Modelling and Optimization Containers Dwell-Time in Tanjung Priok Port Indonesia

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Abstract—Import containers stay too long, around 6.2 days at container terminals in Indonesia, which is negatively affecting logistics cost and is causing a serious adverse effect in terms of logistic costs for domestic businesses and prices paid by consumers. In this paper, we propose a method which controls and reduces dwell-time of import containers in The Port of Tanjung Priok. The controlled object is modeled as a reengineering business proses of import containers which controls time duration, processes and weights. Experimental results demonstrate the optimization of the proposed method and reduce the dwell-time.

Keywords—Dwell-time, control, container

I. INTRODUCTION

The container queue is a problem which is frequently found in the container port. This problem has adverse effects to the distribution system in the port such as the delay in delivering the containers, the increased cost, and even the level of customer satisfaction that decreases. In this research, the 'queue issue' discussed is the dwell time. Dwell time is the time required for containers to be unloaded from a container (unloading) and then placed in the container yard (cargodoring) and leaving the port through the main door (distribution). Considering the dwell time issue, researcher conducted research on modeling and optimization of container dwell time.

The previous studies related to the container Dwelling Time, i.e comparing the method of Genetic Algorithms (GA), Tabu Search (TS), Simulated Annealing (SA), Squeaky Wheel Optimization (SWO). For the research in this thesis, the researcher used Heuristic Algorithm method. Researcher used this method in order to give good results in the optimization of container dwell time.

In researching on container dwell time, the researcher examined each stage in the process of dwell time, ranging from the dismantling of the container (unloading), placing the container in the yard (cargodoring), the distribution and even the administrative process. The researcher studied the factors that caused the dwell time and the solution of the problem.

The result of this research is a model of container dwell time and a solution in forms of optimization of container dwell time. The result of this study is expected to reduce container dwell time from 6.2 days to 3 days. Because the dwell time of 3 days is an international standard of stevedoring. The result of this research is a real contribution from academic world to the problems that occur in ports and particularly in Tanjung Priok.

II. MODELS

This section discusses the Queue Models of Container Process in discrete time where the container is modeled with sets of queues. In the model, there is a stakeholders mode i.e customs and modes of operational equipment that is quay crane and gate. The Queue Models of Container Process along with Discrete Event System are depicted in the Figure 1. In the figure the queue model of containers is clearly shown.

Figure 1 Queue model of container import process

Figure 1 is a queue model of container import process which are adapted to conditions on the field. From these pictures, the container interprocess operation is modeled into a set of discrete time equation with a sample time of \( T \). Step time \( t = 0,1, \ldots \) represents the arrival rate of containers in the terminal. The arrival of the container is represented by \( a_1(t) \) variable and the container leaving gate of the port is expressed by \( d_1(t) \). The arrival process of \( a_1(t) \) and the leaving of \( d_1(t) \) are the variables that represent the container at the time of \( t \). The process is equivalently modeled as a sequence / series of deterministic processes or as sequences which are
random. The arrival of the container is an exogenous variable which represents the input data for the optimization problem of the queue model.

Complete model of the container import process as a whole in accordance with the pictures, in which each equation for each queue expressing the flow of container process which are analogized with the conservation laws of fluid flow, represented by the following discrete time equation:

\[
q_i(t+1) = q_i(t) + T[a_{i,j}(t)u_j(t)]
\]  

\[
q_2(t+1) = q_2(t) + T[a_{1,2}(t)u_1(t)u_2(t)]
\]  

\[
q_3(t+1) = q_3(t) + T[a_{1,3}(t)u_1(t)]
\]  

\[
q_4(t+1) = q_4(t) + T[u_4(t)u_5(t)]
\]  

\[
q_5(t+1) = q_5(t) + T[u_5(t)u_6(t)]
\]  

\[
q_6(t+1) = q_6(t) + T[u_6(t)u_7(t)]
\]  

\[
q_7(t+1) = q_7(t) + T[u_7(t)u_8(t)]
\]  

