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Human Resources management with using of Analyses Queue Approach

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Abstract

Human resources management is considered as one of the most important integration processes in providing and attracting the human resources. In this study, we used queue theory to recognize the optimal number of required human resources in the organization. The queue theory parameters are composed of (average waiting time, coefficient utilization, spent time average and average queue length). The data and information were collected and analyzed for various amount of servers (employees). The results indicate that decreasing in required number of human resources can play as an important role in problem solving guidance.

Key words: Human Resources; Human Resources management; Queuing Theory.

Introduction

Since nowadays, human Resource is one of the most valuable factors in production and important asset of any organization and as the main source of competitive advantage and generating of fundamental capabilities in every organization. One of the main organizational planning is human resource planning (Azar *et al.,* 2002). The important factor for requiring human resource planning is for achieving the skill that needs, training and eventually making human resource optimal (Mazaheri *et al.,* 2010; Talebian, 2004; Rothwell, 1996). The correct human resource planning can eliminate many problems, which are hampering the developing ways (Khastar *et al.,* 2009; Jahanian, 2009; Zolnour *et al.,* 2002). The precise human resource planning can compensate the reducing costs due to job absence, and low productivity rate. Nowadays resorting the ideal methods to reach the best results has substantial importance (Jazani, 2010). After a period, we observe the various transformations, which are taking place in many scientific fields. Negligence to these developments and new tools, leads to mistrusting the results and solutions. Management theorists try to equip the planners to these new technologies. Queuing theory, which is called as random service theory, is one of the researching branches in mathematics science (Dieter, 2001) the existing techniques in queuing theory have substantial importance in solving the mathematics problems and system analyzing. One of the important features of this method is that according to mathematical logic and analysis the possibility of the precise and logic deduction without noticing to

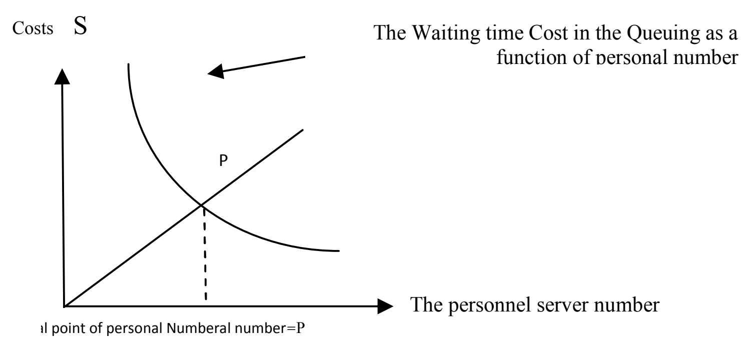

Fig. 1. The Optimal Solution of the Queuing problem

the environmental factors and its elicited errors.

The successful implementing of this technique in solving the economic and management problems could make a desirable vision towards implementing of quantity techniques in various services and production fields. Among the queuing theory implementations, we can indicate to assessment parameters such as operational efficiency, response time, and utilizing rate and so on (Amini, 2004). With regard to the role, economic and social importance of queuing theory in engineering fields, telecommunications, transportation system, service, many researches are done over queuing theory. Moreover, in this research along with extending the analytical methods, the presentation of new implementations is emphasized. The tools are selected according to their performance (Zhou, 2005), determination of optimal number of returned goods sensitive to time, determination of optimal number of machines (Shafiei *et al.,* 2007), analyzing of service system (Mortazavi, 2005; Zeephongsekul, 2006), transportation (Amini, 2004), analysis of radio networks according to performance (Kamali *et al.,*2009; Brannstrom, 2004) and the evaluating of employee's performance (Momeni *et al.*,2006). All are parts of researches, which were done through queuing theory models. The cost of people maintenance in the line has related to their waiting time in the queue. So the optimal number of services are the place of curves confluence point which are shown in Fig.1. One of these curves is the waiting cost in queue which is dependent to the number of servers namely the employees that has descending state in the Fig.1, it means that with increasing of personal number namely servers, the number of queues increased so the waiting cost in queue decreases. Another curve that is ascending and it is dictating the cost of generating server or hiring the new employee which increasing in their number and the organization cost soars straightly. Since the waiting cost in queue has the inversely relationship with the number of employees and more over increasing in the number of employees has straight relationship with rising in employment costs. In addition, it has straight relationship with allotment of necessary facilities, the confluence point of curve of waiting cost, the cost of generating the servers and employing the new personnel. This point is called P, which shows the optimal number of employees. In this point, the cost waiting in queue for applicants is equal to the cost of generating the servers and employment of personal for the organization. Regarding to the mentioned requirements , plan, policy and organization's strategy in this research and with the usage of queuing theory (multi-service model) we will answer to this question " what is an optimal number of employees (number of required employees) in the considered unit? "

