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OPTIMUM SCHEDULING SYSTEM FOR CONTAINER TRUCK BASED ON GENETIC ALGORITHM ON SPIN(SIMULATOR PELABUHAN INDONESIA)

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***Abstract*— The logistic process of Container is very crucial to the port, but often problem occur due to lack of truck scheduling so that adds to the turn around time. Response to this problem, this thesis will try to generate scheduling trucks by genetic algorithm to minimizes the traveling distance when operating in unloading and loading cargo so can reduce the turn around time. This optimization will embedded to SPIN (Simulator Pelabuhan Indonesia) so user can see the result with 3d visualization.**

Because the genetic algorithm used in a simulator, the computing time becomes an important issue. Therefore, genetic algorithms built using several techniques, such as permutation with two part chromosome, greedy crossover, tournament selection, and simple swap mutation

The test results of this study prove that by using the techniques described above, the time and distance it takes to complete the process of unloading is a decreased and computation time program is relatively small.

From the results of experiments conducted it was concluded that genetic algorithms can reduce unloading time that there is a way to assign the truck to the next job that has the shortest distance. With shorter unloading time, the direct impact on the costs to be incurred by mooring the vessel so that the port becomes more underserved customers.

Implementation of scheduling optimization truck simulator port has exciting potential to be developed, among others:

1. Usually the number of trucks that are assumed to be static parameters while in reality the number of trucks is dynamic because the truck can be increased or decreased (due to strike for example). Similarly, the condition of the equipment, eg the crane damaged, roads were jammed, and so on. Through this simulator can be adaptive and visualized.

2. With the successful implementation of the GA, it proves that the simulator can be used as a sort of template SPIN test optimization strategies. So that future SPIN can be implemented by various strategies.

3. With the ability to accelerate time, manipulate the situation, and add and reduce the object. SPIN can be used as forecasting tool and decision support systems for operators and management of container terminals.

***Keywords*— Simulation, optimization, port, container, terminal, genetic algorithm, scheduling, truck, crane.**

I. INTRODUCTION

Container Port is one main aspect of the Indonesian economy. Container Terminal must be effective and efficient to provide superior service for their customer. But sometimes terminal management is complicated because of many factors that must be considered. Therefore SPIN (Simulator Pelabuhan Indonesia) developed to help management to monitor and predict the impact of the allocation of resources including container terminal dock, crane, human, etc in an interactive way and estimate the gains and losses generated by simulation before applied in the real world to increase the success rate of the management of the container terminal. Before SPIN monitoring a terminal using multiple tools (CCTV, data tables, walkie talkie, etc.). SPIN allows management to see the whole harbor and realtime activity can also see the impact that would occur from the addition and application of 3-dimensional visual policy.

One of problem SPIN want to solve is optimization of loading and unloading process at Crane . Crane is usually the most expensive a container handling device in terminal , but often the cause of bottlenecks in the port (Steenken et al . , 2004) . One cause of the bottleneck is the lack of good scheduling of trucks , causing idle time on cranes that have to wait for the arrival of a truck or vice versa where a number of trucks had to queue up waiting for container handling cranes are still another truck which in turn led to increase the turn around time ship unnecessary . Therefore we need a truck scheduling that minimizes the time delay at Crane . Scheduling an efficient and effective truck can accelerate time to handling containers , which in turn increases the productivity of container terminals .

There have been several methods proposed to resolve the above among others Polynomial - Time Heuristic (Dell'Amico et al (1993)) , Integer Linear Programming (Vis et al (2005)) , and Genetic Algorithm (Lee et al (2008)) , Although the Genetic Algorithm hereinafter referred to as GA notoriously expensive computed but this algorithm proved good enough in completing various types of scheduling problems . In this thesis will try to modify the algorithm GA with programming techniques (the form of encoding , how to obtain offspring , elitism , etc.) so that the simulation time feasible to deal with scheduling problems on a simulator .

After doing the above activities , the results of research conducted thus be implemented in SPIN so SPIN can simulate trucks optimized scheduling for consideration of the port management .

II. LITERATURE REVIEW

Dell'Amico et al (1993) studied the problem which the vehicle must come to some depot at the specified time frame . The goal is to minimize the number of vehicles and total operating costs . New Polynomial -time heuristic method proposed to resolve the issue.

