Simulation Modeling for a Container Terminal with Enhanced Information Technology

Rie Gaku

Abstract Information systems have been introduced to accumulate real-time tracking data on containers and transporters at container terminals in ports. Logistics managers of container terminals need an intelligent tool to analyze the performance of highly complex and large logistics systems using of the accumulated real-time tracking data. This paper addresses proposing a procedure of analyzing the performance at a real container terminal, especially by making use of the electronic real-time tracking data that is accumulated from united terminal IMSs (IMS: information management system). To analyze the operations performance, all of the operational activities of an actual container terminal in Japan are simulated. It is found that the information obtained by performing simulation is effective for analyzing the performance of the operation.

Keywords Container terminal • Materials handling • Simulation

1 Introduction

Container terminal operation systems are complex and large and are designed to provide customers with high-quality service. United Terminal IMSs have been introduced to control operations and to accumulate real-time tracking data on containers and transporters at container terminals in ports. There is a potential need for logistics managers to have an intelligent tool, which should be developed to analyze these highly complex and dynamic logistics systems, making use of accumulated real-time tracking data.

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2 Brief Literature Review

There are many studies focused on various issues concerned with container terminals. Several studies have used computer simulation to schedule cargo-handling equipment at container terminals (Kim and Kim 1999; Ng 2005; Guo et al. 2008). The issues of storage and stacking in the planning of ships and container yards can be addressed using simulation, which has been studied in recent years (van Asperen et al. 2010; Dekker et al. 2006; Zeng et al. 2010).

A current review of the literature indicates that few studies have been reported on the modeling of a whole container terminal system with a simulation based approach using electronic real-time tracking data. In this paper, a simulation approach is employed at all of the operations of real container terminals in Nagoya, Japan, specifically at the Nabeta Pier container terminal, to analyze the performance. The procedures of analyzing the operations performance is described, especially by using electronic real-time tracking data accumulated from the United Terminal IMS.

3 Simulation Modeling Steps

This section presents a brief overview of the steps of simulation modeling for materials handling systems of a container terminal.

Figure 1 represents a series of steps for applying simulation to container terminal systems. The first step, *Raw Data Collected from United Terminal IMSs*, helps to acquire a series of raw data, including handling instructions and handling completion information for transfer cranes, straddle careers, and top lifters, inbound vessel information. At Step 2, a series of raw data is processed and input data for simulation is extracted from the processed data based on the operation flows. During the simulation model-building step, system design configurations are developed based on the essential operation flows (i.e. importing process and exporting process). At Step 4, verification and validation of the simulation model is performed to determine whether the simulation model adequately describes the actual system performance. At the last step, simulation experiments are performed to analyze statistical parameters.

4 An Example

4.1 Nabeta Pier Container Terminal

The Nabeta Pier Container Terminal in this study sustains the central Japan economic arena with a focus on multi-frequency small-sum cargo. A general view of the container terminal is shown in Fig. 2. Responding to the increasing amounts

