the ship. This sensor can output the level of vibration value that occurs on the ship. The results of the vibration sensor output can be shown in Figure 5.

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0.08
0.00
0.40
0.38
0.07
0.02
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Fig. 5. Vibration Sensor experiment results

From several functionality tests of each device tested, it shows that each device used successfully runs as desired. The overall results of the device trials used can be shown in Table 1.

Table 1. Functional experiment results of the proposed device.

Device	Results	Description
Lorawan	Success	Can connect between lora devices
BME sensor	Success	Can measure temperature, humidity and air pressure
Accelerometer sensor	Success	Successfully measure the slope of the X, Y, and Z planes
Vibration sensor	Success	Successfully transmit vibration data
GPS	Success	Successfully tracking GPS coordinate position

Integrating AIS transponder devices with Lorawan can increase the functionality of existing AIS systems. The AIS transponder system can only be used to transmit standard AIS data, so it cannot be customized to add sensors on the ship. With the integration of AIS with Lorawan, the ship's safety system becomes more complete, thus adding safety features to the ship.

4. Conclusion

The designed system is an integrated AIS system with lorawan. This system can transmit AIS data using the AIS transponder. In addition, this system can also send data other than AIS data sent through the lorawan device. The data sent through Lorawan are accelerometer, vibration, BME, and GPS sensor data. Experiments were conducted by testing the functionality of each device used. From the results of the experiments that have been carried out, it shows that the system can run as expected.

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