Discrete Event Simulation Modeling for Classifying the Container Yard Availability Considering Dock Unloading Activity

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Abstract. The development of systems and technology in the industry especially in the supply chain sector currently has a significant influence on the speed and accuracy along the supply chain. This is one of the reasons to build a container loading and unloading service company located in Surabaya, Indonesia that applies the green port concept with renewable loading and unloading equipment technology. One of the unique and prominent renewable concepts is the docking station, which aims to speed up loading and unloading activities. Currently, the port has five yards available with 30 docking gates. The problem is in the utility yard or yard occupancy ratio (YOR) in unloading activity which has a low percentage value (27%). Even though the percentage value should be around 60%, therefore value of yard utility didn't optimal yet. A discrete-event simulation aims to help classifying which yards are suitable for unloading activities and the rest for loading activities. This study focus only on for unloading activities, because these activities at the most activity in the company. The model verification is obtained "*no error*" and model validation is less than 5%. The study conclude that the best scenario is to use three yard containers with six gates of docking for each yard.
Keywords: *Discrete-event Simulation, Docking Station, Container Yard.*

1. Introduction

The development of systems and technology in the industry especially in the supply chain sector currently has a significant influence on the speed and accuracy along the supply chain. Throughout the supply chain the influence of various facilities has an important role in the value of the supply chain itself (value chain), one of which is warehouse. In the modern industrial warehouse used not only as a storage area, but as a place of consolidation of products to be distributed. This consolidation functions as a collection of products from several suppliers that will be distributed directly to various destinations, namely consumers. Consolidation does not only occur in the manufacturing industry but also in the service industry. The Port is a new container loading and unloading service company in Surabaya. Founded in 2013-2014 with renewable loading and unloading equipment technology. But the performance of service operations in container yards shows receiving time over 30 minutes, which means the process in CY (container yard) is relatively long. Whereas the flow of containers in terminal from 2015 to 2018 continues to increase (Figure 1). The loading ports have their own daily demand rates, which vary from one month to another due to the seasonal cycle [3]. Unlike in [4] the flow of containers in the terminal do not have any time windows. They may be loaded and unloaded any time because of complete facilities.

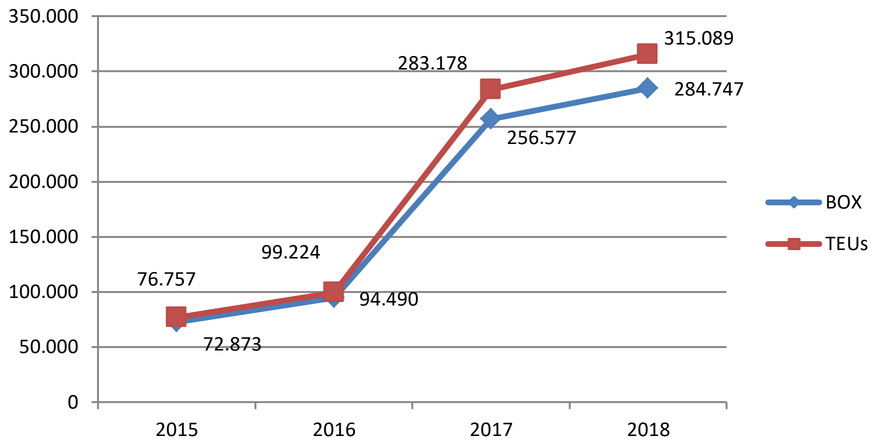

Figure 1. Domestic Container Flow (2015-2018)

This indicates the need for improved loading and unloading performance, one of which is the performance in the container yard itself. The purpose of this study is to create a loading and unloading service system model that uses the docking concept and determine the number of docking gates and the number of container yards used to accommodate containers coming from the dock. Operating performance in CY (container yard) is usually measured by the length of time it receives and delivery time, when the container enters the waterside until it exits to the landside. Currently, the port has five yards available with 30 docking gates. Therefore at the operating level, uncertainty is very high, such as ship arrival, truck arrival, box volume to be transported. As a result, adjustments are often made to the original layout. To improve efficiency, planning in the field must take into account uncertainties that occur during the operational level [2]. The problem is in the utility yard in unloading activity or yard occupancy ratio (YOR) which has a low percentage value. Even though the percentage value should be around 60%, therefore value of yard utility didn't optimal yet (Table 1). Level of stacking field usage or YOR containers, are the ratio of the number of container stacking field usage calculated in 1 box container per day or m² per day with capacity stacking available.

