Simulation of a Queuing System Case Study: Call Center Service in Organization A.

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Abstract
The objectives of the study is to fine the queuing system of the call center service in Organization A by using the simulation situation. The simulation situation main purpose is to fine the queuing characteristics and offer the alternative way to reduce the customers queuing time. This study use the ARENA program to simulated situation to learn about system efficiency under the uncertainty of the time to spend on service. And the uncertainty of the arrival of customers. Assumes that arrival time follow a Poisson probability distribution and the service times are distributed exponentially. In this study the queuing characteristics of the call center service in Organization A is analyzed by multiple-channel queuing model to fine the average number of customers in the system, the average number of customers in line waiting for service, The average time a customer spends in waiting line, the average time a customer spends in the queue waiting for service and Utilization rate. This study use ARENA software to compute the performance measure of Multi-server queuing system at call center service in organization A using arrival rate (λ) = 121.185 customers/hr, service rate (μ) = 25 customers/hr and number of service (m) = 27. The study results on efficiency of the queuing system of call center of Organization A revealed that even though there is a change in number of 15-21 outsourcing agents, the efficiency values of queuing system are still close to the current situation where 21 outsource agents are employed.

Keywords: The queuing system, Multiple-channel queuing model, ARENA program

Introduction

Problems on operation of call center which affect service rendering efficiency are uncertainty of incoming calls from the customers (arriving customers) and uncertainty on amount of time each telephone operator rendered service. For instance in some period of time the number of arriving customers exceeds the number of telephone operators or some telephone operator takes too much time to provide service to each customer due to such operator does not have enough skills. Consequently, some customers' call may not be answered immediately and they have to wait before the operator pick up their call. Therefore some customers shall not wait as it makes them have waiting cost, so they choose to purchase products from other company instead. On the other hand, if there are too many operators, service cost shall be higher.

The above problems made the researcher interested to conduct an analysis on queuing system of call center of one organization. The objectives are to find guidelines to develop efficiency of services, to make service user have faster service, to balance waiting cost and service cost, to create business operation worthiness of the organization and to maximize satisfaction of the service users.

Objectives of the Project

1. To conduct a study on queuing system on service rendering in call center of Organization A
2. To conduct a study on queuing system model in call center of Organization A.

Related Theories

Simulation of Problem

Simulation of problem is a model design process of real system, then conduct experiment to learn behavior of real system under the specified requirements to assess operation of the system and the experimental result shall be analyzed before it can be used to solve problems in the actual circumstance (Shannon, 1975, referred to in Roongrat Pisuchpen, 2008). As the current industries always have complexity with variable factors involved. For example, in service industry, the variable factors are uncertainty of arriving customers and uncertainly of service rendering time and etc. Therefore, it is quite difficult to manage the works and allocate resources to make them achieve the objectives of such industry by using arithmetic model to solve the problem. Hence, creation of model by using computer program is one of the options to study behavior of the system to find guidelines to solve the problem. In addition, when using computer program to create model, a change of model to create guidelines to improve the system to make it have better efficiency and effectiveness without any interference of real system can be done quite conveniently (Roongrat Pisuchpen, 2008).

Queuing System

Queuing Theory has been initiated and developed by A. K. Erlang, a Danish engineer, in 1910.

Queuing occurred because demand for services exceeds capability of service rendering, therefore it is very important to have adequate service unit to render services. In order to be able to provide service adequately with the demand, it is necessary to know the amount of arriving customers and when as well as time used for rendering service to each customer. If there are too small amount of service units, queuing shall occur, which is deemed as one of the loss of expense problems and it can also make the business lose the customer. On the contrary, if there are too many service units, expenses incurred shall be more than necessary, for instance service unit shall have too much idle times (Sutthima Chumnanvej, 2011).

Procedures to Conduct Research

Collect information on number of receiving customers, time used for providing service of operator in call center, period of time where there are a lot of arriving customers (08.00-16.00), from database of Organization A.

