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Queuing theory application to present optimal model of service providing to customers of social security organization of Isfahan province

Hossein Ostadi, Maedeh Taaki *

Department of Economic, Dehaghan Branch, Islamic Azad University, Isfahan, Iran

Abstract: In service organizations, customer-oriented strategy is on priority for the managers of these organizations. Thus, the customer-oriented organization is the one fulfilling the customer satisfaction by presenting exact, rapid and timely services. By Queuing theory, a network of four service stations is evaluated in social security organization to reduce the waiting time of the customers. After the investigation and fitting, Queuing theory of each station is determined. Then, by defining evaluation criteria of each station (Queuing length, waiting time in queue, service provider idle rate), the data sensitivity analysis is performed to analyze the general behavior and the changes of evaluation criteria and based on the results, we can define the service providing optimal model to the customers based on manager waiting level.

Key words: Queuing theory; Optimal model; Social security

1. Introduction

All of us have experienced the suffering of waiting in queue. Unfortunately, this phenomenon is developed by increasing population density and urbanization of society. Waiting in queue is not pleasant but people are faced with different types of queues leading to eliminating of time, force and capital. The times wasted in bus, lunch hall, shopping and etc. queues are tangible examples of wastes in life. In current societies, there are many queues that their economic and social costs are more than above simple examples as the queues of urban traffic and the queues in airports, ports and telecommunication institutions and production processes. It can be said the waiting in queue is not an exception and it is rule-based.

In the current competitive world, manufacturing and service institutions to keep their situation and customer-orientation can optimize and increase their customers' satisfaction. Social security organization as the greatest insurance organization is associated with great part of society and this creates long queues leading to the fatigue and tension among the customers and employees. The organization managers are dissatisfied of customers waiting as these queues impose some costs. The main and most important duty of manager is decision making as taking the methods helping the organization condition improvement is of great importance. The lack of consideration of progresses and new tools can lead to uncertainty in decision making. Thus, the theorists attempt to equip the decision makers regarding these tools and techniques (Atayipour, 2006).

Queuing theory as a statistical technique to analyze the systems is of great importance. Queuing theory evaluating queuing from math view evaluates the effect of the queue constituents and logical ways of waiting time reduction. We cannot eliminate queue power completely, we can achieve suitable ways to reduce queue (Modares Yazdi, 2001).

The present study aimed to use Queuing theory to attract the customer satisfaction in social security organization of Isfahan province to minimize the customer waiting in queue to receive service and reduce unemployment of service providers. Generally, our goal is to establish a balance between the number of service-providers and their idle time and customers waiting time in queue. Based on this theory, at first we investigate four work stations of registration and individual account, insured affairs and insurance book and pension receivers' affairs as the main and crowded parts of organization. By evaluation of the condition of stations and application of queuing applications, at first evaluation criteria of each station are found and then, by analysis of sensitivity to suitable criteria, optimal service providing model to customers from the view of manager is defined to avoid creation of long queues in organization.

2. Study methodology

This study analyzes four service stations in social security organization based on queuing models. At first, queue models of each station are defined based on the data of observation and then by evaluation of the data and the results of queue models, the data sensitivity analysis is considered to define the optimal service providing model to customers.

* Corresponding Author.

At first, the general view of organization is as follows that customers after entering the organization based on the requested service are in the required station and wait for service receiving. Figure 1 shows the general view of system.

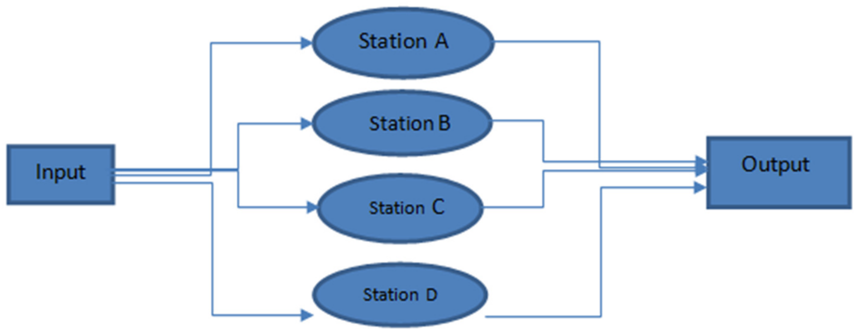

Fig. 1: The general view of system

Generally, a customer is put in one or some queues to receive different services but in this study, each queue is calculated and evaluated separately and the customer in each queue is calculated as new customer.

