ISSN: 1231-4005
e-ISSN: 2354-0133
ICID: 1133228
DOI: 10.5604/12314005.1133228

CONTAINER TERMINAL AS A QUEENING TRANSPORT NETWORKS

Leszek Smolarek

Gdynia Maritime University, Department of Transport and Logistics
Morska Street 81-87, Gdynia, Poland
tel.:+48 58 690-18-38, tel./fax +48 58 621-66-18
e-mail: leszsmol@am.gdynia.pl

Przemysław Wilczyński

Gdynia Maritime University, Department of Ship's Operation
3 Jana Pawla II Av. 81-345 Gdynia, Poland
tel.:+48 58 661-69-85, phone +48 58 690-11-58
e-mail: pswilczynski@gmail.com

Abstract

The queuing networks consist of several connected simple queuing system. In container terminal as an open network containers enter the queuing network from sea and landside, received adequately service at system and leave the network. Jackson's network is simplest form of queuing networks, characterized by unlimited overall numbers of customers belong to the one class of customers. Customer – containers arrived' system with exponential arrival pattern (Poison or Erlang) and are served on single or multi-channel servers with exponential service time. Another case of queuing networks is network of Kelly with different classes of customers (containers) but each class of containers has fixed route (service model) in the transport system. The Baskett, Chandy, Muntz and Palacios – BCMP networks include different class of customers, with different queuing discipline and generally distributed time. Routes (service model) through the network may depend on the class of customers – containers, and the containers can change its class while passing through the system. This article describes different queuing networks, which can be used to modelling of the container terminal as a queuing transport network. The Queuing Theory may be used to determine the appropriate level of capacity required at container terminal and the staffing levels required at service facilities, over the nominal average capacity required to service expected demand. The model of the container terminal called a queuing network had better represent the real structure then a single system.

Keywords: *container terminal, queuing theory, queuing networks*

1. Introduction

Each queuing network is describes by several basic parameters such as, [7]:

- arrival Processes,
  - the probability density distribution that determines the customers arrivals in the system,
- service Processes
  - the probability density distribution that determines the customer services times in the system,
- number of Servers,
  - number of servers available to service the customers,
- number of Channels,
  - single channel,
  - N independent channels,
  - multi channels,
- number of Phases or Stages,
  - single Queues,

  - series or Tandems,
  - cyclic Network,
- queue Discipline,
  - first com first served (FCFS or FIFO),
  - last in First out (LIFO),
  - random,
  - priority.

All parameters of queuing systems are presented with Kendall's notation, which is well-known classification standard notation *A/B/X/Y/Z* ,

where:
A – distribution of intervals between arrivals,
B – distribution of service duration,
X – numbers of servers,
Y – capacity of system,
Z – queuing discipline.

Main parameters queuing system contain below presented table.

Tab. 1. Main parameters of the queuing system for container terminal, [4-6]

Parameter	Symbol	Commentary
A-distribution of intervals between arrivals	M Ek G G-G Cox	Poisson Erlang with parameter *k* general general – oscillating Cox's
B-distribution of service duration	M D Ek G G-G Cox	Poisson Deterministic Erlang with parameter *k* general general – oscillating Cox's
X-numbers of servers	X	1, 2, …, ∞
Y-capacity of system	Y	1, 2, …, ∞
Z-queuing discipline	FIFO LIFO RSS PR	First in – First off, Last in – First off, Random service, Priority

Containers, which are served by container terminal, are customers to such queuing network systems. Container terminal is an open queuing network, which can make a service for several different classes of customers, [1, 3, 7]. Between the containers, we can distinguish different class of the customers; some of them have priority in service in queuing network.

2. Structure of the queuing systems

Between queuing system, which can be applied to the structure of the containers terminal network we can distinguish several type of simple queuing system.

The first type of the queuing systems are the system consist form single (Fig. 1a and 1b) or multi-channel server. (Fig. 1c and 1d).

Other type of systems can be organized with queue or without. (Fig. 1b and 1d).

