IOT Framework to Support Maritime Highway Program:
A Case Study in Indonesia

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ABSTRACT

As one of the largest archipelagic countries in the world, Indonesia has been running the maritime highway system in recent years. This study focuses on how to improve the role of IOT platform in the maritime highway system. Furthermore, in this study, the authors are designing a new IOT system framework to support the operation of the maritime highway program in the seaport logistics system in archipelago countries, especially Indonesia. Each part of the port management stakeholders like port authority, commodity products company, shipping companies, and the government with their different policies (unique) in each island region has created its own IT system and links it to every website in its organization partially and not yet fully integrated. This research provides newly integrated frameworks with the IOT approach, and also a few recommendations related to practical and theoretical contributions that can be further developed in the seaports sector.

KEYWORDS

IOT, Logistics System, Maritime Highway Program

INTRODUCTION

Seaports are one of the most important parts of the transportation network. They need to be able to support the transportation of people and goods from one place (hinterland) to another (foreland). The maritime transportation system between regions is highly dependent on the condition of the seaports. Developing ports that provide the best service is one of the most important factors to benefit the economy around the port area, as well as the country itself; this is especially important in archipelago countries (Pelindo, 2012).

Based on World Population Review data (2019), Indonesia is the country with the largest archipelago in the world, and requires the use of maritime transportation networks to meet the needs of its people across the country. Based on the data from the Indonesian Ministry of Transportation for 2005–2013, the number of national maritime transport companies increased by about 7.7% per year, and the provision of the national fleet increased by about 10% per year. In 2013, the share of ocean freight cargo by national shipping companies had reached 99.7%. It is clear from these data that the role of the maritime transportation system in Indonesia is of great importance.

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However, there are problems with the seaport operation systems of the transportation network in Indonesia. Based on the annual reports of Pelindo (Indonesian Port Authority Company), the problem in Indonesia in 2012 was logistics costs (and port costs), which were some of the highest in the world (24% of total GDP or IDR 1.820 trillion per year, compared with Malaysia (15%), and Japan and the USA (10%)). According to the Pelindo annual report, and our own observations and interviews with representatives of one of the port authorities in Indonesia, the average dwelling time in Indonesian ports is 5–6 days, compared with only one day in Singapore, and that included pre-clearance, custom clearance, and post clearance time. The differences in port operation costs between the regions of Indonesia are also high. By 2023, the logistics market will have become one of the largest industries in the world, but currently ports in Indonesia still have low competitiveness compared with other countries (World Bank, 2018). The reason is that logistics costs are still expensive and dwelling time is still high.

The urgency of providing an efficient national connectivity cost reduction within the national logistics framework has been put on the national agenda. In 2014, the President of Indonesia, Joko Widodo, started to develop a maritime highway (in Indonesian called *Tol laut*) that would be used as the connection backbone and make Indonesia the world's maritime axis. Its development requires major changes in the pattern of organization for maritime transportation that will take many years to complete. The changes include provision of port infrastructure, network management, and business systems.

The first maritime highway system was introduced by the United States government about eight years ago, based on America's Marine Highway Report to Congress (2011), submitted by U.S. Department of Transportation, Maritime Administration The implementation of a maritime highway system in an archipelago country has not been addressed clearly in previous studies. Protopapas et al. (2013) only addressed the issue of marine highway transportation in relation to toxic inhalation of hazardous materials in the North American region.

Relating to supporting infrastructure especially information technology (IT) systems at seaports, Seetha Raman et al. (2018) in their research results have shown that in logistics management and supply chain communication patterns in particular, Internet of Things (IoT) is one of the important factors affecting the supply chain industry regarding operational value added, cost optimization, customer satisfaction, visibility, and reducing the communication gap between demand management and supply chain management (SCM). Adopting big data technology can create added value and great monetary benefits for the company and will soon become a standard in all industries.

In this research, we try to focus on designing the IT system framework to support the operations of Indonesia's maritime highway program and especially the logistics system. In fact, some port systems in Indonesia, although still partial, have implemented approaches such as ERP systems. Each part of the port management creates its own information system and links it to every website in its organization. Utilization of the existing ERP system will become the main key in designing new framework with IOT concept. Based on Rajendran et al. (2015) studied that most industries implemented ERP to increase sales and profits and reduce legacy system problems in their organizations. However, at the implementation stage itself they face many challenges, sometimes they even face failure in implementation.

Some researchers investigate the relationship between ERP and transportation or logistics systems (Rondinelli et al., 2000; Ince, 2013; Kandananond, 2014). As transportation and logistics systems continue to be integrated, their impact on the physical environment will become more complex. Economic globalization, agile manufacturing, fast delivery to markets, and supply chain management create greater demand for intermodal transportation services and multimodal transportation infrastructure (Rondinelli et al., 2000). Earlier, enterprise resource planning (ERP) and logistics or supply chain management represent important information technology investment options for operation or IT managers and have been acclaimed in the practitioner and academic literature for their potential to improve business performance.