Table 1. Yard Occupancy Ratio In 2018

Month	Unloading Service Time (Hour)	Total Box	Settles (Day)
January	725	11748	42
February	712	13608	55
March	745	10308	35
April	758	12334	43
May	745	9627	43
June	708	6462	55
July	780	11492	43
August	725	11310	49
September	685	14366	42
October	743	14486	47
November	715	13632	47
December	739	14310	47
	Total	**143683**	**548**
Yard Occupancy Ratio (%)		**27,32**	

2. Methods

For those matter we take the most lots in one month and simulate it with discrete-event simulation. In discrete event simulation (DES), the operation of a system is represented as a chronological sequence of events. Every event happens instantly in time and marks a change in status in the system. Discrete event simulation is an experimental approach that is often used; allows a high level of detail to be modelled because assumptions about buffer space, processing time distribution, or priority delivery can be modelled [1]. According to [5], creating a discrete event simulation model using the simulation software can analyze several material problems in the terminal. The problems faced are cargo transportation, and handling engine performance, also faces several problems regarding stockpiling of raw materials and production of materials.

For assumptions in this study include the number of docking gates used for simulation, there are 6 gates, no damage to loaded containers, no disruption in the dock area (ship/vessel) during the loading-unloading container process, and do not consider berths. In addition, the purpose of implementing docking only refers to the increase in the percentage of YOR (yard occupancy ratio). At this stage describes the problem conditions in container yards (CY). This is to make it easier to get the identification of problems that occur in container yards (CY). The following is a scheme of activities and conditions in the company (Figure 2).

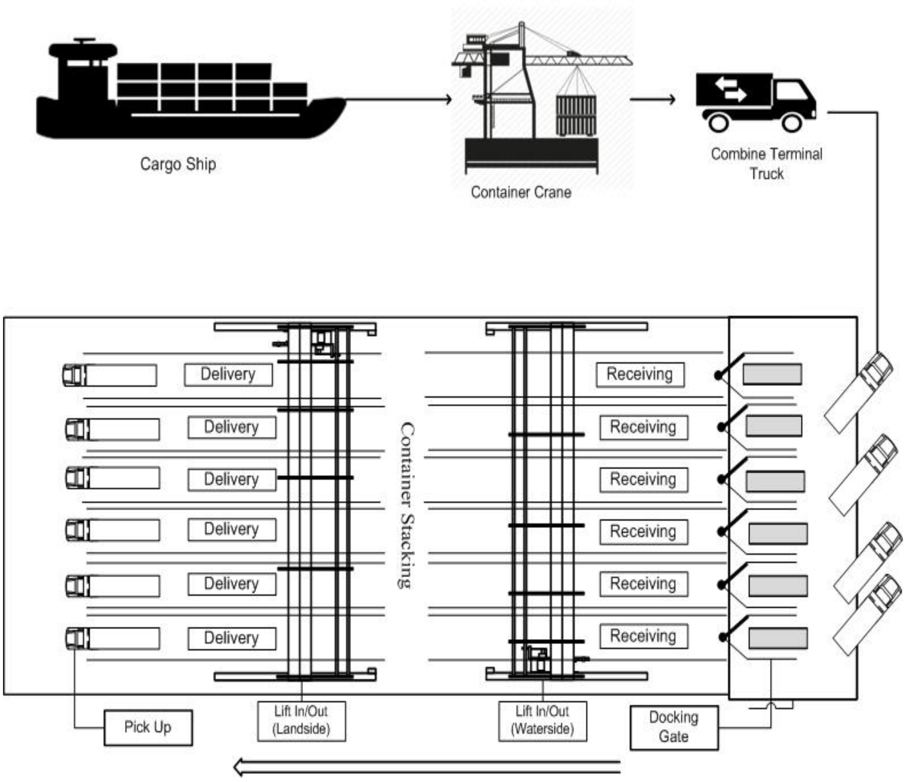

Figure 2. Unloading Activity In Docking Station

In the simulation stage, modelling must be done first before making the simulation model. In making models must draw a real system in the company. Before making a simulation model it is better to make a flowchart to help drawings of the actual system. Flowcharts describe the process flow to facilitate the making of simulations in software. The flowchart model will be created in simulation software to create a real simulation. The results of the model created must be able to interpret the actual results that exist in the company. Conceptual models in existing condition can be interpreted in flow logic diagram or flowchart. The conceptual sub-model for cargo arrival can be seen in the figure 3.