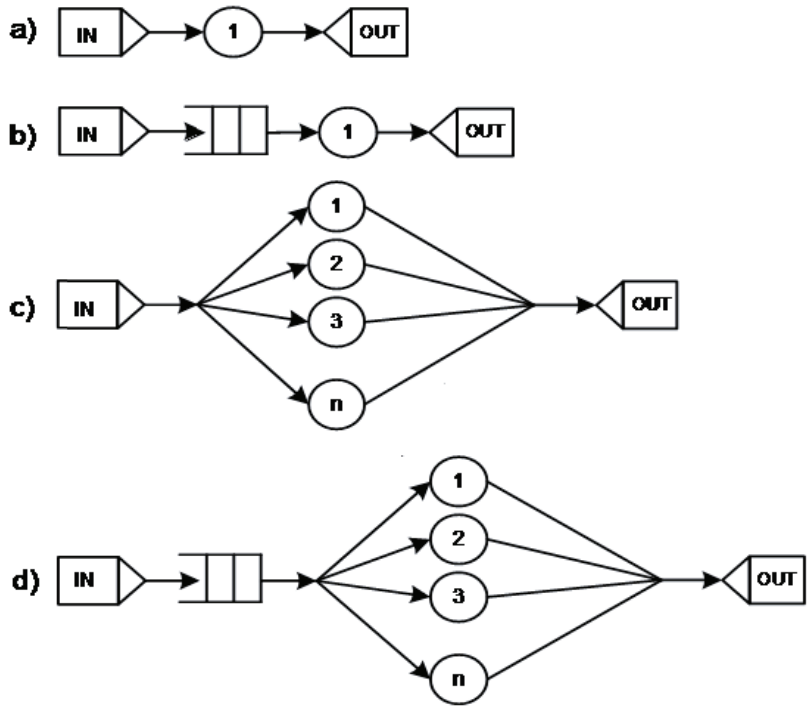

Fig. 1. Type of queuing system using for modelling container terminal network

Another type of queuing system, which can keep the length of the queue within the limits, is the oscillating system, [2]. In this type of queuing system service time and the input stream can be changed. Below Fig. 2 presented oscillating queuing system.

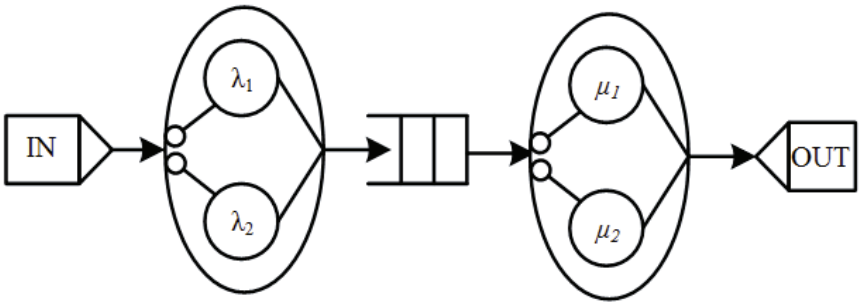

Fig. 2. Oscillating queuing system, [3, 4]

Last type of system using for modelling terminal's queuing network is Fork-Join system and Fig. 3 shows such working system.

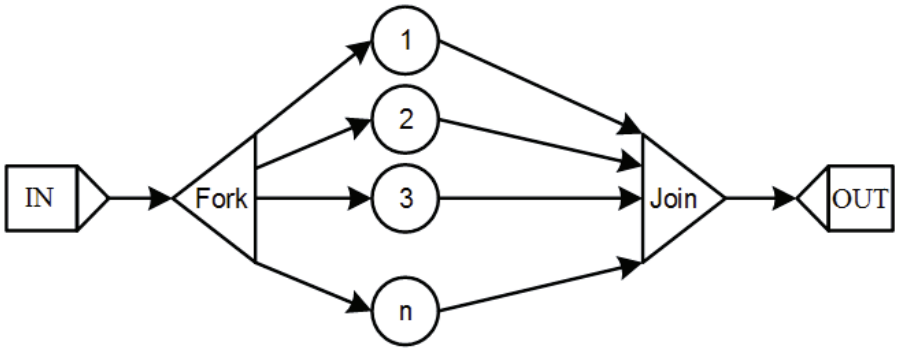

Fig. 3. Queuing system type Fork-Join

Customers arriving to a fork –join queue split (at fork point) into n independent tasks that are simultaneously assigned to n servers. Each customer requires a serve. When service of customers-containers is over, it will wait at the join queue until all its sibling customers are served.

