Simulation and Optimization of Services at Port in Indonesia

M. Dachyar

Dept. of Industrial Eng, Univiversity of Indonesia, Depok 16424, Indonesia
mdachyar@yahoo.com

Abstract

Port of Merak and port of Bakauheni is the biggest ferry port in Indonesia, which linking two main islands; Java and Sumatra. The growing population of both islands have effected to the increasing of economic level and mobilities. The existing of port users have to be accompanied by the reduction of time services which caused reduction of waiting time and vehicles queuing. This study uses simulation methods to obtain a description of conditions of port of Merak and port of Bakauheni at various scenarios which are number of ships, number of docks, passenger arrival rate, sea wave, and intervals of ship arrivals.The results showed,on weekdays and weekend, vehicle waiting time was about 10-30 minutes. On national holidays the waiting time increased to more than 10 hours. The recommendation to data analysis; the port should operates 5 docks and 3 additional ships at long holiday to solve vehicle queues, which can reduce to 1-3 hours.

Key Words*: Port, quality services, simulation, operations management*

1. Introduction

Port of Merak and port of Bakauheni are sea-link transportation between Java and Sumatra which can support economics to both island and to some part of cities or small islands in Indonesia. Every day hundreds of passengers and vehicles pass through this port. Nevertheless, the ports still have problems on serving the time services to the user, which clearly can be seen on national holiday, idul fitri (moslem holiday). The number of passenger increased drastically this lead to the need of additional ships. However this must be considered as an economic factor; additional of new ships and numbers of additional dock. A recommendation of changing the port facilities had to be well analyzed to overcome the queuing and developed the best solution.

The method to analyze the overall system is simulation, which is predictively and accurately evaluates the performance of even the most complex systems. By using the computer simulation to modeling a system before the system was built, it has to be validated to avoid failures. In addition, simulation can also provide flexibility on doing various scenarios; minimum risk, low cost, and does not require much time. This study uses simulation methods to obtain a description of Port of Merak in the different scenarios, and analyzed the results and search solutions to overcome the problems.

2. Literature Review

System is a set of objects that work together or interact in some of the regular mutual dependence to achieve a desired goal. System is often influenced by changes that occured outside the system; it can be said occured in the system environment. In modelling the system, decisions must be made within the limit of the system and the environment [1]. According to Blanchard, the system is defined as a collection of elements that work together to achieve the desired [2]. Important issues that are covered in a system are: a. System consists of multiple

elements. b. Elements are interrelated and work together. c. System exists in order to achieve certain goals.

In simulation, system can be comprised of entities, activities, resources, and control. These elements defines who, what, where, when, and how the entities are processed. Elements of the system are related to one another in a ways that often result in complex interactions. System complexity especially influenced by the mutual dependence and inter-element variability in the behaviour of elements that generate uncertainty. Mutual dependency of the behaviour of one element can affects other elements in the system. Variability is the difference in the inherent characteristics of some systems that involve humans and machinery.

2.1 Model

Model is a representation of a system. For most studies, it is important to only consider the aspects of the system that affect problems being studied. The aspects are represented in the model of the system, so the model is said a simplification of the system, but detailed enough to make the decision on the system [3]. Model is a representation of the fact that is being simplified. Thus, the exact way in which an operation is performed is not important as the way in which the operation can impact to the rest of the system. An activity should always be viewed from how these activities affect the elements of the other system, not how the activity is performed.

Model is usually taken from number of assumptions relating to the operating system. Assumption is expressed in mathematical relationships, logical, and symbolic of elements in the system. Through modeling, we describe some of the real system that can be used to predict and formulate strategies controlling system [4].

2.2 Simulation

Simulation is an imitation of operation of process or system, in order to evaluate and improve system performance. According to Shannon (1976), simulation is the process of designing the simulation model of the system and makes experiments with model for the purpose of understanding the system behavior and evaluates various strategies for the operating system. According to Schriber (1987), simulation is the modeling of a process or systems in such way that the model mimic the response of the actual system that take place over time. However, the development of computer technology and software capabilities can support the use of simulation aided for management problems [5]. Human knowledge, simulation models, and methodological decisions in integrated information system offers new standard of problem solving in quality management. Simulation model is used as tools for the better understanding of the decision making process and learning process in port [6], enterprise and school [7].

3. Research Methodology

To perform the simulation, there are several steps that must be done. Figure 1 shows the steps of simulation.