Literature Review

Providing the human resources is a strategic goal in each organization to achieve their objectives. Mohammadi *et al*. (2005) scrutinized the determination and recognition of human resource planning with predictive Box and Jenkinz model. In this research according to the information (the number of patients and physicians), the evidence and documents in 10 years ago, the required numbers of physicians for five future years have been estimated. Human resource planning a case study with usage of chains Markov model in Sepah regional bank of Mazandaran is the name of a paper that Azizi Norouzi and Mohsen Yahyapour have done (2010). With the aim of internal offer prediction in human resources, the prediction of arrival and departing rate in organizational units and at last estimating process of surplus and deficiency in mentioned organization according to chain model of Markov. In addition, responding to the prediction of pure offer in human resources in various units and stations of organization during a period. The research result is depicting the current data and suitable anticipating process of human resources in the future. A research titled human resource planning with emphasizing on human resources demand prediction in the Vagon Pars Company, that by using of Regression procedure, according to

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two variables, production volume and sale volume human resources prediction in terms of kinds of jobs, education, service time, age & kind of training during years 2002-2011 which have been studied by Morteza Karami (2004). Adel Azar (2002) used Fuzzy mathematical model for human resource planning and considered the reason of usage from this model for human resource planning as existing of the ambiguous and inaccurate parameters in predicting matters. Linghua Li, Liling (2000) presented a goal model with multi-goals oriented, which includes the flexibility of jobs from replacing way. In this model, the number of required employees for planning period is determined in budget and validity sphere and goals, which are in priority level from each other. Although many attempts are done for, using of quantity methods in Human Resource Planning but there was an empty room for a research with using of queuing theory in the analyzing issues.

Research Methodology

Queuing theory

Erlang's attempt in 1909 for analyzing the density of telephone lines with uncertain demand in telephone system of Kopenhak under the name of new queuing theory was successful (Shafiei *et al.,* 2007). Nowadays this theory is one of the most important tools in different professions because of its ability to solve and stimulate many problems by queuing theory. Queuing theory is a method based on probability theory and random processes and with usage of mathematical logic and analyzing, which provides the analytical logic and precision analysis and it can provide the suitable solution for them. For this project two kinds of models are presented, the first model, which is called descriptive model, concentrates on situation explaining and the real problem. The second model which is called prescriptive model declines, what should be the situation of real world, namely it introduces the optimal behavior for introducing the goals (Ji, 2008). In other words, they are describing the queuing theory in the way that consumers visit to achieve services to a system and then after waiting in the system for desired service, would go to the related department and after passing the required time for ending the service, they would depart from it. By the way, the mentioning of the consumer or server is not only a human agent and thoroughly we considered all the parts including applicants, people, human or a server (Irfan, 2007).