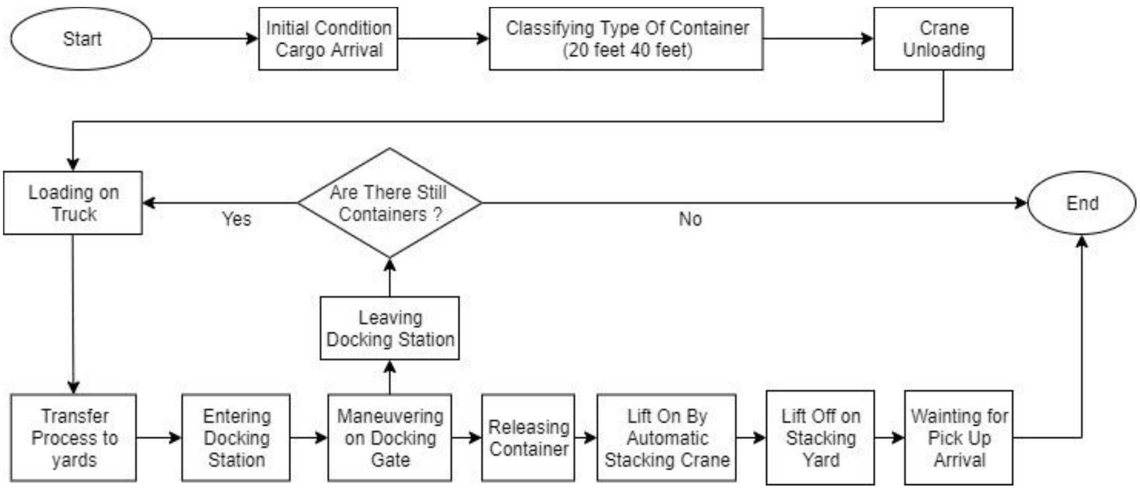

Figure 3. Flowchart For Cargo Arrival

The scheme above (Figure 3) explains the arrival of the container or the ship's cargo will enter the dock according to the data fitting that has been done, then the container will be separated based on the type, namely 20 feet and 40 feet. Furthermore, containers enter the pier and will be processed by crane or can be called ship to shore (STS) with working time based on the existing distribution. There are 5 STS that work for each container arrival. Then the container will be loaded into combine terminal truck (CTT). This CTT has a capacity of 40 feet for one load and if the container of 20 feet type is entered it will first be batched 2 times. CTT will go directly to container yard (CY) for the stacking process. This CTT has a speed specification of 20 km / h which will be converted to a model of approximately 333 meters / minute, and has a distance from the pier to container yard as far as 1.51 km or 1515 meters. For choosing yard considering the yard's capacity can be seen in figure 4.

