Research On Reducing The Cost of Stopping Port By Queuing Theory

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Abstract

With the development of global economic integration, the import and export trade has been increased, and a large number of import and export trades have been completed by sea. Therefore, the throughput of domestic ports has been increasing.In order to allow the ship to obtain a better service in a shorter berth time, the port berth operating fee, ship's berth fee and other related expenses incurred by the port berth will be reduced. In combination with the queuing theory in operations research, a reasonable modeling is made to the queuing phenomenon, and the queuing system is planned according to the port berth.

Keywords

Throughput; Queuing theory; Modeling; Cost; The berth.

1. Introduction

Port trade plays an irreplaceable role in the economic benefit of port companies.

In the port trade, the order of the ship entering and leaving the port involves the queuing process, how to make the port's configuration facilities and berths are fully used. The reasonable number of port berths can reduce the length of the queue and the time to enter the port. The number of berths is too small, and the waiting time of the ship will be prolonged, the ship will not unload in time, resulting in stagnation, and the port cost of the ship will become more; Too many berths are not ideal, some berths are idle, no ship service is carried out, and the related management fees are still needed, and the port can not get more profit.

2. Port throughput

According to the data of recent years, the port throughput of our country is basically in the trend of continuous growth, and it is known that the port is a bridge to guarantee the economic relations between countries.

2.1 Comparison of data

From the following data, we can clearly compare the period of 2016 to 2015, and the change of port throughput basically shows the phenomenon of continuous growth.

Port foreign trade throughput in2015

port month	1	2	3	4	5	6	7	8	9
Coastal ports	28600	24300	26700	27200	27050	27200	27800	27800	26900
Inland port	2990	2550	2730	2980	3050	3100	3090	3070	3060
The Yangtze river port	2340	2050	2200	2310	2410	2460	2500	2450	2390

Port foreign trade throughput in2016

port month	1	2	3	4	5	6	7	8	9
Coastal ports	28560	24500	27200	27900	28100	28200	28700	28700	27600
Inland port	2950	2600	2890	3100	3250	3370	3320	3300	3300
The Yangtze river port	2350	2100	2340	2490	2610	2720	2790	2710	2620

2.2 Problem of throughput disclosure

The increase of port throughput, the number of ships in and out of the port will also be more, the ship has a series of operations such as berthing, loading and unloading. If the berth is full, the other ships that want to come in need to wait in line, so that the port cannot meet the demand and carrying capacity of the market, and the time and cost of waiting for the ship will increase. So in order to solve this problem, then we use queuing theory in operational research modeling, rational planning, or of the ship, shorten the waiting time of ships, and compare to the ship dock port cost calculation.

3. Queuing theory model construction to solve the ship′s waiting.

3.1 Relevant knowledge of queuing theory

Queuing theory is a theory branch in operational research, is a specialized research due to the influence of random factors and the crowding of science, also known as the theory of stochastic service system, has been widely used in all aspects of life. In reality there are a number of services will face line, such as supermarket queue to pay for items, register queue to see a doctor in a hospital, waiting in line to buy tickets, bus station ticket office, etc., queuing for buses will be produced due to the randomness of the customer arrival and service time queuing phenomenon, even appear crowded phenomenon.

Queuing theory is to study, how to ensure the quality of services under the premise of maximizing efficiency of service, namely: use mathematics method to study how to determine the most appropriate number of service personnel and equipment, to obtain good quality of service, service costs the least. The so called related concepts, in each of the different queuing system, its customers are accept service people, things, and give the customer service people, things, (system) into the reception desk. Queuing system, each customer by the customer source in a certain way arrive service system, first joined the queue queue wait for service, choose the customer service desk according to certain rules from the queue for service, service customers to leave immediately. Generally, at least one of the arriving time intervals and service hours is random.