The basic parameters of such system are the speedup defined as the ratio of the mean response time in the system with n sequential task to the mean response time in the Fork–Join system with n servers, and synchronization overhead defined as the ratio of the task's mean time in the join queue to the mean response time of the Fork–Join system.

Queuing networks

The queuing networks consist of several connected simple queuing system. In container terminal as an open network containers enter the queuing network from sea and landside, received adequately service at system and leave the network.

The well-known queuing networks are describing below.

Jackson's network

This type of the queuing network is simplest form of queuing networks, characterized by unlimited overall numbers of customers belong to the one class of customers. Customer – containers arrived' system with exponential arrival pattern (Poison or Erlang) and are served on single or multi-channel servers with exponential service time. Customers in the all system in network are served in order of arrival *FIFO*, [3, 7].

Kelly's network

Another case of queuing networks is network of Kelly with different classes of customers – containers. Between the classes, we can distinguish:

- containers without the dangerous goods,
- containers with dangerous goods,
- containers with high-risk dangerous goods.

Similar to the Jackson's networks each type of class containers has an exponential arrival pattern and exponential service time. Each class of containers has fixed route (service model) in the transport system. Each system could serve several different classes of customers, [3, 7].

Network BCMP

This type of queuing network *Baskett, Chandy, Muntz and Palacios – BCMP* is a multi-class network. The customers – containers entered this type of networks can be divided into several classes:

- containers without dangerous goods,
- containers with dangerous goods,
- containers with high risk dangerous goods,
- and all above-mentioned classes could be affected by failure.

These networks include different class of customers, with different queuing discipline and generally distributed time. Routes (service model) through the network may depend on the class of customers – containers, and the containers can change its class while passing through the system.

In this type of network, which can be applied to the container's terminal we can distinguish three types of systems:

- *FCFS* (*ang. first come, first serve*) – with multiple servers, with the same time of service for all classes of containers, with discipline *FIFO*,
- *LCFS – PR* (*ang. last come, first serve with preemptive)* – system with one server, different customers classes have a different general service time distribution, the service discipline is LIFO- PR,
- *IS* (*ang. infinite server*) – system with an ample numbers of servers and the mean service time for customer classes can be different [3, 7].

At Fig. 4, the part of container's terminal working according fork-join type queuing network is presented.