Information gained from database shall be used to create model to analyze queuing circumstance at present by using computer program, such as service usage rate and service rendering rate of the telephone operator in order to find average service user in queuing system (L), average number of service user in the queue (L_q), average time each service user is in the queuing system (W), average time each service user is in the queue (W_q), probability of system availability (P_o). After that, model shall be crated to test the concept to improve efficiency of the queuing operation system.

Research Methodology

1. Compile information on time used for service and completion time for providing service of the operator from call center database of Organization A.

2. Study and analyze information to specify the appropriated queuing model as M/M/m queuing model under assumption that usage of service user is on random basis with Poisson Arrival Process Distribution, time used for providing service is on random basis with Exponential Service Time Distribution, there are more than 1 service unit (m Unit), 1 queuing and with one step service rendering, unlimited number of service usage population, average service usage rate (λ) is less than average service rendering rate multiplied with number of service unit ($m\mu$), average service rendering rate of service unit is equal.

Form the model the probability of having n customers in the system is given by:

1. *The probability that there are zero customer in the system:*

$$P_0 = \frac{1}{\sum_{n=0}^{n=m-1} \frac{\left(\frac{\lambda}{\mu}\right)^n}{n!} + \left[\frac{\left(\frac{\lambda}{\mu}\right)^m}{m!} \frac{(m\mu)}{(m\mu - \lambda)}\right]}$$

2. *The average number of customers in the system:*

$$L = \frac{\lambda\mu(\lambda/\mu)^m}{(m-1)!(m\mu-\lambda)^2} P_0 + \frac{\lambda}{\mu}$$

3. *The average time a customer spends in the system:*

$$W = \frac{\mu(\lambda/\mu)^m}{(m-1)!(m\mu-\lambda)^2} P_0 + \frac{1}{\mu} = \frac{L}{\lambda}$$

4. *The average number of customers in line waiting for service:*

$$L_q = L - \frac{\lambda}{\mu}$$

5. *The average time a customer spends in the queue waiting for service:*

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

6. *Utilization rate:*

$$\rho = \frac{\lambda}{m\mu}$$

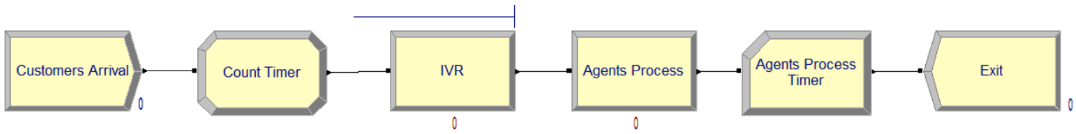
Where, λ = the arrival rate of customer per unit time, μ = the service rate per unit time, m = the number of servers, P_0 = the probability that there are no customer in the system, L_q = the average number of customers in line waiting for service, L = the average number of customers in the system, W_q = the average time a customer spends in the queue waiting for service, W = the average time a customer spends in the system, ρ = Utilization rate.

Details of Current Problem

Call Center of Organization A provides service 24 hours. Period of 08.00 to 16.00 hrs. is the time that the call center has the largest amount of arriving customers and outsourcing agents are hired to support the work in such period.

At present, during period of 08.00-16.00 hrs., there are 6 permanent agents of Organization A and 21 outsourcing agents provide services on such period. Average arriving customer is 0.495 minutes and service rendered is one person each and there is no limited number of maximum service users. In order to enhance efficiency of operation, the researcher has conducted a study on balance between number of telephone operators and service usage rate of customer.

Create Model by Using Computer Program

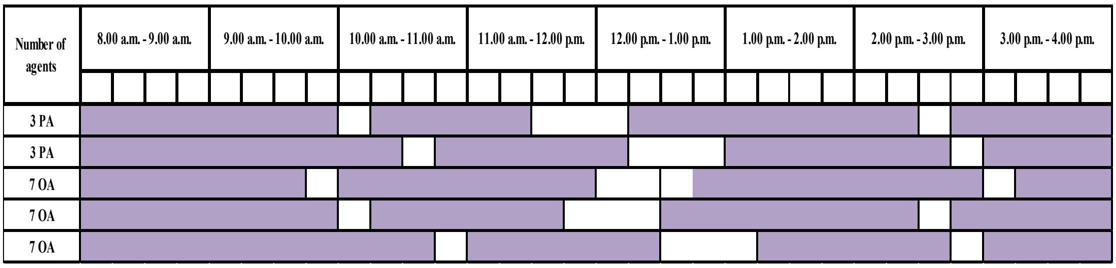


This study use ARENA software to compute the performance measure of Multi-server queuing system at call center Service in organization A using arrival rate (λ) = 121.185 customers/hr, service rate (μ) = 25 customers/hr and number of service (m) = 27.