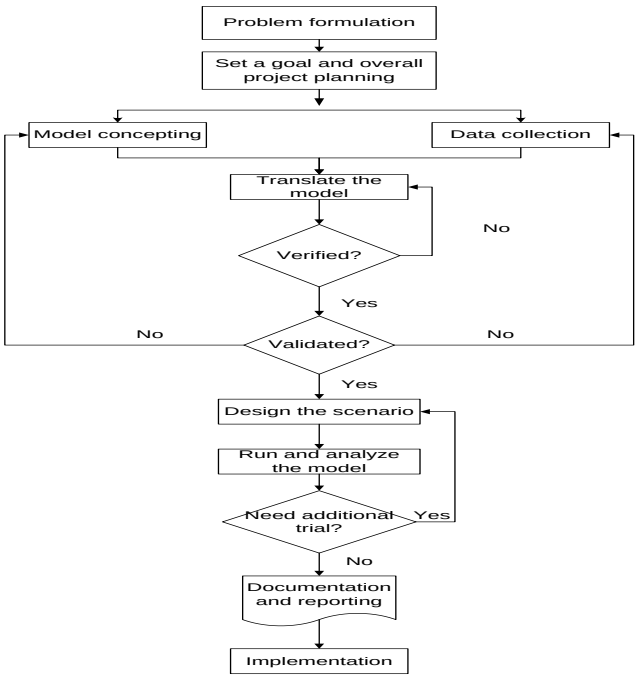

Figure 1. The Steps of the Simulation

The problem is formulated based on the background that has been described. The planning was done in accordance with the steps in the simulation of Figure 1. Model concepting is done simultaneously with data collection so that the concept model that is made in accordance with the real situation. Collecting data is done through the company's historical data, direct observation of the locations and the flow of passengers and vehicles, and time study to calculate the time of each process. Data that has been collected then translated into a computer simulation model using software ProModel.

4. Results and Discussion

4.1 Model Input

Data input for the model include the type of passengers, the passenger arrival patterns,

Table 1. Passenger of Port of Merak

Passenger's Types	
Passengers	
Adult	
Children	
Vehicles	
Class I	Bicycle
Class II	Motorcycle
Class III	3-wheeled vehicle
Class IV (passengers)	Car
Class IV (goods)	Pick up
Class V (passengers)	Small bus
Class V (goods)	Small truck
Class VI (passengers)	Big bus
Class VI (goods)	Big truck
Class VII	Tronton
Class VIII	Trailer

number and specification of the ship, ship schedules, port layout, the number of docks, the number of passenger, and vehicle counters. There are two kinds of passenger port of Merak, which are passenger (people) and passenger (vehicle) which are classifed into several groups, as can be seen in Table 1.

Level of passenger arrival at the port of Merak each monthh are between 100 - 150 thousand of passengers and vehicles. However, during the Idul Fitri; Islamic holiday, the number of passengers increased drastically reaching almost 200 thousand passengers. Passenger arrival pattern can be seen in the Figure 2.

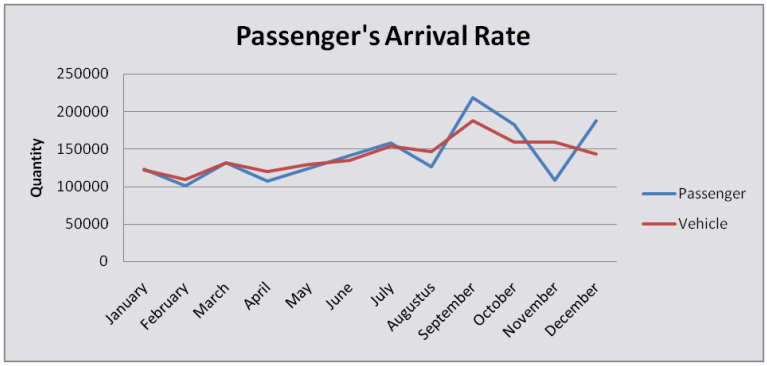

Figure 2. Passenger's Arrival Rate

Passenger arrival rate can be categorized into four seasons, weekdays, weekends, holidays, and Idul Fitri.

Port of Merak has 32 ships with the capacity varies between 300-1000 passengers and 40-200 vehicles. Everydays, 18-19 ships are been operated with the interval of 15 minutes and waiting time of 45 minutes. The ports entrance is divided into two; passenger entrances and vehicles entrances. Passengers enter the port to purchase tickets then walked to the dock through the access bridge to the ship. There are eight counters for vehicles; each counter simultaneously can only serve one vehicle at the same time.

Figure 3. Port of Merak *layout*

Port of Merak and Port of Bakauheni has four ferry docks and one speed boat dock. Ferry dock is facilitated with gang way, side ramp, and movable bridge which is bridge between the docks and ships. Gang way is used to load and unload passengers. Side ramp has functioned

on loading and unloading small vehicles such as; motorcycles and cars. The movable bridge functioned to load and unload vehicle such as; buses, trucks and trailers. Gang way is located on the dock 1, 2, and 3. Side ramp is located on the dock 1 and 3, while the movable bridge is located on each dock. All vehicles will enter and exit the ship through the movable bridge through dock 2 and dock 4. Layout of the port of Merak can be seen in Figure 3.