Rajotia et al (1998) studied the problem to determine the number of vehicles on flexible manufacturing environment. Load time, vehicles traveling empty, waiting time, and time jammed considered as a model to minimize empty vehicle trips. Vis et al (2001) studied the problem to determine the number of trucks needed on a container terminal. Problem solved with minimum flow polynomial. Vis et al (2005) discuss the problems buffer container terminal area where the container should be sent within a specified period with the aim of minimizing the number of vehicles. This problem is formulated as an integer linear programming. Lee et al (2008) propose Genetic algorithms and Greedy Heuristic Algorithm proposed to resolve the problem with the aim to minimize container unloading time by reducing congestion and waiting time from the truck yard. Li and Vairaktarakis (2004) examined the problem of minimizing the time of loading and unloading at a container terminal with a fixed amount of internal truck. Optimal algorithm is developed for the case of one quaycrane. The effectiveness of the program is shown by the analysis and computational experiments. The algorithm runs optimally when the number of trucks are still a few (2 or 3 trucks). Grünow et al (2004) examined the delivery of multi-load AGV. Priority-based approach is a flexible rule was developed and compared with formulations Mixed Integer Programming (MIP) on different scenarios. AGV delay reduction successfully demonstrated. Hartmann (2004) develop a general model for a variety of scheduling problems that exist in the logistic container terminal. The model consists of a scheduling assignment to resources and temporal arrangement in accordance with the constraints of work and sequence-dependent setup time. This model can be used for scheduling of trucks, AGV, straddle carriers, gantry cranes, and even workers.

III. MODEL DESCRIPTION

According to Wang [10] formulation of the problem for truck scheduling and allocation of container loading and unloading can be described as follows :

***Objective Function*:**

***Minimize*:**

$$Z = \alpha_1 \sum_{i \in J} d_i + \alpha_2 \left(\sum_{i \in J} t_i + \sum_{i,j \in J} s_{ij}\, y_{ij}\right) \quad \text{...(1)}$$

Subject to:

$$\sum_{i \in J} x_{ik} \leq 1 \quad \forall\, k \in K \quad \text{.....(2)}$$

$$\sum_{k \in K} x_{ik} = 1 \quad \forall\, i \in J \quad \text{.....(3)}$$

$$\sum_{j \in J} y_{ij} = 1 \quad \forall\, i \in J \quad \text{.....(4)}$$

$$\sum_{i \in J} y_{ij} = 1 \quad \forall\, j \in J \quad \text{.....(5)}$$

$$w_i \geq a_i \quad \forall\, i \in J \quad \text{.....(6)}$$

$$d_i \geq w_i + t_i - b_i \quad \forall\, i \in J \quad \text{.....(7)}$$

$$w_j + M\left(1 - y_{ij}\right) \geq w_i + t_i + s_{ij}$$

$$\forall\, i \in J \text{ and } \forall\, j \in J \quad \text{.....(8)}$$

First objective function (1) represents the total weight of the delay and the total travel time from the truck yard . Constraint (2) ensure that each storage location will be assigned to one vehicle . Constraint (3) ensures that each vehicle will be assigned to one storage location . Constraints (4) guarantee = 1 if the truck yard to process the request after request i j . Constraints (5) guarantee = 1 if the truck yard I request processing before the request i. Constraints (6) ensure that the request that the request can only be served after the time allowed nearby . Contrains (7) calculate the delay of each request . Constraints (8) gives the relationship between the start time of the request and its successors . M is a large positive number .

As explained at chapter 1 , the authors will conduct research of container truck scheduling and optimize the scheduling using genetic algorithms .The purpose of this system model is to find a form of scheduling the loading process into multi yard that has the smallest makespan by minimizing the distance and time of the truck .Performance measurement is how long makespan in each solution , where the less makespan then the better the performance . Furthermore, performance measurement is manifested in the fitness function in genetic algorithms .The whole time spent in the modeling and calculation converted into seconds.