Model is starting from Create Module, named Customer Arrival into the system on randomly basis (Expo) with average value of 0.495 minute and service used is 1 person at a time, without limiting the maximum service users. Next procedures after the customer is in the system are to assign module named Count Timer to specify qualifications to the customer to record starting time when the customer is in the system, assign qualification named TimeEnter to TNOW to collect current time when the customer enters into Count Timer Module to calculate time that customer used in the system at a later time by using Record Module.

After the customer enters into the system, there shall be an Interactive Voice Response (IVR) via Process Module named IVR. Define operation procedure as Delay with unlimited resources, so it is not necessary to reserve the resources, so no queue is occurred. Time used for performing activity is fixed (Constant) at 37.75 seconds. Next, the customer uses service with Agents via Process Module named Agents Process. Define operation procedure as Seize Delay Release to reserve the existing 27 agents. After the activity is completed, the agent shall be set to available to provide service to the next customer. Use Set resource named Agent and Delay Type is Expression with 27 members in the Set. Type of resources is specified to be non-constant production capacity based on schedule.

Working time of agent is specified to be 8 hours with morning interval for 15 minutes, lunch break for 40 minutes, afternoon break for 15 minutes. Schedule Rule is specified to be as Wait. When it is the time to break, but if the service rendered to customer by the telephone operator has not yet completed, such operator shall keep on providing service until it is completed and shall take a break after that. When such operator resumes the work, starting time shall be extended, so total period of time in maintaining workforce of agent shall be the equally same. After that Record Model shall be created as Time Interval to record time and number of customers who finish service usage with the Agent, and customers exit from the system.



Number of agents: *PA=Permanence Agents,*OA=Outsource Agents

Figure 1: Working Time Table of the Agents (during period of 08.00-16.00 hrs.)

Number of Agents	Morning break (15 minutes)	Lunch break (40 minutes)	Afternoon break (15 minutes)
3 Agents	10.00 a.m. - 10.15 a.m.	11.40 a.m. -12.20 p.m.	2.30 p.m. – 2.45 p.m.
3 Agents	10.30 a.m. - 10.45 a.m.	12.20 p.m. - 1.00 p.m.	2.45 p.m. - 3.00 p.m.
7 Outsource agents	9.45 a.m. – 10.00 a.m.	12.00 p.m. – 12.40 p.m.	3.00 p.m. – 3.15 p.m.
7 Outsource agents	10.00 a.m. - 10.15 a.m.	11.50 a.m. - 12.30 p.m.	2.30 p.m. – 2.45 p.m.
7 Outsource agents	10.30 a.m. - 10.45 a.m.	12.30 p.m. - 1.10 p.m.	2.45 p.m. - 3.00 p.m.

Number of agents: *PA=Permanence Agents,*OA=Outsource Agents

Figure 2: Permanence Agents and Outsource Agents break Schedule

Summary of Current Situation of the Call Center of Organization A by using ARENA Simulation Program is as per Figure 3.

Based on the study, the current situation of the Call Center of Organization A is as follows:

1. The period that call center has the largest amount of arriving customers is from 08.00 - 16.00 hours and there are totally 27 agents, comprising of 6 permanent agents and 21 outsource agents, provide services at that time.
2. The average arrival rate of customer = 121.185 customers/hour.
3. The average service time of each agent = 25 persons/hour.
4. The average number of customers in the system (L) = 5.91 persons.
5. The average number of customers in line waiting for service (Lq) = 0.01 person.
6. The average time a customer spends in the system (W) = 3 minutes.
7. The average time a customer spends in the queue waiting for service (Wq) = 0 minute.
8. The average utilization rate of 27 agents = 21%.