The queuing theory is extended for describing the phenomenon of waiting in line in applying units sections to achieve services. Depending on the way of entrance and servicing in line of system is probability or certainty function according to the model of queue is (Wen, 2005). In the considered unit, arrival and service variable usually are random, so we used from probable model to describe them. From the fundamental features of queuing theory, we can name consumer's arrival pattern, the service pattern of servers, the discipline of queue, the system capacity and the number of parallel servicing channel which awareness of these features in generating a model is inevitable matter (Joris, 2008). Service time in queuing procedure may be in one of the probability distributions. A distribution which often is considered for service time, is a negative exponential distribution, if the distribution of time service were negative, the consumers arrival rate is based on Poisson distribution and the consumer's arrival is in terms of the Poisson arrival rate. In addition, the service is according to service time (negative exponential), which is explained in literature of queuing theory. Service rate, according to definition, is composed of the average number of consumers, which in a time unit get service from one server. According to Poisson model, the arrival distribution is not without experimental basic. Many statistical studies show the majority of queue procedures. The costumer's arrival rate is according to Poisson distribution. Poisson distribution assumes that the costumer's arrival is completely random, because the arrival of every costumer is completely independent of other system state. Therefore, for real experimental implementations the queuing analyzing is required that the hypothesis is

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controlled before its usage in the system (Brannstrom, 2004).

Multi-server Queuing Systems - M/M/m

The multi-server queuing mathematical model is known in Kendall's notation as the M/M/m model, where:

- M signifies a Poisson distribution (see explanation below)
- m = number of parallel service channels in the system.

The M/M/m model is one of the most commonly used to analyze the queuing problem in toll plazas. This model computes average wait times and queue lengths, given arrival rates, number of servers, and service rates. For $m>1$ (m: number of servers), the mathematical model is complex. When m = 1, a more readily calculable set of equations applies. This particular model applies where there are multiple channels served by a single queue, as at a bank teller or many airline tickets counters.

The outputs of the model are:

- Expected waiting time per customer in the system
- Expected waiting time of customer in the queue
- Expected number of customers in the system
- Expected number of customers in the queue

The exact calculation of these measures requires knowledge of the probability distribution of the arrival rate and service time. Furthermore, even

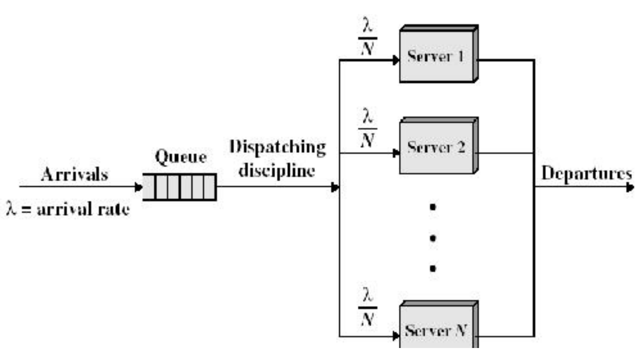

Fig. 2. The Multi-Servers Model (Brannstrom, 2004)

with that knowledge, the resulting formulae are exceedingly complex. Thus, some simplifying assumptions are required.

- The most basic of these assumptions is that the arrival rate obeys *Poisson* distribution, which is equivalent to saying that the interarrival times are exponential.
- The second assumption is regarding the nature of the probability distribution of the service times. With a *Poisson* distribution, the service times are assumed to be exponentially distributed.

Moreover, successive inter arrival times and service times are assumed to be statistically independent of each other. Collectively, the Poisson assumptions of the M/M/m model make for a reasonably tractable solution. Figure 1 below shows a generalization of the simple model of a multi-server queuing system. In this case, there are multiple servers, all sharing a common waiting line. If a user arrives and at least one server is available, then the user is immediately dispatched to that server. If all the servers are busy, a waiting line begins to form. As soon as one server becomes free, a user is dispatched from the waiting line using the dispatching discipline in force.

Research model

The observation of visitor's behavior (the arrivals) is very important in determining the queue model. In this paper, the system behavior is survey in a period of time. The study of consumer's behaviors showed that in more than 90% of cases, they select one of the servers from 8 options. The acceptable amount will be observed as m=8, and the suitable model for mentioned hypothesis will be as M/M/m, this model has M servers, from the queue capacity and there is no limitation for the consumer's population. The rate of consumer's arrival is stable and is equal to μ for every amounts of (n), the service rate of every server is supposed as μ.

