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Prototyping of e-fisherman web server to support Indonesian fishermen's activities

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ABSTRACT

This paper presents a webserver for Indonesian fishermen, to support fishing activities. This is one of the sub-systems of *e-Nelayan* (in English: e-Fisherman) architecture, which was connected to *e-Nelayan Apps*; it helps to provide interaction between two users, including the administrators and fishermen. Using hypertext preprocessor (PHP) language, the website was developed to function on an Apache web server, with the adaptation of my structured query language (MySQL) framework for the database. This system was subsequently divided into two parts: (1) the front-end, which is responsible for the accessibility of data collection and (2) the back-end, where administrators update or modify crucial information: price, fishing result, illegal activity report, save our ship! (SOS) potential fish zone, and ship tracking. The administrators are unable to update the real-time weather information for the front-end part. The application was found to record the information obtained from the fishermen through the *e-Nelayan* apps and meteorology, climatology, and geophysical agency (BMKG in Indonesian). This web system is expected to carry out the following functions: to ensure easier interactions between fishermen and administrators, to enable easy update of information, to promote monitoring and recording of results, and to ensure fishermen's safety.

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1. INTRODUCTION

The marine fisheries has become one of the major driving force behind the economic growth of Indonesia [1], [2]. This is an incredibly vital sector, where any development plans should have the ability to support the sustainability of the field [3]. Most of Indonesian fishermen are satisfied with their status as a fishers [4]. To maintain a sustenance level, several factors need to be adequately considered, i.e., (i) fish stocks should be managed to ensure the welfare of the fishermen while avoiding the environmental concerns stemming from overfishing, (ii) the supply and demand of various fish types from nearby ports need to be considered for the maintenance of balance and fair trade assurance, and (iii) the physical and mental well-being of the fishermen should also be maintained, to ensure peak performance during their works, especially the ability to contact on-shore party for an emergency. To enable this, communication systems need to be installed in a

fishing boat for constant interactions between the crew over time. As a developing country, Indonesian fishermen often carry out their daily activities with small traditional boats [5]. Despite the importance of the communication systems for performance improvement, a few of them were still unable to have these installations, indicating that the stability and security of these boats were low [6]. These are caused by several reasons, ranging from low awareness level toward information of communication technology (ICT) Therefore, with an affordable and easy-to-learn communication system, the transfer of information and messages becomes less difficult. This helps to improve and ensure their performance and safety. The utilization of ICT as E-Fishery also supports various fishermen's activities, while being enabled as a boundary alert system [7], especially addressed for traditional purposes. Therefore, this study aims to develop an online system, including *e-Nelayan* (in English is called as E-Fishermen), for Indonesian fishermen, to address fishing problems and enable the penetration of industry 4.0 in the fisheries area.

The system is primarily developed to assist traditional fishermen and policymakers with small-vessel tasks. This explains that fishermen often use the program to determine information on the best fishing time and zone, communication with on-shore parties, as well as threat and law violation reports such as illegal activities. Meanwhile, the policymakers employ the system for processing reports and updating information in related databases. For adequate goal achievement, an administrator is found to often assist in the performance of these activities. The system also contains three components, divided into two 'sides' based on the user activities, *i.e.*, (i) a mobile application (*e-Nelayan* Apps version 1.0) installed on an *e-Nelayan* device (LoRa radio) to be used by "clients" (fishermen), and (ii) a web application acting as a "server" to be used by an administrator assigned by policymakers and law enforcement personnel. The design of the mobile application and the LoRa radio were elaborated in [8]–[10], with the structure, implementation, and evaluation of web application part being more highlighted in this present study. In the fishery sector, the report on ICT application is still an interesting and open analysis area in Indonesia, especially for small boat fishermen [11], [12]. However, a few reviews are found to focus on web server topics. The design and implementation of a web server system is one of interesting studies on information system discipline, as concerned by various researcher, such as [13]–[15].

Maulidi and Irmiyana created a monitoring tool with a very simple interface in a web-based fishing tracking system [16]. This was in line with [17], where a similar e-Fishermen system known as "Thoondil" was created in India. In this condition, the application served as a viable and cost-effective solution for fishermen's security and safety issues. It also provided ease of use and low-cost accessibility, with the observation of many features such as *e-Nelayan*, *i.e.*, compass, weather, potential fishing zone, daily and live/past trips, my crew and boats, rescue plan, incident report, and emergency (SOS) [17]. Additionally, Thoondil was integrated with a geographic information system (GIS) based on web-interface dashboard, to monitor defined parameters. Despite these merits, its features still differed slightly from *e-Nelayan*, regarding the fishing reports. This verified that the e-Fishermen system provided more varied features and complements than previous references. Irrespective of these conditions, the information obtained by the *e-Nelayan* system was used to provide the excellent knowledge responsible for supporting government policies in advancing the fishing economy. Therefore, this study aims to develop a simple prototype web server divided into two main parts, namely the front and back end. Based on the front-end part, a display of weather information, fish prices, and accessible contacts are observed by the public, especially the fishermen and administrators. Meanwhile, the back-end is only accessed by the administrators, to input the data of the affiliated fishermen. In this category, several data were often obtained through a unique Android-based smartphone application (e-Fishermen Apps), including fish prices, location, and results, illegal fishing reports, SOS information, and ship tracking. The fish result menu also helps the administrator to record all fishing activities on an available list, as the webserver application is operated on a Windows 7 OS personal computer (PC), which is internet-enabled with the ability to launch Apache, *my* structured query language (MySQL), and hypertext preprocessor (PHP) services. Despite requiring a hosting service and a domain, this application is still operated over the local network, with the use of the localhost portal for testing purposes. It is also designed to have an interactive feature with fishermen, through the *e-Nelayan* Apps on a communication device.

