GROSTLOG 2021
Global Research on Sustainable Transport & Logistics

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/altr

EVALUATING COST-EFFICIENT QUEUE PRIORITIES FOR BERTH ALLOCATION VIA SIMULATION

Nur Syaza Izurin Zolkefley[1], S.Sarifah Radiah Shariff[2], Abdul Khabir Rahmat[3] , Muhamad Safuan Shamshol Bahri [4]

1. 2.3. 4. Malaysia Institute of Transport (MITRANS)
Universiti Teknologi MARA, Shah Alam, Selangor,
Malaysia

2. Centre for Statistics and Decision Science Studies,
Faculty of Computer and Mathematics,
Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia

3. Faculty of Business Management, Universiti Teknologi MARA,
Puncak Alam, Selangor, Malaysia

4. School of Logistics, The Ship Campus,
Peninsula College Northern Sdn Bhd, Penang, Malaysia

✉ corresponding author: shari990@uitm.edu.my

Abstract: Maritime transportation has become very important mode of transportation with the increase of volume traded regionally and internationally. It has become a challenge to port operators in maintaining its efficiency in operations. This is because failure in delivering the expected services to the shippers will result in no visits, higher operation cost, loss of revenue and business. This study focuses on analysing process of berth allocation of tankers in selected Malaysian port in which waiting time and demurrage cost incurred are used as the decision variables. The current berth allocation process and the queue is analysed and improved. The improvement model proposed the arrival time to be the based for queueing decision and simulated for one year. The result shows that the model can improve the waiting time by 17 percent and at the same time reduces the total demurrage cost incurred by 21 percent.

Keywords: Berth Allocation, Simulation, Waiting Time, Queue priorities, Tanker Vessel

Introduction (Include Literature Review)

Maritime transportation is one of the most important forms of freight transportation with over billions of tons of goods per year transported by sea. Maritime transportation remains the backbone of global trade and the nation's manufacturing supply chain as more than four -fifths of the world's merchandise trade is done by sea. This reflects developments in the world economy and trade activities. As world economies become ever more globalised and interlinked, international logistics and

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/altr

maritime industries are experiencing challenges as well as enjoying greater business opportunities.

According to Maritime Transport UNCTAD 2019 Report, tanker trade shipments for oil, gas and chemical shipments, accounted for 29.0 per cent of total maritime trade volume. This is consistent with the ongoing shift in the maritime trade structure that is largely rooted in the 1980s as depicted in Figure 1. Over the same period, major bulks, including iron ore, grain and coal, increased by more than half. The world maritime sector continues its economic recovery. Had it not been for geopolitics and tariff battles, 2018 would have given a fantastic start for a good uptick despite the uncertainties brought forth by ballast water management system requirement and the fast approaching 2020 low sulphur fuel oil mandate. Nevertheless, it is still a rising tide and the industry will gain further momentum.