Logistics and ERP system applications had acknowledged that the logistics practices and ERP system have positive effects on firm performance and competitive advantages (Ince, 2013). On the other hand, Kandananond (2014), in his study said that a good application of ERP relies on five important elements: defining the business case, preparing the system and users, stabilizing it to get normal operation and maintenance, and improving. In addition, organizational internal learning is another key factor for successful implementation. However, some of the previous studies have not yet discussed the IOT (Internet of Things) effect on the implementation of ERP system framework to support maritime transport systems, especially maritime highway programs such as those in Indonesia. Therefore, in this research, we try to design the framework of IOT implementation to support maritime highway system to improve the effectiveness and efficiency of maritime transportation system and logistics particularly in Indonesia.

In this research, the process of determining the variables as the basis of user needs in the application is done by interviewing several port authority officials and related parties, as well as doing field observation in several major ports in Indonesia, among others are Lamong Bay Terminal and Tanjung Perak. As a comparison data, so that this model will be modular, we observed port of Klang Malaysia, which have tried to implement this IOT system.

In the next section we review related studies and summarizes their findings. In section 3, we propose the research process, explain the results, and provide discussions. in section 4, we propose the objective and main function of design in IOT maritime transportation system. In section 5, we propose outlines of the implication and recommendation. Finally, in section 6, we propose conclusion, limitations and areas of future research.

LITERATURE REVIEW

Zhou, Liu, and Wang (2012) analyzed the IOT concept along with its architectural system to meet the demands of intelligent transportation function in intelligent urban transportation management. In addition, they also discussed key technologies involved in urban intelligent transportation management and designed detailed structural models of intelligent transportation systems based on IOT. Ultimately, the foresaw the potential of China's intelligent transportation system based on IOT. As Yaw Obeng and Boachie (2018) explained in their research on the analysis of the impact of IT innovation in the banking system, they explained that the impact of high innovation was more likely to contribute the highest to employee productivity during the new process or was significantly more likely to contribute highest (34.9 times more than other predictors) towards innovation satisfaction.

In this research, we focus on maritime transportation system, especially in Indonesia, a country that has started to release maritime highway program. The maritime highway program and logistics system particularly, as an emerging program, has gained more attention recently among researchers.

The design of the seaport system is in accordance with the IOT approach, which optimally integrates its supply chain system and becomes very important in today's global business and local economy. Several studies have tried to reveal how ERP framework helps design effective and efficient systems. Therefore, in this study, we try to propose the integration of a new model from the previous ERP approach. Then, IOT concept approach model is used to design an effective and efficient maritime highway program framework.

In our study, we collected data and opinions of experts in the process of designing IOT frameworks by distributing thirty open questionnaires to each stakeholder representative. To maintain the validity and credibility of each response, the chosen respondents are experts who have worked at least five years in each institution in the field of transportation and logistics. Distribution of questionnaires and data collection involves several stakeholders as shown in Table 1.

Table 1. Respondent data for questionnaire distribution

No.	Stakeholders	Company / Organization	Respondent
1	Shipping/ Logistics Company	3 shipping companies	Each company has 2 experts
2	Commodity products Company	2 Commodity products companies	Each company has 2 experts
3	Government	Representative of Ministry and Local Government	10 expert officers
4	Port Authority	Pelindo and Terminal Teluk Lamong	10 expert officers

Marine Port System

In national logistic system, the pattern of distribution networks between maritime territories, maritime industries, and ports has undergone many developments in order to play its role in supporting the economic growth of a region. The fact is seaports in Indonesia are still largely conventional, especially in eastern Indonesia (Kemenhub, 2013). The ineffectiveness of the role of seaports in some areas of Indonesia can also influence the distribution pattern and commodity prices in Indonesia. Therefore, Indonesian maritime highway program to improve the nation's economic growth, especially through optimization of the seaport system, is crucial. In this study, we also give another perspective for the existing literature by introducing seaport logistic system development to support Indonesian Maritime highway program in industry 4.0 era. It is clear that the regionalization phase and associated hinterland concepts requires advanced approaches to port control and a functional focus that exceed conventional port perimeter because each province in Indonesia does have its own characteristics, especially related to its seaport system. Several previous studies have discussed designs related to the development of port logistic systems, at both strategic and operational levels.

Liang (2012), in his research, determined a viable solution for the implementation of knowledge management in port, in which the top five solutions include data storage and data mining systems arrangement, decision support systems arrangement, information and communication infrastructure development, database development for document management, and utilization of groupware and other software. In developing and enhancing the growth of seaports, we should be able to facilitate the influence of cultural, institutional, and governance factors of the home country, the influence of economic and competitive environment in the home market, and stakeholder management (Dooms, 2013). Kavaliauskiene (2014), using service quality approach, indicated that logistic service users are conservative enough so that they cautiously consider innovations. Nevertheless, they properly meet IT integration and are aware of their shortage of technological adjustments in logistics processes at different stages of customer service. Moreover, Lee (2014), using Structural Equation Models (SEM), determined some variables improving port performance such as Servqual dimension, brand awareness, brand loyalty, and overall value of brand equity.

Fruth and Teuteberg (2017) in their study shows that it is important to capture the potential for the development of current digitalization in maritime logistics in order to benefit from profits. However, research is still in its infancy, and there is a lack of theoretical and empirical work. Taking into account the methodology and research findings of each of the previous studies, we conclude that there are still gaps that need to be corrected in the development of the seaport system. Through the case in our research in archipelagic countries, some adjustments need to be made to the variables, especially regarding stakeholders in each area of the port authority. Including, the regulations and policies of each local government in each island will certainly affect the port's development system.