2. SYSTEM ARCHITECTURE

As stated in Introduction, the system is aimed for use by two parties, namely traditional and small-vessel fishermen and policymakers. Therefore, the system must do the following tasks as base requirements, i.e., fishermen, policymakers, and law enforcement personnel. For fishermen, the system must assist in obtaining information about the weather forecast and fishing spots and enable communication with on-shore parties, especially in case of emergency. While for policymakers and law enforcement personnel, the system must do illegal fishing reports, information updates, and other tasks to assist fishermen. Furthermore, some factors must also be taken into consideration before determining the specification:

The system is aimed for use by two parties, *i.e.*, (i) the traditional and small-vessel fishermen, and (ii) the administrator assigned by policymakers and enforcement personnel. This showed that the systematic

performance of the following tasks is needed as base requirements, *i.e.*, fishermen, policymakers, and law enforcement personnel. For fishermen, the system needs to assist in the collection of information on the weather forecast and fishing spots, as well as enable communication with on-shore parties, especially during emergencies. Meanwhile, illegal fishing reports, information updates, and other assisting tasks need to be systematically conducted based on the policymakers and law enforcement personnel. Some other factors also need to be considered before determining the specification:

- The main target users, traditional or small vessel fishermen, generally operate within 5-10 km from the shoreline. This shows that the communication system needs to cover this specified range without trouble or errors. In this condition, a cellular network such as global system for mobile application (GSM) is usable, although not necessarily reliable based on the requirement of high-power usage.
- Not all Indonesian shoreline areas have fast and reliable connections, *i.e.*, >hundreds of kb/s. This indicates that the web application should be light-weighted and secured, as well as designed for adequate comprehensive and up-to-date information.
- The system's potential users often originate from non-technological backgrounds, subsequently necessitating the ease of use as a systematic requirement. Additionally, the system should be operated in different environments (especially low-specification), to lessen the cost burden on the users.

Based on these requirements and constraints, Figure 1 shows the design of the system, which contained three primary components in two categories, namely (i) an Android-based mobile application and a LoRa radio for use by fishermen, and (ii) a web application for use by policymakers. The Andorid-based mobile application will be hold by the fishermen in the sea accompanying with the Lo-Ra radio installed in their mobile phone, whereas a web application will be operated by the administrators in the near-located of the sea (offshore area or other places). In this condition, the fishermen application was developed due to the widespread availability of Android-based mobile phones, although unable to only rely on a cellular network regarding the possibility of signal loss. This led to the need for the LoRa radio, to relay the messages from the application to the shoreline party. The selection of this radio was due to its suitability with the target users' conditions, regarding its extended coverage, as well as low power consumption and bitrate operation. Furthermore, the application and the LoRa radio communicated using Bluetooth protocol, with the data obtained by the shoreline party (*i.e.*, policymakers and law enforcement personnel) being processed through the system's web server. This helped to obtain and process information from fishermen and related authority databases. Besides this, more elaboration on the web application design is subsequently observed in Figure 1.

Figure 1. The global architecture of the *e-Nelayan* system

Leads to the adoption of LoRa-based devices, to help boost network availability. The use of global positioning system (GPS) commonly providing accurate results at the sea, hence a GPS location should be

utilized when the fishermen open the *e-Nelayan* Apps or obtain locations at larger intervals. In case of network issues, locations are often saved offline and uploaded to a server through a LoRa radio. This was because no infrastructure was observed for telecommunications operators providing services in marine and remote sea areas, due to the unprofitable link budget of the network providers. Moreover, the operational cost factor was expensive, with difficulties encountered in building telecommunication infrastructures and technology in the sea area. In this case, covering all sea areas with only LoRa technology was found to be impossible, proving that the concept of the developed system was more specific for the small fishermen generally carrying out fishing activities within a maximum radius of 10 km from the coastline. Despite this, the distance was still theoretically feasible in coverage by Lora, for the line of sight (LoS) field. Wi-Fi-based devices also provided the location of the nearest cell towers on the shore, although not the exact area. Furthermore, land analysis was very different from that of the sea, with one only relying on battery-draining GPS utilization. In the subsequent systematic development, GPS neo module and client-side Lora radio were combined, leading to the use for fishing activities by the fishermen. The function of this GPS is to obtain the position coordinates from the satellite signal, which is then transferred to the coastline server-side using the Lora radio technology as a link. Regarding the offline location storage, this strategy was subsequently applied. In the mobile application on the client-side, a tracking feature with a log record storage was also observed as the fishermen's GPS coordinates at sea. This data record was retrieved and used as the client's position tracking information. For example, when a problem connecting the client to the server was obtained through LoRa technology, the GPS coordinate data were not often realistically transmitted to the server. Despite this, the data were still obtained by extracting coordinate records or logs, which were stored offline when the fishermen were on land. However, the extract record feature was manually performed by the administrator, without the observation of application programming interface (API) for automation. For battery issues, several strategies were used to overcome the problem of wasteful usage, including the power-saving mode activation. This was in line with the Lora technology, which had similar features through the sleep mode status activation when the device is not transmitting data. Based on these conditions, the feature was found to significantly save power usage. This was accompanied by the provision of a compact power bank supported by rechargeable solar features. Since Indonesia is located on the equator, the futuristic use of solar panel technology is one of the trending topics in renewable energy. Figure 2 shows the development of the client part, where the LoRa radio equipment was divided into 3 parts, namely casing, application, and hardware.