Number of agents	W – in minutes	Wq – in minutes	L	Lq	Utilization rate (%)
6PA+21OA (Present Situation)	3.00	0.00	5.91	0.01	21.00

Number of agents: *PA=Permanence Agents,*OA=Outsource Agents

Figure 3. Performance Measure of Call Center Queuing Model at Organization A (Present situation)

Efficiency Improvement Guideline:

Simulate service provision of a call center during 8.00 -16.00 hours by specifying that the average arrival rate of customer is fixed at 121.185 persons/hour, the average service time of each agent is fixed at 25 persons/hour and working schedule of each permanent agent and outsource agent is fixed. After that, conduct a test on efficiency comparison of queuing system in case of a change in number of the outsource agents and the current situation, result gained is as per Figure 4.

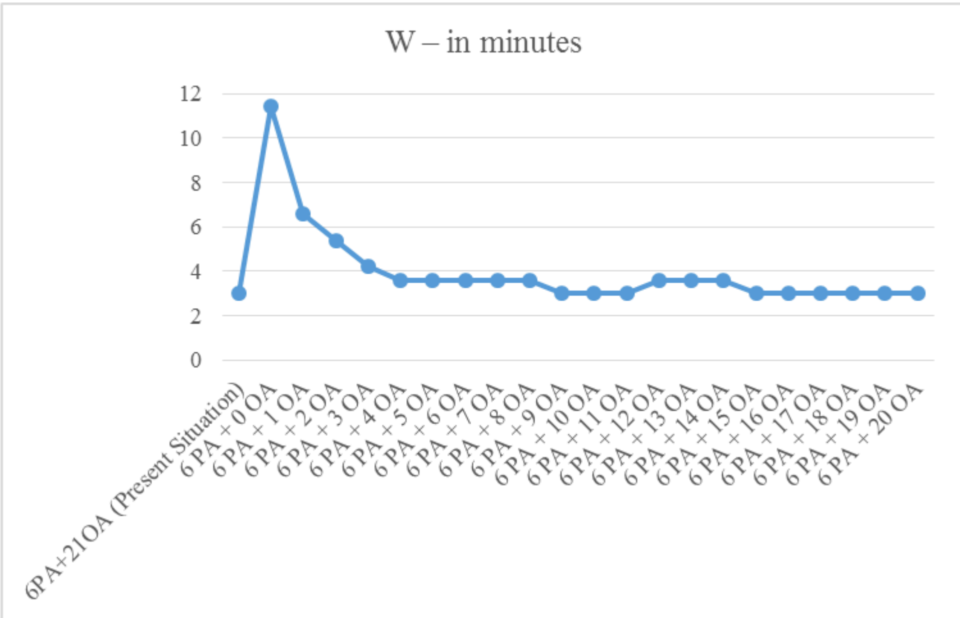
Number of agents	W – in minutes	Wq – in minutes	L	Lq	Utilization rate (%)
6PA+21OA (Present Situation)	3.00	0.00	5.91	0.01	21.00
6 PA + 0 OA	11.40	7.80	22.43	16.35	92.83
6 PA + 1 OA	6.60	3.60	13.12	6.93	81.71
6 PA + 2 OA	5.40	2.40	10.48	4.31	71.63
6 PA + 3 OA	4.20	1.20	8.85	2.55	64.78
6 PA + 4 OA	3.60	0.60	7.74	1.62	56.70
6 PA + 5 OA	3.60	0.60	7.06	1.16	49.55
6 PA + 6 OA	3.60	0.60	7.35	1.27	46.92
6 PA + 7 OA	3.60	0.60	7.57	1.50	43.15
6 PA + 8 OA	3.60	0.60	6.70	0.80	39.00
6 PA + 9 OA	3.00	0.00	6.27	0.39	36.20
6 PA + 10 OA	3.00	0.00	6.27	0.39	33.88
6 PA + 11 OA	3.00	0.00	6.27	0.37	31.94
6 PA + 12 OA	3.60	0.60	6.88	0.90	30.61
6 PA + 13 OA	3.60	0.60	6.89	0.87	29.32
6 PA + 14 OA	3.60	0.60	6.67	0.74	27.55
6 PA + 15 OA	3.00	0.00	6.10	0.20	20.05
6 PA + 16 OA	3.00	0.00	5.92	0.05	24.68
6 PA + 17 OA	3.00	0.00	5.92	0.01	23.61
6 PA + 18 OA	3.00	0.00	5.98	0.04	22.92
6 PA + 19 OA	3.00	0.00	5.99	0.02	22.16
6 PA + 20 OA	3.00	0.00	5.98	0.01	21.19