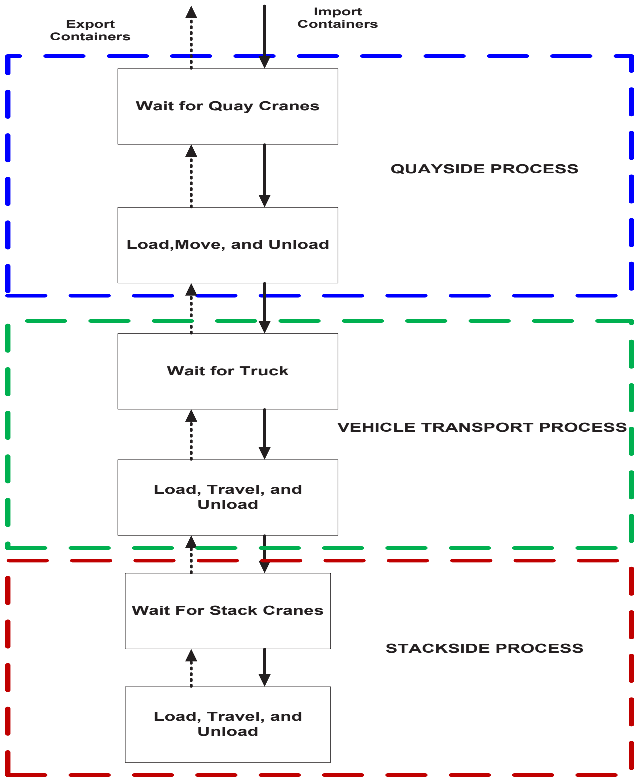

Fig1. Truck Cycle

A truck will get some assignments shipping containers to be placed in the yard . One cycle of a truck (the term in the harbor is rit) is a condition in which the given container truck at Quayside to return to the quayside in the process of loading or of StackSide back to StackSide the unloading process . At each cycle , the truck will pass through several stages of the trip to PickUp Location , stopping at PickUp Location , wait Crane took the container , truck receiving container , the journey to dropoff Location specified , Waiting Crane , Deliver the container to Crane , and a trip to next PickUp Location.

In the container terminal is assumed to truck running at a speed of 15 km / h . Gross crane rate (average 1 cycle of action) = 27.7 movements / hour so to take one container from the ship to the apron or from the truck to the yard is 60 minutes / 27.7 = 2.17 min ≈ 130 seconds [Andika 2014] . Travel time between the two locations is equal to the distance between the two locations divided by the speed of the truck . The duration of work equal to the amount of travel time from the location of the job to the destination and the total treatment time by two cranes [9] .

Some parameters that must be modeled for the calculation include:

a.) The speed of the truck in units of kilometers / hour . Where to simplification of the model , modeled here only average speed and does not include acceleration and deceleration factors truck . Furthermore, the travel time is converted to seconds.

b .) The amount of used truck

c .) The number of Quay Crane

d .) The number of containers

e .) Distance to the yard .

A. *Genetic Algorithm Implementation*

Genetic Algorithm manipulate chromosomes population, which typically represented in the form of a string. Certain positions in the chromosome called the gene while the value of these genes are called alleles. There are some important aspects that need to be considered in the representation of the chromosome, among others, is mapping the character of the coding and search space. According to the symbol that is used as the value allele of the gene, encoding scheme representation can be classified as, binary encoding, real-number encoding, permutation encoding, and the general structure of data encoding. Binary encoding is the most widely used form in the GA in general. Real number encoding typically used for optimization functions. Permutation encoding used for the permutation problem and is widely used to solve the Traveling Salesman Problem, Vehicle Routing Problem, sequencing problems, and problems in the planning of container terminals. General Data Structure encoding applied on a very complex issue. Detailed explanation of each step is explained as following:

a. Encoding

From the explanation above, the chromosomes encoding scheme used for scheduling optimization trucks is permutation encoding . Permutation Encoding typically used in sorting problems . Because the chromosomes should encode all scheduling information such as the number of trucks and the order in which each truck handled it requires a certain chromosome structure to complete. In this thesis chromosomes form used is Part Two chromosome Structure developed by Carter and Ragsdale (2005).