Related to the Indonesian maritime highway program, Indonesia government especially President Joko Widodo, has been running the maritime highway program in recent years. This program is the effort of President Joko Widodo to provide a maritime transport network together with subsidies and improvement of port facilities. It is expected to reduce logistics costs and make price cheaper. In addition, since the ships are now well scheduled, it is expected that development also becomes more quickly implemented.

As we mentioned in the previous section, the first maritime highway system was introduced by the United States government about eight years ago, based on America's Marine Highway Report to Congress (2011), submitted by U.S. Department of Transportation, Maritime Administration. In America's Marine Highway program there are some benefits that have not been fully recognized in current transportation planning and investment decisions. These include assistance for new and existing ships; useful maritime work for the nation in times of peace and national emergency; reduction of and immediate relief from surface transport congestion (especially on routes that provide ground access to urban ports); enhanced, abundant and cost-effective new cargo capacity; reduction of costs in maintenance and repair of roads and bridges; and the creation of a diverse and more resilient transportation system.

Based on the literature review, we will discuss the study objectives in a comprehensive manner. Moreover, by using an ERP system approach, we expected an output in IOT framework that can encapsulate all of the information from stakeholders.

Internet of Things on Marine Port System

The Internet has grown rapidly to meet all aspects of life. Jang Hyun Kim et al. (2017) in their study tracks the trends of academic research especially on the Internet of Things (IOT) by examining the Web of Science database using semantic network analysis. Many clusters are identified from semantic networks 2015-2017 including smart and smart home networks, sensor networks, physical networks, monitoring and environmental security, and cloud computing and large data.

The application of IOT in seaport service system has actually been widely discussed and applied in some previous researches. Several studies discussed it in the technical scope, the operational system, and the supporting tools of the IOT implementation on the port. Xisong Dong (2013) in his report has also explained the development of informatization of major international ports. The technical requirements of the next generation Intelligent Port implementations have been collected and analyzed. Key related technologies from the Internet of Things, Intelligent Ports Solutions, and their main functions are designed in detail. The research is closed with predictions of the future development trend of Intelligent Ports.

Stietencron (2017) in his report presents a solution approach and implementation of the prototype of the use of the Internet of Things (IOT) to help marine sailors producers in the process of managing the use phase of their products and services. The seafarers' producers face challenges that they need to adjust their schedules for maintenance, repair, operations, and other environmental engineering services to a specified schedule, which are often not communicated well among ships carrying their products.

From these studies, we have also extracted information from the perspective of port authorities to find out the extent of the current IOT implementation. From some port authorities in Indonesia in particular, we conducted an interview with the best port authority namely Lamong Bay. In its operational system, it has the best loading and unloading process technology in its class, but the implementation of information systems such as ERP is still partial and not optimal among agencies or stakeholders.

In addition, based on the recommendation Lamong Bay port authority, we also have observed the implementation of the IOT in Malaysian port authority, Port Klang. Port management has applied the IOT concept, by releasing e-PAN for the benefit of the initial arrival of ships related to the security process of ships to be anchored and also the e-DCFZ system. The implementation of e-DCFZ will help streamline the trading process and anticipate the government's vision to improve the ease of doing business in Malaysia. However, based on the results of observation and analysis, we found that the

IOT's forwarding is still partial and technical in certain fields. Each field makes its own application and not yet integrated as a whole. Then also still technically tend that only focus in certain fields only. Not all information systems of each stakeholder can be integrated optimally, and, from the side of port services user, is still not effective and efficient.

This is also reinforced based on our previous research, Kusuma et al. (2018) about the analysis of the marine transportation system between Indonesia, Malaysia and the USA Country. The results of the descriptive analysis are shown in Table 2.

Table 2. Comparison of maritime transportation industry conditions

	Indonesian	Malaysia	USA
Operation and Policy of Marine Transportation Industry	- There are approximately 70 major ports spread across 34 provinces. - Implement marine toll programs. - The main port is managed by the government as a state-owned enterprise.	- There are about 7 major ports of cargo. - Some ports are managed by private companies.	- There are about 100 major cargo ports. - Implement the American Marine Highway program.
ERP System Perspectivenes	- Implement marine information systems for internal port authority authorities. - Implementation of ERP is still not optimal, and only in some main ports only.	- Implement marine information systems for each stakeholder. - Implementation of new ERP is done in some ports only.	- Each port authority has its own information system.
ERP and IOT Platform	- Has not implemented integration between ERP and IOT. - Has not integrated the entire service process from each stakeholder in all major ports.	- Has applied the e-PAN application for the benefit of early arrival of vessel related to vessel security process which will be anchored. - Implementation of e-DCFZ application, which aims to facilitate processing of dangerous cargo documents and free zones.	- Has not implemented integration between ERP and IOT especially for integration of all service process.

Source: Kusuma et al. (2018)

Therefore, in this research we propose IOT framework for maritime transport system especially in Indonesia based on the previous IOT architecture design which has been done by Zhou H., Liu B., Wang D. (2012) as we have explained before.