Number of agents: *PA=Permanence Agents,*OA=Outsource Agents

Figure 4: Efficiency comparison of queuing system between the current situationand in case of a change in number of the outsource agent

Data in Figure 4 can measure efficiency of queuing system from the simulation by simulating a change in number of the outsource agent and it was found that if there is a change in number of 15-20 outsource agents, the result is as follows:

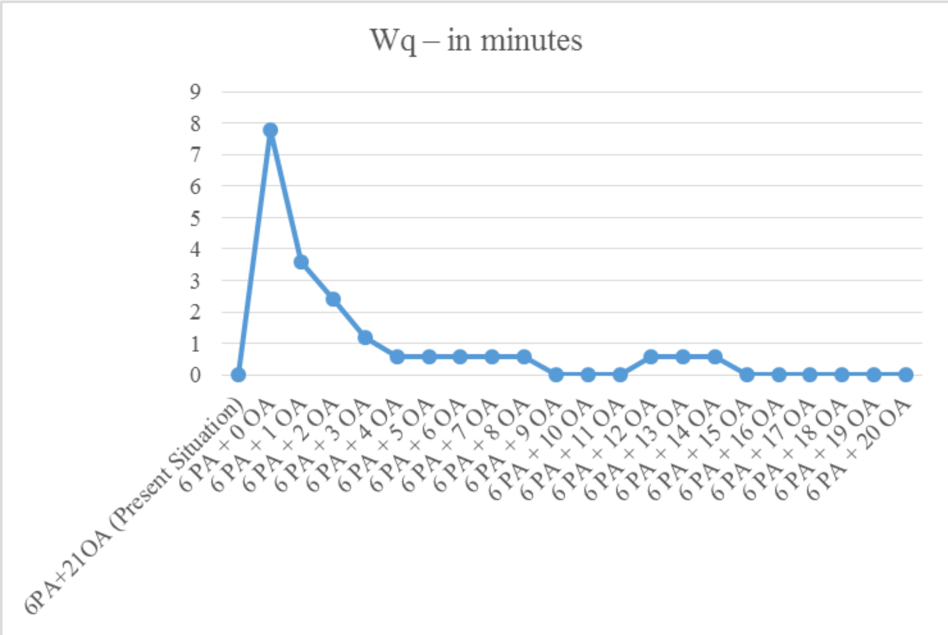
1. The average time a customer spends in the system (W) is still = 3 minutes which equals to the current situation of the call center.
2. The average time a customer spends in the queue waiting for service (Wq) is still = 0 minute which equals to the current situation of the call center.
3. The average number of customers in the system (L) is between 6.10-5.98 persons, which is closed to the current situation which is = 5.91 persons.
4. The average number of customers in line waiting for service (Lq) is between 0.05-0.01 person, which is closed to the current situation which is = 0.01 person.
5. The average utilization rate is between 20.25-24.68%, which is closed to the current situation which is = 21%, result gained is as per Figure 5 -9.