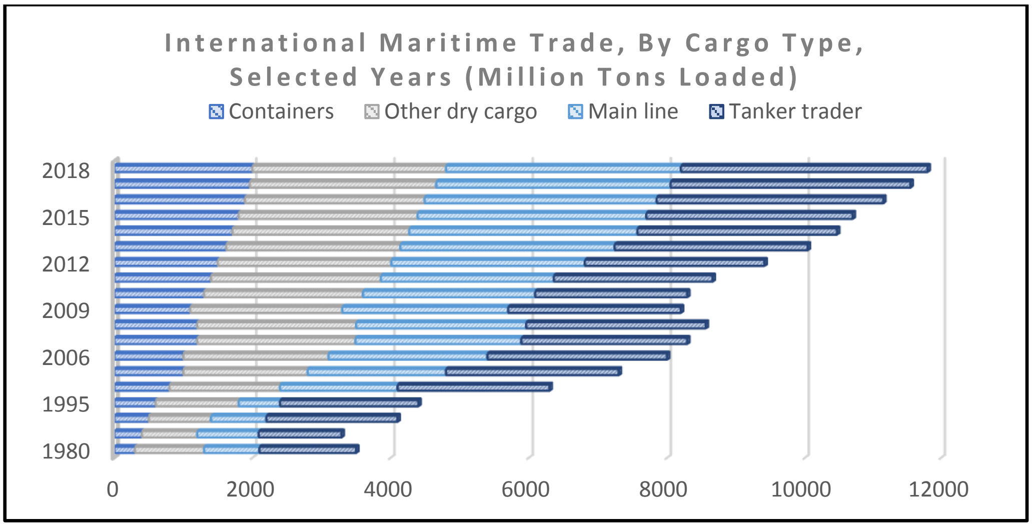
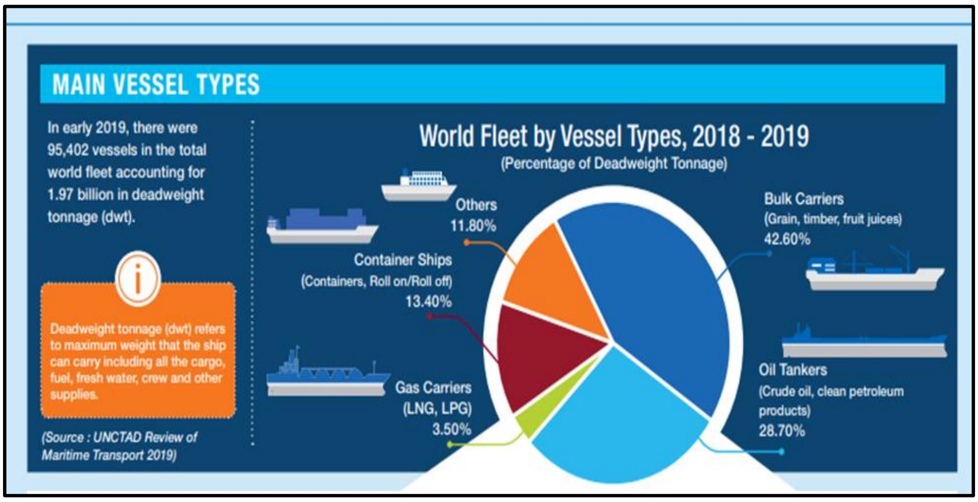


Figure 1. International Maritime Trade by Cargo Type

United Nations Conference on Trade and Development (UNCTAD) in 2019 reported that the tanker market plays a critical role in the supply chain distribution for oil companies and generally involves billions of dollars' worth of freight and demurrage bills every year as in Figure 2. The vessel oversupply situation continued to persist across all sectors in 2019, exacerbated by weak growth in seaborne demand which in turn led to a weak freight market for the tanker industry during most of the year (UNCTAD, 2019).

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/altr

According to 2018, Annual Transport Statistics Report from Ministry of Transport Malaysia, number of ships calling to Malaysian Ports in 2018 was 55,754 in total consolidating Peninsular, Sabah and Sarawak regions. Highest number of incoming vessels to Port Klang, followed by Sabah Ports and Bintulu of Sarawak. This high numbers could be that Port Klang cater 50% of whole Malaysian number of incoming containerized cargoes to Westport and Northport.



Source: Review of Maritime Transport 2019, UNCTAD

Figure 2. World Fleet by Vessel Types for Year 2018-2019

For Malaysian markets itself, liquid tankers is one of those high callings in foreign import export industries. Seen from the statistics above that for foreign going vessels, liquid tankers number comes second after container ships. The berth scheduling problem deals with the assignment of vessels to berth in a marine terminal, with the objective to maximize the ocean carriers' satisfaction and minimize the terminal operational' s cost in timely and monetary wise. In the berth scheduling problem, vessels arrive at a port and the terminal operator assigns them to berths for unloading and loading of containers based on several factors and considerations (Imai (a) et al., 1997; Imai (b) et al. 2001; Imai (c) et al. 2005).