b. Initialization

The first part of each chromosome is made randomly from N jobs . Keep in mind that the total value of M section of the chromosome must be equal to the value N. M gene (X1 , X2 , ... ,XM) is determined by making N discrete random numbers from 1 to M on the list of random numbers created . The first part is a sequence of N work is divided into several parts . Each section represents the number of jobs for certain trucks . The second part is the order of the workload of each truck.

c. Evaluation

In GA fitness function is used for evaluate the quality of the chromosome as a solution to a particular problem. The purpose of the truck scheduling problem is to minimize the makespan (total processing time of all jobs) are always positive value. Because of this minimization then if the solution

A has objective function value is smaller than the solution B, it means a better solution than the solution B.

d. Selection

After evaluation it will be selected . Here, researchers used the concept of elitism and tournament selection . Elitism here means the only chromosome that has the highest fitness value will be secured . Chromosomes worst will be discarded. Tournament Selection in a simple context is a method of selecting individuals from the population to be contested . Winners will be immediately lowered to the next offpring while the losers will go through the crossover and mutation before being lowered into offspring .

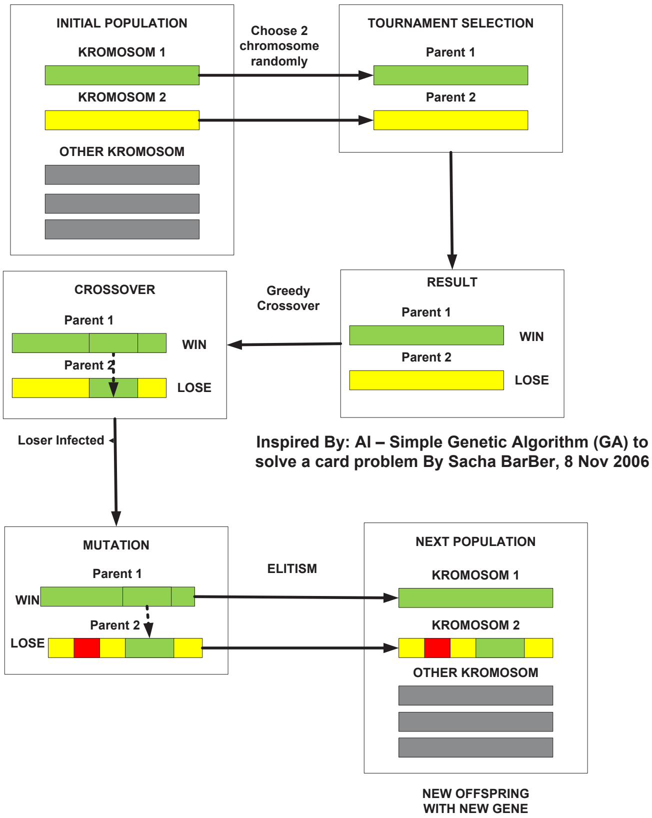

Fig. 2 Concept Of Selection

e. Crossover

Once the selection is done then the next crossover to derive a new generation which will be in the mid chromosomes crossover with the best chromosome to form a new chromosome that fill the place of the worst chromosomes have previously discarded .

f. Mutation

Mutations are genetic operators to make random changes to the chromosomes . Mutations alter one or more genes from the chromosome was selected by random changes usually use probability of mutation . The idea of the mutation operator is to introduce the diversity of the population . Selection of chromosomes and used a crossover operation GA search for solutions aiming expected , whereas the mutation operator is used as a random search in order to explore areas outside local optimum and avoiding premature convergence .

Over the last decade various kinds of mutations operation proposed for permutation encoding , among others inversion , insertion , displacement , reciprocal exchange mutation , shift mutation (Gen and Cheng , 1997) and a simple swap mutation [10].

In the simple swap mutation steps are as follows :

1. In the first part of chromosome selected, randomly select two positions eg 2 and 7 .

1	***5***	4	7	8	3	***9***	2	6	3	4	2

2. Invert substring between two positions

1	***9***	3	8	7	4	***5***	2	6	3	4	2

3. In the second part of chromosomes , genes randomly select, for example two gene is two gene 1 and gene eg 3

1	9	3	8	7	4	5	2	6	***3***	4	***2***

4. Swap the two genes was elected on the second chromosome

1	9	3	8	7	4	5	2	6	***2***	4	***3***

5. The final form after mutation

1	9	3	8	7	4	5	2	6	2	4	3

After the above process is done repeatedly then the best chromosome from the last generation will be taken and used to be a truck schedule .

g. Truck Cycle Calculation

According Yuxuan (2005) a truck must pass through a cycle of doing the delivery of containers of PickUp Location to Location dropoff as illustrated in Figure 3.1 above. So to calculate the time required a cycle time is the time pickup + move + dropoff time. According Andika [2014] of the results of research in JICT time required for handling containers at the crane was for 130 seconds.