RESEARCH PROCESS

In accordance with our previous explanation, some previous studies have not discussed the effect of IOT (Internet of Things) for the implementation of the ERP system framework to support the maritime transportation system, especially maritime highway program such as those in Indonesia. In this study, we propose to design an IOT framework to support maritime highway systems to improve the effectiveness and efficiency of maritime transportation and logistics systems in Indonesia in particular.

The process of determining the variables as the basis of user needs in the application is done by interviewing to some port authority officials and related parties, as well as field observations, among others, at several major ports of Lamong Bay Terminal and Tanjung Perak in Indonesia.

As we have outlined in Table 1, the stakeholders we interviewed and requested to fill in an open questionnaire to determine what variables could be integrated later in the online system that was built. Using the simple method of analytical hierarchy process (AHP), we collect and identify data in order to determine the highest level of importance of each stakeholder regarding what basic variables need to be integrated in the IoT approach later. The results of these variables can be seen in Figure 2.

As comparison data, so this model will be modular especially in southeast Asia region, so we try to do observation to port of Klang Malaysia which have tried to apply this IOT system and have same geographical characteristic with Indonesia.

Integrating all procedures in commodities transport from and to each stakeholder related in a business is one of many ways to increase effectiveness and efficiency of overall supply chain performance in Indonesia's maritime transportation system.

Operating system used at the present time is still conventional and not the integrated one. On one hand, local government, shipping company, and port authority as service supplier are working individually. On the other hand, there are many unlicensed extra costs to ease the process that have to be paid by customer.

As stated in this study's goals, it is important to develop a new system that optimizes logistic system performance and maritime highway program in Indonesia using IOT approach, since the use of ERP only in each stakeholders system for the operating system has not been able to work optimally and in fully integrated manner.

Hopefully, by integrating all procedures from each stakeholder into an integrated information system, it will be easier for customers to access information related to port and maritime transportation services. We try to illustrate the old logistic system and maritime transportation model transformed into an integrated new model, which supports Indonesian maritime highway program, in Figure 1. Using the old ERP system platform and updating it with IOT platform, hopefully the *Marine Highway Tech* application program can integrate port customer service, shipping companies, port authorities, and local government.

The architectural design of IOT specialized for maritime transportation system is a platform with many technical supports such as e-commerce technology, remote radio frequency identification technology, and logistics management. There are some key factors for the implementation of this technology, they are remote sensing technology, information transfer technology, intelligent processing technology, and, of course, internet service access. By using IOT technology, information is exchanged between stakeholders of maritime transportation system, particularly users of Indonesian Maritime Highway, in this integrated application.

The information will be first gathered, then exchanged, and finally integrated in the application program, starting from data collection stage, information exchange, and integration of in-app service procedures.

In information gathering, all stakeholders (customers, shipping company, port authority, and government) are obliged to provide any data related to maritime transportation service procedures. The data that are needed are, for example, product quantity, port facilities, loading and unloading tools, freight type, port capacity, standard costs, customs fare, etc. The more complete the data given in the IOT management center, the more optimal the function of the system. The data completeness is an important foundation in IOT. Information exchange focuses on information technology network aspects of IOT such as communicating using internet services. This step involves data processing centers in the IOT center which are responsible for Intelligent Information Processing.

Therefore, the system needs not only the capability to operate the network but also the capability to improve efficiency of information flow. The improved efficiency is needed by the infrastructure in making IOT a universal service.

