JOURNAL OF ENGINEERING AND MANAGEMENT IN INDUSTRIAL SYSTEM VOL. 6 NO. 2 YEAR 2018

e-ISSN 2477-6025
DOI:10.21776/ub.jemis.2018.006.02.2

DYNAMIC YARD TEMPLATE DESIGN TO IMPROVE UTILIZATION AND OPERATION EFFICIENCY ON VERTICAL LAYOUT-CONTAINER YARDS CONSIDERING UNCERTAINTY OF TRUCK ARRIVAL

Siti Nurminarsih[1], Maulin Masyito Putri[1], Ahmad Rusdiansyah[2]
Department of Logistics Engineering, Universitas Internasional Semen Indonesia[1]
Department of Industrial Engineering, Institut Teknologi Sepuluh Nopember[2]

Abstract *Loading containers into a vessel can be delayed because of inefficient processes in the container yard. These container yard inefficient processes can be caused by inappropriate stacking position and inefficient crane operation. Inappropriate containers stacking positions may need some preparatory jobs of rearranging containers ahead of loading time to reduce delays in the process. The method will allow preparatory jobs to be scheduled together with main jobs to optimize use of the idle time of Automated Stacking Cranes (ASC). This research aims to find a better scheduling strategy of twin ASCs as well as improving land utilization in a vertical-layout container yard to minimize delays in containers loading process. The uncertainty of truck arrival is accomodated by implementing iterative rescheduling in look-ahead planning horizon. The algorithm finds the optimal position of the container in the yard by implementing scoring function for each available slot. Finally, some numerical experiments are conducted to prove the performance of the algorithm.*

Keywords: *Vertical Layout-Container Yard; Land Utilization; Iterative Rescheduling*

1. Introduction

International trade is growing during the economic globalization era. The growth of international trade brings along an increase in utilization of maritime logistics as the main means of transportation to distribute goods across countries. Being passed by 40 percent of maritime global trade route, making Indonesia as an important part of international trade. That means Indonesia should prepare their logistics infrastructures to be efficient and reliable for serving the operations. Unfortunately, Indonesian performance on logistics is still lacking and being ranked as 46th out of 160 countries surveyed by World Bank in 2018 [1]. The logistics performance score of Indonesia, which is 3.15, is lower than other neighborhood countries such as Singapore (4.00), Thailand (3.41), Vietnam (3.27), and Malaysia (3.22). This will be disadvantage for Indonesia to compete globally in economics.

* Corresponding author. Email : siti.nurminarsih@uisi.ac.id
Published online at http://Jemis.ub.ac.id

Based on this issue and the challenge of global economics growth, the government of Indonesia set up the Masterplan for The Acceleration and Expansion of Indonesia's Economic Development (MP3EI) 2011-2025. One of the important elements of this program is to enhance connectivity between regions in Indonesia and internationally through maritime transportation systems. Each region in Indonesia has different part in economic, based on their potentials, and connected by maritime transportation routes called "Sea Toll Road" [2]. These routes connect regions in Indonesia using hub and feeder concept. By this program, the transportation access to all regions in Indonesia will be available regularly on definite schedules.

The impact of international trade growth and Sea Toll Road program increases the container traffic among ports in Indonesia. Ports should improve their infrastructure and operational efficiency to deal with this increasing traffic. In fact, the average dwelling time of ports in Indonesia is above 3 days [3]. Dwelling time is defined as the average time of container being in the port. The causes of this long dwell time are the complicated bureaucracies, the scarcity of land for container yard and a container transfer inefficiency during loading process [4].

Cite this Article as Nurminarsih, S., Putri, M., & Rusdiansyah, A. (2018). DYNAMIC YARD TEMPLATE DESIGN TO IMPROVE UTILIZATION AND OPERATION EFFICIENCY ON VERTICAL LAYOUT-CONTAINER YARDS CONSIDERING UNCERTAINTY OF TRUCK ARRIVAL. Journal of Engineering and Management in Industrial System, 6(2), p74-85.
Paper Accepted : Nov, 17th 2018
Paper Published : Dec, 31st 2018

e-ISSN 2477-6025
DOI:10.21776/ub.jemis.2018.006.02.2

Operational constraints at the container yard are usually caused by a scarcity of the land and infrastructure in the port. An efficient yard management is needed in the condition of increasing demand and the scarcity of the land and infrastructure.

To implement an efficient yard management, it is important to generate yard template which can respond to uncertainties of operational condition. Yard template is a guideline of yard operator to determine the position of incoming container on the yard. The yard template of vertical-layout container yard should be dynamic because the position of containers can change all the time while in container yard. This research developed an algorithm for determining dynamic-yard template while considering the scheduling of ASCs and optimizing space utilization. The rest of this paper is organized as follows. Section 2 provides the literature review. Section 3 details the methods of the problem. Section 4 explains the numerical experiments and results. Finally, section 5 gives conclusion and possible future development of the research.

2. Literature Review

Several studies have been conducted to find better method and approach of yard management. Most of the research focus on the factors that cause inefficiency in the yard area, including the number of containers reshuffle and traffic congestion. Yard planner put containers on the yard based on position spesified on the yard template. The quality of yard template planning affects the efficiency and productivity of container handling. Generally, a yard template is made in the planning phase when the ship had not arrived yet. Whilst when it comes to the operating phase, some adjustments are often made to the original layout because of high uncertainties, such as the arrival of the ship, the arrival of the truck, and the volume to be transported. To improve the efficiency, planning at the container yard should consider the uncertainties that occurs during operation level [5].

To improve efficiency in the yard area, Lee et al. [6] combined the optimization of the reshuffle and traffic congestion to make yard planning of transshipment containers. A consignment strategy has been introduced to minimize reshuffle by locating export and transshipment containers at the certain area dedicated for the ships. The probablity of traffic congestion has been minimized by implementing "High Low Workload Traffic Balancing Protocol". A mixed integer linear programming (MILP) then developed to determine the crane scheduling. The implementation of dedicated-yard area increases container accessability, but on the other hand also decreases yard utilization because of empty spaces that arise due to the absence of containers. In 2012, Jiang et al. [7] continued the research by suggesting the space-sharing concept as the solution to the lack of yard utilization that caused by the implementation of consignment. Jiang et al. [7] created a framework for allocating space-sharing plan for each ship arrival. However, this research worked at the planning level where uncertainties in the operational level are ignored.