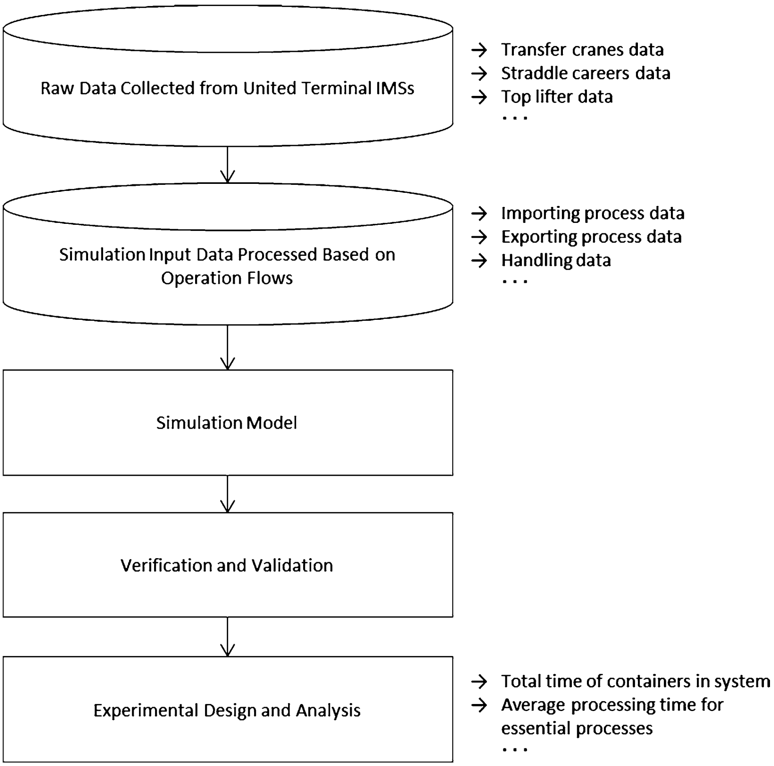


Fig. 1 General simulation modeling steps

Fig. 2 A general view of a container terminal

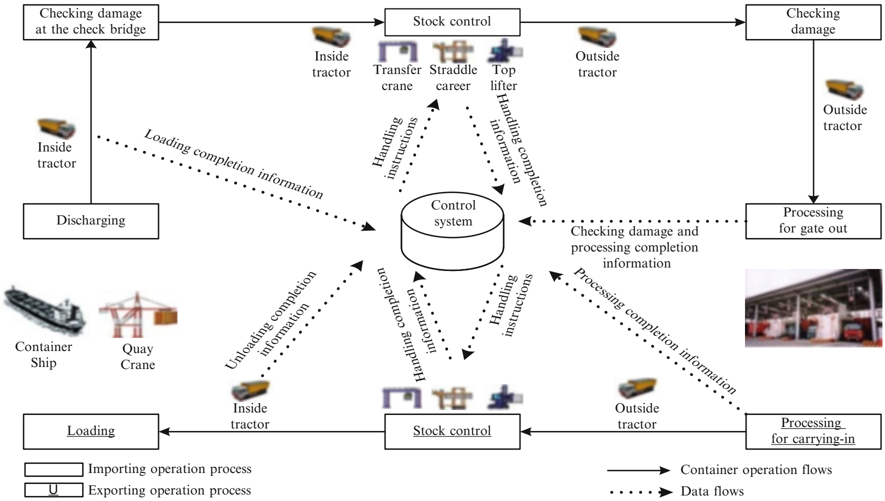


Fig. 3 Container operation flows and data flows in the Nagoya United Terminal IM

of container cargoes, the efficiency of materials handling operations are becoming a vital problem. Although the advanced United Terminal IMS has contributed to tracking the situations of containers and cargo-handling equipments to make operation control easier than before, it is still difficult for logistics managers to resolve the problem of ship inbound and outbound delays which can only be accomplished with real-time tracking data. Logistics managers need a sophisticated tool to integrate the electronics real-time tracking data with the advanced United Terminal IMS to analyze the bottleneck of operation flows, the processing time of different cargo-handling equipment and the average waiting time of the inbound and outbound ships.

4.2 United Terminal IMS

The Nagoya United Terminal IMS is a computer-aided information management system used for planning for vessels, cargo-handling equipment and yard storage planning. Figure 3 shows the flow for the container operations and the data flows via the Nagoya United Terminal IMS. When a ship berths at the container terminal, a container is discharged by a quay crane and is unloaded onto an inside tractor that is waiting to transfer material to the yard storage blocks. Once the container is unloaded onto the bed of the tractor, the information on the loading completion will be transferred to the IMS. Nearly at the same time, handling instruction for containers-storage spots will be sent to cargo-handling equipment at the yard, including transfer cranes, straddle careers, and top lifters. It is possible to send these information to the next job in advance of the actual tractor arrival. In addition, it is valuable for the cargo-handling equipment at the yard to choose the next job in helping to make the proper decisions. In the meantime, the Nagoya United Terminal IMS will record the exact time when instructions are sent out as well as the time that handling completion information is accepted.

