Smart Port Priority Queueing Services Base on Long Range (LoRa) Communication Network: Case Study Anchored Ship Management

Ari Wijayanti, Okkie Puspitorini Nur Adi Siswandari and Haniah Mahmudah
Department of Electrical Engineering, Politeknik Elektronika Negeri Surabaya,
Jl. Raya ITS Keputih Sukolilo, Surabaya, Indonesia

Keywords: LoRa, Smart Port, Fuzzy Djikstra, Simple Additive Weighting.

Abstract: To improve port services, it is proposed to use LoRa communication network in the process of numbering ship queues to ports based on priority. This system will use two main devices, namely lora nodes that will be installed on ships and gateways that will be placed in ports. The lora node will send ship data to the gateway so that the distance and RSSI value of each ship will be known. This data will be processed using the Dijkstra fuzzy algorithm to get the queue number of the ship while the SWA algorithm is to determine the priority of ships entering the port. Based on the test results, it was found that the coverage of the LoRa communication area in an unobstructed area can reach 7.91 km. with an average RSSI value above -120 dBm. In selecting nodes, Djikstra's Fuzzy Algorithm is 100% successful in determining the nodes that come together. Likewise, the results of experiments with the Simple Additive Weighting algorithm on 16 ships at 7 docks with certain specifications resulted in a percentage of 100%.

1 INTRODUCTION

Regulating and monitoring in the large port environment is important, especially in the smooth loading and unloading activities of cargo and passenger ships. The port is an important entry point for economic and transportation activities for Indonesia, which is an archipelagic country. Smart ports are a prerequisite for efficiency and improved performance in the port environment. Based on this, the Indonesian government made major changes to the port communication system by building an internet network and digitizing the port management using Internet of thing (IoT) system toward smart port category. (Yongsheng Yang *et all*, *2018*)

To improve ship services at ports so that they can run fast, reliable, transparent, and standardized with minimal costs, the Directorate General of Sea Transportation of the Ministry of Transportation has implemented the Inaportnet application at ports which has also become the Quick Win of the Minister of Transportation. The implementation of Inaportnet is planned to be implemented in 16 ports in Indonesia, where in the early stages it has been implemented in 4 (four) Main Ports namely Makassar, Belawan, Tanjung Priok Port, including Tanjung Perak Port. Implementation of Inaportnet for ship and goods services at the Port which aims to improve services and smooth the flow of goods at ports, cut service time to be faster and more efficient, reduce logistics costs and as a step for service transparency at ports.

In previous studies conducted, the vessel detection process carried out with an ultrasonic sensor, where this sensor has limited range to detect vessel (Swapna Ch, *2017*) (A Kamalov, *2019)* The weakness are the process of detecting objects tends longer and there is no port clustering process first, cause system performance to be less than optimal in determining the port for ships (Unnati, 2017). However, in port applications, IoT systems must be conceived by exploiting heterogeneous sensors equipped with intelligence and interconnected with each other through Low Power Wide Area (LPWA), able to widely distribute information (A. Rajabi et all, *2018*), (S. Verma, *2022*). The Long-Range Communication Network Technology are chosen to support in several purposed in marine (Pensieri S, *2021*)

In this paper, the research has result smart port communication network which is developed by Long Range Technology (LoRa) to detect the arrival of ships at the port entrance which will be describe in

Wijayanti, A., Puspitorini, O., Adi Siswandari, N. and Mahmudah, H.
Smart Port Priority Queueing Services Base on Long Range (LoRa) Communication Network: Case Study Anchored Ship Management.
DOI: 10.5220/0011861600003575
In *Proceedings of the 5th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2022)*, pages 656-662
ISBN: 978-989-758-619-4; ISSN: 2975-8246

section 2. LoRa system are built with a processor in the form of an ARM Cortex-M4 microcontroller, which has high performance (168Mz clock) but low power consumption 238uA/MHz, ~40 mA) (ST microelectronic, *2017*). The information signals are sent via radio waves using VHF channel in the frequency range between 923 MHz – 925 MHz. The chosen of VHF channel Long Range onshore network because more resistant to interference when the data are transmitting among ships at sea (N. Jovalekic, *2018*). In section 3, the process of regulating ships entering the port will be reviewed based on their priorities. Selection process between ships using the Simple Additive Weighting (SAW) algorithm. The last section, fourth, will be discussed about result of research and future research activity.

