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UNIVERSITAS MALAHAYATI
BANDAR LAMPUNG
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Proceedings of

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QUANTITATIVE METHODS
USED IN ECONOMICS AND BUSINESS
2008

UNIVERSITAS MALAHAYATI
INTERNATIONAL CONFERENCE ON QUANTITATIVE METHODS
USED IN ECONOMICS AND BUSSINESS

PREFACE

The International Conference on Quantitative Methods Applicend in used economic and Business was conducted by Faculty of Economic, Universitas Malahayati on 15-17 October 2008. The conference was organized by Faculty of Economic Universitas Malahayati and collaborated with Universiti Malaysia Terengganu (UMT) International Islamic University Malaysia (IIUM), and University Putra Malaysia (UPM).

The participants of the conference are about 200 come from more than 20 higher institutions, among others: Universitas Malaysia Perlis, Institut Pertanian Bogor, Universitas of Montenegro, Universitas Bung Hatta, Universitas Putra Malaysia, Universitas of Peshawar Pakistan, Al-Bayt University Al Mafraq- Jordan, Universitas Indonesia, Universitas Gunadarma, Universitas Pendidikan Indonesia Bandung, Universitas Trunojoyo Madura, Universitas Negeri Papua, Universitas Jambi, Universitas Halouleo Kendari, Universitas Sriwijaya, Universitas Ahmad Dahlan Yogyakarta, Universitas Parahiyangan Katolik Bandung, Universitas Yarsi Indonesia, Poltek Negeri Medan, Universitas Islam Indonesia Yogyakarta, University of Malaysia, Politeknik Lampung, Universitas Lampung, Institut Teknologi 10 November Surabaya, Universitas Syarif Hidayat Jakarta, Universitas Maranata Bandung, Universitas Atma Jaya Yogyakarta, Universitas Malahayati. Which reflect the importance of the Internasional Conference on Quantitative Methods Used In Economics And Business.

I hope that this conference will become a place for scientists and economist to share their knowledge and experience and also to promote their expertise in their fields.

This kind of conference will surely have a positive impact on higher education in general as well as development of science, economics, business and research, in particular. For higher education in Indonesia, it is expected that this conference will encourage the faculty members as researchers to do more research as one of their duties.

On behalf of Steering Committee, we would like to express our deepest gratitude to the Foundation - Alih Technology, Rector Universitas Malahayati, International Advisory Board members, and also to all participants. We are also grateful to all organizing committee and all the reviewers, without whose efforts such a high standard for the conference could not have been attained. We would like to express our deepest gratitude to the Faculty of Economic Universitasersitas Malahayati for conducted such conference. This is the first International Conference for the Faculty and we expect that this is will become annual activity for the Faculty of Economic.

Bandar Lampung, 15 October 2008

Iing Lukman, Ph.D
The Organizing Chairman

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OPEN QUEUING NETWORKS AND APPLICATIONS

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ABSTRACT

Queuing phenomenon occurs in many situations in daily life. Waiting to be served in the restaurants, banks; or waiting for paying road toll, etc. Queuing also can be applied on goods, for example; commodity that need to be loaded on the ship, data that need to be processed on the central computer, cars that need to be served and so on. In this paper we will discuss one type of queuing models that occurs in daily life that is open queuing networks, and give some of its applications.

Keywords: open queuing networks,

1. Introduction

Each of us maybe has spent a great time of waiting in lines. Waiting in the traffic light, waiting in the checkout cashier in the supermarket, waiting in the doctor or dental clinic, waiting for take off (for an airline), and so on. The formation of waiting lines is, of course, a common phenomenon that occurs when the current demand for a service exceeds the current capacity to provide service. Decisions regarding the amount of capacity to provide must be made. Providing a lot of service will end with excessive cost, but, not providing enough service capacity will cause the waiting line to become long. Thus, the ultimate goal is to achieve an economic balance between the cost of service and the cost associated with the waiting line (whether it be a social cost, the cost of lost customer goodwill, etc).

Queuing theory was developed by an engineer from Denmark, A.K Erlang in 1910. Queuing theory provides a large number of alternative mathematical models for describing a waiting-line situation (Hillier and Liebermann, 1990).

The important factors in queuing system are the customers and the servers in which there a time period needed for a customer to be served. Customers requiring service are generated over time by an input source. These customers arrive and join a queue in the queuing system. Then, a member of the queue is selected for being serviced by some rules known as queue discipline. Some of the queue discipline are : First In First Out (FIFO), Last In First Out (LIFO), or Service In Random Order (SIRO).