4.3 Data Collection and Processing

The overall flow of the data processing in this study is shown in Fig. 4. The electronic real-time information regarding the operation processes is designed for performing simulations repeatedly and effectively. Selected resultant input data for a real container terminal simulation is summarized in Table 1. A similar idea for creating experimental data for simulation experiments appears in the simulation of hospital wards (Takakuwa and Katagiri 2007; Wijewickrama and Takakuwa 2006). The simulation can be performed automatically, using a model together with the input data. Therefore, a judicious integration of real-time data into the simulation model will reduce the work load of specification, coding, validation, and verification of the simulation.

4.4 Simulation Logic

Computer simulation is a methodology that can be used to describe, analyze and predict the performance of a complex business process without the limiting assumptions. In this paper, the simulation model is conducted with the Simio modeling software, version 3.48 (Kelton et al. 2010; Pegden and Sturrock 2010).

The fundamental operation processes in a typical terminal including importing and exporting processes are shown in Figs. 5 and 6. The importing process means that an inbound container is discharged from an inbound vessel by a quay crane and is unloaded onto an inside tractor that transfers material to the yard storage blocks.

The exporting process is that an outbound container is loaded onto a tractor by cargo-handling equipment at the yard, such as transfer cranes, straddle careers, and top lifters, then transferred to an outbound vessel by quay crane. By using Simio modeling software, dynamic 3D animated models of container terminals can be built efficiently.

4.5 Analysis

The simulation model can be run to examine the overall operation processes for all of the cargo for the coming day, based on the exact electronic real-time data