\[
q_8(t+1) = q_8(t) + T[u_8(t)u_9(t)]
\]  

\[
q_9(t+1) = q_9(t) + T[u_9(t)u_{10}(t)]
\]  

\[
q_{10}(t+1) = q_{10}(t) + T[u_{10}(t)u_{11}(t)]
\]  

\[
q_{11}(t+1) = q_{11}(t) + T[a_{1,11}(t)u_{11}(t)]
\]  

\[
q_{12}(t+1) = q_{12}(t) + T[a_{1,12}(t)u_{12}(t)]
\]  

\[
q_{13}(t+1) = q_{13}(t) + T[a_{1,13}(t)u_{13}(t)]
\]  

\[
q_{14}(t+1) = q_{14}(t) + T[u_9(t)u_8(t)]
\]  

\[
q_{15}(t+1) = q_{15}(t) + T[a_{1,15}(t)u_{15}(t)u_{16}(t)]
\]  

\[
q_{16}(t+1) = q_{16}(t) + T[a_{1,16}(t)u_{16}(t)u_{17}(t)u_{18}(t)]
\]  

\[
q_{17}(t+1) = q_{17}(t) + T[a_{1,17}(t)u_{17}(t)u_{18}(t)u_{19}(t)]
\]  

\[
q_{18}(t+1) = q_{18}(t) + T[u_{17}(t)u_{18}(t)]
\]  

\[
q_{19}(t+1) = q_{19}(t) + T[a_{1,19}(t)u_{19}(t)u_{20}(t)]
\]  

\[
q_{20}(t+1) = q_{20}(t) + T[a_{1,20}(t)u_{20}(t)]
\]  

\[
q_{21}(t+1) = q_{21}(t) + T[u_{20}(t)u_{21}(t)]
\]  

\[
q_{22}(t+1) = q_{22}(t) + T[u_{21}(t)u_{22}(t)]
\]  

\[
q_{23}(t+1) = q_{23}(t) + T[u_{22}(t)u_{23}(t)]
\]  

\[
q_{24}(t+1) = q_{24}(t) + T[u_{23}(t)u_{24}(t)]
\]  

\[
q_{25}(t+1) = q_{25}(t) + T[u_{24}(t)u_{25}(t)]
\]

In the equation 2, equation 3, equation 11, equation 12, equation 13, equation 15, equation 17, equation 19, equation 20, the coefficient of \(a_{i,j}(t), t=0,1,...\) is called a priori variables, which means that the variable value is determined in advance, based on the distribution of the number of containers in each queue state of the container arrival or its leaving from the port gate. This hypothesis does not affect the linearity of the models but has a certain influence on the specific state which is significant for the optimization problem in the next section.

As mentioned before, in this sample of container queue model, the variable of \(q_i(t), \) for each \(i = 1,2,...,25,\) and \(u_i(t), \) for each \(i = 1,2,...,24,\) represents the state variables and decision variables. Constraint or restriction, either for the state variables or decision variables, which are positive and some other additional requirements are also needed, in order to obtain constraints or limitations as follows:

\[
0 \leq u_i(t) \leq u_{i\max}, \text{for } i=1,2,...,24; \tag{26}
\]

\[
0 \leq q_i(t) \leq q_{i\max}, \text{for } i=1,2,...,25; \tag{27}
\]

\[
T u_i(t) \leq q_i(t), \text{for } i=1,2,...,24; \tag{28}
\]

\[
u_i(t) \text{ quaycrane}_{\max}; \tag{29}
\]

\[
u_2(t) + u_{25}(t) \text{ gate}_{\max}; \tag{30}
\]

\[
u_{i4}(t) \text{ customs}_{\max}; \tag{31}
\]

\[
u_{15}(t) + u_{16}(t) + u_{17}(t) \text{ SPPB}_{\max}; \tag{32}
\]

\[
u_{i8}(t) + u_{19}(t) + u_{20}(t) + u_{21}(t) + u_{22}(t) + u_{23}(t) + u_{24}(t) \text{ exchange}_{\max};\tag{33}
\]

\[
\sum_{i=3}^{13} u_{i}(t) \text{ stackholder}_{\max}; \tag{34}
\]
III. OPTIMIZATION

A. Minimization Process

Model import containers after reduction process.

