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APPLICATION OF NON PREEMPTIVE PRIORITY QUEUING FOR BASRAH COMMERCIAL PORTS

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ABSTRACT:

Waiting for commercial vessels inside the port is one of the most important problems facing traders and offshore companies, which often lead to material losses. The ports of Basrah are characterized by continuous congestion, which leads to the diversion of ships to the ports of the neighboring countries, causing the loss of many revenues to the country. This paper emphasizes the importance of non-preemptive priority queues (with multiple servers and multiple priority classes) to the problem of congestion of ports in order to promote sustainable development of the ports of Basrah. The aim of this paper is to apply a non-preemptive priority queues at ports of Basrah and calculating the average customer waiting time for the ships at berths.

KEYWORDS: Non-preemptive priority, Multi server queues, ports, Multiple priority classes.

1. INTRODUCTION

Basrah ports have recently witnessed an increase in traffic through their ports. Port congestion is increasing along with the economic development of the country. Sometimes, ships in the port must wait at queues a lot of time before the berthing. This is due to many reasons, the most important of which are: the movement of current port facilities is not commensurate with the growing global trade do not consider the priority of ships, as well as some government policies and regulations (Oyatoye, et al. 2011). The port congestion may cause to the diversion of ships to the ports of the neighbouring countries, leading the loss of many revenues to the country. Maduka (2004) defined "Port Congestion" as massive unclear cargo in the port, resulting in delay of ships in the seaport. According to him, this occurs when ships spend longer time at berth than usual before being worked on or before berth. Onwumere (2008) refers to port congestion as a situation where the ships on arrival spend more time waiting to berth because the cargoes coming to the port are more than the storage facilities that can handled. Therefore, more ships are lined up and waiting in the channels in order to obtain a space at the pier. The waiting time of ships at the pier is one of the methods to measure the efficiency of the port, which is calculated according to the time of the ship's service (Onwumere, 2008). Generally, a random arrival of the ships and don't consider the service priority is make port congestion. One of the most powerful mathematical tools for reducing port congestion decision and calculating the waiting time easy is the queuing theory (Oyatoye, et al. 2011). Papers written on queuing theory as applied to ports have been few and far between. Some of the earlier application of the queuing theory on ports can be found in the engineering literature. They were concerned with the question of optimum port size and the test of whether ship arrivals conform to the Poisson process. Examples of papers in this line of research includes Nicolaou (1967), Plumlee (1968) and Weille and Ray (1974).

Nicolaou used the Chi-square test to confirm that ship arrivals in the some ports in Cyprus follows the Poisson distribution. Also, the author presented a graphical analysis of how investments in port can be achieved based on the criteria that the optimal port investment is achieved when the marginal benefit of reduced port congestion is equal to the marginal cost of that investment. Plumlee tested the Poisson assumption using data from several ports in South America. It was found (as in Nicolaou) that the ship arrival pattern can be represented by the Poisson distribution. Plumlee also showed how we can determine the correct level of investment in port. The difference between his approach and Nicolaou is that Plumlee minimized the combined cost of ships waiting time and the cost of vacant berths. The investment level that minimize s the total cost is the

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optimal capacity for the port. Weille and Ray (1974) used the standard queuing model to show that the optimal investment level is achieved by weighing the benefits of reduced waiting time as a result of additional investment against the cost of making that investment. None of the papers mentioned above has analysed the issue of optimal port based on optimal dynamic queuing behaviour (Nor, 1988). In these models ship operators are not allowed to balk and there are no congestion tolls imposed.

This paper applied a non-preemptive priority queues (with multiple servers and multiple priority classes) to the problem of congestion of ports in order to promote sustainable development of the ports of \h. Cobham (1954) initiated the research on non-preemptive priority queues. In his paper, he developed formulas for the average waiting time in queue for both M/G/l and M/M/m two level priority queuing systems with the same service time. He derived an equation for the average waiting time in queue for each priority level using expected mean arguments. The aim of this research is to highlight the importance of considering priority in ship service and its impact on the waiting period spent by commercial vessels during shipping or unloading operations. In this research a non-preemptive priority queuing theory (for multi-server and multi-priority level i) was applied for Basrah ports order to know the wait required for loading and unloading ships, which in turn is reflected on the port's capacity to absorb large numbers of merchant ships time. The rest of this paper is structured as listed. The non preemptive priority queuing system is discussed in section 2. The analysis of non preemptive priority queuing system for some Basrah ports is presented in section 3. Discussion and conclusion are discussed in section 4.