2 LONG RANGE (LORA) COMMUNICATION NETWORK FOR SMART PORT SCENARIO

This study took place at the Tanjung Perak port of Surabaya, Indonesia. Subjects studied include ship detection and ship selection to be guided to the dock in accordance with its specifications. LoRa sensors are needed to detect ships. The LoRa node is located on the ship that will drop anchor to the port, while the LoRa gateway will be installed at the port entrance, namely Karang Jamuang Island where the island is where the pilot ship standby. As shown in Figure 1, LoRa nodes will be installed on ships that will enter the port where these nodes have ship ID and GPS which will be processed by the system and given a registration number. The ship with the LoRa node will send its data and be received by the LoRa gateway. The selection of the numbering sequence for the queue of ships entering the port from several ships that come using the fuzzy Dijkstra algorithm. The fuzzy Dijkstra algorithm is used to find the closest distance and consider the parameters when detecting ships and determining the order of ship numbering.

There are 2 (two) parameters, namely distance and RSSI (Received Signal Strength Indicator) value. The output of fuzzy logic will enter the Dijkstra algorithm to consider the distance. The ship selected from the Fuzzy Dijkstra algorithm will be notified with a registration number.

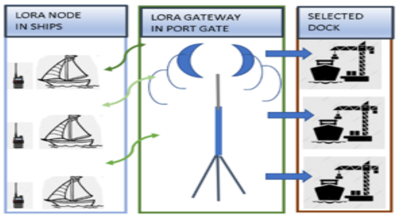

Figure 1: Long range communication network for smart port scenario.

2.1 Ships Communication Equipment

In the communication system using Lora, there are two types of hardware based on their placement
1. Long Range (LoRa) nodes on each ship
2. The Long Range (LoRa) Gateway is placed at the port entrance on Karang Jamuang Island

2.1.1 Long Range (LoRa) Node on Ship

The Long Range (LoRa) node here uses the EK-S76GXB. The node with serial number EK-S76SXB supports Lora WAN Class A, B and C so it can be used as needed This node already contains LoRa and its microcontroller and is also equipped with GPS (figure 2). LoRa nodes will be given an ID as the identity of the ship. Long Range (LoRa) nodes are equipped with antennas and GPS, transmitting data over frequencies between 923 MHz – 925 MHz This LoRa node is programmed using the Termite software. LoRa nodes will configure the delivery interval for 30 seconds.

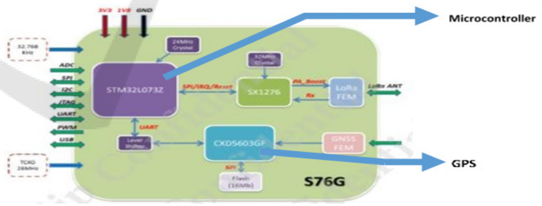

Figure 2: EK-S76GXB block diagram for node long range.

2.1.2 Long Range (LoRa) Gateway

Gateway uses femto which is stationed on Karang Jamuang Island. This tool will be used to receive data from LoRa nodes. The gateway configuration can use a LAN or Wi-Fi cable that is transmitted, then the browser is accessed by IP from the gateway. Gateway configuration view can be seen in Figure 3.

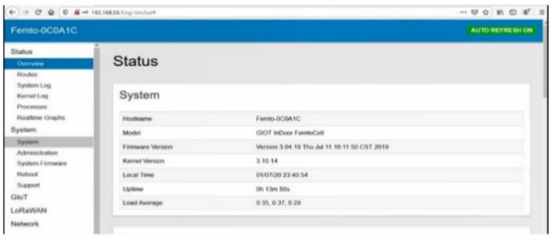

Figure 3: Gateway configuration.

2.2 Long Range Gateway Installation Design at the Port Entrance

Karang Jamuang Island is an island north of Bangkalan in the Java Sea has chosen as entrance gate to Tanjung Perak Port. Currently the island functions as a pilot station located on the outer verge at position 06º - 53'-34" south latitude dan 112º -43'-46" east longitude from Tanjung Perak Port (figure 4). This island is used as a specific area for shipping navigation which is very vital in regulating the flow of ships that will enter the port of Tanjung Perak. The shipping lane is one of the main facilities of the regional designation waters of a port and has a key role as access to and/or entry to the port. In addition, on the island of Karang Jamuang, there are ship piloting service providers to support operational activities and ship navigation to the port. based on this, the placement of the Long Range (LoRa) gateway on Karang Jamuang Island will assist the process of ship traffic that will dock at the port of Tanjung Perak.