Number of agents: *PA=Permanence Agents,*OA=Outsource Agents

Figure 5: Comparison of the average time a customer spends in the system (W) between the current situation and in case of a change in number of the outsource agent

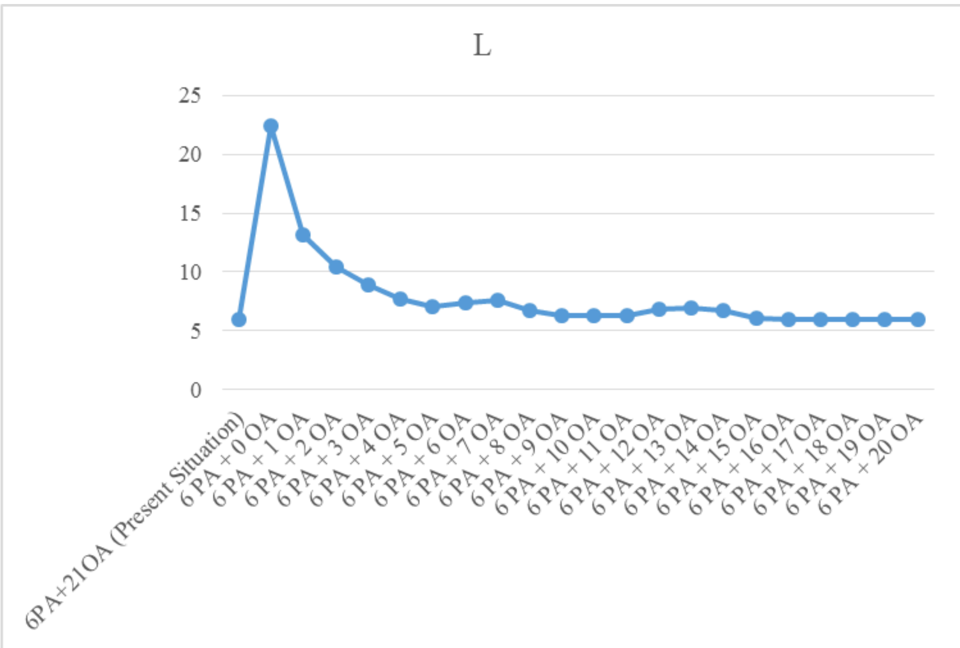
From Figure 5: When comparing the average time a customer spends in the system (W) between the current situation and in case of a change in number of outsource agents, it was found that the efficiency of queuing system on the average time a customer spends in the system (W) during a change in number of 15-20 outsource agents equals to the current situation which is = 3 minutes.



Number of agents: *PA=Permanence Agents,*OA=Outsource Agents

Figure 6: Comparison of the average time a customer spends in the queue waiting for service (Wq) between the current situation and in case of a change in number of the outsource agent.

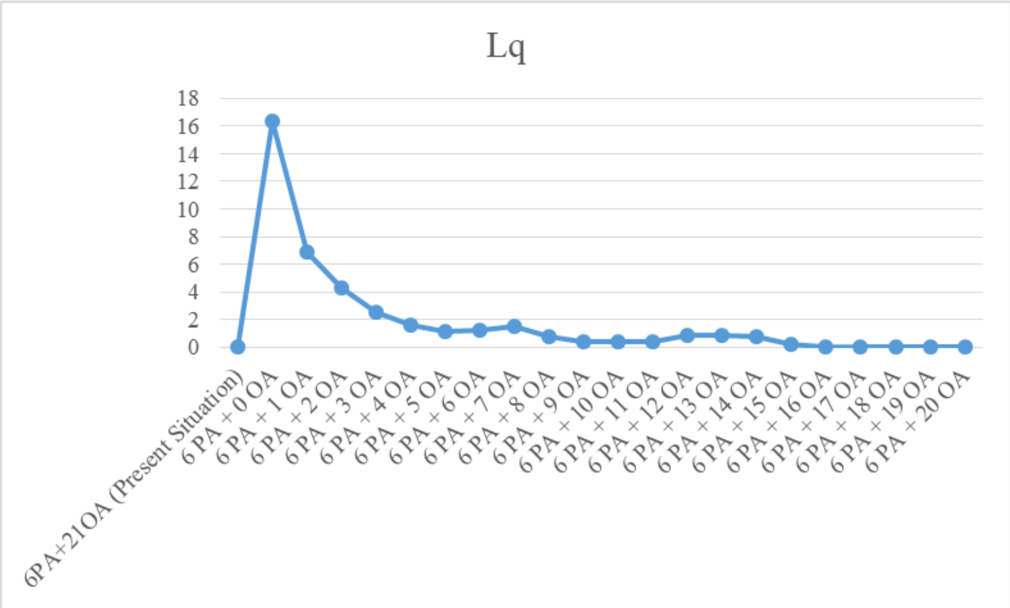
From Figure 6: When comparing the average time a customer spends in the queue waiting for service (Wq) between the current situation and in case of a change in number of outsource agents, it was found that the efficiency of queuing system on the average time a customer spends in the queue waiting for service (Wq) during a change in number of 15-20 outsource agents equals to the current situation which is = 0 minute.



