OPTIMIZATION OF PRODUCT EXPEDITION PROCESS IN INDUSTRIAL ENTERPRISE

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Abstract

People are met with waiting in queues every day. They wait in queues in shops, at gas stations, elevators etc. It does not have to be only people, it can also be planes circling around an airport waiting to land, machines waiting to be repaired, cargo trucks waiting to be loaded etc. The problem of queue management tends to be complicated, because the scope of provision of services of various types grows quickly. The goal of these problems is establishment of an appropriate level of services. The method that enables solving these types of problems is called queueing theory.

The goal of this article is to bring the optimization of requirements for expedition processes in an industrial enterprise where customers arrive randomly and require fast and high-quality service.

Keywords: Optimization, queueing theory, expeditions

1. INTRODUCTION

Expedition processes represent a typical situation in which service is provided. On one hand, service requirements vary, there are fluctuations depending on certain periods (e.g. the number of customers at the beginning and end of shift) [1]. Additionally, unforeseen changes to requirements occur. On the other hand, the time of service may change due to the specific requirements of customers. The result is the difficulty of meeting the requirement immediately after it's been laid, especially during the peak period.

The only way to immediately satisfy the requirements every time is to build up a high service capacity that always meets the highest requirements. It is usually very expensive to build, operate and maintain servicing devices so that they always meet all the requirements when they occur [2]. It is very costly to constantly change and adapt the service capacity to the emerging requirements. The operating systems are designed in such a way that their capacity is less than the maximum requirements. Whenever a request exceeds a capacity, a queue arises. This means that customers do not get the service immediately when they ask for it and have to wait. On other occasions, the service units are idle. With a high service capacity, the customers don't have to wait long, but the service units are often idle and their costs is high [3]. With lower and less expensive handling capacity, its idle time is shorter, but the customers have to wait longer.

Managing service processes is a really complicated and demanding process. If the management demands customer satisfaction, it is very inefficient as of time and cost criteria, and sometimes it is impossible to satisfy everyone in any time. This is why the management is interested in finding the right level of service that suits both customers and business in aspects of efficient cost [4]. The area that deals with these issues is called queuing theory [5].

2. SOLVING APPROACHES

"Common sense" solutions are the least desirable for queue situations. Most managers assume that to achieve the best activity, the average service rate must approximately correspond to the average request rate. Such an arrangement is far from effective when arrivals and service times are systems subject to random deviations [6]. Therefore, the use of service process models is very important.

3. PERFORMANCE INDICATORS IN SERVICE PROCESS MODELS

When evaluating service variants, performance indicators are used, especially when monitoring costs. These indicators are derived from three input variables:

λ - average arrival rate,

μ - average service intensity,

φ - average traffic intensity.

Performance indicators:

Average service intensity:

$$\mu = \frac{T}{T_1} \tag{1}$$

T_1 - average service time of one customer,

T - monitored service time.

The average arrival rate is determined as the arithmetic weighted average of observed frequencies:

$$\lambda = \frac{\sum Z_i x_i}{T_c} \tag{2}$$

$i = 1, 2, ..., n$

Z - number of customer in system,

x - observed customer frequencies,

T_c - total observation period (time frame interval).

Average time W - time the customer spends in the system - waiting for the service:

$$W = \frac{1}{\mu - \lambda} = \frac{1}{\mu\,(1-\varphi)} \tag{3}$$

The average waiting time in queue W_q - the average time a customer waits in queue until serviced:

$$W_q = \frac{\lambda}{\mu(\mu-\lambda)} = \frac{\varphi}{\mu(1-\varphi)} \tag{4}$$

Probability of inactivity of the service device *P(0)* - the probability that there is no customer in the system (device is idle):

$$P\,(0) = 1 - \frac{\lambda}{\mu} = 1 - \varphi \tag{5}$$

The probability that the system is active P_w - this probability is the same as the probability that the system will not be idle, that is:

$$P_w = 1 - P(0) = \frac{\lambda}{\mu} = \varphi \tag{6}$$

Determining the average number of customers in the system

$$N = \frac{\varphi}{1-\varphi} \tag{7}$$

Calculating the average number of customers in the queue

$$N_q = \frac{\varphi^2}{1-\varphi} \tag{8}$$

There are more queue performance indicators; however, these are sufficient for solving this problem.

4. SAMPLE OPTIMIZATION OF AN INDUSTRIAL ENTERPRISE EXPEDITION PROCESS

Time frame taken during a 60minute interval gives us data about rate distribution of different number of customers who arrive at the expedition warehouse with one employee who performs the service with sufficient queue spaces. The determined distribution is given in the **Table 1**:

Table 1 Arrival rate of individual customers

Number of customers	0	1	2	3	4	5	6 or more	Total
Customer rate	2	5	6	8	4	3	1	29

The average customer service time is 30 minutes.

Define the basic performance characteristics of the service process system.

5. SOLUTION

This is the model *M/M/1/∞*, where the order of the operators is the same as the arrival order.

First, we count the average intensity of service according to formula (1):

$$\mu = \frac{T}{T_1} = \frac{60}{30} = 2 \text{ customers per hour}$$

Then we determine the average arrival rate of customers in the expedition according to formula (2):

$$\lambda = \frac{\sum Z_i x_i}{T_c} = \frac{0*2+1*5+2*6+3*8+4*4+5*3+6*1}{60} = \frac{79}{60} = 1{,}32 \text{ customers per hour}$$

By substituting into formula (6) we determine the probability the customer waits for the service in the system:

$$P_w = 1 - P(0) = \frac{\lambda}{\mu} = \varphi = \frac{1.32}{2} = 0.66 * 100 = 66\ \%$$

i.e. 66 out of 100 customers will not go through the service smoothly.

Provided that φ <1, we determine the essential characteristics of the system.

By substituting into equation (3), we obtain the average time the customer spends in the system waiting for service

$$W = \frac{1}{\mu - \lambda} = \frac{1}{\mu\,(1 - \varphi)} = \frac{1}{2(1 - 0.66)} = 1.47 hours\ = 88\, minutes$$

By substituting into equation (4) we obtain the average time the customer spends in the queue before being serviced

$$W_q = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{1.32}{2 * (2 - 1.32)} = 0.97 hours = 58\, minutes$$

Therefore the customer complaints are legitimate. By substituting into equation (7), we obtain the average number of customers in the system customers in the system

$$N = \frac{\varphi}{1-\varphi} = \frac{0{,}66}{1-0{,}66} = 1{,}94 \text{ customers in the system}$$

By substituting into equation (8), we obtain the average number of customers in queue

$$N_q = \frac{\varphi^2}{1-\varphi} = \frac{0{,}66^2}{1-0{,}66} = 1{,}28 \text{ customers in queue}$$

The result shows the lack of service in expedition process, the solution is to hire another worker.

6. CONCLUSION

The queue theory is a tool that is mainly used for calculation of the service system indicators. Management uses this information to design the service system and to improve its performance. The main reason for queue creation even in the case when the average service rate is faster than the average arrival rate, is that both rates are volatile in an unpredictable manner. It results in short-term changes in both the arrival rate and the service rate. It leads to unused capacity during certain periods and queuing customers in other periods.

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