4.2 Model

This model is applicable for ships either from port of Merak to port of Bakauheni or from port of Bakauheni to port of Merak.

- Passanger purchased the ferry tickets at the counter. The ticket should be submitted to the dock officer before entering the ship.
- Trucks should go to the weigh bridge for measuring weighing capacities. The tickets can be purchased directly to the counter. For two-wheel drive must go to counter 8. After getting tickets moved to check point to lead to the dock.
- At dock 1 and 3, the entrance of vehicles divided into two, through the side ramp and movable bridge. For two-wheeled vehicles and small vehicle such as a small car, jeep, and truck, and have to go to the side ramp parking area. The larger vehicles have to go to the movable bridge parking area.

4.3 Scenario and Analysis

Picturing varieties of conditions, there are 24 scenarios which are run on this research. They are; the behavior of the system and the effects of the addition of the ship, dock or ship schedule changes. Scenarios are developed based on the seasonal, wave conditions, the number of docks, the number of ships, and headway of the ships. Season is divided into four, the weekdays, weekend, holiday, and Idul Fitri. Arrival rate of vehicles in each season is different as shown in Table 2. In the normal waves all the ships can be operate, while in the high waves ships weighed to more than 3800 GRT (gross tons) are recommended. The result of each scenario will be analyzed to measure the performance of the system; the number of vehicles in the system, vehicle waiting time, and the queue occurs outside port.

Simulation results shows; on the weekdays (Monday-Thursday), the number of the dock have not affected to the waiting time of vehicles. By using 3 docks, the port can serve the passengers and vehicles in 10-30 minutes and did not occur queue even though the condition of high waves. On weekend, the vehicle waiting time is not significant in the normal wave conditions, but it does at the high waves. The difference waiting time of dock #3 to dock #4 docks is about 7 hours, and the waiting time between dock #4 to dock #5 is not much different. Current conditions, only 4 docks are available, when one dock is damaged the waiting time of vehicles will increase up 11 times longer. Operating 3 docks at high waves, queue outside the port can reach to 10 km. Operating 4 or 5 docks; there is no queue outside the port.

On normal wave condition and holidays; if the port operating 4 docks, the queue can reach up to 8 km, and worst condition will occur if only operates 3 docks, the queue can reach up to 12 km which equivalent to 10 hours or more of waiting time. With 5 docks, waiting time of vehicles can be reduced to 3 hours for truck and 1, 5 hours for other vehicles. No queue of vehicles occurs outside the port.

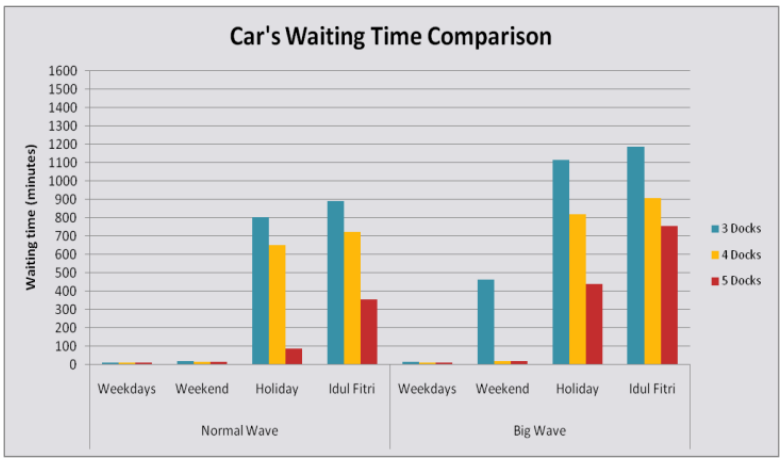

Figure 4. Comparison of the Waiting Time of the Car

On big wave condition, if the port operating 4 docks with 22 ships, waiting time of vehicles can be more than 13 hours, and queue 14 km outside the port. If operates 5 docs with 32 ships, the vehicle waiting time was about 7 to 9 hours and queuing of vehicles outside the port was about 3 Km. On normal condition eventhough holidays, operating 5 docks and 32 ships is an optimal condition.

On Idul Fitri, the waiting time of vehicles is still very long even though the port has maximized the services of 5 docks and 32 ships; waiting time can reached to 6 hours on normal wave condition and 10 hours on big wave conditions (Figure 4).