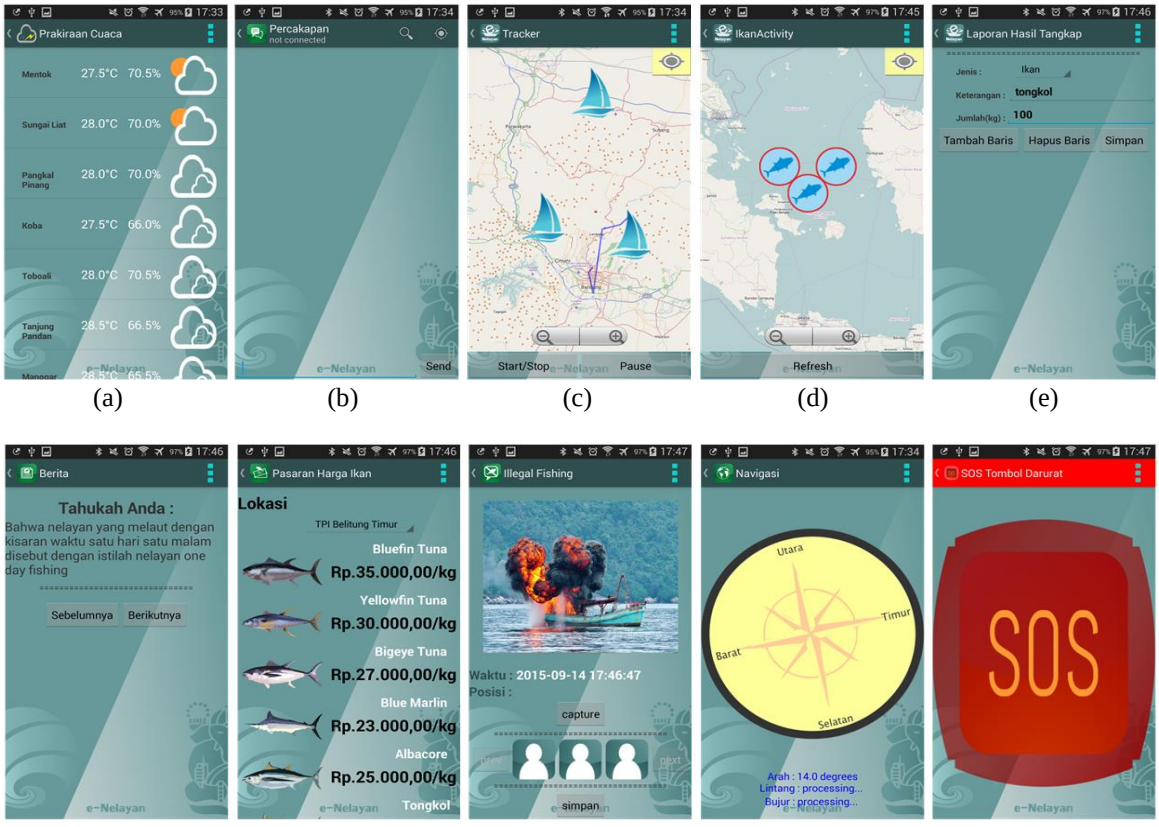
Figure 2. Client-side (Radio LoRa)

The hardware part is specifically contained several circuits, namely (i) minimum system microcontroller unit (STM32L100), which functions as the brain of the system, (ii) LoRa radio module using SX1276RF1JAS (+14 dBm power transmission, programmable, and data rate of approximately 300 kb/s), which transmits and obtains data over the air at frequencies of 433 and 868 MHz, (iii) the HC-06 Bluetooth module, which functions as a communication medium between the smartphone and radio devices, (iv) the 3.3V DC regulator, which supplies the power source for LoRa and STM32L100 radios, (v) the LiOn charger uses the MCP73831 IC, which regulates the process of charging and storing the electric current source into the battery, and (vi) the analog-to-digital converter (ADC) switch uses the MMBT2222A Transistor and MOSFET

P channel, which functions as an information indicator to know whether battery capacity is fully charged. Meanwhile, the mobile application contains 10 menus, namely weather, conversations, navigation, fish locations and prices, legal and illegal fishing reports, ship tracking, news, and SOS. For the installation of this application, the utilized smartphones should have the following speculations, (i) Android OS at least version 2.2 (Froyo), (ii) a Bluetooth device, (iii) a built-in compass, (iv) a GPS, and (v) a front or rear camera.

The fishermen are found to also access information through two interfaces, *i.e.*, the front-end dashboard and *e-Nelayan* apps. In this condition, the front-end dashboard is observed as an internet-based website, which is useful for fishermen in noting weather/fish spots when at the shore, although not very handy like a mobile app. Unless a mobile app is deployed onto fishermen's handsets with the connection of LoRa devices, the web application is observed to be of little use. Therefore, *e-Nelayan* Apps are only used by the fishermen during fishing at sea. When on land, the front-end dashboard is then accessed using a cellular signal irrespective of the network status, due to the easy accessibility of the website.

Figure 3(a) shows the weather feature providing information on the latest climate forecast (cloudy, rain, bright sun) and the rain potentials on a percent scale. Furthermore, the chatting features serve as a medium to communicate with other fishermen, through text conversations as shown in Figure 3(b). The tracking channel used to record the distance and route travelled during fishing activities, as shown in Figure 3(c). For the fish location feature, the fisherman is provided with the potential zone information (position and coordinates) of fish distribution as shown in Figure 3(d), with the reporting channel employed to reveal the marine products obtained by clients during their fishing activities as shown in Figure 3(e). Based on Figure 3(f), the news channel providing useful information, tips, and tricks, before going to sea, with the fish price feature provides information on the cost of the marine products located at the market centre, with Figure 3(g). The illegal fishing report feature is also used to record the illegitimate activities carried out by foreign fishermen as shown in Figure 3(h), with the navigation feature also provides the fishermen's position information GPS and guide in the form of cardinal directions (digital compass), as shown in Figure 3(i). Additionally, the SOS feature is used to send broadcast emergency signals to the port servers as shown in Figure 3(j).



(a) (b) (c) (d) (e)

(f) (g) (h) (i) (j)

Figure 3. The screenshot of *e-Nelayan* Apps version 1.0, the application contains several crucial features, such as: (a) wheather, (b) chatting, (c) tracking channel, (d) fish location, (e) catching result report, (f) news channel, (g) fish price information, (h) illegal fishing report, (i) navigation, (j) SOS

3. RESEARCH METHOD

As explained in Section 2, the webserver application communicates with the e-Fisherman android application as a client. The webserver handles several features similar to the application features: a weather feature that provides information to fishermen about the latest weather forecast, sea surface temperature, wind direction, speed, and sea wave height. The conversation features as a medium to communicate through text conversations between fishermen and fishermen to administrators. Navigation feature to provide position information GPS of fishermen when fishing. Fish distribution feature that provides fisherman with potential zone information (position and coordinates) of fish distribution. Report feature employed by fishermen to report marine catches obtained during their fishing activities. The fish price feature provides information on the cost of fish located at the fish market center. Fishermen utilize the tracking feature to record the distance traveled and the route when doing fishing activities. The report illegal fishing feature is used by fishermen to report illegal fishing carried out by foreign fishermen. Finally, the SOS feature is used by fishermen to send broadcast emergency signals (i.e., to other fishing boats and servers in ports). This work will focus on the webserver part run on Windows operating system and firefox-based internet search.