![Import process after reduction process](image)

B. The Approach with Receding - Horizon Method

The optimization problem for container queuing system described in the previous section will then be optimized by the method of receding - horizon. The decision variables in the container queue model can be equivalently represented as the control variables. The system dynamics in the container queuing model can be written into the following concise form:

\[
q(t+1) = Aq(t) + Bu(t) + Ew(t), \quad \text{untukt}=0,1,...
\]  

(35)

where \( q(t) \) \( n \times 1 \), \( u(t) \) \( m \times 1 \), and \( w(t) \) \( p \times 1 \) denote the state vector, the control signal vector, and vector of signal interference/disturbance. In general, the above equation represents the concise form in accordance with the sample of container queuing model, where

\[
q(t)=\begin{bmatrix} q_1(t) & q_2(t) & \ldots & q_{25}(t) \end{bmatrix}
\]  

(36)

Equation 36 is a set of state variables, the control signal variable is represented by equation 37.

\[
u(t)=\begin{bmatrix} u_1(t) & u_2(t) & \ldots & u_{124}(t) \end{bmatrix}
\]  

(37)

For \( W(t) \) is a vector of interference signal, which in this model represents the arrival and departure of containers in the terminal by the ship, truck, or train. The arrival of containers in the terminal can be deterministic and random. In accordance with the queuing model of containers, if it is specified in the form of a matrix vector:

\[
w(t)=\begin{bmatrix} a_1(t) & d_1(t) \end{bmatrix} \quad i=1
\]  

(38)

\[
w(t)=\begin{bmatrix} a_1(t) & d_1(t) \end{bmatrix}
\]  

(39)

while for the limitations / constraints of the queue model of container can be written into the following concise form

\[
Vq(t)+Wu(t) = z
\]  

(40)

where \( z \) is a vector which value is constant, \( V \) and \( W \) is the matrix corresponding with the state variables and decision variables.

General scheme of control with the receding - horizon can be seen in Figure IV.4. When the system is in the state \( q(t) \) at a time \( t \), the problem solution of optimal control is searched with finite horizon (FH) for the \( N \) - stage, in order to obtain the optimal control vectors sequences \( u(t)^{FH}, ..., u(t+N-1)^{FH} \). The first sequence of the vector control would then become a control action \( u(t)^{FH} \) which is generated by the RH regulator at the time \( t \). This means that only the optimal control vector sequence \( u(t)^{FH} \) which is first applied to the system for the next time \( t+1 \). Moreover, in this way, the control law is obtained because the control vector \( u(t)^{FH} \) depends on the current state \( q(t) \). For the case of the container queuing model, the objective function (cost function) of FH can be written as follows:

\[
J^F(q(t+1,t+N),u(t,t+N-1)) = \sum_{k=t}^{t+N-1} c^T q(k), \quad \text{untukt}=0,1,...
\]  

(41)

where:

\[
u(t)=\begin{bmatrix} u_1(t),...,u_1(1) \end{bmatrix}
\]  

(42)

\[
q(t)=\begin{bmatrix} q_1(t),...,q_1(1) \end{bmatrix}
\]  

(43)

\[c=\begin{bmatrix} c_1 & c_2 & \ldots & c_n \end{bmatrix}\]

(44)

\[c_i > 0, i=1,2,...,n\]

(45)

C. Simulation

![Simulation using SimEvent Matlab](image)

IV. CONCLUSION

Result form this research is container dwell time in Tanjung Priok port can be 3 days. Container dwell time modelled in Discrete Event Systems. Simulation this model using Matlab dan SimEvent Matlab. The result from simulation can be compare dwell time right now and dwell time after optimization. The result of this research is the best result for dwell time in Tanjung Priok port.
REFERENCES