2. THE NON-PREEMPTIVE PRIORITY QUEUING SYSTEMS

This section illustrates the steps that used to generate the performance measures of a finite capacity $M/M/m/k$ non-preemptive priority queuing systems. Generally, a non-preemptive priority queuing is based on the analysis of $M/M/m/k$ system in which m ships arrive according to a Poisson process with rate λ and the service times have a general distribution (Silva, et al. 2010). Queues with non-preemptive priority disciplines as shown on Figure 1.

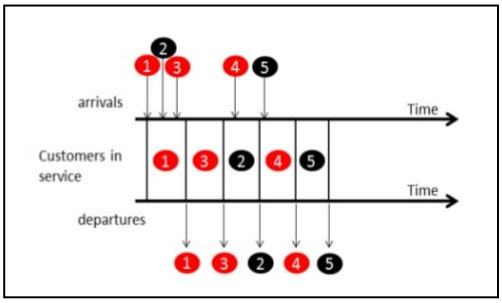

Figure 1. Queues with non-preemptive priority disciplines

Focusing on $M/M/m/k$ non-preemptive priority system, we consider a finite capacity queuing with the following characteristics:

- There are r priority levels in the system where priorities are set in advance and do not change. Also, an arriving ship knows which priority level it belongs to.
- Priority level i as a non-preemptive priority over priority level $i+1$ which means that upon arrival of a unit from priority level i, it will join the head of the queue if there is not any unit from higher priority levels.
- Priority discipline within each priority level is First Come First Served (FCFS).
- The number of units (ships) from each priority level is n_i, $i=1,\cdots,r$.
- The number of units (ships) in the system at any time is m.

The follow Table 2.1 describe the details of the performance measurements of the $M/M/m/k$ non-priority queuing model.

Table 2.1: The details of the performance measurements of the $M/M/m/k$ non-preemptive priority queuing model

Symbol	Describe
λ	Average arrival rate to the system (port)
λ_i	Average arrival rate for units (ship) of level priority i $(i=1,\cdots,r)$
μ_i	Average service time for ships belonging to level i
μ	Average service time
W_i	Average queuing time for priority level i
W	Average time that ship has to wait in queue
ρ_i	System utilization for priority level i
p_0	Probability of no units in the port
p_Q	Queuing probability
L_i	average system length for units belonging to level i
L	average length in the system

Non-preemptive priority queuing model holds that:

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$$p_Q = p_0 \frac{m^m}{m!} + \frac{\rho^m}{(1-\rho)} \quad (1)$$

$$p_0 = \frac{p_Q \, m!\,(1-\rho)}{(m\,\rho)^m} \quad (2)$$

$$L_i = \sum_{m=1}^{k} m\, p_Q \quad (3)$$

$$L = \sum_{i=1}^{r} L_i \quad (4)$$

$$\rho = \sum_{i=1}^{r} \rho_i, \qquad \rho_i = \frac{\lambda_i}{m\mu} \quad (5)$$

$$W = \frac{\rho\, p_Q}{\lambda(1-\rho)} \quad (6)$$

$$W_i = \frac{p_Q / m\mu}{(1-\rho_1-\rho_2-\cdots-\rho_{i-1})(1-\rho_1-\rho_2-\cdots-\rho_i)} \quad (7)$$

3. THE ANALYSIS OF NON-PREEMPTIVE PRIORITY QUEUING SYSTEM FOR SOME BASRAH PORTS

Iraq has a number of commercial ports distributed in certain areas of Basrah. These ports operate on the export trade of goods and import various materials. As most of the Iraqi commercial ports are public ports and not specialized ports, that is, they are doing more than a commercial business except the oil ports which specialized in the export of oil. Some commercial ports practice the export of oil as well as the export and import of commercial goods as in the port of Khor Al – Zubair (Asaad H. A., 2011). A non-preemptive priority queuing model was applied to data for four Iraqi commercial ports: Old Umm Qasr port, the port of the ten berths, Khor Al – Zubair and Abu Floss (see Table 3.1 below). These ports were studied basis on the rate of service (unloading and loading) and the waiting time that the ship spends inside the queue waiting for loading/ unloading. According to (Asaad H. A., 2011), the data as was included time of arrival the ship, time of departure, time of loading/ unloading, waiting time at queue as well as priority for each ships. The model in use can be applied to situations that meet these assumptions:

•The waiting line has two or more identical servers.