In this study, the web server application was found to communicate with the *e-Nelayan* android application as a client, due to the possession of several similar features. Figure 4 shows the interactive patterns of the administrators and fishermen with *e-Nelayan* Apps, subsequently indicating the exhibition of the front-end (4 menus) and back-end (9 menus) by the webserver. However, the *e-Nelayan* apps contained ten menus, as elaborated in Section 2. In this condition, the administrators and fishermen also had access to the back-end and the front-end servers, respectively, *i.e.*, (i) weather information including city, conditions, as well as minimum and maximum temperature and humidity, (ii) fish prices, (iii) contact, and (iv) the main page (dashboard), which contains three brief information on the weather forecast (area, temperature, humidity, and conditions such as sunny, cloudy, or rainy), as well as fish position and price. Additionally, the clients were found to observe the current weather from the *e-Nelayan* Application, although the information was more concise than the front-end visuals, namely city, temperature, humidity, and conditions. Table 1 subsequently describes the parts of the front-end server. Based on this server, three types of administrators were observed, namely the *e-Nelayan*, BMKG, and KKP (Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia) teams, respectively. This indicated that the BMKG and KKP management was specifically tasked with the weather and latest news updates, respectively. These were accessible by fishermen through the utilized application as shown in Figure 3. In this condition, the BMKG team was provided with a special system for connecting weather data to the front-end server and the *e-Nelayan* application. Meanwhile, a special system was also provided to the KKP team, with news updates only linked to *e-Nelayan*. Irrespective of these conditions, the administrator of the *e-Nelayan* team still accessed the webserver to obtain data from the application, such as fish prices and locations, marine catches, illegal reports, SOS, and boat tracking. Subsequently, the fish price section was displayed on the front end for public accessibility, especially for the fishermen. In the system, the administrator of the *e-Nelayan* team was able to input every registered fisherman and marine catch through the client's data and fish list menus, respectively, as a form of digital recording that was also observed at the front-end by pressing the website view. Based on these conditions, the report aims to only provide a web server to the *e-Nelayan* team, with other parameters not considered.

The back-end menu includes the following, (i) fisherman data, (ii) fish list, (iii) fish prices, (iv) fishing catch, (v) illegal fishing reports, (vi) SOS, (vii) fish locations, (viii) boat tracking, and (ix) website viewing, as shown in Table 1. The web server was designed to perform on Windows operating system and Firefox-based internet search while also being accessed through localhost. This is because most Indonesian computers, including those used by related policymakers and law enforcement, often operate the Windows OS and Firefox/Google Chrome web browser. Based on the Statcounter statistics from April 2021-2022, we got an impressive information recorded by Statcounter website that the OS market share was observed: Windows (26.4%), IOS (6.46%), OS X (1.62%), Linux (0.65%), others (1.97%), and Android (62.8%). Meanwhile, the web browser market share is: Chrome (83.03%), Safari (6.43%), Firefox (3.23%), Edge (2.07%), and Others (3.59%). Using PHP language, the website is developed to operate on an Apache server, through the MySQL database framework. It is also divided into two parts, *i.e.*, the front-end part, where information is accessed by the public, and the back-end part, where administrators such as policymakers often update or modify information. Figure 5 reveals the database structure for the proposed webserver system for *e-Nelayan.*

Based on Figure 5, five attributes are observed in the fish position, namely fish_id, latitude, longitude, as well as created and updated date times. Meanwhile, the fisherman data has 11 attributes, namely the identity number, full name, address, date of birth, phone number, username, password, remember token, as well as created and updated date times, which were obtained from sos_signals, illegals, and reports_ikans attributes. The tracking_kapals also contain seven attributes, namely fishermen_id, ship_id, track_id, latitude, longitude, as well as created and updated date times. For the reports_ikans, six attributes are subsequently observed,

namely fishermen_id, fish_id, quantity, description, as well as created and updated date times, which are obtained from the fish attribute and markets. This revealed that the label name of *Nelayans* and Tracking_kapals contained the fisherman identity data and cruising fish boat tracks, respectively. Reports_ikans also consisted of the marine catch report data, with Posisi_ikans, Sos_signals, and Illegals containing the coordinates of the predicted fish, boat, and illegitimate activity positions, respectively. However, the Markets and Ikans contained the sales & purchase prices of auctioned fish, as well as the catch types & pictures, respectively.