Figure 1. Research process

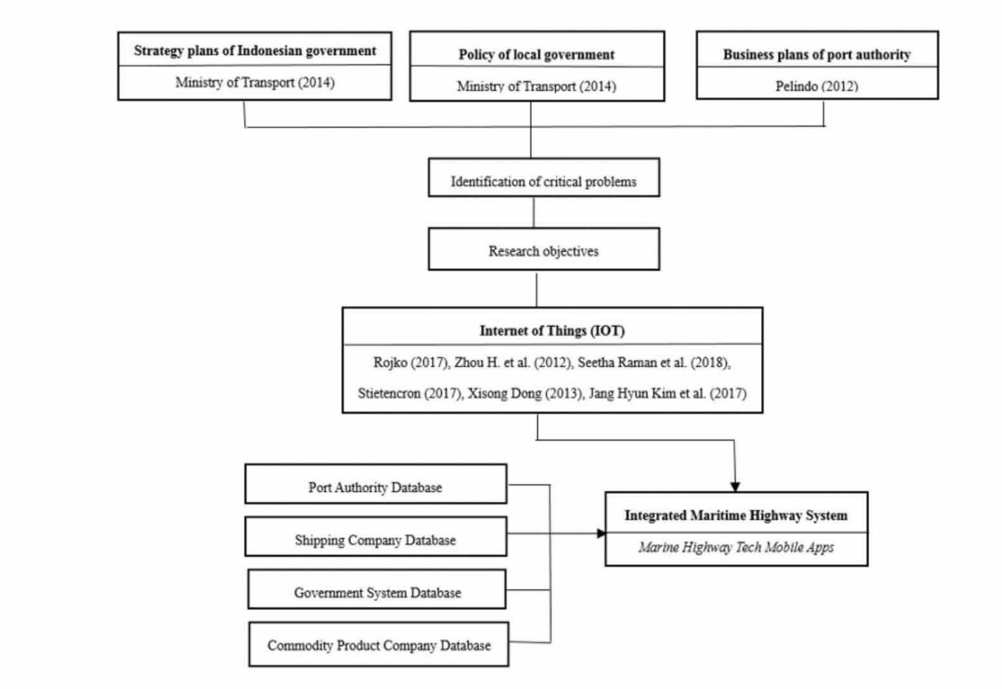
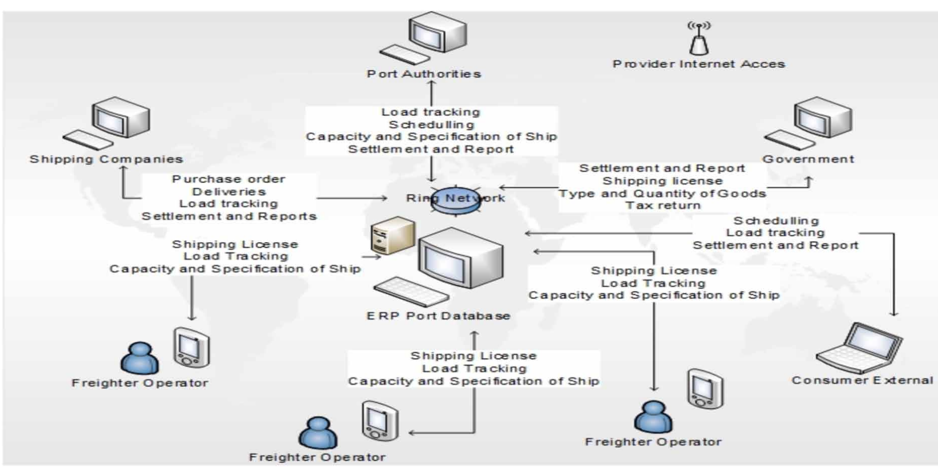


Figure 2. Results of the variables



Integration of service procedures in the application is aimed to accomplish the integration of IOT technology with port operating system so that port service customers find it easy to access all service procedures set by port service suppliers in *Marine Highway Tech*.

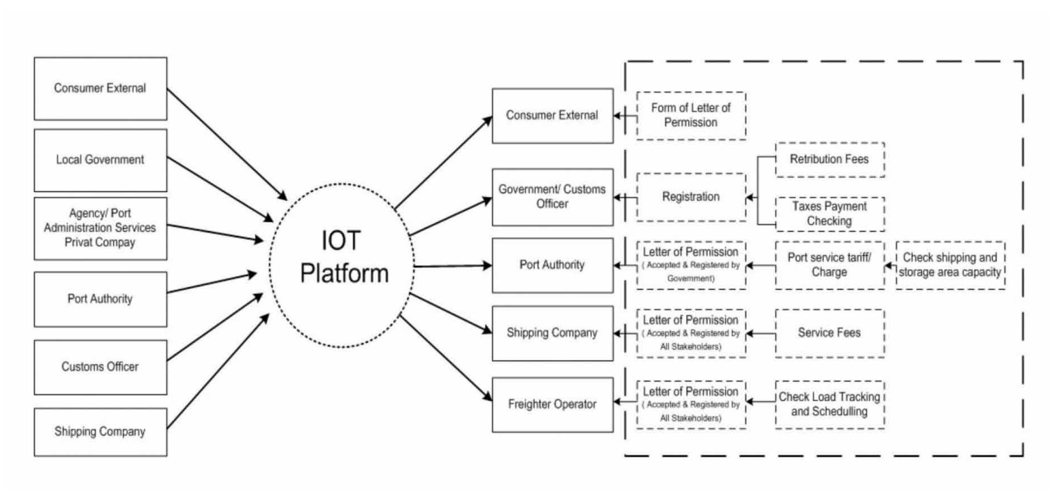
THE OBJECTIVE AND MAIN FUNCTION OF DESIGN IN IOT MARITIME TRANSPORTATION SYSTEM

We suggest technical implementation of IOT to all stakeholders that are involved. We have designed a platform that can be accessed by port services users to assist the service process, where all stakeholders can also access it for their interest in accordance with the procedures.

In Indonesia's maritime highway program, there are 7 major ports, which are the main supporters of commodity distribution channels throughout the province from a total of 24 marine ports throughout Indonesia. The seven ports are spread across several islands, connecting the island of Sumatra, Java, Sulawesi, and Papua. With the development of this new system framework, the maritime transportation information system or maritime highway program can integrate the operational system of seven major ports in one application platform. We illustrate the global plot comparison between the current seaport information system and the new system development design of IOT technology platform later.

Only a few seaports have adopted information system through ERP system approach. However, in reality, it does not run optimally, and many ports are run conventionally. Figure 3 can slightly illustrate the current global flow of information systems.