Uncertainties are often occured at the operational phase, for example due to delays in operations at the previous port, weather, arrival of external trucks, and number of receiving and delivering containers. The longer the vessel's path, the higher the level of uncertainty. A few studies have examined port operations under uncertain environments [8]. Most of them studied the impact of vessel arrival time and operation time in quay or berth areas. Han et.al [9] and Zhen et.al [10] studied about berth allocation and quay crane scheduling problem under those uncertainties. At the yard areas, Zhen [5] addressed on the problem of planning a robust yard template considering uncertainty in number of receiving and delivering containers. These uncertainties affect the determination of sub blocks in container yard (CY) which are assigned in fully-dedicated or sharing mode for each vessel. In this research, vessels are scheduled to visit the port periodically (weekly, 10-days, or biweekly). The number of receiving and delivering containers from (or to) a vessel also fluctuates in each period. The traffic congestions in the yard and multiple schedule cycle time for vessel arrival pattern are also considered in the developed model. Both of Jiang et al. [7] and Zhen [5] developed method to optimize the utilization of horizontal layout-container yard which is commonly used in Asian ports. The operational of vertical layout-container yard is different with horizontal layout. It is hard to determine the dedicated area on the yard for certain vessel because the containers are moved several times at the yard since arrival until departure.

The movement of the container on the vertical layout-container yard can be divided into three types of movements. The first one is movement that occurs when container first arrives at the yard, both carried by external truck or AGV. Next movement is rehandling. This movement is needed when the container to be retrieved next is not at the top of a

e-ISSN 2477-6025
DOI:10.21776/ub.jemis.2018.006.02.2

stack which causes relocation of all containers above the target container. Rehandling is the major source of loading delays [11]. Another factor that causes delay is the traveling distance of ASC to move container to be loaded. To minimize loading delays due to these two factors, the third type of movement arises, namely remarshaling. Remarshaling rearranges the containers in some appropiate ways well ahead of their loading time [11]. Park et al. [12][13] suggested the remarshaling jobs that contribute the most to the reduction of future loading delays to be selected for the mix of job queue. Therefore, starting and stoping time of remarshaling jobs should be determined manually and not yet scheduled together with the current requested jobs. Later in 2013, Choe et al. [11] proposed method to schedule the twin ASCs in such a way that the remarshaling jobs are performed intermittently while the ordinary requested jobs are performed. Adopting the predetermined fixed-length look-ahead horizon in a regular interval framework by Park et al. [14], the remarshaling jobs are mixed to the requested jobs unless the load of requested jobs is heavy. The objective function of this method is to minimize the total waiting time of external truck, delay of AGV, and total makespan of the schedule. The utilization of space is not a major consideration in this research.

Previously, Nurminarsih et al. [4] has been developed a sharing-area framework for vertical layout-container yard under uncertainty of the arrival of containers which is adopting the method developed by Jiang et al. [7] and Zhen [5]. The research is developed based on real situation in one of port in East Java, Indonesia, which implement vertical layout-container yard. The uncertainty of container arrival is translated into container arrival probability during the slot opening horizon, 5-days ahead the vessel arrival schedule. This probability is based on historical data of container arrival. Nurminarsih et al. [4] only introduced the framework and method for implementing the space-sharing concept without considering the movement of ASC. This research aims to develop the previous research of Nurminarsih et al. [4] by taking into account the scheduling of ASCs. Model for scheduling ASCs is adopted from Choe et al. [11] while adding the consideration of space utilization as the outcome of sharing-area concept.

3. Methodology

3.1 Operation in Vertical Layout-Container Yard

Vertical layout-container yard is often called the European Layout, because this layout is generally used in European container ports. In the vertical layout-container yard, the yard has blocks positioned perpendicular to the quay (see Fig. 1) and the I/O points are located at both ends of the blocks to handle storages and requests from the seaside and landside [15]. Based on the the direction of flow, the containers handled on the yard terminal can be categorized into three groups: export, import, and transhipment containers. An export container carried in by external truck (ET) and being stored in the yard until the arrival of carrier ship, the container then being moved from the yard and loaded into the ship by Quay Crane (QC). On the contrary, the import container carried in to the yard by Automated Guided Vehicle (AGV) after being unloaded from the ship by QC. The import container will be stored at the yard until carried by ET. A transhipment container is also unloaded from ship and carried in by AGV to the yard, but the container will be carried out again by AGV to be reloaded to another ship instead of being carried out by an ET.

The movements of a container in the yard are handled by Automated Stacking Crane (ASC). There are two identical ASCs for each block in the yard, namely seaside and landside ASC. Seaside ASC works on the quay side, assigned to deliver (or take) a container to (from) AGV. On the other hand, the landside ASC is assigned to carry in (out) a container to (or from) yard from (or to) an ET on the landside H/P. Because the size of both ASCs are identical, the ASC cannot move through each other and separate by a transfer area which is called handshake area. Unlike the transhipment container, both import and export container enter a block through one end of a block and go out through the opposite end of the block, this means that both import and export container cannot help being handled by both seaside and landside ASC. The job of moving container from landside H/P to the yard or vice versa is called lanside job. While the job of moving container from seaside H/P to the yard or vice versa is called seaside job. Both landside and seaside job are categorized as main job to differentiate it from preparatory job: rehandling