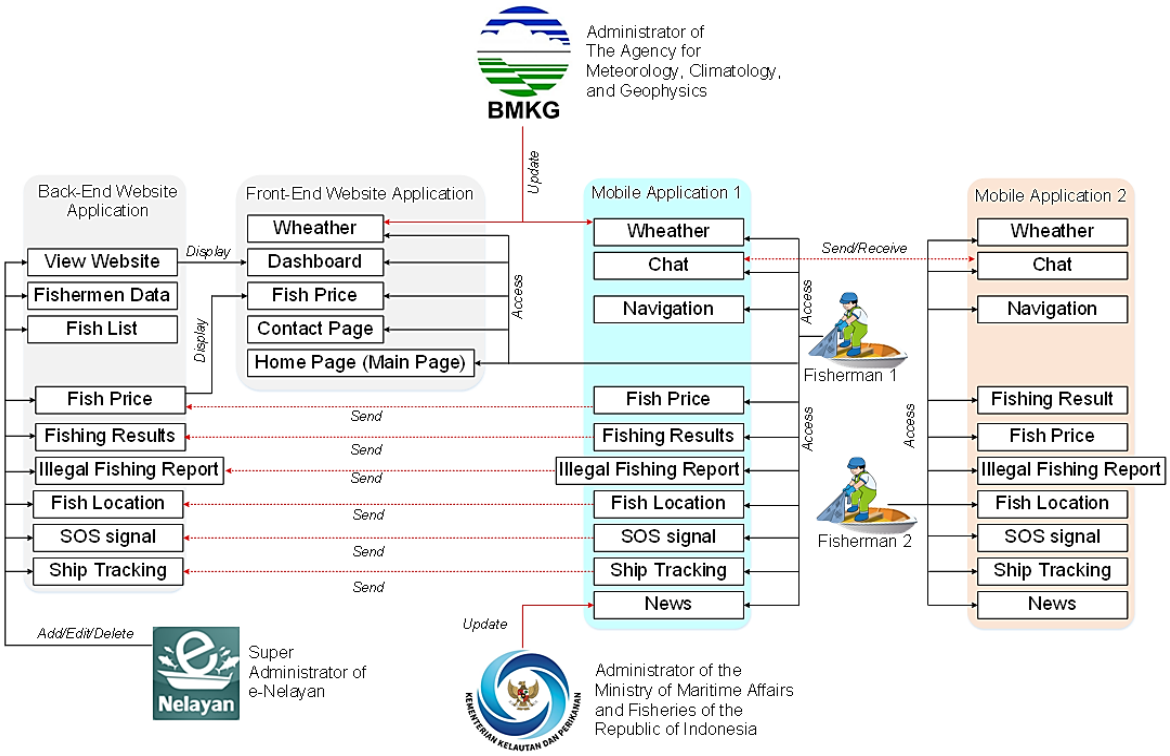


Figure 4. The use case of the web server and *e-Nelayan* apps

Table 1. Structure of *e-Nelayan* web application

Section	Page name	Function
Front-end	Frontpage	Welcomes the visitor and provides a brief overview of the website
	Weather	Provides information on the weather forecast in various areas
	Fish location	Provides the locations of various types of fish and their coordinates
	Fish price	Provides the fish price in various auction sites and fish markets
	Dashboard (front-end)	Provides and compiles the information from previous pages into a single type
	Contact	Allows visitors to contact the site administrators
Back-end	Login	Verifies administrators before accessing the back-end section.
	Dashboard (back-end)	Contain links to other back-end pages and is accessible when the administrator is successfully verified
	Fishermen data	Allows the administrator to add, modify, or delete the fishermen's data within the area
	Fish list	Allows the administrator to add, modify, or delete the fish list available within the area
	Fish price data	Allows the administrator to obtain, add, modify, or delete the fish price data in various locations
	Fishing result data	Allows the administrator to obtain, add, modify, or delete the number of fish caught
	Illegal fishing report	Allows the administrator to obtain the report of illegal fishing from the fishermen
	Sos report	Allows the administrator to obtain, add, modify, or delete incoming SOS messages from the fishermen
	Fish position data	Allows the administrator to obtain, add, modify, or delete the data of various fish positions
	Ship tracking data	Allows the administrator to obtain, add, modify, or delete the data of ship positions
	View website	Allows the administrator to observe the front-end page after processing the data from a back-end server