Figure 3. The architecture of IoT technology platform



Design of Port Service User

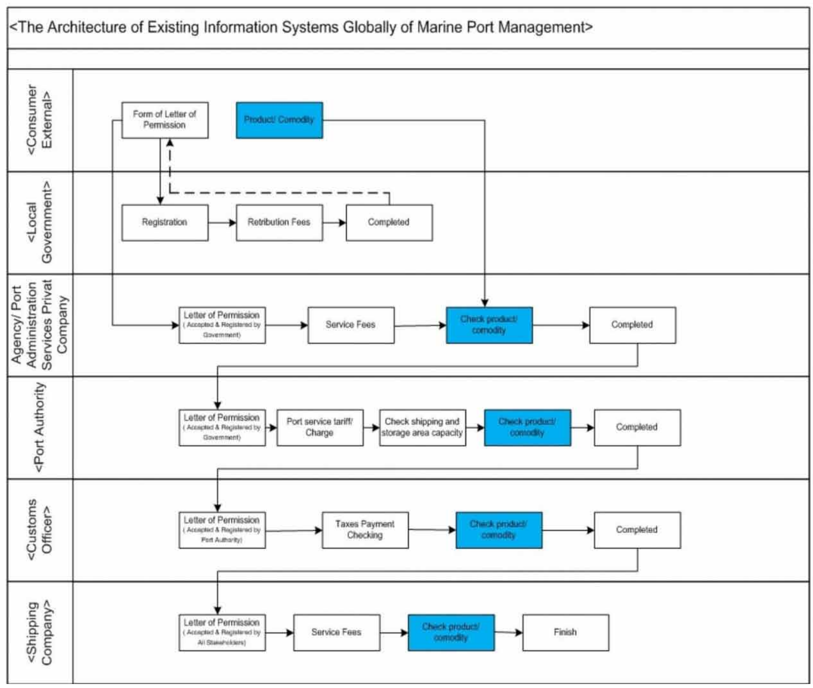
The important tasks that must be performed by port database system service provider are designing the application platform, collecting data, describing the information network of each stakeholder, and integrating it in one application.

In its implementation, the service provider or the operator of *Marine Highway Tech* database system will involve a third (external) party under the control or supervision of the Indonesian government because the service provider should provide warranty related to the data of port service users and other stakeholders who join the new system.

At this stage, we have tried to collect data from all stakeholders in the service operational procedures and systems for port service users. From these service variables, the structure of the information network are compiled in accordance with the order of the predefined procedures. After arranging the order of all procedures, we try to integrate them and redesign it into a more effective and efficient procedure in terms of time and cost parameters that must be borne by both service providers and port service users. All these stages have been discussed and validated with the authorities and experts of each stakeholder.

Figure 4 illustrates the results of our verification from each leader's representatives of all stakeholders regarding process variables that can be simplified and integrated. From several stages of

Figure 4. The architecture of existing information systems



the previous process of each stakeholder, the IOT framework is simplified into a single window. All similar administrative processes of each stakeholder are incorporated into an online application system.

Design of Shipping Company Service System

Delivery process through port especially in Indonesia so far is still conventional and partial. When users intend to deliver goods, they must first go through the transportation service company in the port. The company takes care of all the shipping administration process in port- authority before the processed administration is given to different shipping companies. It certainly takes a lot of time and unstructured costs.

Using IOT platform, a single window system will be created online. The entire administrative process, until the goods are ready to be shipped by the shipping company, is only done online without having to involve many parties outside the integrated system.

Especially for shipping companies, there are several variables in this platform that become the company's needs when they are to register or supervise the goods shipping process; among others are the delivery of order data from consumers or users, delivery of goods data, tracking access to the position of goods and vehicles, as well as procedures for payment and reporting.

Design of Port Authority System

According to Indonesian laws and regulations, ports are vital objects that must be managed and protected by the state. Because there are so many interests in the operational and service process, regional port authorities are the extension of Indonesian government.

In port management process, the authorities should be able to work with several stakeholders, especially customs – who are directly in touch with loading and unloading process. Determining ship service cost and time in ports is also a very sensitive issue for port authority.

Therefore, in carrying out the IOT system, the minimum requirement is that the port authority can manage information such as load tracking, scheduling, ship capacity and specifications, and completion and reporting processes.

Through the use of the online application form, it is expected that port authorities are informed about all loading and unloading activities in the port, can determine acceptance and delivery permits, arrival and departure schedules, container storage capacity, including payment administration process or port service charges.

Design of Government System

In order to integrate port information system in physically serving ships and goods from all agencies and stakeholders, the Ministry of Transportation has implemented a single service system through ERP approach and online system. However, the service system is still partial, in which every stakeholder institution has its own domain that port users must pass. The implementation of online-based information system for ship service and port goods is contained in the Regulation of the Minister of Transportation of the Republic of Indonesia No. PM 157 of 2015. The information System will be for ship service and goods including incoming vessel, moved ship, exiting ship, mooring extension, and cancellation service.

Governmental agencies and related stakeholders in ports include Office of Main Authority, Office of Main Harbormaster, Harbormaster Office and Port Authority, Port Operator Unit Office/ Port Office, Customs Office, Port Health Office, Agricultural Quarantine Center, Fish Quarantine Office and Fish Quality Monitoring, Immigration Office, Port Business Entity, The National Sea at the Port and Loading and Unloading Company at the Port.