e-ISSN 2477-6025
DOI:10.21776/ub.jemis.2018.006.02.2

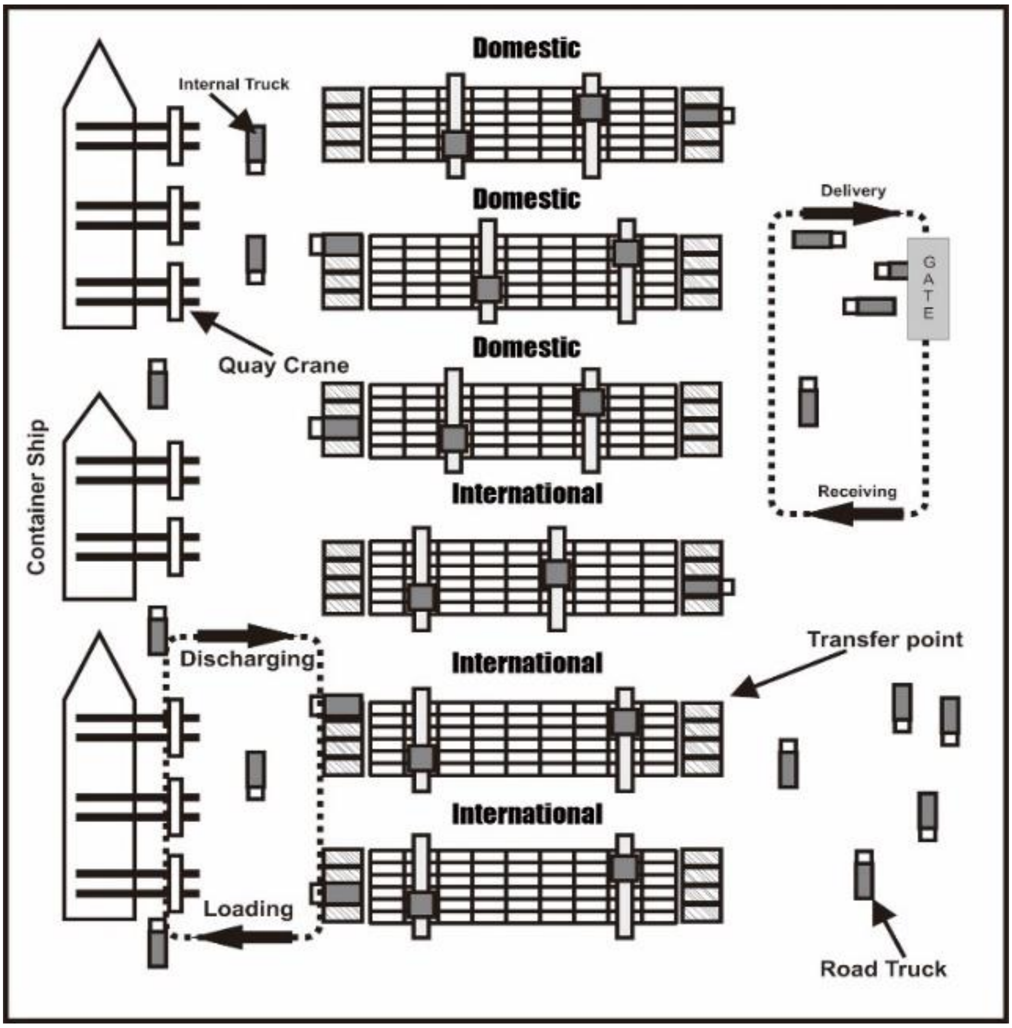

Fig 1. Container Yard Configuration

and remarshaling. The main job is given top priority to be done by an ASC, unless some preparatory jobs are needed, for example the targeted container is not on the top of the stack so some rehandling jobs are required to be done first. The efficiency of loading operation is considered the most critical to the productivity of the whole terminal because the berthing time of a ship depends on how fast the containers are loaded [11].

In this research, we observe one of international container port in Indonesia which has yard area consists of 6 blocks: 3 blocks for domestic shipping and 3 blocks for international shipping. Each block consists of 9 containers width (row), 39 containers length (bay), and 5 container stacking height (tier). One slot container can accommodate one 20-feet container. Figure 1 shows the configuration of container yard in this port.

This port implements consignment strategy, which the agent books some slots for upcoming vessel 6 days prior to vessel departure. The booked space in the yard will be assigned to a vessel for 5 days before the vessel departure. From the provided data, we obtain that higher workload of incoming containers always happen near vessel departure date, even some containers arrive when ship is already docked. The distribution of the container arrival follows pattern as shown in Figure 2. This behavior leads consignment strategy produce high inefficiencies in the operation because of the unoccupied booked spaces. In fact, the real arrival containers sometimes different from the booked containers. Because of this problem, yard operators usually open less than 100% of the booked spaced on early booking day. At first, 30% of the booked spaced are opened and the percentage of opened booked space will be added if the incoming containers increase [4]. By this strategy, the land efficiency will increase, but some containers for the same vessel may be placed far from others. This will

e-ISSN 2477-6025
DOI:10.21776/ub.jemis.2018.006.02.2

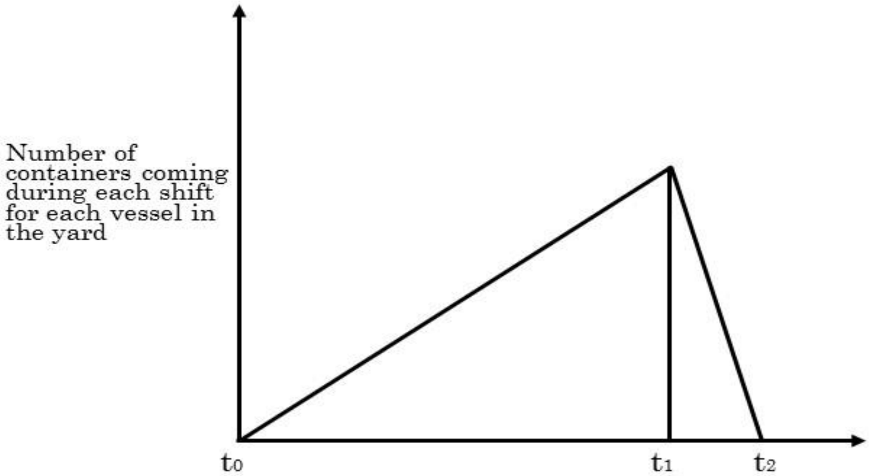

Fig 2. The Pattern of Containers Arrival [7]

cause the inefficiency of yard movements.

In this research, the incoming container will be placed temporary on the handshake area and will be moved later to the landside or seaside area by the remarshaling jobs. There is no special area dedicated to containers from certain vessels (such as in consignment strategies), but containers from the same vessel will always be placed close to each other. Containers from other vessels will tend to be placed in different locations at the yard. This strategy will minimized delay that is caused by rehandling job.