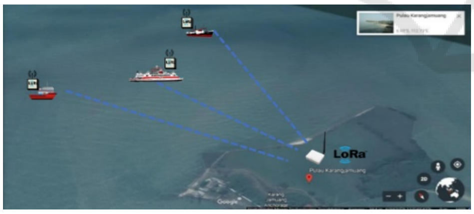

Figure 4: Hardware installation design on gateway.

In the selection process before entering the port of Tanjung Perak, the ship that already has a LoRa node will do the following activity on gateway (figure 5)

1. LoRa node registration
2. Receipt of ship data by gateway

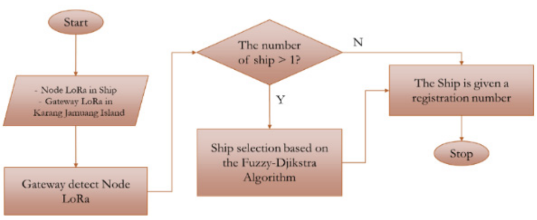

Figure 5: Ships selection on gateway.

2.2.1 Lora Node Registration

LoRa nodes that will send data through the gateway must be registered first. In the Lora WAN protocol, there are two activations, namely OTAA and ABP. The node used this time is registered on OTAA as seen in figure 6.

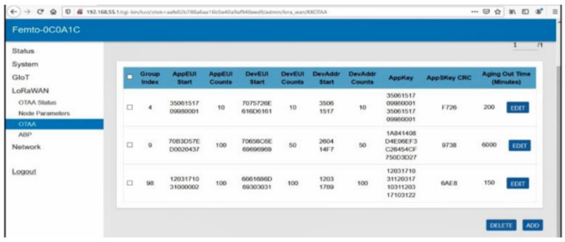

Figure 6: LoRa node registration in OTAA.

2.2.2 Receipt of Ship Data by Gateway

Receipt of data at the gateway using the MQTT protocol. The MQTT protocol configuration on the gateway can be configured with a hostname/broker according to the IP of the computer that will be the server. subscribe topics are used to receive data as seen in figure 7.

Figure 7: Network server setting.

Program to receive data using Python software. The data that will be taken by the gateway for processing are:

• Ship ID
• Distance
• RSSI value

These data will be used as parameters to determine which vessel will be assigned a registration number first if several vessels are detected by the gateway.

Fuzzy logic is used to model the multi parameters of the events that occur. Distances and RSSI values are processed by fuzzy logic as seen in figure 8.

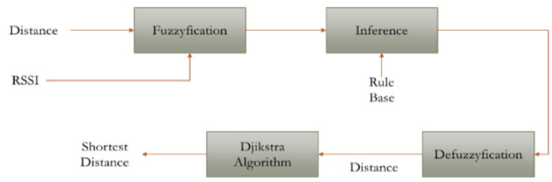

Figure 8: Block diagram of fuzzy djikstra algorithm.

The results of the algorithm will determine which ship will be given a queue number first. The output of fuzzy logic in the form of distance will enter the djikstra algorithm, where the output value of the smallest or closest distance to the gateway will be given a queue number first. In Figure 9 the following is a test of three nodes that have different distances and RSSI values.

No	ID	Time	Port	Counter	Distance	RSSI	Channel	Hasil	Pendaftaran
1	purnamaa	2019-12-05T08:58:15+07:00	223	12	4.81911	-45	923400000	4.92895	3
2	fahmi001	2019-12-23T07:05:17+07:00	222	6	4.63609	-14	923400000	3.22707	1
3	pelniiii	2019-12-23T07:10:23+07:00	220	18	4.79489	-35	924400000	4.13463	2

Figure 9: Result of fuzzy djikstra algorithm.

3 QUEUING PRIORITY ANCHORED SHIP MANAGEMENT

Tanjung Perak Port itself serves ships with various cargoes from passengers, containers, cargo, and others both domestically and internationally, for this reason this port provides thirteen docks that can be used with different specifications according to the cargo carried (figure 10).

Figure 10: Tanjung Perak Harbour plan.