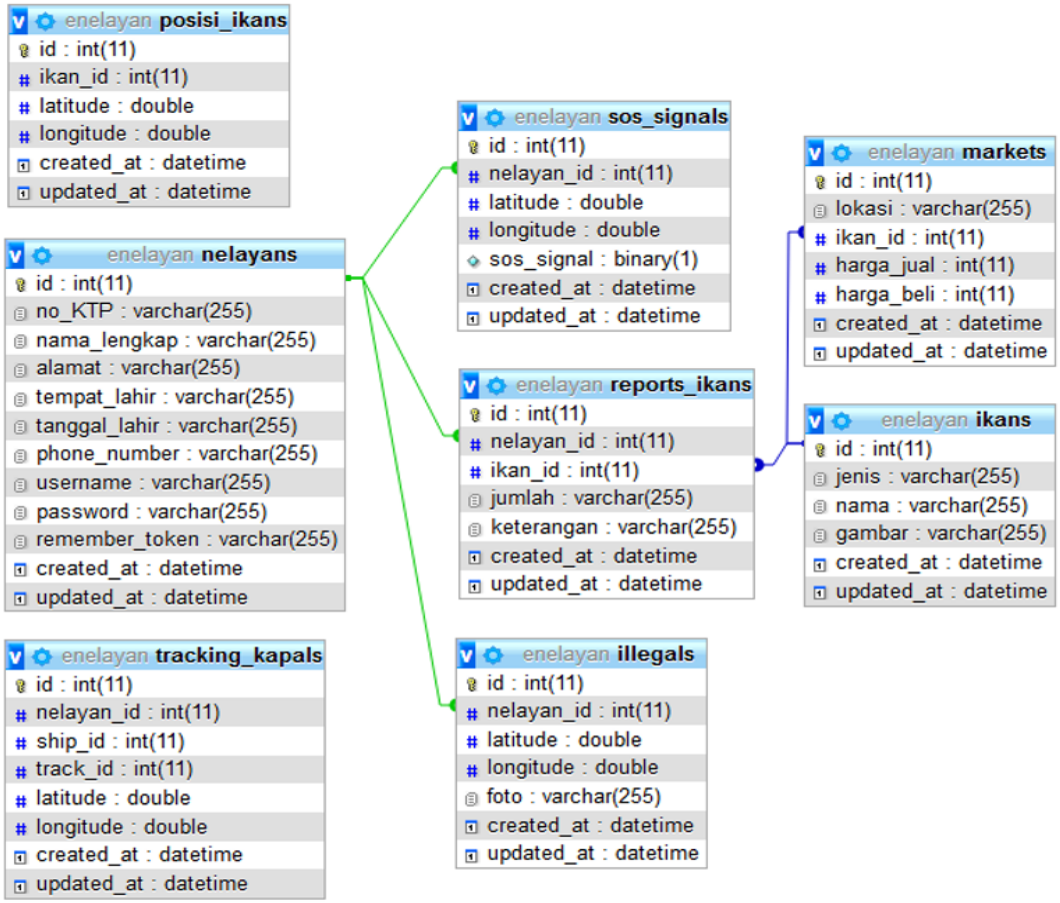


Figure 5. The database structure of the *e-Nelayan* web server

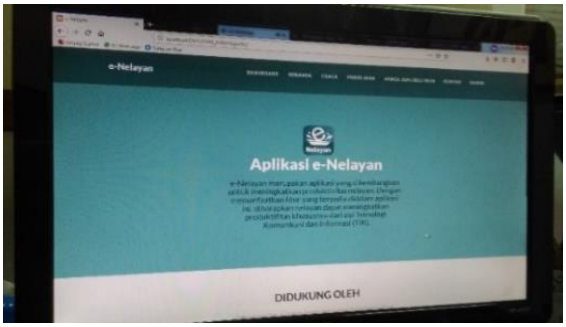
4. RESULTS AND DISCUSSION

The results of the front-end and back-end servers of the web application are depicted in Figures 6(a) and (b), respectively, with the website being designed to operate on a 64 bits screen resolution. This was subsequently analyzed on both local servers based on the adoption of the Institut Teknologi Bandung (ITB) campus portal, with two PCs used for testing the functionality of each section through the Firefox browser. The first PC was used to display the front-end section, whereas the second PC was used to show the back-end section. These Two PCs were accessed by the same network and it can run the application well as expected. The front page was the default site channel provided when visitors access the website's address. This welcomed the user and contained several information on the purpose of the website. The mock-up design of the front-end sector is depicted in Figure 7(a), where all pages contained the navigation to various sections and the login page. In this condition, the structure of the navigation links and front page were composed, i.e., ENELAYAN_SERVER/public/target and ENELAYAN_SERVER/public. A typical example of a Dashboard is observed as ENELAYAN_SERVER/public/dashboard. For other navigation, such as *Cuaca* (weather), *Posisi ikan* (fish positions), *Harga jual/beli ikan* (fish prices), *Kontak* (contact), and admin, the links are observed ad …/public/cuaca, posisi_ikans, harga_jual_beli_ikan, contact, and admin, respectively. The mock-up design of the administrator login page is also depicted in Figure 7(b), where three objects were found, namely username and password fields, as well as a submit button. When the credentials are correct, the users are immediately redirected to the backend dashboard. However, an error message was formed at the input fields when the details are incorrect, containing a link to allow users to reset their password.

4.1. Front end dashboard page

On the front-end dashboard page, all information from previous pages was listed within one page, which was subsequently divided into two columns. In this case, the left and right-hand columns displayed the weather forecast, as well as the fish location and price information. The user can simply reach available menu on the front-end section because we layouted it by considering user friendly aspects. All of menu(s) were tested by using Blackbox method and it can run smoothly. The weather information page, which contained two

objects, namely (i) a drop-down menu, which allows users to select from 33 Indonesian provinces, and (ii) a table menu of cities, temperature, humidity, and conditions. The information on this page is often retrieved from the BMKG database. The fish location information page containing a map of Indonesia marked with the clickable GPS coordinate symbols of fish concentration. The information on this page is mostly retrieved from the KKP database. This indicated that one of the declines in fishing yields was caused by the traditional customs of fishermen, whose activities were still predictive based on experience and information. The field condition also revealed that the distribution of fish changed every time due to being oceanographic. This affected the physiological conditions of the animals, making them switch positions according to their respective characteristics. With this webserver application, fishermen obtained information on potential fishing positions and zones, which subsequently helped them in the acquisition of stable fish stocks. The fish price information page contained four objects, namely (i) a drop-down menu allowing users to select from the different auction and market sites, (ii) a drop-down menu to determine the number of entries displayed on one page, (iii) a search field, and (iv) a table containing fish names, as well as the selling and buying prices/kg. The information on this page is commonly retrieved from the Indonesian Ministry of Marine Affairs and Fisheries. Furthermore, the contact page containing five objects, including a name, e-mail address, title/subject, and message field, as well as a submission button. In this case, the first three and message fields were single and multi-line textboxes, respectively. This proved that messages were often transmitted as an e-mail to enelayan@pme.itb.ac.id.



(a)

(b)

Figure 6. The the *e-Nelayan* website appearance on Firefox browser: (a) front-end pages, and (b) back-end pages

(a)

(b)

Figure 7. The appearance of Mock-up for the proposed webserver system for *e-Nelayan*: (a) a global view of the front-end pages, and (b) the administrator login page

4.2. Back-end dashboard page

The back-end dashboard page containing a navigation menu leading to the sector channels and a search field. In addition, two more buttons were observed at the top corner of the page, *i.e.,* (i) the button on the top left corner showed or hid the menu, and (ii) the button on the right-top exhibited a drop-down menu, which allowed the administrator to change their account settings or log out from the back-end. At the back of this section, nine navigations were observed with links to their respective target directories, based on the following format, ENEAYAN_SERVER\app\views\admin\xxx. For example, *Data nelayan and tangkapan laut* (fishermen and fish data) were observed as ENELAYAN_SERVER\app\views\admin\nelayans and ENELAYAN_SERVER\app\views\admin\ikans, respectively, with the naming of the xxx corresponding to the

respective target directory. The other seven navigations/labels included, (i) *harga jual/beli ikan* (fish price data)/market, (ii) *laporan hasil tangkapan* (fishing result report)/reports_ikans, (iii) *laporan* illegal fishing (illegal fishing report)/illegals, (iv) SOS signal/sos_signals, (v) *posisi ikan* (fish location data)/posisi_ikans, (vi) tracking *kapal* (ship tracking)/tracking_kapals, and (vii) View website/front_end.

4.3. Another back-end menu

The fishermen's entry page containing two channels were observed, (i) the data input or modification channel, and (ii) the present entry channel, where the administrator decides to edit or delete existing entries. For the fishermen's data, eight fields were observed and divided into five input types, *i.e.*, (i) date, text (numerical input), (ii) text (alphabet input), (iii) text (numerical and alphabet input), and (iv) text (multi-line input). These date inputs were observed as the place of birth and date of birth (PoB and DoB) of the fishermen, based on their national ID data. The text types (alphabet inputs)/(numerical inputs) also represented the Username, as well as the National ID and Phone numbers of the fishermen, respectively. Meanwhile, the text input (alphabet and numerical inputs) represented the password and full names of the fishermen, based on their national ID data. In this condition, the username and password of the clients were always required for logging in from the Android application (*e-Nelayan* Apps). For the multi-line input text, the address of the fishermen was observed regarding the national ID data. The "fish list" entry page contained two pages, *i.e.*, (i) data input or modification channel, and (ii) present entry channel, where the administrator decides to edit or delete existing entries. In this condition, three fields were observed and divided into 3 inputs, namely drop-down (type field name), text (name field name), and file (picture field type), containing the type (fish, shrimp, and squid), name, and photograph of the product, respectively.