3.2 Real-time scheduling of ASCs

The algorithm of real-rime ASCs scheduling used in this research is developed from Algorithm for Opportunistic Remarshaling (AOR) by Choe et al. [11]. Firstly, the ASC scheduling method sorts out all the landside and seaside jobs within a look-ahead horizon and finds out whether preparatory jobs (rehandling, repositioning) are needed. Then the method performs an optimization search to specify the ASC to perform each of the preparatory jobs, the order of jobs, and the priority in case of ASC interference. AOR adds some remarshaling jobs for the upcoming vessel to be done at any idle time in-between the ordinary jobs. Due to accomodating the uncertainty of the environtment, the outdated schedule is refreshed by iterate this process at short regular intervals.

We follows the iterative recheduling method by Choe et al. [16] in which the process of developing a new schedule is repeated in a predetermined recheduling interval r as indicated in the timing diagram of Figure 3. In the diagram, t_1 is the starting time of scheduling for the jobs in the i-th iteration. The scheduling is made for the next look-ahead horizon h, within s permittable computational time. Therefore, the schedule period is between t_1+s until t_1+s+h. The rescheduling process will be repeated every interval r. The length of rescheduling interval and look-ahead horizon should be determined carefully considering various tradeoffs [16]. As h gets longer, a better scheduling result might be expected because a greater number of future jobs are taken into account. However, longer h demands a larger amount of computational times to generate a schedule, also it is not desirable because the uncertainty at the operational level regarding ET arrival time is very high, thus make the schedule obtained has poor quality. As in the Choe et al. [11], we determine the values of r,h,s are 300, \1800, and 60 seconds respectively.

3.2.1 Job Priority Determination

Before determining the priority, the first step of this method is determining the jobs to be scheduled. The jobs can be divided into main jobs and preparatory jobs. The main jobs include seaside jobs which the expected AGV arrival times are within the look-ahead horizon

e-ISSN 2477-6025
DOI:10.21776/ub.jemis.2018.006.02.2

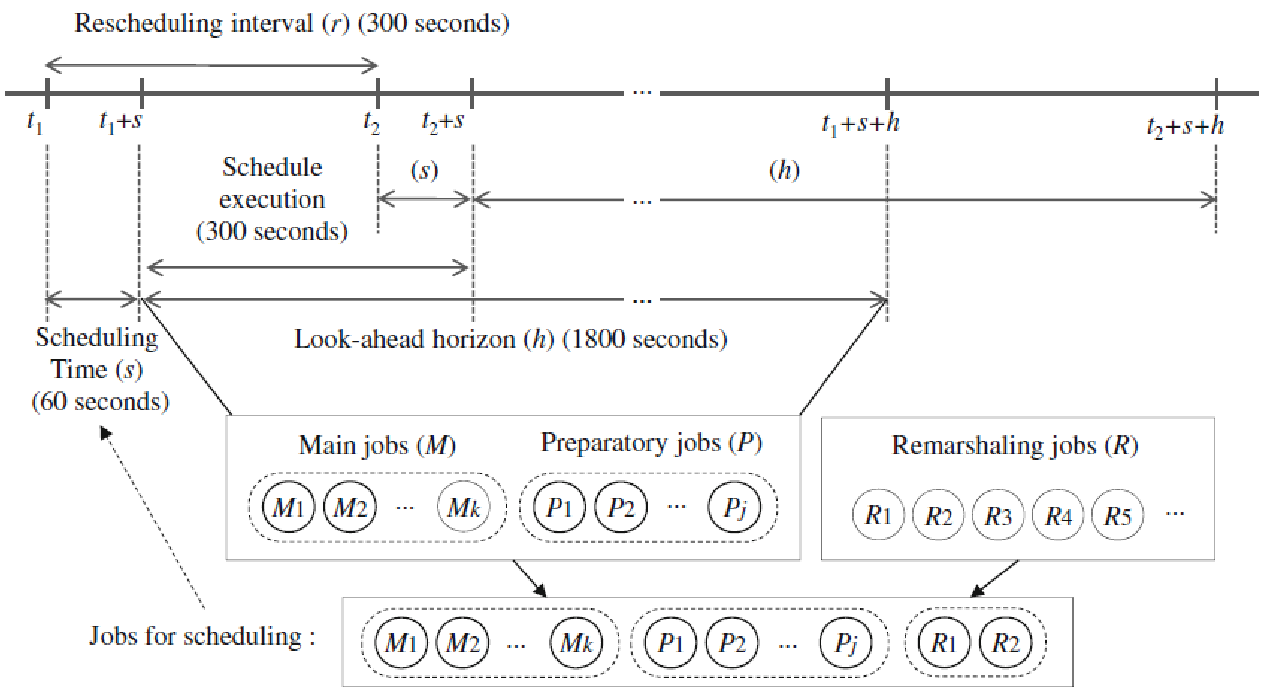

Fig 3. Timing Diagram of Iterative Rescheduling [11]

and landside jobs which the ETs have already arrived at the landside H/P. The arrival of ET is randomly generated to reflect the uncertainty in real system. The preparatory jobs included in the scheduling are the rehandling and repositioning jobs required to be done in order to access the container of the main jobs. If there is still time left on the look-ahead horizon, some remarshaling jobs for upcoming vessel will be scheduled. The seaside jobs are given top priority among all types of jobs, because it is critical of causing the loading delays and affecting the port performance.

For sorting out the list of jobs, firstly we calculate the estimate finish time of each job. To maintain the preparatory jobs are done right before their main jobs, we pair them into a single consecutive job and sum up their processing time. For each determined job, we calculate the difference between expected arrival time of ET/AGV/vessel and the estimate finish time of the job. Then we sort jobs by giving priority to jobs that have the smallest difference. The overall scheduling process can be seen in the flowchart in Figure 4.

3.2.1 Determination of Stacking Locations

This procedure is used to determine the optimal location for container handled in the yard. Several policies to determine the optimal location is modified from Choe et al. [11], which is also modification of previous work by Jang et al. [17]. This stacking policy is required whenever an ASC has to drop a container at some location in the yard. The drop off location can be an empty ground in the block or at the top off every stack which has not reached the stacking limit. As for the stack which has already reached its allowed maximum, the stack has to be filtered out from the list of candidate positions. The stacking location should be determined not only for incoming containers but also for rehandled or remarshaled containers. In this research we limit the problem only for 20ft container and ignore the container weight stacking rule.