If it is assumed that there are three objectives yard blocks to be simulated, ie one yard within 500 meters, 2 yard within 1000 meters, and 3 yards within 1500 meters. Then it is assumed that the velocity is constant truck at 15 km / h as observed by Yuxuan (2005) in Hong Kong Intenational Terminal.

Travel time formula used is as follows:
S = v x t

Where:
s is the distance (km or m)
v is the speed (km / h or m / s)
t is the travel time (hours / sec)

Travel time required for trucks to travel from one yard within 500 meters to the quay, are as follows:
t = s / v
t = 0.5 / 15 = 0033 hours = 1.98 minutes = 119 seconds

Travel time required for trucks to travel from yard 2 within 1000 meters to the quay, are as follows:
t = s / v
t = 1/15 = 0067 hours = 4.02 minutes = 242 seconds

Travel time required for trucks to travel from 3 yards within 1500 meters to the quay, are as follows:
t = s / v
t = 1.5 / 15 = 0.1 hour = 6 minutes = 360 seconds

While the travel time between each yard is as follows:
Yard Yard between 1 and 2 is 500 meters away, so the latency:
t = s / v
t = 0.5 / 15 = 0033 hours = 1.98 minutes = 119 seconds

Yard Yard 2 and 3 is 500 meters away, so the latency:
t = s / v
t = 0.5 / 15 = 0033 hours = 1.98 minutes = 119 seconds

Yard Yard 1 and 3 is 1000 meters, so that latency:
t = s / v
t = 1/15 = 0067 hours = 4.02 minutes = 242 seconds
So that the travel time table is as follows

TABLE I
CALCULATION OF TRAVEL TIME

Pick Up Location	DropOffLocation	Waktu Tempuh
Quay	Yard1	119
Quay	Yard 2	242
Quay	Yard 3	360
Yard 1	Yard 2	119
Yard 2	Yard 3	119
Yard 1	Yard 3	242
Yard 1	Quay	119
Yard 2	Quay	242
Yard 3	Quay	360
Yard 2	Yard 1	119
Yard 3	Yard 2	119
Yard 3	Yard 1	242

IV. DESIGN

Travel time calculation above will be input into SPIN service to simulate optimisation of load/unloading process in simulator. SPIN service is an application plug-ins that add functionality SPIN for certain features. To keep the simulator is still running smoothly then the developer separating SPIN with its service, so SPIN only simulate port activity in general terms. SPIN service is built using web service where the results are stored into a database service that is checked regularly by the simulator, when there is new data coming from service then SPIN will grab the content data contained in the database. Furthermore the plot can be seen in the image below:

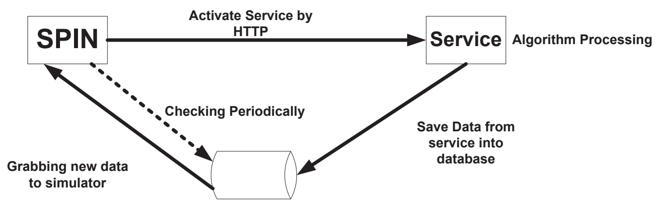

Fig. 3 SPIN Service

V. EXPERIMENT

Experiments performed on a laptop with specs I3 Processor 1.7 GHz , 4GB of RAM , and 512 MB VGA . Truck running at a speed of 15 km / h at the terminal area . The time required cranes to handle containers is 130 seconds . Each location is identified with coordinates x , y . Terminal region has a length of 1,200 meters and a width of 600 meters as the result of distance measurement JICT1 Container Terminal in Tanjung Priok which used as an example the case in this thesis . Container terminal operating system determines the time is ready for the job and the time is ready for the truck . At a planning horizon there are 150 containers and truck fleets there are also as many as 12 units .