Number of agents: *PA=Permanence Agents,*OA=Outsource Agents

Figure 7: Comparison of the average number of customers in the system (L) between the current situation and in case of a change in number of the outsource agent

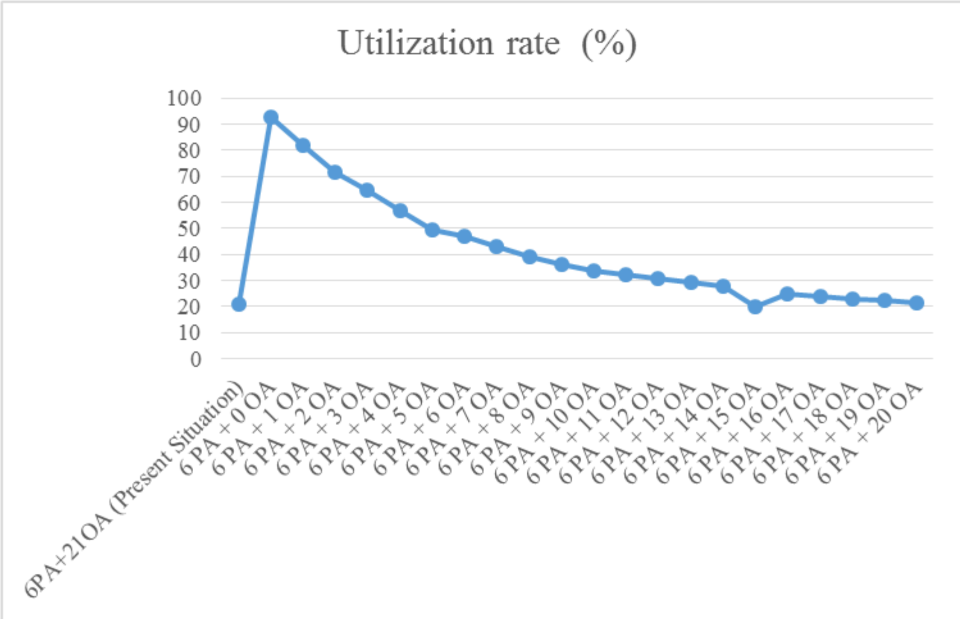
From Figure 7: When comparing the average number of customers in the system (L) between the current situation and in case of a change in number of the outsource agents, it was found that the efficiency of queuing system on the average number of customers in the system (L) during a change in number of 15-20 outsource agents is between 6.10-5.98 persons which is closed to the current situation which is = 5.91 persons.



Number of agents: *PA=Permanence Agents,*OA=Outsource Agents

Figure 8: Comparison of the average number of customers in line waiting for service (Lq) between the current situation and in case of a change in number of the outsource agent

From Figure 8: When comparing the average number of customers in line waiting for service (Lq) between the current situation and in case of a change in number of the outsource agents, it was found that the efficiency of queuing system on the average number of customers in line waiting for service (Lq) during a change in number of 15-20 outsource agents is between 0.05-0.01 person which is closed to the current situation which is = 0.01 person.



Number of agents: *PA=Permanence Agents,*OA=Outsource Agents

Figure 9: Comparison of the average utilization rate between the current situation and in case of a change in number of the outsource agent

From Figure 9: When comparing the average utilization rate between the current situation and in case of a change in number of the outsource agents, it was found that the efficiency of queuing system on the average utilization rate during a change in number of 15-20 outsource agents is between 20.05-24.68% which is closed to the current situation which is = 21%.