We modified the scoring function of Choe et al. [11] by adding function to calculate container similarity. The container similarity function is used to direct container to locations where other containers with similar destinations are located. By implementing this function, the need for preparatory jobs will be minimized because all containers in the same stacking location have similar destination vessel. We eliminate the transshipment function because transshipment process is not considered in this study. The stacking rules for different types of containers in different situations can be seen in Table 1. Each rules of the policy in the table has a scoring function. Given a set of candidate

e-ISSN 2477-6025
DOI:10.21776/ub.jemis.2018.006.02.2

posisitions X, scoring function s_i will determine the

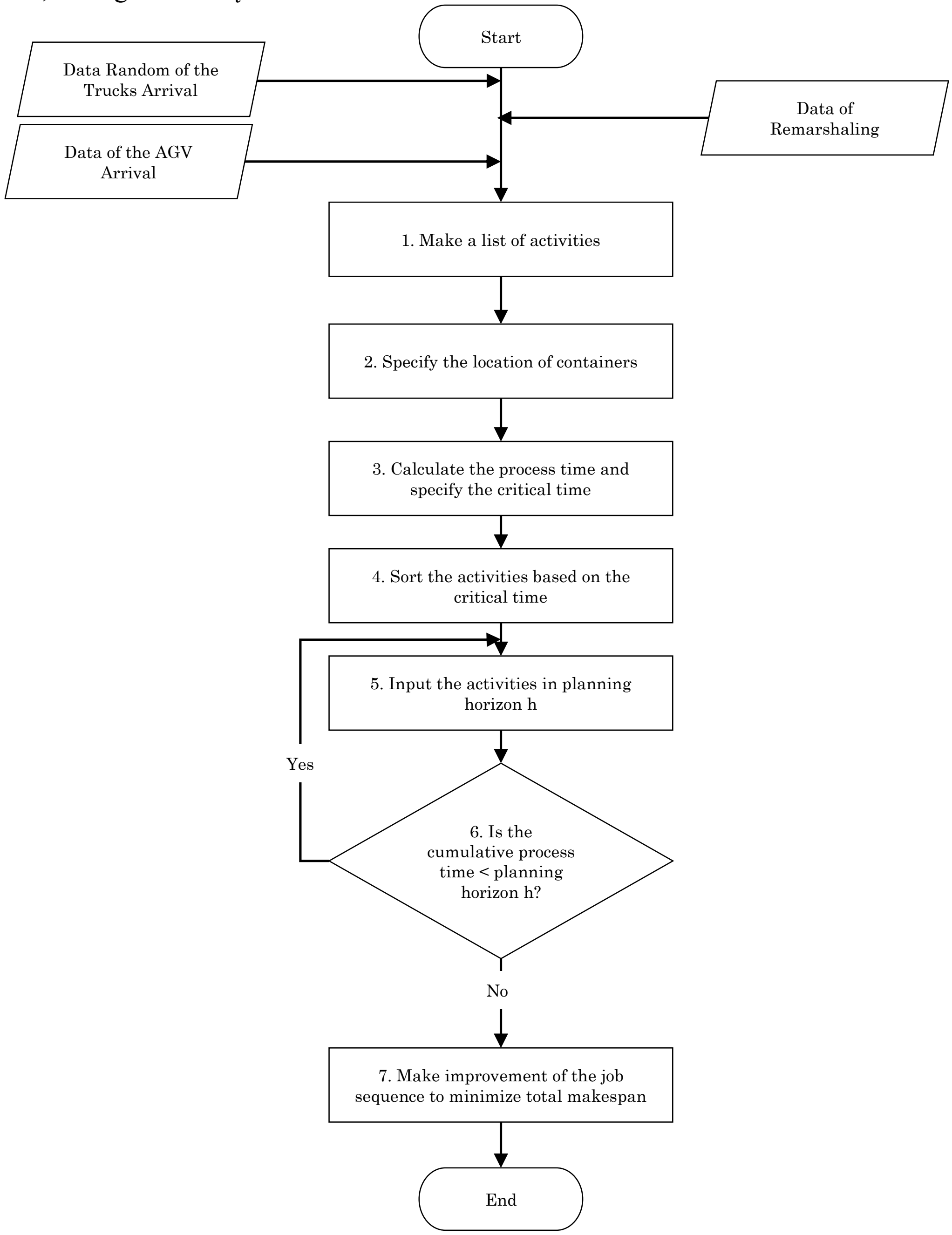

Fig 4. Flowchart of Scheduling Process in CY

best position $x^*$from X. The score $s_i(x)$ of a candidate posisition x is calculated by the weighted sum function below. Where $C_{ij}(x)$ is the evaluation value of position x according to the rule of s_i. The weight of C_{ij} is w_{ij} and k_i is the number of criteria employed by s_i.

$$\boldsymbol{s_i(x) = \sum_{j=1}^{k_i} w_{ij} C_{ij}(x)} \quad (1)$$

Table 1. Clasification of Containers Stacking Rules

Condition	Types of Containers	Evaluation Criteria
Incoming	Import	s_1
	Export	s_2
Rehandling	Import	s_3
	Export	s_4
Remarshaling	Import	s_5

e-ISSN 2477-6025
DOI:10.21776/ub.jemis.2018.006.02.2

	Export	s_6

Evaluation criteria used in the scoring function could better be understood by examining the scoring functions more detail. Following is detail scoring function of S_2 used for incoming export containers:

$$s_2 = w_1 D_1(X) + w_2 D_0(X) + w_3 H(X) + w_4 T(X) + w_5 K(X) \quad (2)$$

Where D_1 is the distance of the current position to candidate position X. $D_0(X)$ is the distance of candidate position X from landside H/P. $H(X)$ is the stack height of candidate position. $T(X)$ is the likelihood of causing rehandling if target container is put on candidate position X. While $K(X)$ is the uniformity score of the candidate position X in which represents the degree of destination similarity with other containers surround it. For all candidate positions X, the value of s_2 is calculated then the candidate position with smallest value is chosen as the optimal position for the target container.