Every data processing on fishing results is often manually recorded at the seaport, leading to the creation of high error potentials. With the utilization of ICT, these catch recording and monitoring errors were subsequently carried out. On this webserver, the "fish price page" feature was also used to record fishing results (*e.g.*, shrimps, fishes, and squids) and report to the administrator. Moreover, the fish price page contained two sections, namely (i) the data input or modification channel, and (ii) the present entry channel. In this section, four fields were observed, one of which required previous data (*i.e.*, fish name as drop-down input type). This field was then divided into three input types, namely (i) text, (ii) drop-down, and (iii) text (numerical input). This confirmed that the text and numerical inputs contained the auction/market site (location), as well as the selling and buying prices of the product per kilogram, respectively. The "fishing result" feature was used to systematically obtain the catch records, due to the data requirements of the administrator. Besides this, it was also utilized by the Fishermen to report the fishing results. In this condition, the feature was used to improve the accuracy of forecasting a catchment area. Based on these results, local governments need to rely on the obtained data as a reference for program development, due to the catch being digitally and automatically carried out. This explained the need for government to regulate and direct fishing activities, for overfishing not to solely occur in specific areas.

Afterward, the fishing result page was observed with two channels, namely (i) the data input or modification channel, and (ii) the present entry channel, where the administrator decides to edit or delete existing entries. In this section, four fields were found, with two requiring previous data, *i.e.*, username and fish name (drop-down input type). These fields contained three input types, namely (a) drop-down, (b) text (numerical input), and (c) text (numerical and alphabet inputs). This indicated that the numerical input and text (numerical and alphabet inputs) represented the amount of marine catch and additional fishing activity information, respectively.

The reporting feature was also on the client application side, due to being used to report the fishermen's marine catches and recorded in a server-side database. This was carried out by inputting the reports through the *e-Nelayan* Application and transmitting them to the server while on land. Despite this, the policy for reporting these parameters was still experimental. Therefore, some officers should be futuristically used to control the conformity between the facts and reports of the catches. For example, sanctions should be implemented by competent authorities for non-compliance with specified regulations, regarding the revoke of fishing permits for fishermen. When they are diligent in reporting and complying, rewards should consequently be awarded, such as the provision of subsidized fuel. However, the pattern of policy implementation is for the respective regional authorities and stakeholders to decisively perform.

Based on these results, the "illegal fishing report" feature supported the ship identity marking system, where a unique ID was provided to fishermen as a marker of a vessel's identity. This data was used for management purposes at different Indonesian ports. The clients were also part of the community's work and served as field monitors for the ownership of several marine areas. This proved that the fishermen helped the country's maritime security and sovereignty against illegal fishing. With this feature, they should be able to minimize errors in reporting the results of illegitimate activities and foreign vessel entries, due to their direct plunge into the ocean the illegal fishing report page containing two channels were observed, namely (i) the data input or modification channel, and (ii) the present entry channel. In this section, four fields were observed,

with only one requiring previous data utilization such as username. This field subsequently had three input types, namely username (drop-down), text, and file. In this condition, the text and file inputs contained the scene's latitude and longitude coordinates, as well as photograph evidence, respectively. Besides illegal fishing, any problem encountered or noticed during the trip should also be reported. This revealed that the developed system should be used to report problems such as ship accidents and illegal fishing at sea, through the SOS feature and transmission of unknown vessel photos. Illegal catcing in the sea, including fis and crustaean, is one of serious problem faced by Indonesian fishermen till today [18]. Using this system, it is expected to solve this issue.

Fishing is the main livelihood for almost all Indonesian coast people [19], at <5 gross tonnage (GT), with the fishermen observed to only carry out one-day activity [20]. This showed that the use of long-distance wireless communication technology greatly assisted small vessel clients to increase their productivity and safety. Within 10 to 15 km of distance, commercial cellular signals were found to be unreachable, with the use of smartphones as a communication medium almost impossible. This helped raise the awareness that fishing was a very dangerous activity [21]–[25]. Therefore, alarm notification devices capable of transmitting SOS signals through mobile applications were needed. With this webserver application, administrators were able to monitor the fishermen providing hazardous notifications with immediate response. The "SOS signal" page containing two channels were observed, *i.e.*, (i) data input or modification channel, and (ii) present entry channel, where administrators decide to edit or delete existing entries. In this section, four fields were detected, with three requiring previous data utilization, including username, latitude, and longitude. These fields were subsequently observed to have three types of input, namely drop-down (username of fishermen), text (Latitude and longitude), and numeric SOS code (drop-down). The SOS report feature allowed the administrators to add, modify, or delete incoming emergency messages, which is a signal from a fisherman to a land base. In this condition, the administrators have the authority to delete incoming SOS messages, regarding the sole utilization for system administration purposes. For example, the administrator is allowed to delete these messages when an incoming signal had filled a record in the database. The possibility of "fake SOS incoming messages" is also highly assumed, prompting immediate deletion after being detected. However, the presently developed system has not reached the stage of facilitating the handling of fake emergency signals. Due to the occurrence of different accidents at sea, this feature needs to be used by fishermen to notify land bases, subsequently necessitating the urgency to continuously develop the SOS report.

The "fish location" page containing a data input/modification and present entry channels were observed. In this section, three fields were found, *i.e.*, fishname (drop-down), latitude, and longitude (text). This stated that the feature originated from a trusted source, where all data were completely obtained. In this case, the administrator needs to add/modify/delete any form of information for maintenance and administration purposes only This was due to the dynamism of the information, which needs to be regularly updated. Moreover, the fish area spot information was generally obtained from observations and surveys of the KKP management, although its accuracy was unable to be guaranteed due to the periodic movement of fishes as living things. Access to this information was also difficult for fishermen to achieve, although some clients are observed to realistically have more accurate fish spot data with others not willing to share. This unwilling act to share was based on reducing competition and increasing their incomes. Based on these results, this feature provided fishermen with the opportunity to share information, irrespective of the circumstances.

The "ship tracking" page was also used to monitor and track fishing activities, with clients often transmitting their paths as GPS points to the administrator. This supported the SOS feature and enabled the position of fishermen to be unlimitedly tracked and monitored by the webserver. The fish price entry page containing the data input/modification and present entry channels were observed. In this section, six fields were detected, with four of them requiring previous data utilization, including username, latitude, longitude, and date. These fields were subsequently divided into four input types, namely drop-down (username filed), text (latitude and longitude fields), date (record date), and numerical text, which represented the Ship and Track ID based on the number of the shop and identification record, respectively. In this case, the administrator was authorized to only observe the incoming data from the fisherman's mobile application. The positions of their ships were not also needed, due to the activation of the tracking feature on the client's side (LoRa radio device), which periodically transmits the GPS coordinates to the server. In this condition, the coordinates were then recorded and processed, as well as presented in the form of a log or a map tracking path.