The competitiveness of ports such as Tanjung Pelepas and Klang could be observed with waiting times of 2.2 hours and 2.4 hours, respectively. The average waiting time at Tanjung Priok, which attracted mainline calls in 2017, was also 2.4 hours. Despite the strategic locations along the Straits of Malacca, Malaysian ports continue to play second fiddle to Singapore's terminals. The lack of a national strategy to coordinate the ports is one of the major reasons why Port of Tanjung Pelepas (PTP)

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/altr

and Port Klang continue to play bridesmaids to Singapore. According to analysts and observers, lagging of performance due to the slow progress of capacity expansion at Malaysian ports (The Edge Markets, 2019).

As the transaction volume increases, every port experiences shortness in capacity that results in ships experiencing increasing waiting times in queue before mooring in a given berth (Wanke, 2011). When this happens, demurrage costs occur. Demurrage costs are the waiting charges levied by ship-owners if their ships are not loaded or unloaded within a specified time. Inefficient port operations can result in “not visited “by vessels and loss of income for port operators as well as for the country. Hence, in this study an improvement model to smoothen the berth allocation process at the selected port is proposed for more efficient process.

Method

In this study, we build a simulation model, in which actual data is collected to gather valuable information needed. Besides, at this stage, any issues encountered by the assembly can be easily identified and Figure 3 displayed the current operations process for vessel to queue for berthing at terminal port. In the process, it starts with the arrival announcement of vessel to notice the terminal on the arrival. So that, terminal to provide the berth allocation policy to the vessel master and to their agents for them to get indication on the berthing prospect as well as for their readiness to book pilot to bring the vessel to terminal jetty.

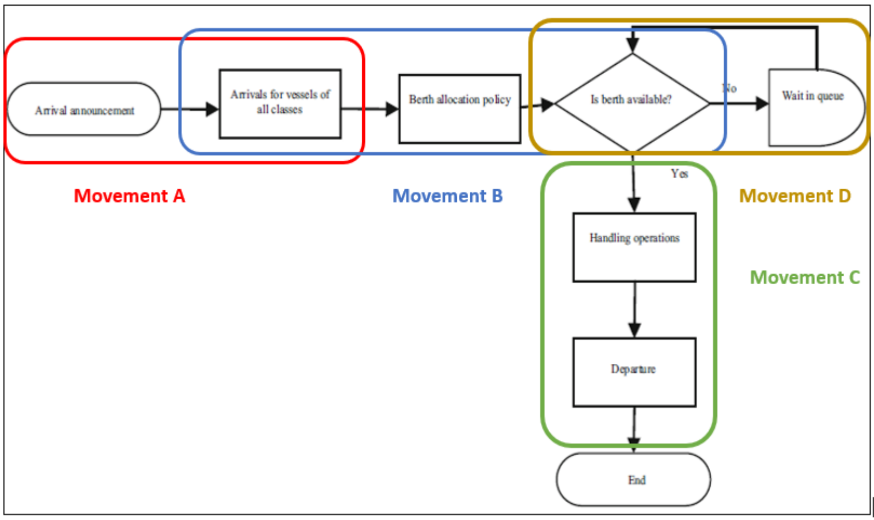


Figure 3. Process of vessel berthing operations at terminal

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/altr

Figure 4 encompassed of one-year data of incoming vessels to Port X starting from early January 2019 to the end month of December 2019. The data also consolidated the vessels of Import and Export total demurrage which incurred at Port X. The monthly increase in total demurrage incurred can be seen in Figure 4 when the data trend shows the awaiting hours and demurrage incur is positively correlated.

In this berth allocation process, it starts by the arrival notices of vessels belonging to product carried or to carry. To aid decision makers, the simulation model is designed to provide a high degree of flexibility with a good level of parameterization. Several related parameters are included as the input of the simulation model such as arrival schedules, vessel size, product loads, and handling rates. Parameters are related with preference defined for vessels. Altering one or more of these parameters will have an impact on the whole system and consequently on the results reported to the user.