3.2.1 Searching for an Optimal Schedule

After the job-queue for a look-ahead horizon is fixed, the schedule then optimized by swapping the sequence of the jobs to find a combination which gives minimum makespan. The objective function for schedule optimization is the following weighted sum that should be minimized:

$$f = w_1 D_{AGV} + w_2 D_{ET} + w_3 M + w_4 R \quad (3)$$

where D_{AGV} is the average delay of AGVs, D_{ET} is the average waiting time of ETs, M is the makespan, and R is the rehandling jobs. The minimation of D_{AGV}, D_{ET}, and R are obtained in generating jobs phase, while the minimation of makespan is generated from second phase, which is improvement of job queue by swapping the sequence.

4. Experimental Results

The experiment involving a set of vessel arrival data, random ET arrival data, and generated AGV arrival data. The vessel data includes information of date of vessel arrival and the number of containers being loaded or unloaded from the ship. The AGV arrival data generated within the window of vessel arrival and departure, the number of trips is adjusted by the number of containers being carried, both for loading and unloading containers. The available information is AGV arrival time to the yard, type of operation, container code that being handled, and vessel code that being served. Different from AGV, the random arrival data for ET to deliver the container is spread between 5 consecutive days prior the vessel departure. While the arrival of ET for retrieving the import containers is generated randomly after vessel arrival. The information of ET arrival also includes ET arrival time, type of operation, container code that being handled, and vessel code of container destination. Those data are compiled into Input Job data as the input of the scheduling process. Table 2 represents several input jobs for this experiment.

We set the scheduling parameter of r, h, s is 300, 1800, and 60 seconds respectively. The algorithm first generated the queue job by identifying the arrival of ET and AGV within the look-ahead horizon to be scheduled as the main jobs. When ET or AGV brings in container to the yard, then the algorithm will find the optimum posisition on the yard by implementing the scoring function. On the other hand, if ET or AGV will takes out container from the yard, the algorithm will find the location of targeted container and identify whether some preparatory jobs are needed.

Some preparatory jobs (i.e rehandling and repositioning jobs) are needed if the targeted container is located not on the top of the any stack. In order to access the container, some containers above the targeted location have to be moved to other location first. The destination location of rehandling and repositioning container also being optimized using rule number 3 and 4 on the Table 1. The rules are implemented to prevent any other movement of that container in the future. The original targeted container can be moved to ET or AGV by an ASC after all its preparatory jobs finished. The processing time of the jobs become longer because of the additional preparatory jobs. Table 3 shows the job that needed some preparatory jobs. An ET need to carry out a container “MRLU2363500” from the location of slot 1,3,2 at the yard. Unfortunately, there are three containers above that have to be moved first before accessing the targeted container. The schedule will determine the best location for the rehandling containers, which are on the neighboring slot. Finally,

e-ISSN 2477-6025
DOI:10.21776/ub.jemis.2018.006.02.2

the targeted container can be moved to the landside area after all

Table 2. Input Jobs

Arrival Date	Vehicle	Activity	Vessel ID	Container ID
1/1/2018 0:02	ET	1	RELI006	MRTU2149246
1/1/2018 1:27	ET	1	RELI006	MRTU2045641
1/1/2018 1:30	ET	1	RELI006	TGHU0572960
1/1/2018 1:46	ET	1	RELI006	MRTU2042643
1/1/2018 3:05	AGV	1	RERO006	MRLU2387707
1/1/2018 3:10	AGV	1	RERO006	MRLU2363860
1/1/2018 3:15	AGV	1	RERO006	TEXU2582173
1/1/2018 3:20	AGV	1	RERO006	MRLU2341265
1/1/2018 3:25	AGV	1	RERO006	MRLU2380451
1/1/2018 3:25	ET	1	RELI006	TRLU9164682
1/1/2018 3:30	AGV	1	RERO006	MRTU9601872
1/1/2018 3:35	AGV	1	RERO006	MRTU9614904
1/1/2018 3:40	AGV	1	RERO006	MRLU4200287
1/1/2018 3:45	AGV	1	RERO006	MRTU2124891
1/1/2018 3:49	ET	0	RERO006	MRTU2059796
1/1/2018 3:50	AGV	1	RERO006	MRTU2059796
1/1/2018 3:55	AGV	1	RERO006	MRTU2155022
1/1/2018 4:00	AGV	1	RERO006	MRTU2054752
1/1/2018 4:05	AGV	1	RERO006	MRLU2363500

Table 3. Iterative Scheduling Result

No	Container Name	Origin	Destination	Processing Time	Finishing Time	Arrival Time at HP	Deviation	Information
1	MRLU2335880	Slot 1,3,5	Slot 1,4,1	31.1				Rehandling MRLU2363500
2	MRTU2022776	Slot 1,3,4	Slot 1,4,2	31.1				Rehandling MRLU2363500
3	MRTU2063369	Slot 1,3,3	Slot 1,4,3	31.1				Rehandling MRLU2363500
4	MRLU2363500	Slot 1,3,2	Landside	22.1	1/1/2018 4:26	1/1/2018 4:25	-0.000856	Target Rehandling
5	MRLU2320771	Seaside	Slot 18,1,1	55.9	1/1/2018 4:25	1/1/2018 4:25	-0.000637	In AGV
6	MRTU2072165	Seaside	Slot 18,1,2	50.7	1/1/2018 4:25	1/1/2018 4:30	0.0028935	In AGV
7	MRTU2154704	Seaside	Slot 18,1,3	45.5	1/1/2018 4:25	1/1/2018 4:35	0.0064236	In AGV
8	MRTU2096927	Landside	Slot 22,1,1	55.9	1/1/2018 4:25	1/1/2018 4:35	0.0065625	In ET
9	MRTU9615135	Seaside	Slot 18,1,4	40.3	1/1/2018 4:25	1/1/2018 4:40	0.0099537	In AGV
10	MRTU9608157	Seaside	Slot 18,1,5	35.1	1/1/2018 4:25	1/1/2018 4:45	0.0134838	In AGV
11	MRTU9601830	Seaside	Slot 18,2,1	55.9	1/1/2018 4:25	1/1/2018 4:50	0.0167245	In AGV
12	MRTU2063369	Slot 1,4,2	Slot 1,4,3	15.6				Rehandling MRLU2335880
13	MRLU2335880	Slot 1,4,1	Landside	27.3	1/1/2018 4:25	1/1/2018 4:53	0.0189583	Target Rehandling
14	MRTU9608157	Slot 18,1,5	Slot 1,4,2	43.9	1/1/2018 4:25	1/1/2018 3:03	-0.057442	Remarshaling
15	MRTU9615135	Slot 18,1,4	Slot 1,4,3	38.7	1/1/2018 4:25	1/1/2018 3:03	-0.057384	Remarshaling
16	MRTU2154704	Slot 18,1,3	Slot 1,4,4	38.7	1/1/2018 4:25	1/1/2018 3:03	-0.057384	Remarshaling
17	MRTU2072165	Slot 18,1,2	Slot 1,4,5	38.7	1/1/2018 4:25	1/1/2018 3:03	-0.057384	Remarshaling
18	MRLU2320771	Slot 18,1,1	Slot 1,5,1	38.7	1/1/2018 4:25	1/1/2018 3:03	-0.057384	Remarshaling
19	MRTU9601830	Slot 18,2,1	Slot 1,5,2	38.7	1/1/2018 4:25	1/1/2018 3:03	-0.057384	Remarshaling
20	MRTU2096927	Slot 22,1,1	Slot 39,6,4	33.5	1/1/2018 4:25	1/2/2018 23:19	1.7871181	Remarshaling