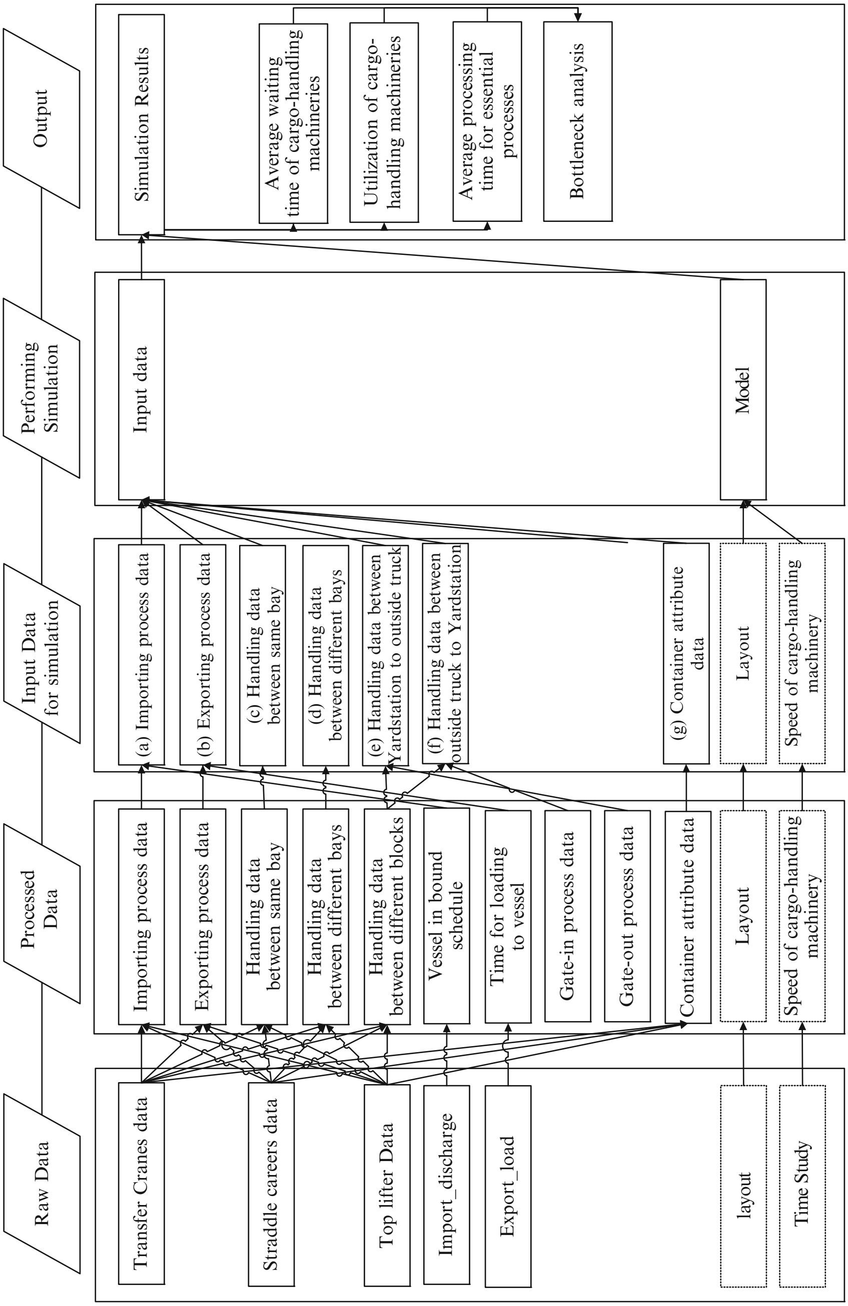


Fig. 4 Overall flow of data processing

Table 1 Selected resultant input data for the simulation of an actual container terminal

(a) Importing process						(Operation types: UL and TU)
No. (Priority No.)	Container No.	Vessel No.	Berth crane No.	Real time of loading completion for a truck	Truck No.	Real time of handling instruction for a cargo-handling machinery
1	TRIU8380996	STNG	1	9.18	KR024	9.06
2	NSSU0072627	HTYO	4	10.71	TX170	10.69
Real Time of last job finished for a cargo-handling machinery	Cargo-handling machinery No.	Block No.	Bay No.	Row No.	Real time of job finished for a cargo-handling machinery	
9.18	TC11	1F	15	4	9.29	
10.62	TC11	2F	12	3	10.80	
(b) Exporting process						(Operation types: LD)
No. (Priority No.)	Container No.	Cargo-handling machinery No.	Block No.	Bay No.	Row No.	Real time of handling instruction for a cargo-handling machinery
1	PCSU2120915	TC18	2C	40	5	10.98
2	PCSU2108036	TC18	2C	40	6	11.01

(continued)

Table 1 (continued)

Real Time of last job finished for a cargo-handling machinery	Real time of job finished for a cargo-handling machinery	Truck No.	Berth crane No.	Vessel No.		
11.01	11.03	KP118	V4	HTYO		
11.03	11.06	TK136	V4	HTYO		
(c) Handling between the same bay in a block						(Operation types: RS and IS)
No. (Priority No.)	Container No.	Cargo-handling machinery No.	Block No.	Bay No.	Row No. (from)	Row No. (to)
1	CRSU6022868	TC11	1F	17	2	3
2	YMLU7415614	TC11	1F	10	2	3
Real time of handling instruction for a cargo-handling machinery	Real Time of last job finished for a cargo-handling machinery	Real time of job finished for a cargo-handling machinery				
8.80	8.80	8.87				
9.36	9.34	9.43				
(d) Handling between different bays in a block						(Operation types: IB)
No. (Priority No.)	Container No.	Cargo-handling machinery No.	Block No.	Bay No. (from)	Row No. (from)	Bay No. (to)
1	CKLU4107919	TC30	3E	07	04	04
2	PCLU4050914	TC30	3E	07	05	04

Row No. (to)	Real time of handling instruction for a cargo-handling machinery	Real Time of last job finished for a cargo-handling machinery	Real time of job finished for a cargo-handling machinery			
05	7.57	8.32	8.36			
04	7.57	8.36	8.40			
(e) Handling between yard station to outside tractor						(Operation types: SO and D)
No. (Priority No.)	Container No.	Cargo-handling machinery No.	Block No.	Bay No.	Row No.	Real time of handling instruction for a cargo-handling machinery
1	KKTU7880852	TC15	1J15051	15	05	8.41
2	DFSU2085042	TC15	1J15022	15	02	8.41
Real Time of last job finished for a cargo-handling machinery	Real time of job finished for a cargo-handling machinery					
8.63	8.67					
8.67	8.69					