To resolve the problem with the Genetic Algorithm , the genetic parameters used were :
Population size = 30
Total Generation = 100
Mutation Rate (Pm) = 0.5

TABLE III
EXPERIMENT RESULT

Experiment 1 (Computation Time : 23.43 seconds)			
No	**Comparison**	**Before Optimation**	**After Optimation**
1	Container Quantity	50	50
2	Truck Quantity	9	9
3	Time	7.6877778 h	1.184722 h
4	Distance for every truck	25 km	18.5 km
Experiment 2 (Computation Time: 44.78 seconds)			
No	**Comparison**	**Before Optimation**	**After Optimation**
1	Container Quantity	100	100
2	Truck Quantity	10	10
3	Time	13.445833 h	2.033611 h
4	Distance for every truck	54.5 km	34.5 km
Experiment 3 (Computation Time : 88,66 seconds)			
No	**Comparison**	**Before Optimation**	**After Optimation**
1	Container Quantity	150	150
2	Truck Quantity	12	12
3	Time	21.1655556 h	3.369444 h
4	Distance for every truck	92,5 km	47.5 km

VI. CONCLUSION

Simulation can provide a new perspective in improving the quality of operations in container terminals. Terminal in Indonesia, Tanjung Priuk suppose so far only use simple strategies namely FCFS by stacking containers on a particular yard block. This thesis offers a new approach that blocks the spread of the concept of double cycling yard using the scheduling is optimized using a genetic algorithm. Simulators are built into the instrument of proof. The goal is to find out how much optimization resulting in the application of genetic algorithms to the scheduling truck as one of the important points the smooth process of unloading containers.

From the results of experiments conducted it was concluded that genetic algorithms can reduce unloading time that there is a way to assign the truck to the next job that has the shortest distance. With shorter unloading time, the direct impact on the costs to be incurred by mooring the vessel so that the port becomes more underserved customers.

Implementation of scheduling optimization truck simulator port has exciting potential to be developed, among others:
1. Usually the number of trucks that are assumed to be static parameters while in reality the number of trucks is dynamic because the truck can be increased or decreased (due to strike for example). Similarly, the condition of the equipment, eg the crane damaged, roads were jammed, and so on. Through this simulator can be adaptive and visualized.
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REFERENCES

[1] Dell'amico, M., Fischetti, M. & Toth, P. *Heuristic algorithms for the multiple depot vehicle scheduling problem*. 1993.
[2] Rajotia,S.,Shanker,K. and Batra,J.L., *A heuristic for configuring a mixed uni-/bi-directional flow path for an AGV system*.International Journal of Production Research, 1998.
[3] Dachyar, M, *Simulation and Optimization of Service at Port in Indonesia*, Dept. Of Industrial Eng, University Of Indonesia, Depok, 2012.
[4] Muhyi, Yumarsono, *Pemodelan Penjadwalan Otomatis Sistem Kereta Rel Listrik (KRL) PT. KAI*, Universitas Pembangunan Nasional Veteran, Jakarta, 2010..
[5] Qiu, Ling et al. *Scheduling and routing algorithm for AGV's : A Survey*, International J.Prod Pres vol 40 no 3 745 – 760, Taylor & Francis, 2002.
[6] Bradley Skinner, et al. *Optimisation for job scheduling at automated Container Terminals Using Genetic Algorithm*, University of Technology, Australia, 2007..
[7] Wall, Matthew Bartschi. *A Genetic Algorithm For Resource-Constrained Scheduling*, Department of Mechanical Engineering, Massachusetts Institute Of Technology, 1996..
[8] Butar, Maulida Boru Butar, et al. *Penggunaan Simulasi Untuk Pemecahan Masalah Transportasi*, Fakultas Teknologi Industri Universitas Gunadarma, Depok, 2008..
[9] Yuxuan, Zhang. *Scheduling Truck in Port Comtainer Terminals By A Genetic Algorithm*. University Of Hongkong, Hongkong, 2005.
[10] Wang, Z.X, et al. *Storage Allocation and Yard Trucks Scheduling in Container Terminals Using a Genetic Algorithm Approach*, ICIC'S, Singapore, 2003.