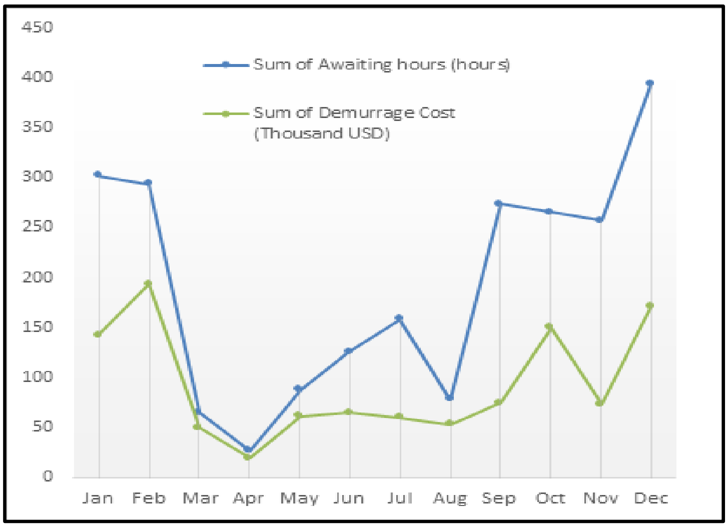


Figure 4. Sum of Awaiting Hours and Demurrage Incurred for Year 2019

Each parameter has its own effect, hence, cargo size carried is commonly considered in determining and evaluting the handling rate. This is because the longer time it takes to finish load or to unload cargoes will exceed the laytime chartered. This method is exercised in some jetty where berth dedicated priority is according to smaller cargo size. This is when port managers factor in this policy as to avoid the next awaiting vessel from longer wait and total demurrage rate can be lesser due to less awaiting time. Vessel classifications may be based on vessel size or TEU volumes. Vessel size is often

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/altr

closely correlated by the demurrage rate with per day prorated. Hence, port managers may opt for giving higher priority to bigger vessel as the longer waiting time will incur more demurrage with higher rate incurred.

The Model

The objective of this study is to propose feasible allocating strategy that improves efficiency of berth **allocation in minimizing demurrage** and other relevant costs. Simulation is conducted by using PROMPT software as the tool to calculate the demurrage. In order to find the consistency and reliability of the date, Monte Carlo methods is applied to get repeated random sampling to obtain numerical results.

To build a simulation model in the PROMPT Shipping Software Laytime Calculator, there is a bunch of data that need to be collected beforehand:

- ✓ Vessel name and voyage no
- ✓ Identify the operation as loading or discharging
- ✓ Demurrage rate
- ✓ Cargo quantity
- ✓ Loading/ Discharging rate
- ✓ Vessel arrival time
- ✓ Notice of Readiness tendered time
- ✓ Vessel berthing time
- ✓ Vessel commence loading/ discharging time
- ✓ Vessel complete loading/ discharging time
- ✓ Documents on board time
- ✓ Vessel sail off time
- ✓ Interruptions and exceptions (if any)

Nevertheless, some assumptions and constraints need to be set up so that the simulation can be customized to real-world system and assigned values and constraints to the variable that can be controlled. The constraint of the simulation model and assumptions of this research can be of:

- o Each awaiting time is dependent within one another
- o The mooring activities of the vessel to the jetty is done by the terminal crews manually that there is no idle time in between the activities.
- o Vessel berthing allowance is subject to many factors including of those related to port authorities and vessel readiness
- o In real scenario, it is expectable to have stoppages in between activities as in the line displacement, vessel shifting, bad weather, terminal or vessel issues and many more

- Laytime calculation in this study is basis allocation at subject port only and not countering against the credits received by prior or after ports
- Actual operational time is dependent to the vessel and terminal capability

To address the mentioned questions, a series of iterations with the main factor queue priority was developed and conducted, in order to assess their impact on the time a ship spends in queue. For this purpose, the ship-berth link operation of a Malaysian oil terminal, Port X was modeled. Port X is a coastal-tanker terminal, with only one berth that can allow calling of maximum length overall of 170.0 meters and maximum permissible draft of vessel allowed at 9.0 meters. The layout of this oil terminal is depicted in Figure 5.