(continued)

Table 1 (continued)

(f) Handling between outside tractor to yard station						(Operation types: SI and R)
No. (Priority No.)	Container No.	Cargo-handling machinery No.	Block No.	Bay No.	Row No.	Real time of handling instruction for a cargo-handling machinery
1	SNBU2114676	TC11	2F	33	02	8.50
2	TRIU8666969	TC26	2E	27	01	8.51
Real Time of last job finished for a cargo-handling machinery	Real time of job finished for a cargo-handling machinery					
8.52	8.57					
8.55	8.58					
(g) Container attributes						
Container No.	Size	Type	Height	FE (Full = 1/Empty = 0)	Weight	Vessel name
PCSU2120915	20	DC	86	1	15,563	HTYO
CRXU6921757	40	RC	86	1	28,900	JID

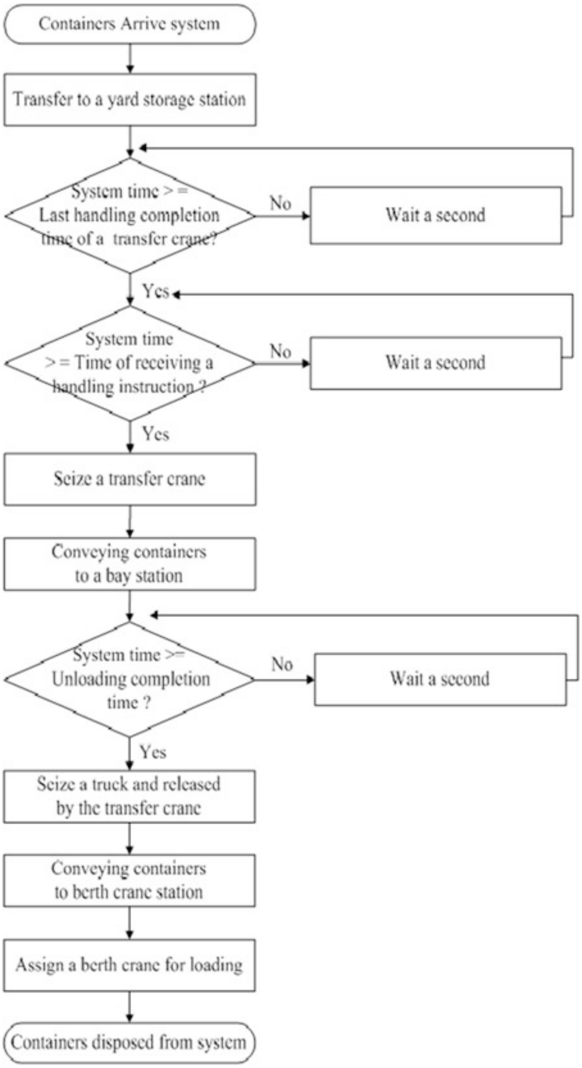
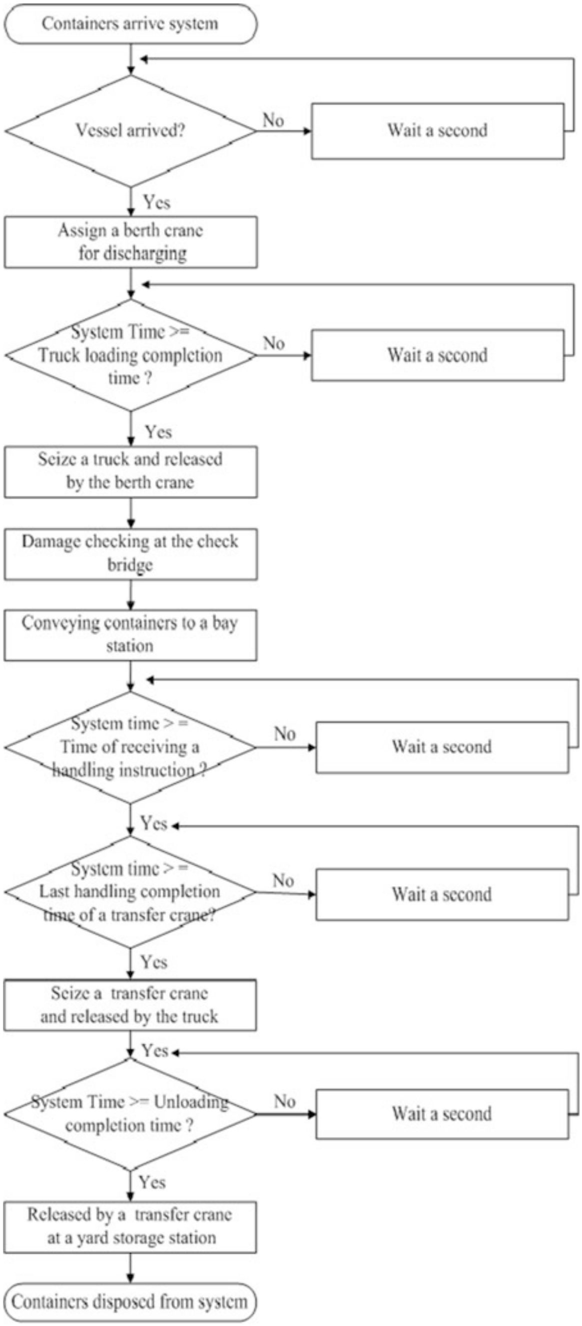