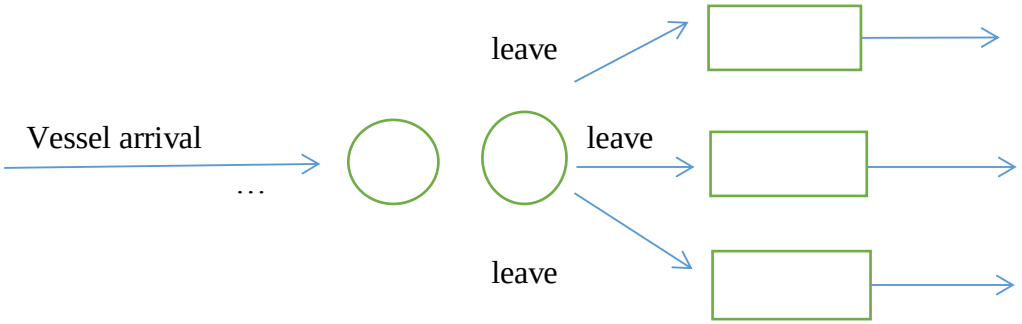
Are involved in the queuing theory knowledge of the probability theory, the queuing system, customers have arrived at intervals with service time distribution are mainly negative exponential distribution, poisson distribution, Erlang distribution.

3.2 Queuing modeling of ships.

According to the queuing theory in operations research, ship queuing is also a dynamic stochastic system. Make sure to the port of shipping for the customer, reward port berth as the service desk, and the queue for an infinite number of customers waiting in line, so, ship and provide handling berth and anchorage for waiting for shipping line constitutes a random service system. Due to the randomness of the ship to the port, the single team and the parallel multi-service platform (the service number is b) are adopted, namely M/M/b model; Similar to the standard M/M/1 model, the ship queuing service time is handled when the port berth number is b. In the M/M/b model, the rules are still keeps consistent, the difference is that of vessel arrival process said the first M obey the poisson distribution,

said the service time of the second M obey exponential distribution, (because when service time obey negative exponential distribution, the unit of time to complete ship dock loading and unloading of goods or service rate can obey the poisson distribution, so the second and first said are M), the third b indicates the port can be docked on the number of berths. Its queuing rules are first to first served, and the time interval distribution and service time of ships are random. This requires knowledge in probability theory.

In this model, the work of port berths is independent of each other and the average service rate is the same. The average service rate of the whole service organization is bμ. The service rate of the queuing system and systems related to the ship to the port Numbers, when the queuing system of the ship to the port number is not greater than the number of port berths, namely 1≤s≤b, or less or less all the berth system of a ship, the system of service rate for sμ; When the number of ships in the system is s ＞b, b ships have been docked in the berth, and the remaining vessels are waiting for service in the anchorage, the service rate of the system is bμ. In order to better solve the state probability of the system, the diagram below is the state transfer diagram of the system, which is easy to understand.



From this diagram, we can use the relevant mathematical formula to solve it. Get system status 0,1,2... , n,... The stable probability equation.

$$\lambda P_0 = \mu P_1$$

$$\lambda P_{n-1} + (n+1)\mu P_{n+1} = (\lambda + n\mu) P_n \quad (n=1,2,3,\ldots,b)$$

$$\lambda P_{n-1} + b\mu P_{n+1} = (\lambda + b\mu) P_b \quad (n=b+1,b+2,\ldots)$$

And we can solve it by the above equation $\sum_{n=0}^{\infty} P_n = 1$.

$$P_0 = \left[\sum \frac{1}{s!} \left(\frac{\lambda}{\mu}\right)^s + \frac{1}{b!} \frac{1}{1-\rho} \left(\frac{\lambda}{\mu}\right)^b \right]^{-1}$$

$$P_n = \begin{cases} \frac{1}{n!} \left(\frac{\lambda}{\mu}\right)^n P_0 & n \le b \\ \frac{1}{b! b^{n-b}} \left(\frac{\lambda}{\mu}\right)^n p_0 & n > b \end{cases}$$