•The arrivals units (ships) follow a poison probability distribution with a mean arrivals rate of λ.

•The service times follow an exponential probability distribution.

•The service time (which is the time period that started when the ship arrival to port until its departure) same for all ships in the system.

•The capacity of the system is finite and is equal to k.

Using these assumptions, the dcision-makers can be determining the operating characteristics of the multi-server non-preemptive priority queuing model such as waiting time thereby causing port congestion which may not be desirable for all stakeholders.

Table 3.1: Commercial ports in Iraq (2009)

Name of port	Number of berths	Occupation
Old Umm Qasr Port	8	Commercial
The port of the ten berths	10	Commercial
Khor Al - Zubair	14	Oil & commercial
Abu Floss	3	commercial

The following Tables 3.2 and 3.3 are describe the experimental results of unloading rates for the four ports that based on apply non-preemptive priority queuing model, respectively.

Table 3.2: The experimental results of average arrival rate, average service time and system utilization of non-preemptive priority queuing model

Name of port	Total number of ships	Number of ship at berth	λ	μ	ρ
Old Umm Qasr	130	85	0.1747	0.2016	0.866
The port of the ten berths	200	75	0.2688	0.2016	1.333
Khor Al - Zubair	105	76	0.1411	0.2016	0.6999
Abu Floss	110	91	0.1528	0.2016	0.7579

Table 3.3: The experimental results of average system length, average system length for ships to level i, average time to wait in queue and average queuing time for priority level i of non-preemptive priority queuing model

Name of port	L	L_i	W	W_i
Old Umm Qasr	9	8	0.0416	0.0219
The port of the ten berths	2.25	2.667	0.02208	0.0123
Khor Al - Zubair	1.333	4.5	0.0138	0.0155
Abu Floss	3.667	7.333	0.0278	0.008

3.1 EXPERIMENTAL RESULTS OF AVERAGE LENGTH IN THE SYSTEM

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Table 3.2 shows the Old Umm Qasr port has the highest waiting time (9) hours, this is due to depended this port on few number of vacuum equipment for unloading process. This few number has led to an increase in the number of ships expected in the unloading row, this affects the delay of ships in the port. While the lowest rate of waiting for ships at the Khor Al - Zubair port was (1.333) because of adoption this port on the typical cranes, reducing the congestion of ships in the queue. Figure 2. Shows the results of average length in the system for four ports.

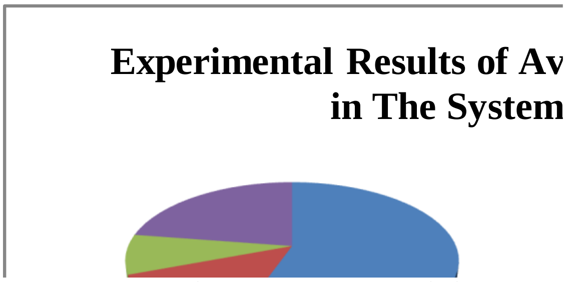

Figure 2. The results of average length in the system for four ports

3.2 EXPERIMENTAL RESULTS OF AVERAGE LENGTH FOR UNITS AT LEVEL i

Table 3.2 above shows that the port of the ten berths recorded the lowest expected rate of waiting ships reached (2.667), due to several reasons; this port receives small ships with loads of not more than 150-350 tons, also this port is one of the modern ports used a rapid equipment, resulting in a lower expected rate of waiting ships at level i. While, the highest expected rate of waiting ships was at the Old Umm Qasr port (8). This is due to several reasons, depended this port on few number of vacuum equipment for unloading process, moreover, these equipment are very slow caused to remain in the ships longer time in the port. Figure 3. shows the results of average length for units at level i.