Fig. 5 Exporting process for a typical terminal

of the day. By performing the simulation, a number of performance measurement variables can be recorded and output. A part of the simulation results about tracking the outgoing containers is shown in Fig. 7. The average or maximum total time in this system can be analyzed and outputted by performing simulation. This result can be used to improve the performance of materials handling at the container terminals.

Fig. 6 Importing process for a typical terminal



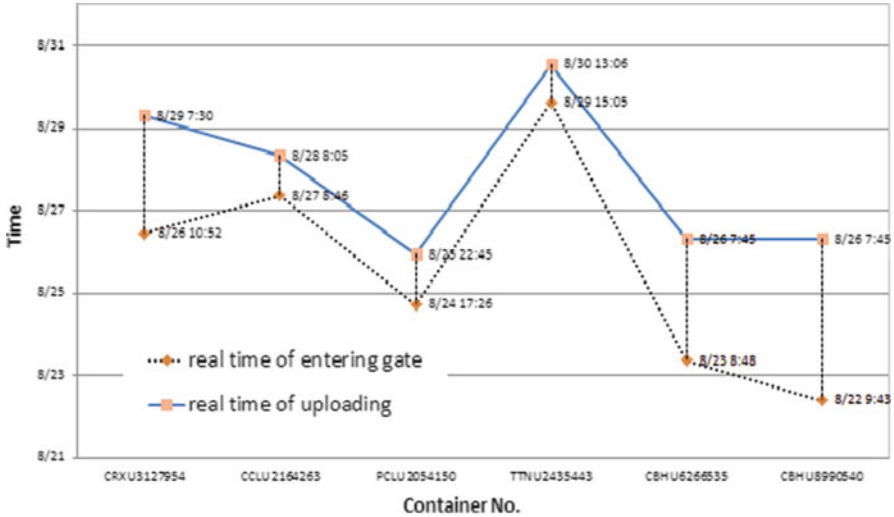


Fig. 7 A part of the simulation result about total time of containers in system

5 Conclusions

In this paper, by making use of electronic real-time tracking data that is accumulated from united terminal IMSs, a procedure is proposed to aid materials handling management for container terminals.

The proposed procedure is applied to an actual container terminal in Japan in order to confirm its effectiveness. It is found that the information obtained by performing simulation is effective for analyzing the performance of the materials handling operations at container terminals. In addition, the procedure is generic and can easily be expanded to model other ports.

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