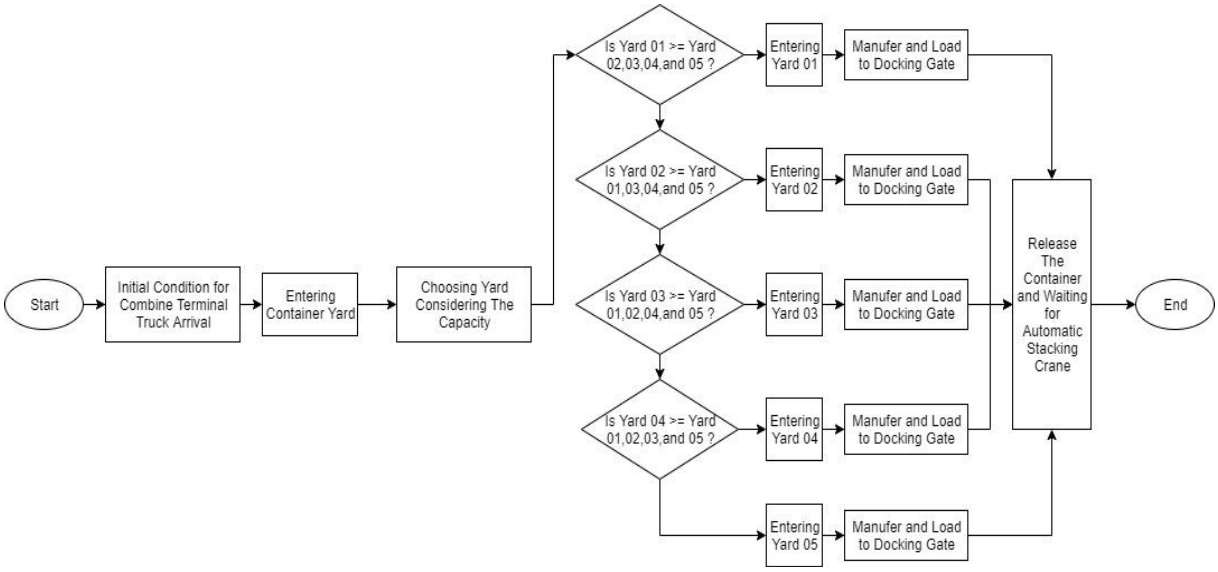

Figure 4. Flowchart For Choosing Yard

The scheme above (Figure 4) explains CTT enters the yard, before entering the yard CTT have to choose the biggest ammount yard's capacity. After that condition, CTT must maneuver to place containers into the docking gate. This manoeuvring process requires the fastest time of 4-5 minutes and the longest until 10 minutes. After the CTT has finished unloading the docking station, the CTT will return to the dock for the next unloading process and if the number of containers runs out the CTT will automatically stop at the docking station (buffer area). Containers included in the docking station will be separated for the purpose of separating 20 feet container types. Furthermore, automatic stacking cranes (ASC) will pick up containers at a speed of 60 meters / minute with a distance of 250 meters to be stacked into a stacking field created with an assign module for capacity updates. ASC is only able to process or carry only one container box. After that the container which is piled up will wait for pickup truck for the delivery process. Delivery process can be seen in figure 5.

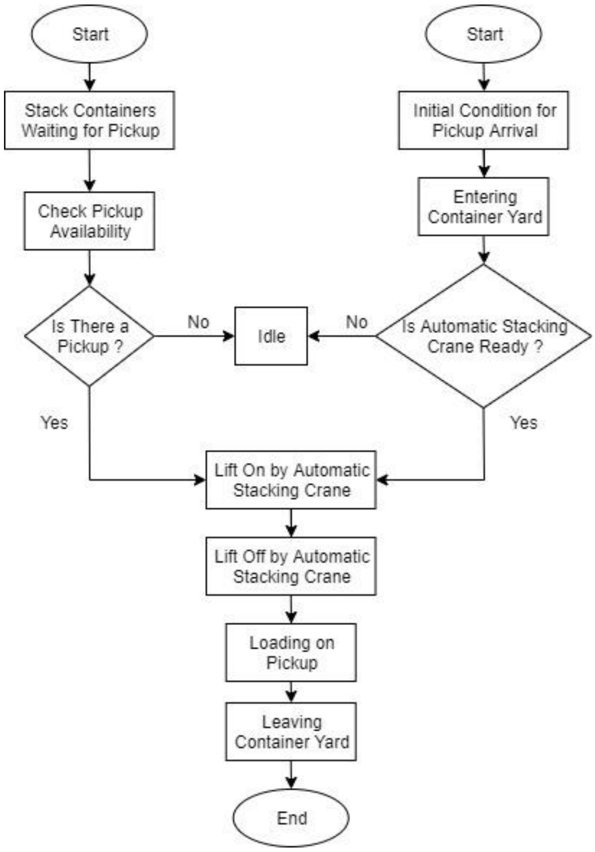

Figure 5. Flowchart For Pickup Arrival

Figure 5 explain the pickups that come are based on the deposition time for each container that is already in the stacking yard. The minimum deposit time for each container is 4 minutes and the longest is up to 14-15 minutes. When a pick up arrives, it triggers a signal for container pickup and yard capacity will be updated to lose the container. The decide module is used to check the available capacity in each yard, lost containers based on the highest stacking capacity in the yard which will be reduced by picking up containers in the yard. The outgoing containers are then processed again by the same automatic stacking crane (ASC) with the same specifications for transportation at the docking station at a speed of 60 meters / minute and a distance of 250 meters. After being processed by ASC the container will be automatically exited or disposed

3. Results and Discussion

After making the model in the simulation software, then the results can be verified whether an error occurs to ensure the model runs as desired. Model verification which interprets the results of "*no error*". The next step is to validate the model. This validation aims to see the suitability of the actual model with the simulation model that has been made. This validation compares the number of boxes, service time, and yard occupancy ratio. After the model has been verified, the model needs to be validated to see whether the model matches the real system in the field. This validation process involves output parameters such as the number of container boxes entered, service time, and the percentage of yard occupancy ratio (YOR). The actual output that has been calculated and the simulation output that comes out will be tested by t-Test: Paired Two Sample for Means in Excel which aims to see whether the t-stat value exceeds or less than the t-critical value of two tails. The validation results can be seen in (Table 2).