As can be seen on Figure 5, the waiting time is increased drastically during holidays and more worst on Idul Fitri. Operating 5 docks with the 32 ships is not recommended, it needs 2 additional ships to minimize the high existence of waiting time. If numbers of the ships can be added to the real condition now, it contributes to the reduction of more than 500 trucks and 200 cars, motorcycles, and buses. The queue outside of the port will not occur, while vehicle waiting time can reduced to 86%; which equivalent to 2 hours for the trucks and 1 hour for other vehicles.

Additional 3 ships with capacity of 200 units of vehicles and tie up time of the ship from 45 minutes to 30 minutes, the number of vehicles in the system can be reduced to about 100-1100 unit for the motor car, bus and truck for less than 200 units. Vehicle waiting time can be reduced drastically enough from 12 hours to 2 hours

At the big waves condition, the long queue cannot be objected because the ships specification are not applicable to the big waves condition, the additional 6 units of ship with large transport capacity; 200 units of vehicles it can reduce tie up time into 30 minutes, then the number of vehicles in the system can be reduced to about 1200 cars and motorcycles, while bus and truck more than 200 units. Vehicle waiting time could be reduced from 15 hours to 3 hours.

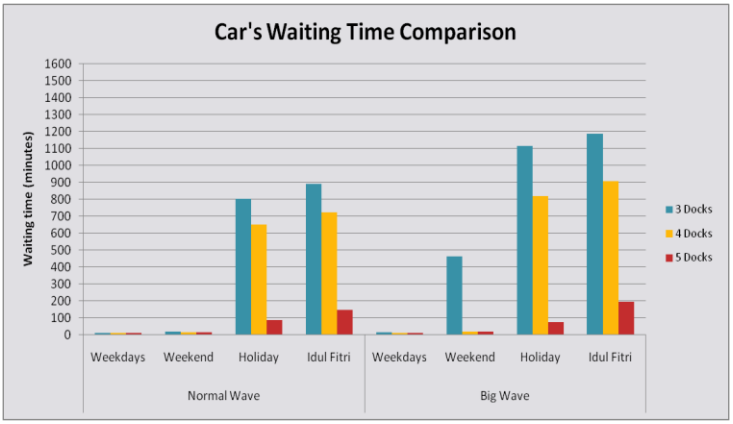

Figure 5. Car's Waiting Time after Solution

If there were change pattern of truck size; either capacity and long build truck entering the ferry, the number of carried vehicle to the ferry is decline, this impacted to the rise of time queueing and queue vehicle outside the port moreover tollway into the port.

5. Conclusions

The simulation has been done to anticipate the queuing problems of the port which is time consume to the users. By operating 3 docks to 4 docks and 5 docks with high capacity of vehicles, the waiting time in maximum only 2 hours either in port of Merak and port of Bakauheni. On big wave condition, the big carrier ships should replaced the small ships so the capacity of the shipping is well maintained.

The rising activities between Sumatera Island and Java Island, additional docs and additional ships are recommended to reduce waiting time.

Acknowledgements

We greatly thanked to Department of Higher Education Republic of Indonesia for financing the whole research and also to Faculty of Engineering, University of Indonesia for facilitating processing the data.

References

[1] J. Banks, "Discrete-Event System Simulation", 4th ed., Prentice Hall, New Jersey, **(2005)**, pp. 9.
[2] C. Harrell, B. K. Ghosh and R. Bowden, "Simulation Using ProModel", 3rd ed., McGraw-Hill, Boston**,** **(2000)**, pp. 25.
[3] M. S. Fayez, "Managing Airport Operation Using Simulation", Journal of Simulation, **(2008)**, pp. 41-52.
[4] R. Y. Rubinstein and D. P. Kroese, "Simulation and The Monte Carlo Method", ed. ke-2, John Wiley & Sons, New Jersey, **(2008)**, pp. 82.
[5] A. Asllani, P. Dileepan and L. Ettkin, "A Methodology for Using Simulation to Optimize Emergency Mass Vaccination Parameters", **(2007)**.
[6] B. Dragovic, "Simulation Modelling of Ship-Berth Link with Priority Service", Maritime Economics & Logistics, **(2005)**, pp. 316–335.
[7] M. Kljajic, "Post Decision-Making Analyisis of the Reengineering Process Supported by Simulation Methods", **(2007)**.

Author

M. Dachyar, was born on Nov 20 th 1959 in Bandung West Java Indonesia. Educational background: Mechanical Engineering (Ir) University of Indonesia – Jakarta, 1985, Industrial Development (MSc) Vrije Universiteit Brussel - Belgium, 1991.

He is a lecturer at Industrial Engineering University of Indonesia since 1986 until now. His expertise in Project Management, Quality, and Information Systems leads to enrich the methods control the time resources and time frame for this research.