For data collection with the presence of organization during July 6, 2014 to September 6, 2014, the data as time interval between two continuous inputs to stations are registered to determine the input rate **λ** and service providing duration of each station to determine **μ** service rate. **λ** and **μ** are arrival and service rate, respectively as calculated of the following equation (Sabagh, 2009).

$$\mu = \frac{1}{E(x)}$$

$$\lambda = \frac{1}{E(y)}$$

By multiplication of λ and **μ** values by 60, their values are obtained based on hour.

After data collection, based on statistical issues and SPSS software, we fit Kolmogorov-Smirnov (K-S) to determine the type of registered data to obtain the arrival distribution and service distribution of each station. Table 1 shows a summary of the obtained data.

Table 1: The obtained data

Stations	E(X)	E(Y)	μ	λ	$(K\text{-}S)_X$ Test	$(K\text{-}S)_Y$ test
A	0.8844	0.946	67.84	63.411	0.010	0.013
B	1.035	1.13	58	53.08	0.019	0.034
C	0.61	0.633	98.36	94.70	0.038	0.008
D	1.410	2.949	42.53	20.34	0.024	0.042

As estimation accuracy is 0.05 and K-S test results are less than this value, it shows the exponential distributions. Based on statistical rules, if probability distribution follows exponential function, probability distribution function is Poisson (Forund, 2006, 201).

Generally, a queuing model is as A/B/C/D as A is time distribution between two continuous arrivals and B indicates service-providing time distribution, C number of service-providers and D limitation on system capacity.

Based on the type of customers to network and service-providing model, we can use open Jackson model for system analysis. The results show that each station has exponential arrival distribution and exponential service distribution, with one a person service provider and as there is no limitation on system capacity, queuing model of each station is as M/M/1.

To evaluate each stations, based on λ and **μ** and the number of service-provider people based on Little relations, we can achieve information as W_Q as average waiting time in queue, L_Q is average customers in queue, P_0 is idle rate and L average existing people in system and W is average waiting time in system (Sabagh, 2009).

Little relations include:

$$W = \frac{1}{\mu - \lambda}$$

$$L = \lambda W$$

$$Wq = W - \frac{1}{\mu}$$

$$L_q = \lambda Wq$$

In this study, to achieve the above values, QUEUING ANALYZ software is used and the values of each station are defined in Table 2.

3. The sensitivity analysis of stations

For analysis of stations, we can analyze the sensitivity of each of stations to C number of service providers, **μ** is service rate and **λ** is arrival rate. As **λ** as arrival rate is not presented to the manager, it cannot be reduced or increased and the main purpose of this study is presenting optimal model based on manager expectations and we can ignore sensitivity analysis **λ**.

Table 2: The evaluation criteria of stations

Station	L_Q	W_Q (hour)	P_0 (%)
A: Booking	13.38	0.211	6.52%
B:Insured affairs	9.89	0.186	8.48%
C:Pension receivers	24.91	0.26	3.72%
D:Insurance book	0.43	0.0102	52.17%

By changing C and **μ** parameters, all evaluation criteria are changed and due to the importance of L_Q and W_Q for managers, it is attempted to achieve the relations between C, **μ** and L_Q and W_Q (Sundarapandian, 2009).

QUEUING ANALYZ software is used to analyze sensitivity based on Little relations. Table 3 shows the sensitivity analysis to C in distance 1< C <5:

As in station D, idle rate is 52.17**%** and W_q is 0.10 and it shows that in this station, there are no long queues and we don't need the analysis of sensitivity and optimization.

Table 3: The results of sensitivity analysis based on C (number of service providers)

	Station A			Station B			Station C		
C	L_Q	W_Q	P_0	L_Q	W_Q	P_0	L_Q	W_Q	P_0
1	13.38	0.211	0.065	9.87	0.186	0.084	24.91	0.26	0.03
2	0.264	0.004	0.363	0.24	0.004	0.37	0.928	0.003	0.35
3	0.0.34	0.0005	0.389	0.032	0.0006	0.39	0.47	0.0004	0.37

The results of sensitivity analysis C show that increasing the number of service providers can lead to the abrupt reduction of queue length and customer waiting time but it also increases the idle rate of service provider. Table 4 can analyze the sensitivity of stations to **μ**. For sensitivity analysis, **μ** of each station is reduced each time as 0.2 units and by reducing it despite the sensitivity analysis C in which the data are reduced suddenly, reducing queening length and customer waiting time are gradually and the increase of idle rate of service provider is logical and mild.