Conclusion

The simulation study results on efficiency of the queuing system of call center of Organization A by using ARENA Simulation Program revealed that even though there is a change in number of 15-21 outsourcing agents, the efficiency values of queuing system are still close to the current situation where 21 outsource agents are employed. This can signify that if the number of the outsource agents are reduced by 6 persons, the efficiency values of queuing system are still close to the current situation. Therefore, for optimum cost efficiency on employment, the management of call center of Organization A should employ only 15 outsource agents and should assign 6 remaining outsource agents to perform other works or delay employment of the outsource agents in the long term.

References

Chomchai, Y., & Chancharatsuk, U. (2013). Performance Improvement of Queuing System by using Simulation. A Case study: The out Patient Department, Lamlukka Hospital. (In Thai). Ladkrabang Engineering Journal, 30(1): 43-48, Retrieved November 15, 2104, form http://www.kmitl.ac.th/lej/PDFjournal56/Volume30_No1_MAR2556_(8).pdf

Duong, T., Huu, N. D., & Nguyen, T. (2013). Adiabatic Markov Decision Process with Application to Queuing Systems. Proceeding of Information Sciences and Systems Annual Conference, 47, 1-6, Retrieved December 2, 2012, form http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6552321&tag=1

Gurumurthi, G., & Benjaafar, S. (2004). Modeling and Analysis of Flexible Queuing System. Journal of Naval Research Logistics, 51(5), 755-782, Retrieved February 15, 2014, form http://onlinelibrary.wiley.com/doi/10.1002/nav.20020/epdf

Kembe, M. M, Onah, E. S., & Lorkegh, S. (2012). A Study of Waiting and Service Costs of Multi-Server Queuing Model In Specialist Hospital. International Journal of Scientific & Technology Research, 1(8): 19-23, Retrieved November 15, 2104, form http://www.ijstr.org/final-print/sep2012/A-Study-of-Waiting-And-Service-Costs-of-A-Multi-Server-Queuing-Model-In-A-Specialist-Hospital.pdf

Olaniyi, T.A. (2004). An Appraisal of Cost of Queuing in Nigerian Banking Sector: A Case Study of First Bank of Nigerian Plc, llorin. Journal of Business & Social Sciences. 9(1): 139-145, Retrieved November 15, 2104, form https://www.unilorin.edu.ng/publications/olaniyi/PUBLICATION%201.htm

Patomsuttirut, V., Piriyakul, M. (2013). Decision Support System on the Administration of Data Service Agents at Social Security Call Center # 1556. (In Thai). Management Journal Faculty of Management Science Lampang Rajabhat University, 6(1): 55-62, Retrieved November 15, 2104, form http://www.mgts.lpru.ac.th/journal/index.php/mgts/article/view/31/30

Pisuchpen, R. (2010). Simulation with Arena Solutions Manual (Rev.ed). (In Thai). Bangkok : SE-Education.

Render, B., Stair, R., & Hanna, E. M. (2012). Quantitative Analysis for Management. 11^{th} ed. New Jersey : Prentice Hall International, Inc.

Rosenquist, C.J. (1987) Queuing Analysis: A Useful planning and Management technique for radiology. Journal of Medical System, 11(6): 413-414, Retrieved November 20, 2104, form http://link.springer.com/article/10.1007/BF00993008

Rungpeng, P. (2013). Simulation of queuing systems for outpatient service: a case study of the internal medicine at Phatthalung hospital. (In Thai). Veridian E-Journal, 6(3): 834-845, Retrieved December 15, 2104, form http://www.ejournal.su.ac.th/upload/770.pdf

S. K. Dhar, Tanzina Rahman. (2013). Case Study for Bank ATM Queuing Model. Journal of Mathematics, 7(1): 01-05, Retrieved November 20, 2104, form http://iosrjournals.org/iosr-jm/papers/Vol7-issue1/A0710105.pdf

Taha, Handy A. (2007). Operation research: an introduction. 8^{th} ed. New Jersey : Pearson Education, Inc.

Vanichbuncha, K. (2010). Quantitative Analysis.(In Thai). 1st ed. Bangkok : Chulalongkorn Business school.

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