In this system, each time that the number of consumers in the system is less than m(n≤m), the departing rate of consumers is equal to nμ and if the number of consumers which are inside, is more than m(n>m) the departing rate is equal to mμ (Karimian,2003). Fig.2 shows the multi-servers model.

Model assumptions

1. Based on the experiment it can be concluded that the obtained findings from a unit can be valid in other units in the organization.
2. Customers are aware of the organizational structure.
3. The arrival rate of customers to queue and the service rate are compatible to Poisson distribution or in another word, the time interval between two consecutive arrivals and time service, both follow from exponential distribution.
4. In the case of customer in the queue, none of the servers must be unemployed.
5. The queue discipline is in the way that the first customer goes to the first server, which is prepared for service.

Model Parameters

Utilization coefficient

It is obtained from dividing the average arrival rate λ (in time) to the average service rate μ. in fact for showing the percentage of time which the system is working we used from factor under the name of utilization coefficient of the system or ρ which can be defined as:

$$\rho = \frac{\lambda}{\mu} \quad (1)$$

Whatever the ρ is larger, the demand will be more, the system must work harder, and the queue will be longer. On the contrary, whatever the ρ is smaller, the queue will be shorter, but in this case, the use of system will be low too. If the arrival time of costumer to system were more than service rate, namely λ> μm in this case ρ>1 which means the system capacity is less than the arriving demand and the queue length becomes increased. Eventually at last, it reaches its highest point namely infinity. So for this reason the conditional μ>1 situation is a stable Condition for most systems.

The average waiting time in queue

The average waiting time in queue is equal to the average time, which a costumer waits in the queue for getting service, its formula is:

$$W_q = \frac{\lambda}{\mu(\mu - \lambda)} \quad (2)$$

The average of time spent in system

Average of time spent in system is equal to total time that a costumer spends in a system which is including waiting time and service time. Namely:

$$W = \frac{1}{\mu - \lambda} \quad (3)$$

The average queue length

The average queue length is composed of average number of people who are waiting in the queue:

$$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} \quad (4)$$

The average number of individual in the system

Is equal to the average number of individuals who are in the line or server:

$$L = \frac{\lambda}{\mu - \lambda} \quad (5)$$

The above factors will be determined if and only if ρ< 1 and in the case that ρ>1, the above factors will reach infinity. In addition, in the case of using multi-servers the above factors will be more complicated. If we suppose that *m* numbers of servers are in the system, the above functions are defined respectively as follows:

$$\rho = \frac{\lambda}{m\mu} \quad (6)$$

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$$W_q = \frac{Lq}{\lambda} \quad (7)$$

$$W = W_q + \frac{1}{\mu} \quad (8)$$

$$L_q = \sum_{n-m}^{\infty} (n-m)\pi_n = \sum_{n-m}^{\infty} (n-m)(\overset{\lambda}{\mu})^m \frac{\pi_n}{m!}$$

$$(m)^{m-n} = \frac{\pi_n}{m!}(\overset{\lambda}{\mu})^m \sum_{n-m}^{m} (n-m)(\rho)^{n-m}$$

or

$$L_q = \frac{\pi_n}{m!}(\overset{\lambda}{\mu})^m \frac{\rho}{(1-\rho)^2} \quad (9)$$

$$L = \lambda W = (W_q + \frac{1}{\mu}) = L_q + \frac{\lambda}{\mu} = \frac{\pi_n}{m!}(\overset{\lambda}{\mu})^m \frac{\rho}{(1-\rho)^2} + \frac{\lambda}{\mu} \quad (10)$$

And the possibility of no costumers in the system:

$$P_0 = \frac{1}{\left(\sum_{N=0}^{m-1} \left(\frac{\lambda}{\mu}\right)^N \frac{1}{N!} + \left(\frac{\lambda}{\mu}\right)^m \frac{1}{m!\left(1-\frac{\lambda}{\mu}\right)} \right)} \quad (11)$$

λ= the average numbers of arrival or arrival rate of clients in expected time level.
μ= the average number of people during the expected time level are using from the services.