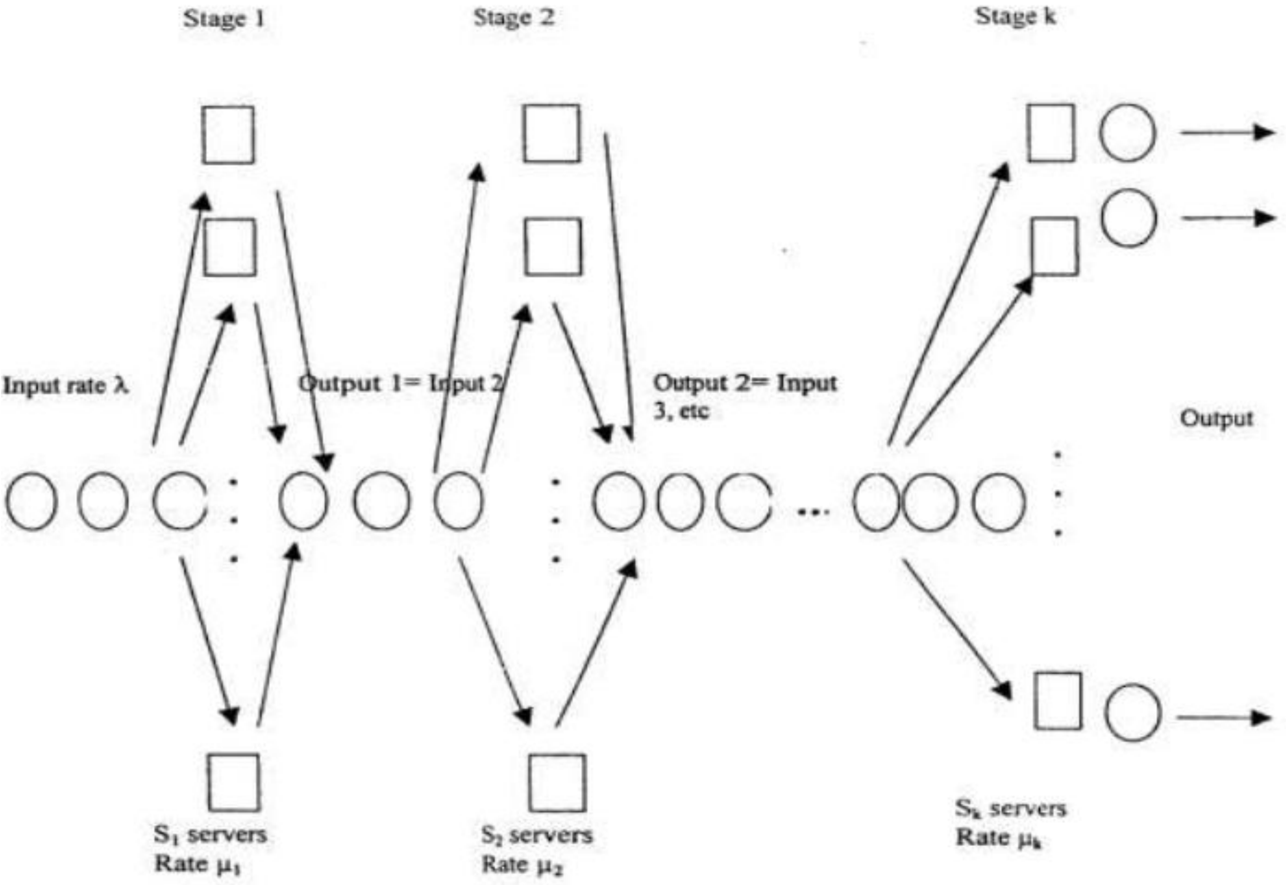
The input source has one characteristic which is the size. The size is the total customers that might require service from time to time and it can be assume either finite or infinite. This population from which arrivals come is referred as calling population, and one general assumption made for the calling population is the process is generated according to a Poisson distribution or exponential distribution (Hillier and Liebermann, 1990).

Jackson (1957) initiated the study of networks of queues, of course, to help analyzing make- to order manufacturing systems. Analytical queuing models have come to be applied widely such as in manufacturing (Suri and Tomsicek, 1988), Segal and Whitt (1989), Karmarkar (1992), Wein (1992); in inventory such as Kimball (1988), Karmarkar (1987), (1988), Zheng and Zipkin (1990, 1992), Svoronos and Zipkin (1991), and many others.

2. Queues in Series

Typical practical cases of queues in series (queues in tandem) may be found in multi stages manufacturing systems where each product is processed through a series of operations. The main different between queues in series with the common queuing system is, in the queue in series, it will not be sufficient to know how many people are in the systems but also where they are, while in the common queue system we are not considering where they are.

Upon entering the system the arrival undergoes stages 1 service (after waiting in line if all stage 1 servers are busy on arrival). After completing stage 1 service, the customer waits for and undergoes stage 2 service. This process continues until the customer completes stage k service, and can be illustrated as follow:



3. Open Queuing Networks

Open queuing networks is a generalization of queues in series. Assume that station j consists of s_j exponential servers, each operating at rate u_j. The customers are assumes to arrive at station j from outside queuing system at rate r_j. The inter arrival times are assumed to be exponentially distributed. When the customer is finished of being serviced at station i, he joins the queue at the station j with probability p_{ij}, and completes the service with probability : $1 - \sum_{j=1}^{k} p_{ij}$.