In practice, ships and cargo services use IOT platforms, especially the released Marine Highway Tech application. The online application system can be downloaded by all service users in Play Store App. The e-Marine Highway platform is integrated with National Single Window (NSW) systems and systems owned by the Directorate General of Sea Transportation, Directorate General of Customs and Excise, Directorate General of Disease Control and Environmental Health, Directorate General of Immigration, Agricultural Quarantine Agency, Fish Quarantine Agency, Quality Control and Security of Fishery Products, Port Business Entities, and other relevant stakeholders.

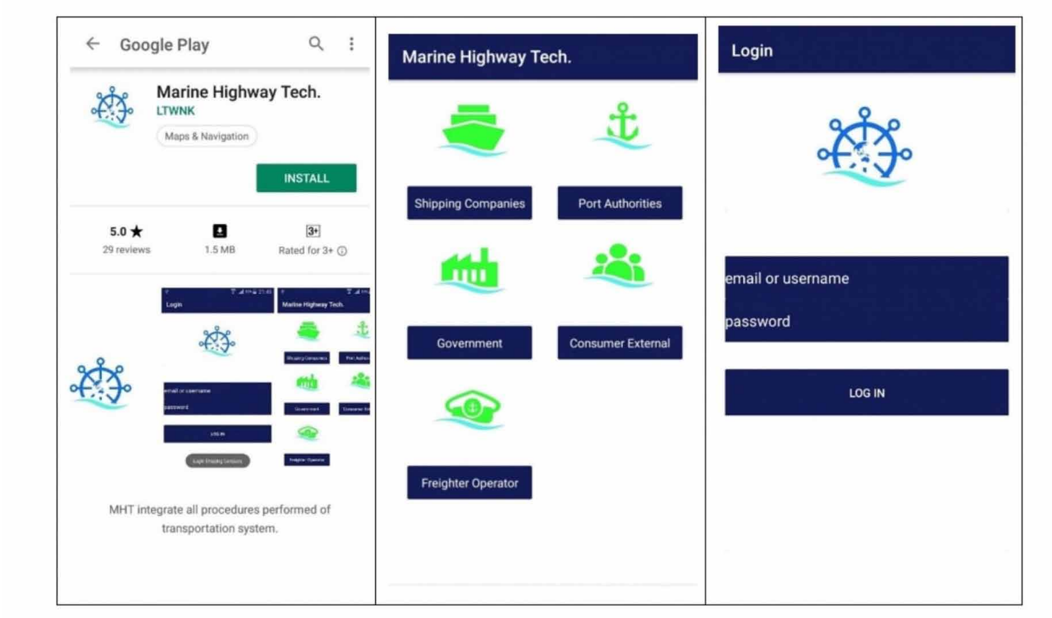
IMPLICATION AND RECOMMENDATION

This research provides newly integrated frameworks with IOT approach, and also a few recommendations related to practical and theoretical contributions that can be further developed in the seaports sector.

Implication for Practice

In Figure 5, we provide one example of the practical application we have proposed as a form of implementation of IOT framework in the maritime transportation system. In the illustration, there is an interface of the *Marine Highway Tech* platform application managed by the application administrator to ease all stakeholders to access all port service information and procedures.

Figure 5. Application *Marine Highway Tech* on Play Store



For users of port services, external consumers in particular, this application will be able to help them to know everything related to the process of delivering or receiving their belongings. In the previous conventional administrative procedures, they have to download the information one by one in each port application, customs, and shipping company. Now all can be done through one application. The payment process for port service fees will be carried out through m-banking integrated with *Marine Highway Tech* system. Ship operators can locate and update the position of their ships, and they are kept informed about everything that happens during the shipping or unloading process of commodities with the integration with Google maps system. For other stakeholder's functions, we will try to explain in the next section in detail.

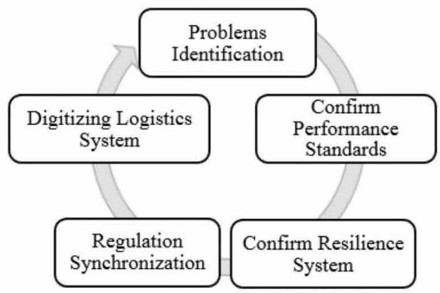
However, another impact that will arise is that there will be many conflicts of interest with shipping agents who have built their conventional systems with port stakeholders. The practices of additional or wild collection fees that have been covered up so far, will be greatly trimmed by the online application system.

Implication for Theoretical

Based on previous research we discussed above, such as particularly Zhou H., Liu B., Wang D. (2012), analyzed the IOT concept along with its architectural system to meet the demands of intelligent transportation function in intelligent urban transportation management. Seetha Raman et al. (2018) in their research shown how IOT or big data technology can create added value and great monetary benefits for the company and will soon become a standard in all industries. And studied from Jang Hyun Kim et al. (2017), Stietencron (2017) and Xisong Dong (2013) in each of their studies related to the marine port system has explained how the development or theoretical contribution produced by their research. So in this study, we clarify the theoretical contributions that can be developed in the application of IOT platforms in the seaport area. Based on the results of our observations and interviews with several expert teams from the government, port operators and service users about the pattern of system integration of each port management stakeholder, the critical aspect is mainly from the government aspect as a policy maker. The pattern of stakeholder interaction is strongly influenced by how strongly the government regulates and oversees the operation of the seaport digitization system. So the regulatory and legal factors of the government that regulate the seaport system need to be studied more deeply, to determine the business policies of the seaport then specifically the application of the IOT platform.