Results and discussion

In the preliminary observations, the educational and financial units were considered due to the amount of visitors but during further studies, the financial unit was selected for minute investigation as a case study. (Various reasons for these selection shows we can indicate to some conspicuous reasons such as the large amount of visitors in this unit and the close inter- relationship of this unit with other units and so on). For data collecting of mentioned unit the following ways are done:

1. Some of information (such as the number of financial experts and activities) are observed from the investigation of the mentioned unit.
2. And other data are collected from interviewing with personnel and staff.

For determining some parameters and digital amounts due to shortage of resources and time constraints, the researcher used of presupposition information. All in all the required information for queue analyzing and for consecutive arrival time of customers for determining the arrival distribution function, the service time for determining the service distribution function, and also the queue length and waiting time were collected in 30 working days by close observation. In the current system one person can serve all the activities such as work flowing pay rolling, accounting, property and so on (the customers of the studied unit are composed of professors, employees and the students of university and even the outside clients from other organization can play as the costumer role in the system).

For collecting the system information in the period of time all days of the week are covered and the time between arriving and departing to the system are determined as μλ, the easiest way for the distribution of data collection is the usage of histogram. The arrival time of costumers and service rate in one store is done by SPSS software,

Table 1: the data related to consumers' arrival time

The sixed group of collected information	The fifth group of collected information	The fourth group of collected information	The third group of collected information	The second group of collected information	The first group of collected information	Description
99	87	94	82	50	76	N
9805	8802	8578	9249	6768	10340	Σsecond
98	101	91	113	135	136	$\bar{X}$ second
0/010	0/010	0/011	0/009	0/007	0/007	λsecond
36	36	40	32	25	25	λhour

finally related data is drawn. Kolmogorov-Smirnov test is the precise non-parametric method for determining the assimilation between data and the experimental data, which were collected by statistical distribution. Here by using of SPSS software the data are collected, in the rest of the paper the procedure of parameters determination are presented in Table 1 and 2.

$\lambda = \frac{\sum_{i=1}^{\sigma} \lambda_i}{n} \cong 32$ The average arrival to the system

Customers with the average number of 32 in an hour are visiting the related unit

Table 2: The data of service time to consumers in the system						
The sixed group of collected information	**The fifth group of collected information**	**The fourth group of collected information**	**The third group of collected information**	**The second group of collected information**	**The first group of collected information**	**Description**
100	88	95	83	51	77	N
17637	18015	19077	22410	12750	15216	Σsecond
176	205	201	270	250	198	Ȳ second
0/006	0/005	0/005	0/004	0/004	0/005	μ second
22	18	18	14	14	18	μhour

$\mu = \frac{\sum_{i=1}^{\sigma} \mu_i}{n} \cong 17$ The average service time in the system

Customers with the average number of 17 per hour get service in the related unit.

For data analyzing, we used from QSB and Excel software and the required parameters are determined as the service time, waiting time, and the service time. The results are in the table 3.

Table 3: The calculating of queuing theory criteria according to various amounts of servers						
I	ρ	**(W) hour**	**L (person)**	**(hour)** W_q	**(Person)** L_q	**Number of servers (m)**
0.0588	0.94	0.515152	16.48482	0.456328	14.6025	2
0.372549	0.62	0.079385	2.540311	0.020561	0.657958	3
0.529412	0.47	0.062888	2.012402	0.004064	0.130049	4
0.623529	0.37	0.059726	1.911226	0.000902	0.028873	5
0.686275	0.31	0.059019	1.888612	0.000196	0.006259	6
0.731092	0.26	0.058863	1.883625	3.98	0.001272	7
0.764706	0.23	0.058831	1.882592	7.48	0.000239	8