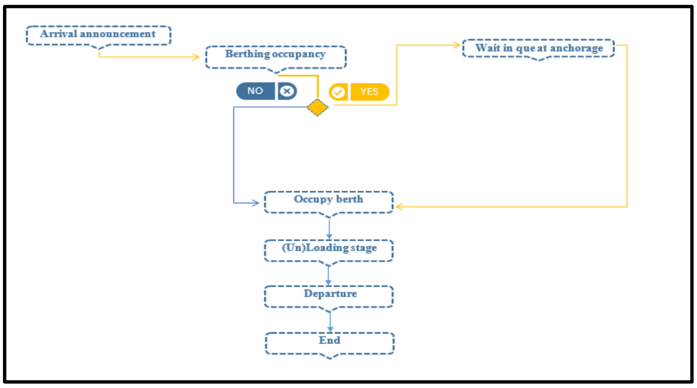


Figure 5. Simulation Model of dedicated berths according to ship arrival time

Discussion and Result

In improvement model, the first step will involve modelling of ship arrival function. The arrival of a ship in a port is unpredictable, and even when it is scheduled, it can be delayed, (JOC, 2018). The arrival pattern of ships follows an exponential distribution, (Esmer et. al., 2013). In order to get average number of ships for a given time period the arrival pattern should be known which can be evaluated by waiting line Poisson model. This Poisson model gives a probability distribution of the arrival of ships in port for a given time period and is expressed as follows, Ozkan et al., (2020).

In this study the queuing model is established for whole year. It is more realistic to look at the pattern of calling vessels and products since there will be the terminal shutdown due to maintenance which occur once every year depending on the terminal facilities requirement. In this event, there will be less shipment and high probability of zero demurrage.

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/altr

From Table 1, it can be seen that the Actual average arrival rate / month = 14.08 ships / month with the Actual average of cargo handled at Port X-2019 = 968.50 kilo barrels / month. The Average cargo handling per ship / per month = 68.77 kilo barrels / month. In the view of demurrage cost per handling ship, we can see the; Actual average demurrage cost / month = USD 93,013.42 / month. This conclude that Average demurrage cost / per handling ship / per month = USD 6,604.50 per ship / month. Next, in the view of ship awaiting hours to berth in que per handling ship, we can see that the Actual average awaiting hours / month = 193.96 hours / month. That makes Average awaiting hours per handling ship / per month = 14hours / month.

Improvement Model

Under this improvement model, vessels are served at first come first served basis according to their turn although a huge backlog of vessels guarantees a high berth occupancy rate for every port, but a large queue reduces productivity, causes berth allocation problems, and creates demurrage charges. However, this model is seen as more economical as it is intended to reduce ships queues and waiting times at anchorage which will benefit customers and total supply chain.

Table 1. Actual Demurrage Data Year 2019

Month	Demurrage Cost (USD)	Awaiting Hours (hours)	No of Ship	Total Cargo Size (KB)
Jan	142,282.99	302	16	1,122
Feb	193,925.14	294	14	933
Mar	49,723.89	65	10	695
Apr	19,877.22	27	14	943
May	61,639.03	88	14	888
Jun	65,390.63	126	13	884
Jul	60,392.64	158	14	929
Aug	53,126.94	78	15	978
Sep	75,099.72	273	12	1,080
Oct	149,935.90	265	14	970
Nov	73,716.25	257	15	1,002
Dec	171,050.69	393	18	1,198
Average	**93,013.42**	**194**	**14**	**969**

Despite the costs that will most likely be paid as a result of other ships waiting in line, first come first serve model is seen as the most unbiased method which does not prejudice to any parties.