Based on the data of the Tanjung Perak port management, the dock types are divided into some utility such as for passenger, dry bulk, liquid bulk, and general cargo named. The Specification of dock services Port as shown in Table 1

In determining the queue number, there are two different schemes in real conditions. The first scheme uses the FIFO (First in First out) queue concept, this scheme will be used if at the same time LoRa detects several ships that do not have the same dock requirements as each other. Then the queue number will be directly obtained according to arrival. Then the second scheme is using the Simple Additive Weighting algorithm, this scheme works if at the same time LoRa detects several ships and in some of these ships require the same dock to dock, then this SAW algorithm will determine the priority of which ship will dock first according to the parameters which is determined

Table 1: Specification of dock services at Tanjung Perak port.

Dock	Commodity Services
Jamrud Utara	Passenger
	Dry Bulk
	General Cargo
Jamrud Barat	General Cargo
	Dry Bulk
Jamrud Selatan	General Cargo
Kalimas	General Cargo
Mirah	Liquid Bulk
	General Cargo
	Container
Berlian Timur	Container
Nilam Timur	Liquid Bulk
	Dry Bulk
	General Cargo
	Container

3.1 Simple Additive Weighting (SAW) Algorithm for Priority Decision

In determining the queue number using the *Simple Additive Weighting algorithm*, it is used if after the system has classified the ship there are several ships that have the same dock requirements so that this algorithm will provide a priority scale according to the parameters of the user, thus allowing the last ship to come to be served first if indeed have a high priority than the previous ships that had arrived first. Figure 11 show the

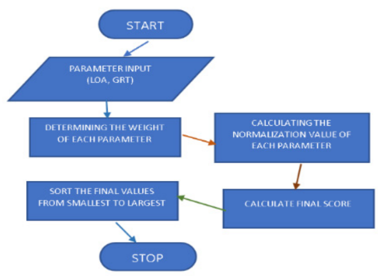

Figure 11: Simple additive weighting algorithm.

The system will determine the weight of each parameter as shown in table 2.

Table 2: Simple additive weighting parameter value.

Parameter	Weighted
LOA	0.4
Gross tone	0.6

To calculate the normalization value of each parameter, the formula as in equation (1) is used.

$$NV = \frac{Parameter\ value\ (GRT/LOA)}{Parameter\ value\ max(GRT/LOA)} \quad \ldots\ldots\ldots(1)$$

With

NM = Normalization Value
GRT = Gross Ton
LOA = Length of All of Ship means the size of the ship and the commodity types of ship's cargo.

The formula in equation (1) will give results if the weight of the ship is lower and the size of the ship is getting shorter it will take precedence or have a high priority. After that the system will calculate the final value with the formula as in equation (2)

Final Value = Normalized Value x Parameter weight value …………… (2)

The system will sort the final values from largest to smallest. This final value will be the reference for the system in determining the queue number according to the final value. The smaller the final value, the initial queue number or high priority, while those with a large final value will get a small priority.

4 RESULT

The results of this study will be described based on experiments on Long Range communication system devices (LoRa) placed on ships and gateways as well as the application of a simple additive weighted algorithm (SAW) on the selection of ships that are guided into the port.

4.1 Long Range (LoRa) Communication Network Testing Result

The scenario of evaluating the communication area coverage is conducted in the ocean. The node is in the Bangkalan area, Madura with a height of four meters above sea level and the gateway is in the Bulak beach area, Kenjeran, Surabaya with a height of 8 meters above sea level (see figure 12).

Figure 12: Sea area coverage test.

The farthest distance that can be achieved when the atmosphere is in a relaxed sea, unobstructed by anything can reach 7.91 km. With the data above, the RSSI (Received Signal Strength Indicator) value has not reached its peak (140 dBm) so that it can still get a longer distance (see figure 13).

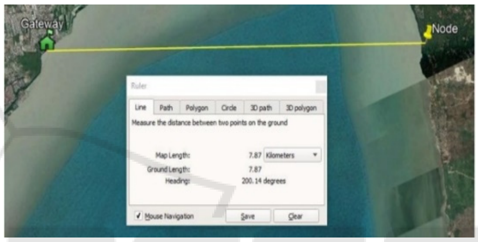

Figure 13: Result of sea area coverage test.

In this test, the data selected is the data that has the furthest distance from each route. When the ship approaches the port and is detected by the gateway, the first data will be selected for processing. The data that is processed as input from the Dijkstra fuzzy algorithm is the distance and RSSI value as shows in table 3.