Table 2. Results for Validation Test

Validation Parameter	t-stat	t-critical two tail		Conclusion
		Lower limit	Upper limit	
Total Box	0,177	-2,069	2,069	Valid
Service Time	-0,102	-2,069	2,069	Valid
Yard Utility	-2,241	-2,776	2,776	Valid

Making improvement scenarios aims to provide priority choices with different parameters. In the repair simulation model, each scenario has a number of different docking gates and a number of yards. There is a combination of the number of docking with the number of yards used. The combination of docking there are 4 types and the number of yards there are 3 types, further creating 12 existing scenarios, for more details scenario and the results can be seen in (Table 3).

Table 3. Scenario Test and Results

Scenario	Yard	Dock	Total Box	Service Time	Utility (%)	
					Dock	Yard
A1	3	3	17411	1567,67	0,17	39,42
A2	3	4	15832	1483,33	0,11	37,05
A3	3	5	14538	1456,00	0,09	36,47
A4	3	6	13317	1335,67	0,06	35,30
B1	4	3	16600	1512,33	0,12	34,31
B2	4	4	14533	1439,00	0,08	32,06
B3	4	5	15079	1457,33	0,07	32,47
B4	4	6	13460	1398,00	0,05	31,33
C1	5	3	16974	1570,00	0,10	29,04
C2	5	4	13688	1421,67	0,06	27,05
C3	5	5	14609	1448,00	0,05	27,37
C4	5	6	15857	1493,67	0,05	26,51

Scenario selection based on utility parameters and service time, therefore interpreted each parameter to compare which scenario is best. The parameters ranging from total box, service time, docking utility, and yard occupancy ratio that have been tested also have a difference from the output value. The results of each parameter interpretation can be explained as follows:

3.1 Scenario of Total Box

In (Figure 6) the addition of a docking gate to each yard will affect the arrival of the container box to be processed. As more yards are added, container reception will decrease. That is because the length of the selection of yards based on existing capacity. Besides the arrival of the container box will also affect the service time or unloading work time. If more and more total container boxes arrive, the loading time will also be longer.

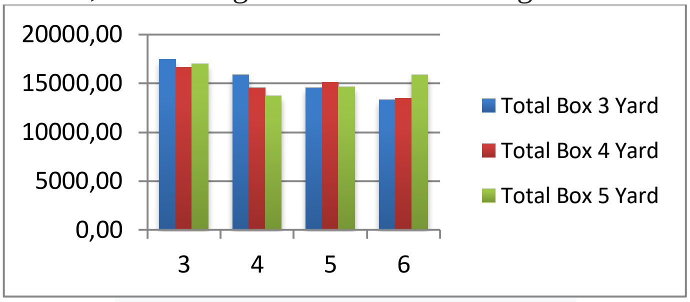

Figure 6. Total Box Comparison Chart

3.2 Scenario of Service Time

In (Figure 7), the graph for the addition of docking gates and yards affect the length of unloading work (hours). The more docking gates and the number of yards that will be used, the service time for loading activities will decrease. No less significant difference is also influenced by the arrival of container boxes as well. The same example also applies to the use of 6 docking gates with 5 yards, where service time increases due to the arrival of container boxes also increase under these conditions.

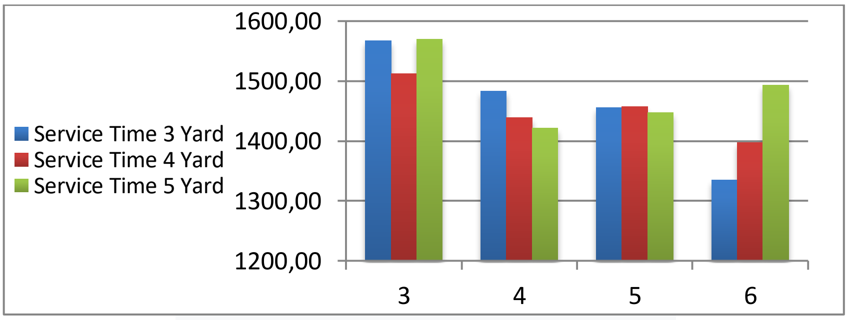

Figure 7. Service Time Comparison Chart

3.3 Scenario of Dock Utility

In (Figure 8), the picture shows the use of docking gate facilities will affect the percentage value of the facility as well. The less docking gate facilities are used, the higher the percentage of utility will be. That is because the docking gate facility often accepts incoming boxes. In addition, container box receipts also influence the percentage value of utilities where more box containers come, the value of docking gate utilities also increases.