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/altr

The result from the Improvement model is summarised in Table 2. In the view of demurrage cost per handling ship, it can be seen that the Average demurrage cost / month = USD 72,891.99 / month in which the Average demurrage cost / per handling ship / per month = USD 5,175.76 per ship / month. Next, in the view of ship awaiting hours to berth in queue per handling ship, the Actual average awaiting hours / month = 161.11 hours / month and Average awaiting hours per handling ship / per month = 11hours / month.

Table 2. Simulation Result from Improvement Model

Month	Demurrage Cost (USD)	Awaiting Hours (hours)	No of Ship	Total Cargo Size (KB)
Jan	75,593.75	207	16	1,122
Feb	220,694.68	380	14	933
Mar	38,757.13	65	10	695
Apr	19,877.22	27	14	943
May	10,298.33	7	14	888
Jun	62,189.58	89	13	884
Jul	60,392.64	158	14	929
Aug	12,988.82	45	15	978
Sep	75,099.72	273	12	1,080
Oct	119,393.33	197	14	970
Nov	54,310.00	185	15	1,002
Dec	125,108.71	299	18	1,198
Average	72,891.99	161.00	14.08	968.50

Conclusion

Allocating the vessels for berthing can be a complex problem considering many factors that actually affect the waiting time when it arrives the port. One of the most effective ways is for the port authorities to prepare for expansion with regards to increase in volume in maritime transportation. However, that is the last solution and takes a lot of effort. Hence, in this study, the allocation process is being revisited and simulated for its effect.

The improvement model that considers the arrival time of each vessel with no regards to its size or cargo type, is simulated for one year. This model has managed to reduce the waiting time from 194 hours to only 161 hours only or a decrease of 17 percent. In terms of total demurrage cost, the improvement is bigger when total cost reduces to USD72, 891.99 from USD93,013.42 or 21.6 percent.

Acknowledgements

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/altr

We would like to acknowledge Malaysia Institute of Transport (MITRANS) UiTM Shah Alam for funding this study and presentation.

References

https://unctad.org/webflyer/review-maritime-transport-2019 (downloaded on March 12, 2020)

Guan Y., and Cheung R. K. (2004) The Berth Allocation Problem: Models and Solution Methods. *OR Spectrum*, Vol. 26, pp.75–92.

Imai (a) A., K. Nagaiwa and C-W Tat.(1997) Efficient Planning of Berth Allocation for Container Terminals in Asia. *Journal of Advanced Transportation*, Vol. 31, 1997, pp. 75–94.

Imai (b) A., E. Nishimura, and S. Papadimitriou.(2001) The Dynamic Berth Allocation for a Container Terminal. *Transportation Research Part B*, Vol. 35, pp. 401-417.

Imai (c) A., X. Sun, E. Nishimura, and S. Papadimitriou. (2005) Berth Allocation in a Container Port: Using Continuous Location Space Approach. *Transportation Research Part B*, Vol. 39, 2005, pp. 199–221.

Özkan, E. D., Koçer, U. U., & Nas, S. (2020). Statistical analysis for modeling ship operation processes in ports. *Zeszyty Naukowe Akademii Morskiej w Szczecinie*.

Esmer, S., Yildiz, G. & Tuna, O. (2013) A New Simulation Modelling Approach to Continuous Berth Allocation. International Journal of Logistics Research and Applications 16(5), pp. 398–409.

https://www.joc.com/port-news/terminal-operators/ocean-reliability-woes-fluster-us-import-pick-predictability_20180815.html (donwloaded on March 17, 2020)

https://www.theedgemarkets.com/article/lacking-national-strategy-malaysian-ports-lose-out-singapore (downloaded on March 17, 2020)

Wanke, P. (2011). Ship-berth link and demurrage costs: evaluating different allocation policies and queue priorities via simulation. *Pesquisa Operacional*, *31*, 113-134.