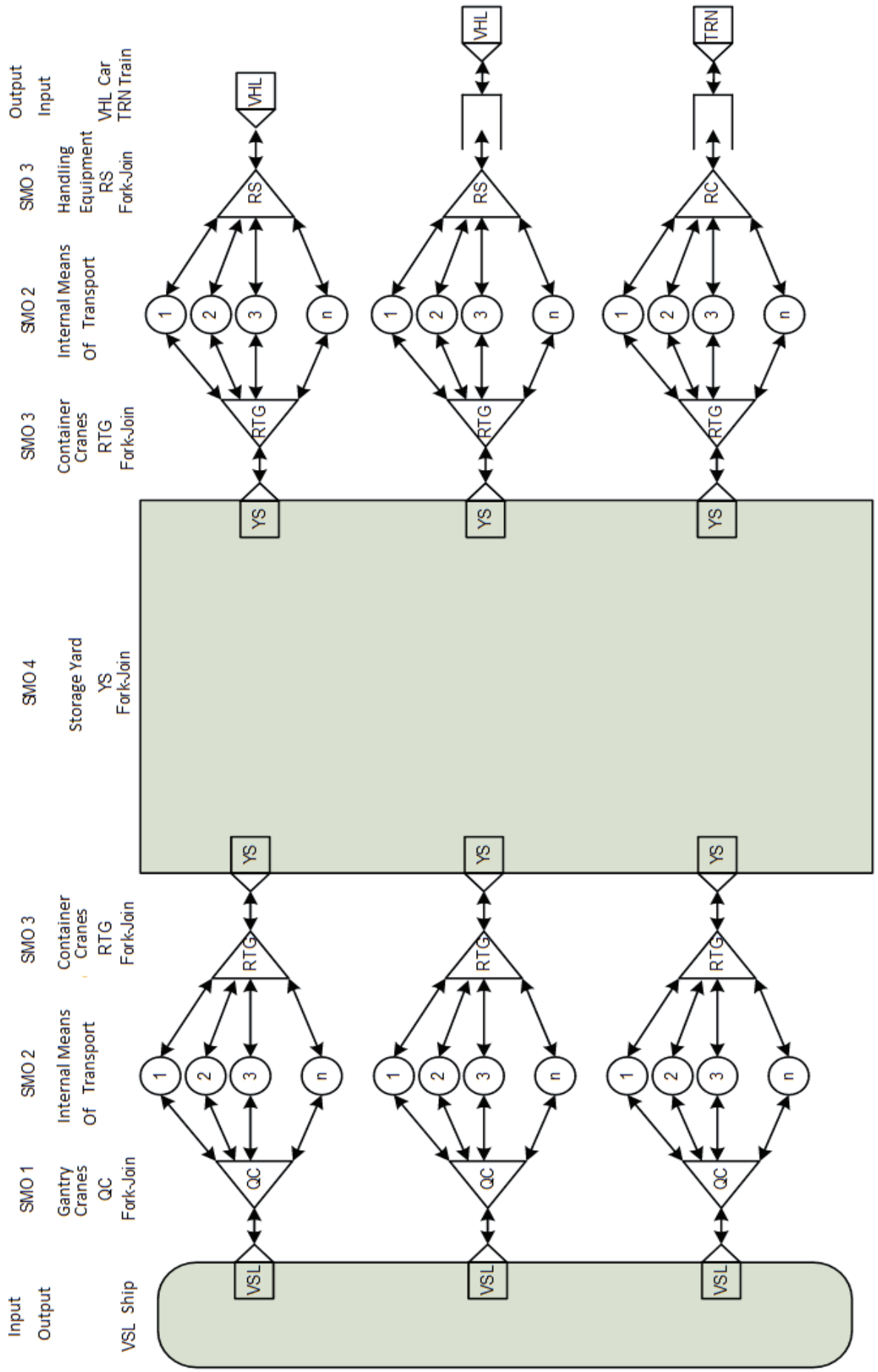

Fig. 4. Queuing transport networks of the container terminal

Summary

Presented queuing networks offer a good tool for modelling queuing transport network – container terminal. They can be used to improve flow of containers as customers, for the evaluation of utilization of container terminal, throughput and response time. Such models together with statistical data can be good base for the optimal decision process concerning with the structure of the containers terminal and service organization. Some parameters obtained from real worked container terminal together with modelling study allow calculating basic characteristic and assess the service process.

References

[1] Bitran, G., Caldentey, R., *Two-Class Priority Queueing System with State-Dependent Arrivals*, Kluwer Academic Publishers, Queueing Systems 40, pp. 355-382, 2002.
[2] Chydziński, A., *The M-M/G/1-type oscillating systems*, Cybernetics and systems analysis, 2, Vol. 39, pp. 313-324, 2003.
[3] Filipowicz, B., Kwiecień, J., *Queueing systems and networks, Models and applications,* Bulletin of the Polish Academy of Sciences Technical Sciences, 4, T. 56. pp. 379-390, 2008.
[4] Jaiswal, N. K., *Priority Queues*, Academic Press, New York 1968.
[5] Klimow, G. P., *Procesy obsługi masowej*, Wydawnictwo Naukowo-Techniczne, Warszawa 1979.
[6] Konig, D., Stoyan, D., *Metody teorii obsługi masowej*, Wydawnictwo Naukowo-Techniczne, Warszawa 1979.
[7] Lazowska, E. D., Zahorjan, J., Graham G. S., Sevcik, K. C., *Quantitative System Performance*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey 1984.