Table 3: Selected data of ship.

No	ID	Distance (km)	RSSI (dB
1	bayulkmn	0.690294	-122.3
2	abdulhfd	1.05784	-121
3	fahminhn	0.583561	-117

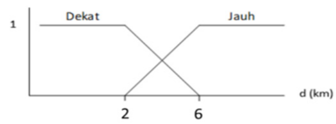

Figure 14: Distance membership function.

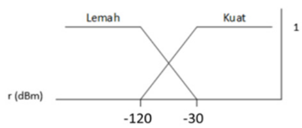

Figure 15: RSSI membership function.

Based on research that has been done by creating a ship queuing system at the port with a LoRa sensor, the farthest transmission distance is approximately 7,9 km. The application of the Dijkstra algorithm is used to determine the ship that has the closest distance while fuzzy logic is used to choose based on the distance parameters and RSSI values so that the results of the coverage area are between 1 km-8 km with RSSI range between 117 dBm – 122 dBm (figure 14 and 15).

4.2 Simple Additive Weighted Algorithm (SAW) on the Selection of Ships Result

Tests were conducted in 2 different scenarios so that the results could be observed

Scenario 1

Scenario 1 is carried out with the following assumptions:

a. All ships have no sick information

b. Free commodities (in this test using passenger commodities)

c. The value of LOA and GRT differs between ships

In this scenario, 16 ships were tested to get the results as shown in figure 16.

Commodity	LOA	GRT	SAW value in database	Queue no
Passenger	500	15000	1	16
Passenger	500	14500	0.98	15
Passenger	500	14000	0.96	14
Passenger	450	13500	0.9	13
Passenger	450	13000	0.88	12
Passenger	450	12500	0.86	11
Passenger	400	12000	0.8	10
Passenger	400	11500	0.78	9
Passenger	400	11000	0.76	8
Passenger	350	10500	0.7	7
Passenger	350	10000	0.68	6
Passenger	350	9500	0.66	5
Passenger	300	9000	0.6	4
Passenger	300	8500	0.58	3
Passenger	300	8000	0.56	2
Passenger	300	7500	0.54	1

Figure 16: Queue number test results with scenario 1.

The simple additive weighting algorithm can determine the queue number of ships using the parameters of illness, ship length and ship weight. From table 4 the smallest SAW value has a high priority or initial queue number, while a large saw value has a small priority, so it has a low priority number. Large queues. If there are ships with the same final value, priority will be given to ships with registration numbers that are first detected by the LoRa gateway

Scenario 2

In this scenario, it is conducted with the following assumptions:

a. There is a ship with a *sick statement*

b. Free commodity (in this test using dry bulk commodity type)

c. LOA and GRT values are different for each ship

In this scenario, 16 ships were tested so that they got the results as shown in figure 17.

There are four ships with sick statements, so they need to be managed faster by getting an initial queue number with a saw value of minus. This is because the system will first calculate the saw value based on LOA and GRT then if the ship has a sick statement, then the saw value of the ship will be minus 1 to get the lowest result. If there are several ships that have a description of illness as in figure 17 above, the determination of the queue number will be returned to the LOA and GRT parameters of each ship that has the disease information.

Commodity	LOA	GRT	SAW value in database	Queue no
Dry Bulk	500	25000	1	16
Dry Bulk	500	24500	0.988	15
Dry Bulk	500	24000	0.976	14
Dry Bulk	450	23500	-0.076	4
Dry Bulk	450	23000	0.912	13
Dry Bulk	450	22500	0.9	12
Dry Bulk	400	22000	0.848	11
Dry Bulk	400	21500	-0.164	3
Dry Bulk	400	20000	0.8	10
Dry Bulk	350	19500	0.748	9
Dry Bulk	350	19000	0.736	8
Dry Bulk	350	15000	0.64	7
Dry Bulk	300	14000	-0.424	2
Dry Bulk	300	10000	0.48	6
Dry Bulk	300	5000	0.36	5
Dry Bulk	300	2500	-0.7	1

Figure 17: Queue number test results with scenario 2.

If there are ships with the same final value, priority will be given to ships with registration number detected by LoRa Gateway first.