Furthermore, we designed a pattern for developing a logistic system at seaports that could be used as a reference in the future development of logistics system, especially for the island nation. With the system digitalization approach, all stakeholders will be connected to each other in a platform that aims to identify problems in the field quickly, check service performance whether it meets standards, adjust parameters for resilience systems, synchronize and set in accordance with regulations from local government, then integrated with digital platforms in a mobile application. The stages of development are shown in Figure 6.

Figure 6. New pattern of development of Seaport Logistics Systems



The comparison of value data among ports is obtained from World Bank regarding Logistic Performance Index (LPI) in the last five years using radar charts as shown in Figure 7. For example, based on LPI data relating to transport cost variables, Singapore has 3.96 points, and Germany has 3.86, but Indonesia is far below 2.90. This means that Indonesia still needs to minimize all costs associated with transportation and administration process in order to compete with Singapore or Germany.

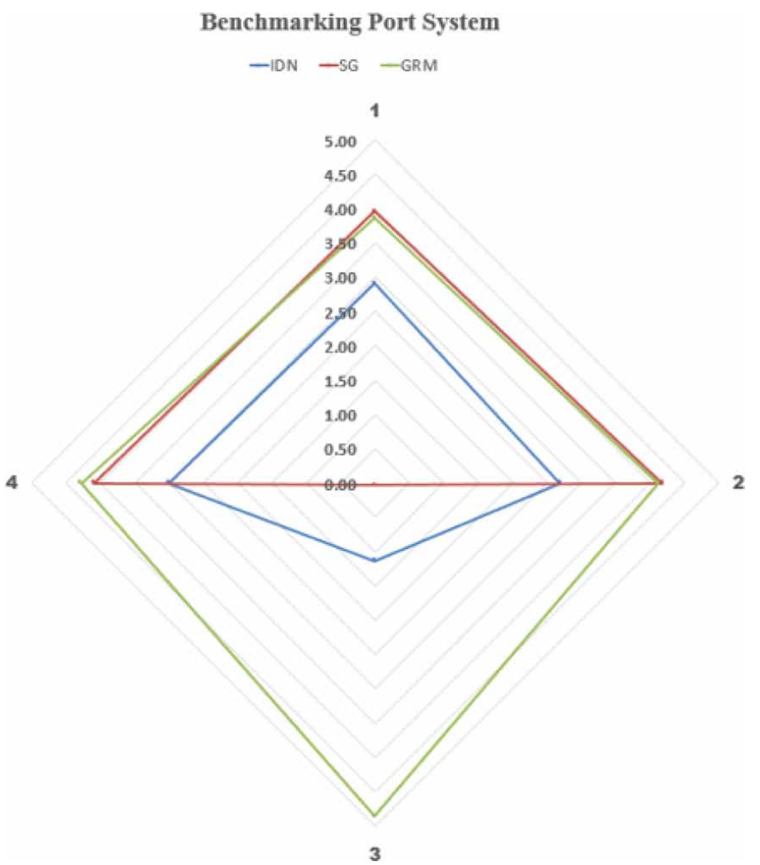
CONCLUSION, LIMITATIONS AND AREAS OF FUTURE RESEARCH

Through this research, we have designed a framework for the use of IOT concepts in maritime transportation systems. By involving unique stakeholders, such as port authorities, shipping companies, commodity products companies, and government officials (with their different policies in each island region) including customs officials.

Improved service process performance in the presence of IOT platform which manifests its implementation in the form of an example application on the user's mobile phone that we have displayed, will certainly reduce much processing time and costs to be incurred. So problems such as high logistics costs, long dwelling time, uneven distribution channels between regions and product price disparities, especially in the eastern part of Indonesia will be resolved sustainably.

The framework with the IOT concept approach will be able to assist the operational system of maritime highway programs in Indonesia, and is expected to be a model for the development of maritime transportation systems in Southeast Asia in general. Countries with demographic

Figure 7. Radar chart of Benchmark Marine Port (LPI World Bank, 2016)



structures such as Indonesia is an archipelagic country, will certainly help with the implementation of the IOT system.

There are limitations of this research, that is not all data access can be open especially related to the process of customs inspection. Because it is considered very sensitive and has many interests in the process by government.

Currently, the development of IOT in the early stages and key technology is still in the exploration stage, but has a very strong momentum. With the development of IOT techniques and large investments, especially examples of *Marine Highway Tech* platform applications in Indonesia's maritime highway program, intelligent transportation will be able to increase the effectiveness and efficiency of seaport services. The technology of the Internet of Things will enable the development of transportation systems into a more intelligent, safe, harmonious, and energy-efficient system.

However, keep in mind on regulation and governance for addressing security and privacy issues should be considered in further research. The integrated system, along with the optimization of service performance, should have the data security level of all stakeholders of seaports is guaranteed confidentiality.

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