Table 4: The sensitivity analysis **μ** by reducing 0.2 units in each station

Station A			Station B			Station D		
L_Q	W_Q	P_0	L_Q	W_Q	P_0	L_Q	W_Q	P_0
13.38	0.211	0.065	9.87	0.186	0.08	24.91	0.26	0.037
12.76	0.201	0.068	9.45	0.173	0.088	23.57	0.24	0.039
12.20	0.192	0.070	9.068	.170	0.091	22.36	0.23	0.04

Thus, to determine the optimal model of each station with the aim of balance between waiting time of customer and idle rate of service provider, only we can change **μ** (service rate) and we ignore the change of service provider numbers.

4. Optimization by manager waiting level criteria

After the display of the results to organization manager, as besides reduction of waiting time and queue of customers, the efficiency aspect and costs of service providers can be considered and we can obtain optimal model for each station based on the reduction of average waiting time of customers of each station to 70% current condition and as in station A service provider efficiency is not less than 90% and in stations B and C the efficiency is not less than 85, 80%, respectively.

4.1. Optimal model of station A

Based on the results of station A sensitivity analysis, we can say based on the waiting level of manager, the increase of service provider due to the sudden increase of service provider unemployment rate is no suitable.

To determine the second strategy evaluation criteria, as reduction of **μ** is suitable as:

MIN μ
S.T
$W_Q \geq 0.7*0.211$
$P \geq 0.9$
$P \leq 1$
$\mu \geq 0$

P is system efficiency as calculated by the following equation:

$$\rho = \frac{\lambda}{\mu} < 1$$

By placement of P and W_Q based on **μ** and **λ**, optimal value of **μ** is obtained:

MIN μ
S.T
$\frac{\lambda}{\lambda(\mu-\lambda)} \geq 0.147$
$\frac{\lambda}{\mu} \geq 0.9$
$\frac{\lambda}{\mu} \leq 1$
$\mu \geq 0$

By solving the above system, **μ** = 70.213 and by placing it in Little relations, the following values are achieved:

L_Q=8.419
W_Q = 0.132
P_0 = 9.687

The comparison between optimal model and existing condition shows that reduction of queue length of 13.28 people to 8.419 people and waiting time from 0.211 to 0.132 can be achieved.

4.2. Optimal model of Station B

MIN μ
S.T
$W_Q \geq 0.70*0.186$
$P \geq 0.85$
$P \leq 1$
$\mu \geq 0$

By placement of little equations and **λ** values, the optimal value is **μ**=60.77 and also:
$L_Q = 6.02$
$W_Q = 0.11$
$P_0 = 12.65$
Based on optimal model, queue length is reached from 9.89 people to 6.02 and waiting time from 0.186 hours to 0.11 hours and idle rate is reached from 8.48% to 12.65%.

4.3. Optimal model of station C

Like other stations, in this station the aim is reduction of waiting time to 70% current and keeping the efficiency of service provider to 805. Thus, like the rest of stations, the optimal model is as:
MIN μ
S.T
$WQ \geq 0.70*0.26$
$P \geq 0.80$
$P \leq 1$
$\mu \geq 0$

By placing the values in equations, optimal **μ** is equal to 100.164 and in comparing this model and present condition L_Q reaches from 24.91 people to 16.39 people and W_Q from 0.26 hours to 0.173 hours. Also, idle rate reaches from 3.72 to 5.45%.

4.4. Optimal model of station D

The lack of long queue and high idle rate of this system indicates the optimality in present conditions.

5. Conclusion

In this study, after determining the existing model in each station and determining the evaluation criteria, we can analyze the stations sensitivity to factors C, **μ**. The results showed that by increasing C, interval option of evaluation criteria is lost and serious changes are observed in evaluation criteria and this causes high idle of service provider and the goal is creating balance between idle time of service provider and waiting time of customers. Thus, **μ** value is changed in a definite distance with the goal. The results showed that the changes of evaluation criteria are balanced and logical and can fulfill the expectations of manager and customers.

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