Let we define λ_j, the rate at which the customer arrive at station j (including the arrivals at station j from outside the system and from other stations). The inter arrival rate time $\lambda_1, \lambda_2, \lambda_3, \ldots, \lambda_k$ can be found using the following:

$$\lambda_j = r_j + \sum_{i=1}^{k} p_{ij}\lambda_i \quad , j = 1, 2, \ldots, k.$$

The expected number of customers in the queuing system, L, can be found by using the formula in Winston (1994) (assuming that the system will get it steady-state condition, $\rho < 1$) is as follow :

$$L = \sum_{j=0}^{\infty} j\pi_j = \sum_{j=0}^{\infty} j\rho^j (1-\rho) = (1-\rho)\sum_{j=0}^{\infty} j\rho^j$$

Suppose that $S' = \sum_{j=0}^{\infty} j\rho^j = \rho + 2\rho^2 + 3\rho^3 + \ldots$ then we get

$$S' - \rho S' = \rho + \rho^2 + \rho^3 + \ldots = \frac{\rho}{1-\rho}$$

thus $S' = \dfrac{\rho}{(1-\rho)^2}$

and $L = (1-\rho)\dfrac{\rho}{(1-\rho)^2} = \dfrac{\rho}{1-\rho} = \dfrac{\lambda}{\mu - \lambda}$.

W, the average time a customer spends in the system can be found by simply applying the formula $L = \lambda W$ to the entire system, where $\lambda = r_1 + r_2 + r_3 + \ldots + r_k$.

L_q, the length of the queue is $\dfrac{\lambda^2}{\mu(\mu-\lambda)}$, and the expected time of waiting in the queue is $W_q = \dfrac{\lambda}{\mu(\mu-\lambda)}$.

To illustrate how the situation applied in daily life for queue in series and its generalization, we discuss the following two problems taken from Winston (1994).

In a car production, the last two things done to a car before completing its manufacture are installing the engine and putting on the tires. An average of 54 cars per hour arrive requiring these two processes. One worker is available to install the engine and can service an average of 60 cars per hour. After the engine is installed, the car goes to the tire station and waits for its tires to be attached. Three workers serve at the tire station. Each works on one car at a time and can put tires on car in average of 3 minutes. The inter arrival times and service times are exponential.

This problem is a series queuing system that consists of two stages, the first stage is installing engine, and the second is putting the tires. The arrival rate λ is 54 cars per hour and service rate at server 1 is μ_1 = 60 cars per hour. When the car finish at stage 1, the car arrive at stage 2 where at that stage there are three servers available; $s_2 = 3$ and the service rate is μ_2 =20 cars.

This type of queuing system will arrive its steady state condition since $\lambda < \mu_1$, and $\lambda < 3\mu_2$. The expected customer in the queuing (for installing engine) is 8.1 cars, and the expected time of waiting in the queue is 0.15 hour. The expected customer in the system (for attaching tire) is 7.47 cars, and the expected time of waiting in the queue for attaching tires is 0.138 hour. Therefore, the expected total time needed for a car waiting for installing engine and attaching tires is 0.288 hour.

Suppose there are two servers. An average of 8 customers per hour arrive from outside at server 1, and an average of 17 customers arrive from outside at server 2. server 1 can serve at an exponential rate of 20 customers per hour, and server 2 can serve at an exponential rate of 30 customers per hour. After completing service at server 1, half of customer leave the system, and half go to server 2. After completing service at server 2, ¾ of the customers complete service, and ¼ return to server 1.

The next problem is an example of open queuing network model with r_1= 8 customers/hour, and r_2 = 17 customers/hour, $p_{12} = 0.5$, $p_{21} = 0.25$, $p_{11} = p_{22} = 0$. By using the formula above we find that λ_1 =14 customers/hour and λ_2 =24 customers/hour.

Using the formula for finding L above we find that L at server 1 is $\frac{14}{20-14}$ =7/3 and L at server 2 is 4. Therefore, an average of 19/3 customers will be present in the system.

The number of customers of course, will affect the time needed for a customer to wait in the system (including the time of being served). The time needed for a customer to wait in the system is $W = \frac{L}{\lambda}$, where $\lambda = 8 + 17 = 25$. Thus, $W = \frac{19/3}{25}$ =19/75 hours or approximately 15.2 minutes.

4. Conclusion

In queuing, the waiting time in the system of course in the real situation plays an important role related with businesses because if there is a potential customer and he cannot afford to wait any longer he can balk or renege and choose other companies providing service, and, if that situation happens that means lost business.

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