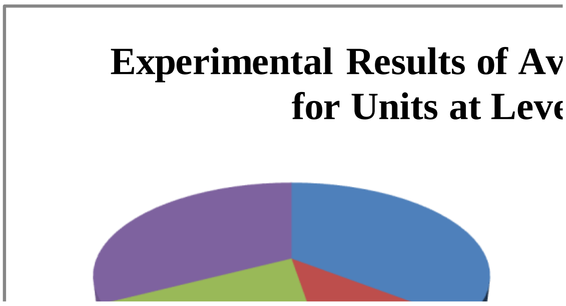

Figure 3. The results of average length for units at level *i* for four ports

3.3 EXPERIMENTAL RESULTS OF AVERAGE TIME OF WAIT IN QUEUE

Table 3.2 above shows the highest average time of wait in queue was at Old Umm Qasr port (0.0416), this is due to depended this port on few number of vacuum equipment's for unloading process, moreover, these equipment's are very slow caused to remain in the ships longer time in the port. While, the Abu Floss port recorded the lowest average time of wait in queue (0.013), due to several reasons; this port receives small ships with loads of not more than 150-350 tons, also this port is specialized to import the perishable food items (such as tomatoes and onions), that requires rapid unloading. The results of the average time of waiting in queue are given in Figure 4.

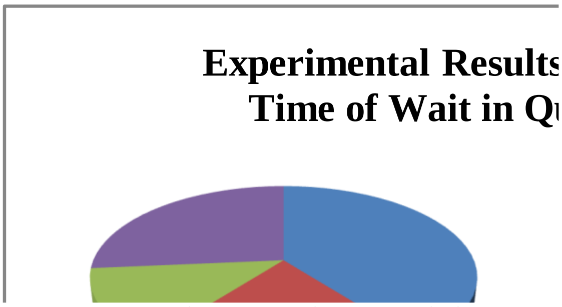

Figure 4. The results of average time of wait in queue for four ports

3.4 EXPERIMENTAL RESULTS OF AVERAGE QUEUING TIME FOR LEVEL i

Table 3.2 above shows the lowest waiting time at queue of priority level i was recorded at the port of ten berths (0.008) was due to the availability of modern and rapid cranes model, which reduced the waiting time for vessels in the port (see Table 3.1). On the other hand, the highest average time of wait in queue was at Old Umm Qasr port (0.0219), this is due to depended this port on few number of vacuum equipment for unloading process, moreover, these equipment are very slow caused to remain in the ships longer time in the port. Figure 4. below show the results of average queue time for level i.

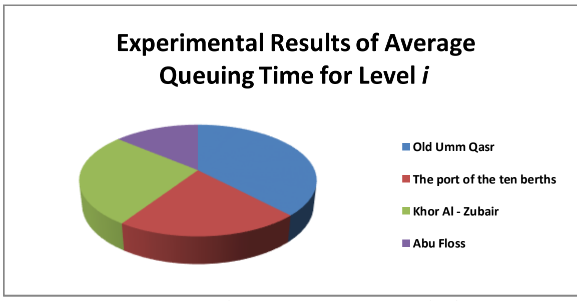

Figure 5. The results of average queue at level *i* for four ports

4. DISCUSSION AND CONCLUSION

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In this paper, a non-preemptive priority queuing theory (for multi-server and multi-priority level i) was applied for Basrah ports order to know the wait required for loading and unloading ships, which in turn is reflected on the port's capacity to absorb large numbers of merchant ships time. The results showed: for the average length in the system that the Old Umm Qasr port has the highest waiting time while the lowest rate at the Khor Al - Zubair port, for the average length at level i also the highest expected rate of waiting ships was at the Old Umm Qasr port while the lowest was recorded at the port of the ten berths, also the highest average time of wait in queue was at Old Umm Qasr port while the lowest rate at the Abu Floss port and finally, for waiting time at queue of priority level i the lowest was recorded at the port of ten berths and the highest was at Old Umm Qasr port.

The results revealed that the commercial ports in Basrah spent a lot of time in unloading or waiting for ships that is not commensurate with the economic situation in the country. This is due to depended the commercial ports in Basrah on few number of vacuum equipment for unloading process. Moreover, these equipment's are very slow. For accelerating the process of loading and unloading, we recommend providing the ports with the typical modern cranes and fast equipment that for reducing the congestion of ships in the queue thus, commensurate with the volume of trade exchange.

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