Using these formulas to obtain the results, the number of M/M/b queuing system is obtained by using the same method as the single service desk system, as follows:

(1) The average number of ships in the queuing system.

$$L_s = \sum_{s=0}^{\infty} d P_d = \sum_{d=0}^{\infty} d \rho^d (1-\rho) = L_q + \frac{\lambda}{\mu}$$

(2) The average number of ships queuing in port.

$$L_q = \sum_{n=b+1}^{\infty}(n-b)P_n = \frac{(b\rho)^b\rho}{b!(1-\rho)^2}P_0$$

(3) The average length of stay in the queuing system is the time when the ship arrives at the port until the service is completed.

$$W_s = \frac{L_s}{\lambda} = W_q + \frac{1}{\mu}$$

(4) The average time spent in the queue is equal to the expected value of the time spent in the system minus the expected value of the service in the system.

$$W_q = W_s - \frac{1}{\mu}$$

3.3 Case analysis

Next, take wenzhou port as an example to simulate the queuing system. Since ancient times, wenzhou port has been a trading port, located on the southeast coast, with advantageous geographical location and abundant port resources, and is the most important transportation hub. There are 16 berths in wenzhou port for loading and unloading operations, and the ports are divided into different operation areas. The port cargo trade between wenzhou port and many countries, such as South Korea and Hong Kong, has opened up different routes to ningbo and Shanghai, and the throughput has been increasing year by year.

Table 1 The throughput and berthing of the port in wenzhou in 2009.

Time/month	5	6	7	8	9	10	11	The total number
Throughput/ TEU	35	36	43	50	53	53	48	318
Berthing quantity/vessels	456	657	565	659	634	765	745	4481

According to a data table, a total of 2009 wenzhou port can be found on the number of ships docked for 4481 ships, the throughput of each month has a growing trend, visible wenzhou port to provide ship dock berth, and efficient use of anchorage, port resources, reduce vessel in anchorage queue waiting time at the same time, take advantage of all conditions of maximization.

Table 2 Calculation of related quantitative indicators.

Comparison of type	Ship to port rateλ	Channel service rateμ	The average of queuing ships（ship）	Average of port ships.（ship）	Queuing time（d）	The mean time of ship berth.（d）
5 berths	57	14.5	84	345.364	135	34.576
7 berths	85.34	25.65	68.7	734	46.57834	49.54734
10 berths	69	28.6	14.546	843.683	174	63.267

On the basis of previous throughput data, when different ship types are queuing through ports, the relevant data from the above table can be used to determine the docking conditions when different berths are set up in the port. Queued to service the number of ships in the port, the system reached port in the average number of ships, shipping line average waiting time, shipping port, the average time these through the statistics and calculation, and familiar with the whole process of system, the indicators to judge the system wait in line. It can be found that the more berths, the reasonable utilization of the port infrastructure equipment; The shorter the average queuing time, the higher the service efficiency of the system and the faster and faster operation of the whole port.

Different ports have different charging standards for different types of ships and tonnage. Ships, and roads during the port to use the port equipment, waterway, berth, loading and unloading operation of the service and pay the relevant expenses: in accordance with state regulations of ship pilotage, tug, berthing, light and to handle the goods produced by handling fees, tallying fees, etc., and some miscellaneous fees. The port shall not be charged for dockage if the ship is not in its own right, as long as it is not its own cause. Docked at the port of anchorage navigation of the ship, the ship in port wharf berthing, in excess of the prescribed time still parked dock port should be charged fees, so, ship will be caused by queue waiting time of need to pay more fees, in order to economic benefit, need to port the berth of reasonable arrangement.

4. Conclusion

The M/M/b model is adopted to translate the queuing phenomenon of ships into the problems solved by mathematical method, which proves the importance of combining theory with practice. This model according to the number of berth port to port resource utilization with explanation, but is not enough, this model also needs to optimize adjustment, under the condition of different throughput, change the model part of the link, dealing with different events.

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