4.4. Discussion

There is a promising potential in the field of maritime, including fisheries, due to the perceived high production rate. The small-scale commercial fishing boat (<5GT category) has reportedly dominated the seacoast in Indonesia, and their movements are observed at approximately 10 km from the shoreline. Most of the fishermen are not equipped with a special-assisting communication device during fishing activities, such as smartphones. This is due to the observation of a weak cellular signal in the sea, irrespective of being <10

km from the shoreline. In this condition, the use of ICT is found of great importance to small boat fishermen, as it increases their productivity and safety. Therefore, this study aims to develop and evaluate (functional test) a webserver for Indonesian fishermen, to support fishing activities.

As a maritime country, the Indonesian Government strongly supported fishermen as the main actors in the fisheries sector. This indicated that traditional fishermen should transform and capitalize on the technological advances in fishing activities. Meanwhile, the application of ICT for these activities was a necessity. In this condition, various efforts were carried out, such as the 1 Million Fishermen Go Online, which was initiated in 2017. This was promoted to improve the welfare and income of fishermen, as well as provide more accurate information regarding safety. The government also provided some recommendations, which were disseminated to Indonesian fishermen, namely the Archipelago Sea application (Aluna) and trade in the fisheries sector (Aruna). The Aluna application was used in increasing knowledge and technology for an easier trip to the sea, with the fishermen abundantly acquiring much information related to water waves, wind direction, weather, forecast fishing area maps, port fish price, fuel calculations, and the marine centre contact. This helped fishermen estimate the location of fish gathering (fishing dome), due to being able to determine the position of plankton, a vital fish food. Meanwhile, when fishermen encounter difficulties in determining their direction, they still manually activate their mobile GPS to locate land again. The Aruna application is a marketplace system used by the fishing community to directly trade their catch with consumers. This had the ability to bridge fishermen with consumers, subsequently breaking the distribution chain expected to provide benefits for both parties. It also enabled the easy monitoring of the selling price more transparently. Therefore, these two applications ensured easier transaction, determination, and knowledge of marine catches, fish locations, and weather developments. Other services were also the integrated national fisherman card and the smart fisherman basic information application (Nelpin) [26], developed by the KKP's official website.

Irrespective of this contribution**,** Aruna and Aluna were the only applications installed on Android, which should be operated by fishermen while on the beach to acquire a commercial cellular signal. This was different from the *e-Nelayan* system providing the flexibility to use applications at sea, due to being integrated with special communication devices producing network connectivity up to 10 km from the shore. The contribution of Aluna and Aruna was highly extraordinary for Indonesians, with the presence of *e-Nelayan* being a complementary system due to having superior features. This system was subsequently included as one of the government's national programs, such as "1 million fishermen go online", Aruna and Aluna, as well as other applications, when implemented *en masse* or within the scope of certain coastal areas. The business innovation centre (BIC) also provided a special award to *e-Nelayan* as one of the most prospective innovations in 2019 (see the BIC website).

Furthermore, the application of this system to the community required a strategy, such as technological socialization, for its characteristical benefits to be adequately considered. This training was carried out for two targets, *i.e.*, the administrators and fishermen, which specifically need to have an ID card and be registered in apps by filling in the provided fields, such as ID digits, full name, address, place, date of birth, cellphone number, username, and password. These were subsequently accompanied by the following (i) the introduction of the various available menus, (ii) the pattern of using each menu from navigation and reporting to SOS, (iii) a case installation pattern, (iv) the pairing method of a Bluetooth smartphone with a LoRa device radio, (v) hands-on practice, and (vi) routine assistance. The system developer was also required to serve as a monitor, for the fisherman to adequately understand the client-side operation. In addition, maintenance should be facilitated by the development team to ensure easy accessibility for fishermen. Socialization should also be more intensive due to the effort being greater than the training of administrators. This is because the average ICT literacy for fishermen is still minimal. This system can support to educate the ICT literacy among fishermen as suggested by [27].

The web server and client section were adequately tested, with each menu observed to function appropriately [10]. The integration of the entire system was also carried out by involving the client and server sections (BMKG-KKP to the E-Fishermen server). Moreover, a field test was carried out to determine the effectiveness of each feature while at sea, especially on the client-side. To integrate the BMKG, KKP, and *e-Nelayan* API portal modules, several factors were considered, such as opening the API requests to the BMKG and KKP database servers, as well as designing the communication protocols between them. The implementation and testing of the BMKG and KKP API portal server module were also carried out through weather and wave height, as well as fish distribution and market prices, respectively. Therefore, *e-Nelayan* is expected to help as an ICT supplement for fishermen and support problem-solving in the fisheries sector. Despite these observations, the application is still a prototype being tested on the laboratory scale; as all functions were adequately operated on a PC with Windows 7 OS and a general web browser (Firefox or Chrome), accessed using Localhost.

5. CONCLUSION

Based on the *e-Nelayan* architecture, a web server application was designed and dedicated to a traditional small vessel fishing community in Indonesia, to increase productivity and support the fishermen's safety at work (fishing activity). This server handled various features, namely weather updates, fish location (potential fish zone), prices, lists, fishing results, illegal reports, SOS signals, and ship tracking. It also passed functional testing (the black box method) and is in line with numerous expectations, *i.e.*, all features had the ability to be operated on Windows OS and firefox. The system was also tested through a local internet connection (Institut Teknologi Bandung campus server) with stable/unstable connectivity. However, it was not integrated into the LoRa-based fisherman client application, with access only observed at the Institut Teknologi Bandung campus, leading to the hindrance of public publication. Based on the results, the system should be futuristically tested with various parameters, such as access time, number of users, and vulnerability. To speed up the deployment process, this system should also be integrated with the KKP and BMKG databases. In this web application, the administrator is not able to contact fishermen at the sea due to the application does not equip a chat feature. The administrator can make a conversation using mobile application connected to the End-node and Gateway. Further study, it is worth to add chat box to the administrator side.

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