Before explaining of the table 3 some points must be clarified: if the amount average waiting time of costumers is more (it means the system is populated), the average number of consumers will be more too. the number of customers in the system are related straightly to the arrival rate, On the other hand relationship of *w* is an average spend time which a costumer spends in the system which is equal to the average spend time in the line plus the time that he/she has been receiving the service. In table 3,when the number of server is 2, the number of client in queue is equal to 14, the average waiting time is 0.45, the people in the system are 16 person, the average time in system is 0.51, system utilization is 0.197, the probably unemployment of system is 0.05. With changes in number of servers, the changes of these parameters will be tangible too also with regarding to the results of table 3, by increasing the utilization, the average queue length and the waiting time of customers in line will be increased too and this matter is completely valid with the issue of utilization factor. In the model, M/M/m, because λ and μ are stable so we just consider those expenses which are related to the number of servers, namely *m*. So the cost function is calculated as:

$$(C(m) = (C_1 + C_2)m + C_5 L_q \quad (12)$$

Which in this formula C_1, C_2, C_5 are respectably as the maintenance cost of unemployed server, investing cost on one server and the wasting time cost of costumer in the line. In this research cost of server per hour on base of paying and the cost of customers' wasting time per hour are considered approximately. In this research the C_2 cost and C_5 cost are gotten from document and interviewing with relevant employees, who on the base of employees' pay and the wasted time cost of customers which are respectively 3000, 5000 Rails per hour. C1 is equal to zero. The optimal number of servers can decrease the waiting time for customers in the system and line (W, Wq) and it can decrease the queue langue in service processing too. The minor amount of *m* must be in the way that $\rho<1$. The optimal number of servers are gained from the less cost spent. If the supposition of identifiable parameters, the optimal capacity of system determined, the assessment criteria such as queue length, waiting time, utilization factor were identified. According to these findings, two types of costs (server cost, wasting time cost in queue) are calculated. In this study, the influence of changing parameters on assessment criteria and finally on total system cost are re-examined. Due to these changes, the best response of cost reduction is achieved. For every various amount of *m* In this case assessment criteria, regarding to mentioned formula the most optimal amount is determined. According to cost function and the result in table 3, the optimal number of servers determined in table 4.

Table 4: The calculating of optimal number of servers with usage of queuing theory

L_q (person)	RialsC (m)	ρ	Number of servers (m)
14.6025	5,380.75	0.94	2
0.657958	1,697.39	0.62	3
0.130049	2,039.01	0.47	4
0.028873	2,508.66	0.37	5
0.006259	3,001.88	0.31	6
0.001272	3,500.38	0.26	7
0.000239	4,000.07	0.23	8

Because ρ must be smaller than 1, the minor amount of servers is m=2. According to the results in table 4, cost of 3 servers is 1,697.39 Rial lower than the other amount, number of servers for considered unit is equal to 3.

Conclusion

Present paper discusses the optimal number of the human resources with data processing, which are obtained from the system coefficient, and parameters of considered unit in the organization, using the queuing theory. Some of the services demanded by customers in compare with other services allocate more time to themselves, also, based on calculated criteria for the system and obtained results, the processes optimizing and procedures should be followed. It means the transparency and certainty of the workflow and improvement of work processes and simplification of issues or eliminating of the superfluous procedures through engineering process should be done a serious work. Finally since the suitable number of servicing channels (employee) can improve the calculated system criteria, so by considering to the obtained results in this research, to reduce the number of employees, creation the developing opportunities for job skill in organization, effective and efficient training and mastering in technical information in related posts can be useful. This research can be applied as a basic for other researches in the human resources planning field. The predictable researches are as following:

1. Because of time constraints and work extension, only a small part of the organization is investigated in this study. The limitation of this study provide opportunities for future research, so for presenting a complete and comprehensive research we can do similar researches in other units for providing more complete analysis.
2. For presenting an optimal method the Graph theory models or other similar methods, an accomplishment to Human Resources Planning is possible too.

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