e-ISSN 2477-6025
DOI:10.21776/ub.jemis.2018.006.02.2

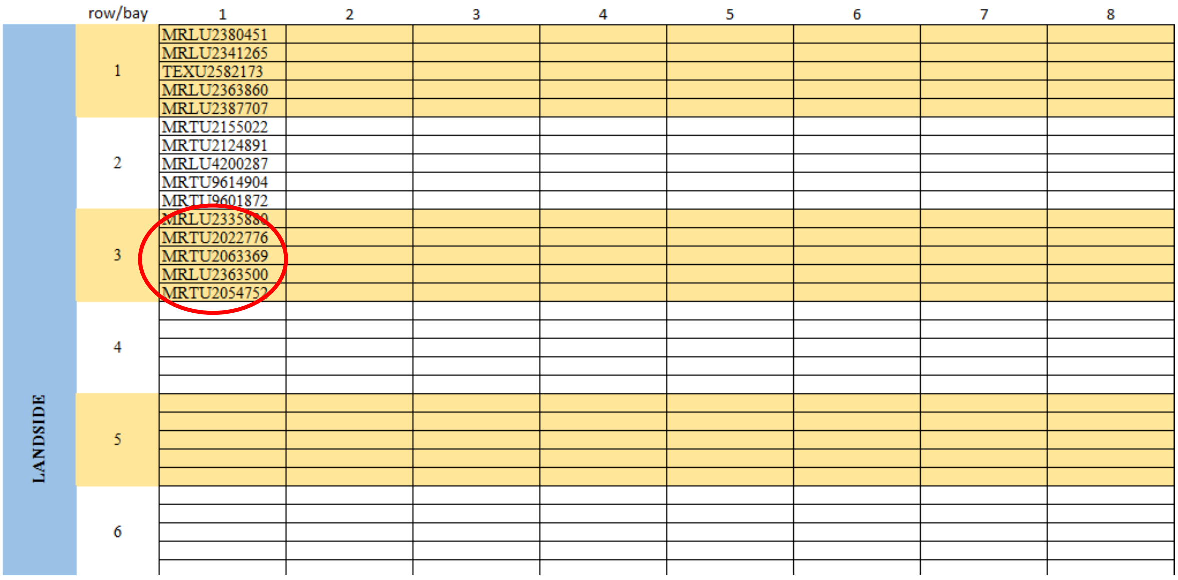

Fig 5. Initial Layout before Rehandling

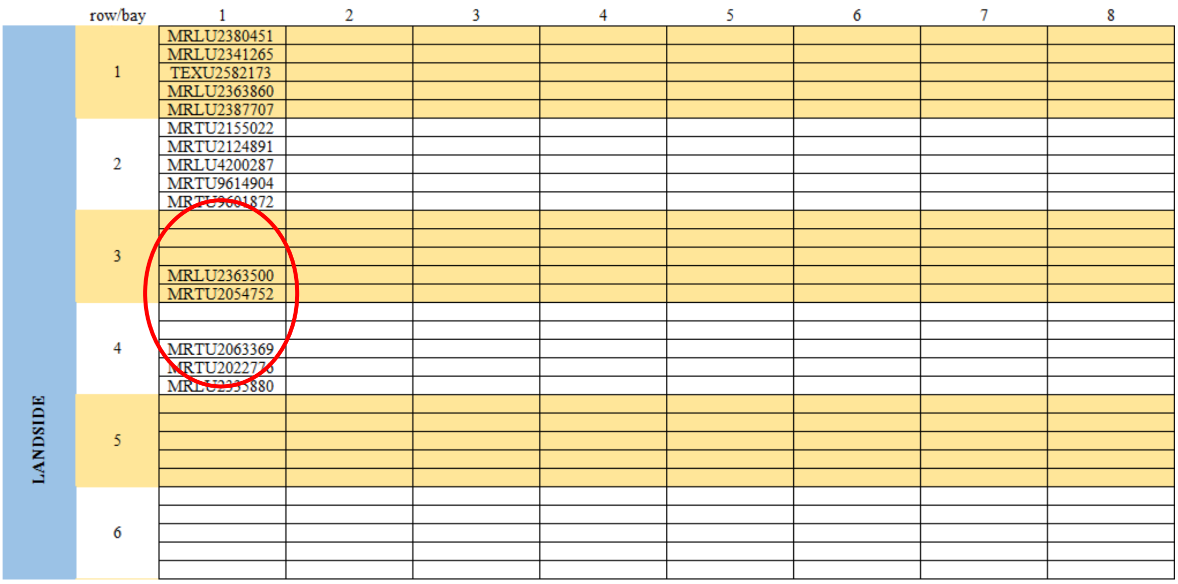

Fig 6. Layout after Rehandling

the rehandling jobs handled. The movement of containers can be seen on figure 5 (initial layout) and figure 6 (after rehandling layout).