Based on experiment using different scenarios for ship types, loaded commodities, different specifications, it can be proven that the SAW algorithm is able to give 100% correct priority to certain ship conditions**.**

5 CONCLUSIONS

Based on onshore Testing, Long Range (LoRa) Communication network has The RSSI value is above -120 dBm at 7.9 km when in a LOS (line of sight) condition or not blocked by anything at sea. Implementation of Fuzzy Dijkstra Algorithm in selection ships queuing number has been success 100 %. The simple additive weighting algorithm can give priority to queue numbers on 16 ships with an accuracy of 100% based on the parameters used.

ACKNOWLEDGEMENTS

The authors would like to acknowledge centre of Research (P3M) Politeknik Elektronika Negeri Surabaya for funding this research and those who give support in carrying this research.

REFERENCES

S. Pensieri., F. Viti., G. Moser., S.B. Serpico., l. Maggiolo., M. Pastorino, d., A. Cambiaso., C. Carraro., C. Degano., I. Mainenti., S. Seghezza and R. Bozzano (2021), e*valuating lorawan connectivity in a marine scenario,journal of marine science and engineering,*, vol. 9, 1218.,https://doi.org/ 10.3390.

S. Verma, Y. Kawamoto and N. Kato (2022)*, "A Smart Internet-Wide Port Scan Approach for Improving IoT Security Under Dynamic WLAN Environments,"* IEEE Internet of Things Journal, vol. 9, no. 14, pp. 11951-11961, 15 July 15, 2022, doi: 10.1109/JIOT.2021.3132389.

N.Jovalekic , Vujo Drndarevic , Ermanno Pietrosemoli , Iain Darby and Marco Zennaro*,(2018), " Experimental Study of LoRa Transmission over Seawater," Sensor journal, 18, 2853; https://www.mdpi.com doi:10.3390/s18092853.*

Yongsheng yang, meisu zhong, haiqing yao, fang yu, xiuwen fu, and octavian postolache (2018), INTERNET OF THINGS FOR SMART PORTS: TECHNOLOGIES AND CHALLENGES**,** IEEE Instrumentation and Measurement Magazine 21(1):34-43, doi:10.1109/mim.2018.8278808.

https://hubla.dephub.go.id/home/post/read/11303/maksimalkan-teknologi-informasi-seluruh-tersus-dan-tuks-di-pelabuhan-panjang-resmi-terapkan-inaportnet

*Era Port Automation Berganti ke Smart Port Tingkatkan Tos Untuk Percepat Bongkar Muat***,***2 Desember 2021, 10:05:01 Wib***.** https://www.jawapos.com/surabaya/02/12/2021/era-port-automation-berganti-ke-smart-port/

A. Rajabi, A. Khodadad Saryazdi, A. Belfkih and C. Duvallet (2018), "Towards Smart Port: An Application of AIS Data," 2018 IEEE 20th International Conference on High Performance Computing and Communications; IEEE 16th International Conference on Smart City, IEEE 4th International Conference on Data Science and Systems (HPCC/SmartCity/DSS), pp. 1414-1421, doi: 10.1109/HPCC/SmartCity/DSS.2018.00234.

Swapna Ch, MuKesh KumarNaswal Kishor Y and Niraj (2017)," tracking and emergency detection of inland vessel using GPS-GSM System", international Conference on Recent Trends in Electronics, Information, and communication technology (RTEICT).

A.Kamalov and suhyun Park (2019)" An IoT based Ship Berthing Method using a Set of Ultrasonic Sensors" MDPI jurnal sensors, 19,5181; Doi: 10.3390/s19235181.

Unnati R. Raval and Chaita Jani (2016). Implementing & Improvisation of K – Means Clustering Algorithm. *International Journal Computer Science and Mobile Computing,* vol. 5, issue. 5, pg. 191-203.

M.Donni L.S, Elviwab, Asprina Br, Surbakti, Andre Hasudungan Lubis, Andysah Putera Utama S (2017), Implementation of simple Weight Algoritm in Particular Instance, IJSRT, Vo.3, issue 6.

Maksimalkan Teknologi Informasi, Seluruh Tersus Dan Tuks Di Pelabuhan Panjang Resmi Terapkan Inaportnet **(***Jumat, 18 Maret 2022) akses tgl 10 agustus,* https://hubla.dephub.go.id/home/post/read/11303/maksimalkan-teknologi-informasi-seluruh-tersus-dan-tuks-di-pelabuhan-panjang-resmi-terapkan-inaportnet