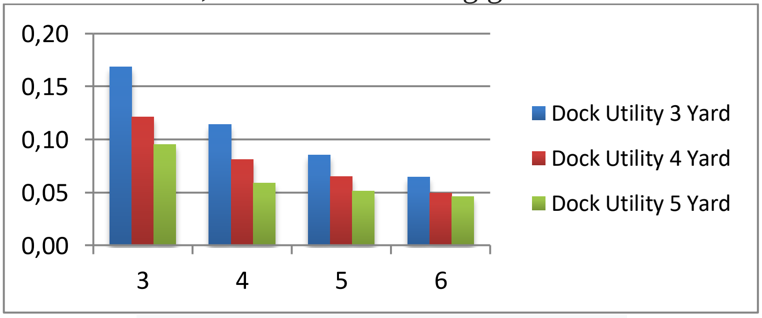

Figure 8. Dock Utility Comparison Chart

3.4 Scenario of Yard Occupancy Ratio

In (Figure 9), based on the yard occupancy ratio graph at below, it can be concluded that the more yards used, the value of utility percentages will decrease. The optimal use of yards based on the graph above or only on the use of 3 yards has the highest utility value.

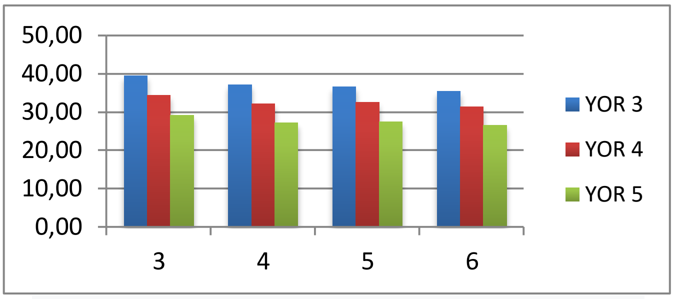

Figure 9. Yard Occupancy Ratio Comparison Chart

4. Conclussion

From the scenario results obtained for each addition of the docking gate will affect the service of container box reception and loading time. The calculation result is obtained the optimal number of uses by using 4 docking gate facilities in each yard. Based on the results of the scenario that has been made, the use of yards does not have to be all required yards. Scenario A4 has a high yard utility with low service time. This explains the use of yards which used to be 5 will be reduced to 3 yards with the use of docking gates amounting to 6. The consideration of selecting the above scenario is based on 2 important parameters, namely utility and service time. Although Scenario A1 has the highest utility, consideration of service time results has suboptimal results. So scenario A4 has the best output compared to scenario A1. Here describes the work time (service time) will affect the waiting time or service time for the process of receiving containers.

5. References

[1] Dewa, M, and Chidzuu. L., 2013. *Managing Bottlenecks In Manual Automobile Assembly Systems Using Discrete Event Simulation. The South African Journal of Industrial Engineering*, 24(2), pp. 155-166.

[2] Nurminarsih, S., Rusdiansyah A., and Maulin, M.P., 2018. *Space-Sharing Strategy for Building Dynamic Container Yard Storage Considering Uncertainty on Number of Incoming Containers. Journal Industrial Engineering*, 19(2), pp. 67-74.

[3] Siswanto, N., Kurniawati, U., Latiffianti, E., Rusdiansyah, A., and Sarker. R., 2018. *A Simulation study of sea transport based fertilizer product considering disruptive supply and congestion problems. Asian Journal of Shipping and Logistics*, 34(4), pp. 269–278.

[4] Siswanto, N., Wiratno, S.E., Rusdiansyah, A., and Sarker. R., 2019. *Maritime inventory routing problem with multiple time windows, J. Ind. Manag. Optim.*, 15(3), pp. 1185–1211.

[5] Yuan, Z., Peilin, Z., and Chuanbo, Y., 2010. *Research on the Simulation of Industry Port Raw Material Terminal. International Conference on Computer Design and Applications (ICCDA)*, 5(1), pp. 108-133.