After all main jobs in the look-ahead horizon have been scheduled, the algorithm investigates for the remaining time available. Some remarshaling jobs are added one by one to the queue until the scheduling time is up. To find the best candidate location for the remarshaling container, the algorithm will implement rule number 5 and 6 on Table 1 depend on the container type. The remarshaling job for the export container will be handled by seaside ASC, while remarshaling for import container handled by landside ASC. The remarshaling jobs will only be done if there is container on the transfer area and the scheduling time is still available. If the ASCs are busy with the main jobs, then the remarshaling jobs will not be handled. In the given scenario, the quantity of the job is not many, makes it sufficient to handle the remarshaling jobs in the idle time of each scheduling window. The remarshaling jobs is marked with "Remarshaling" title in information column of Table 3. The position destination slot will always change during the iterative rescheduling because of any movements from previous actions. The exact location can only be obtained several minutes prior to the processing time.

5. Conclusion

e-ISSN 2477-6025
DOI:10.21776/ub.jemis.2018.006.02.2

Yard management is important to improve the operational performance of a port. Some important factors on yard management are yard template generation and ASC scheduling. Generating yard template has to be robust to accommodate the uncertainties of real operational situations, such as the arrival of external trucks or containers. To accommodate the uncertainties, some ports implement the consignment strategy in which shippers book some location for their upcoming containers. Practically, this strategy can improve the accessibility of the container because container with similar detination vessel will be placed nearch each other, but in some occasions this strategy will lead to inefficient usability of yard area. This low utilization of the yard area is caused by the uncertainty of container arrivals. In this research, the algorithm for improving container yard utilization has been developed and the conducted numerical experiment showed some results, which are:

a. In the algorithm, the utilization is maintained by placing the incoming container at the transfer area first and rearranging it again near the similar vessel destination containers through remarshalling process prior to the departure date.
b. The scheduling process in this research are conducted in two steps, the first step is determining the jobs queue and next step is improving the sequence of the job to minimize the makespan.
c. The improvement process is done manually by swapping the sequence of the queuing jobs.
d. Some scoring rules that have been implemented to determine the optimal location for the containers represent a good performance by placing the similar containers on the neighbouring area.

Future research is needed to accommodate several characteristics of containers, including size and weight. The development of the improvement method is also needed, for example by employing heuristics algorithm rather than arbitrary swapping.

6. Acknowledgment

We are thankful to the Direktorat Riset dan Pengabdian Masyarakat - Direktorat Jendral Penguatan Riset dan Pengembangan - Kementrian Riset, Teknologi dan Pendidikan Tinggi - Indonesia for providing the funding for this research. We also thank all the staff in Lembaga Penelitian dan Pengabdian Masyarakat - Universitas Internasional Semen Indonesia for facilitating this research.

References

[1] The World Bank..Global Ranking 2018. Available from: https://lpi.worldbank.org/international/global [Accessed 17 September 2018].
[2] BAPPENAS. Laporan Implementasi Konsep Tol Laut 2015-2019, Jakarta: Kementerian Perencanaan dan Pembangunan Nasional; 2015.
[3] Pitoko, R.A..Penasaran "Dwelling Time" di Atas 3 Hari, Menhub akan Datangi Tanjung Priok. Available from: https://ekonomi.kompas.com/read/2018/04/03/145600326/penasaran-dwelling-time-di-atas-3-hari-menhub-akan-datangi-tanjung-priok. [Accessed 12 Nopember 2018].
[4] Nurminarsih, S., Rusdiansyah, A. and Putri, M.M.. Space-sharing Strategy for Building Dynamic Container Yard Storage Considering Uncertainty on Number of Incoming Containers. Jurnal Teknik Industri. 2018;19(2): pp.67-74.
[5] Zhen, L.. Container yard template planning under uncertain maritime market. Transportation Research Part E. 2014; 69: pp. 199-217.
[6] Lee, L.H., Chew, E.P., Tan, K.C., Han, Y. An optimization model for storage yard management in transshipment hubs. OR Spectrum. 2006; 28: pp. 539–561.
[7] Jiang, X., Lee, L.H., Chew, E.P., Han, Y., Tan, K.C. A container yard storage strategy for improving land utilization and operation efficiency in a transshipment hub port. European Journal of Operation Research. 2012; 221: pp. 64-73.
[8] Alcalde, E.M., Kim, K.H., Marchan, S.S.. Optimal space for storage yard considering yard inventory forecasts and terminal performance. Transportation Research Pert E. 2015; 82: pp. 101-128.
[9] Han, X.L., Lu, Z.Q., Xi, L.F. A proactive approach for simultaneous berth and quay crane scheduling problem with stochastic arrival and handling time. European Journal of Operation Research. 2010; 207: pp. 1327-1340.
[10] Zhen,L., Lee, L.H., Chew, E.P. A decision model for berth allocation under uncertainty. European Journal of Operation Research. 2011; 212: pp. 54-68.
[11] Choe, R., Kim, T.S, Kim, T.,Ryu , K.R. Crane Scheduling for Opportunistic Remarshaling of Containers in an Automated Stacking Yard.

e-ISSN 2477-6025
DOI:10.21776/ub.jemis.2018.006.02.2

Flexible Service and Manufacturing Journal. 2015; 27: pp 331-349.
[12] Park T, Kim J, Ryu KR. Iterative replanning using genetic algorithms for remarshaling in a container terminal. InProceedings of the 10th IASTED International Conference. 2010; Vol. 674, No. 120, p. 22.
[13] Park K, Park T, Ryu KR. Planning For Selective Remarshaling in an Automated Container Terminal using Coevolutionary Algorithms. International Journal of Industrial Engineering. 2013 Jan 1;20.
[14] Park T, Choe R, Ok SM, Ry KR. Real-time scheduling for twin ASCs in an automated container. OR Spectr. 2010; 32: pp593-615.
[15] Carlo, H.J., Vis, I.F.A., Roodbergen, K.J. Storage yard operations in container terminals: literature review, trends, and research directions. European Journal of Operation Research 2014: 235: pp 412-430.
[16] Choe R, Yuan H, Yang Y, Ryu KR. Real-time scheduling of twin stacking cranes in an automated container terminal using a genetic algorithm. InProceedings of the 27th Annual ACM Symposium on Applied Computing 2012 Mar 26. pp. 238-243. ACM.
[17] Jang H, Choe R, Ryu KR. Deriving a robust policy for container stacking using a noise-tolerant genetic algorithm. InProceedings of the 2012 ACM Research in Applied Computation Symposium 2012 Oct 23. pp. 31-36. ACM.