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Application of Queueing Theory to Airport Related Problems

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Abstract

Air traffic, worldwide, keeps growing strongly, creating critical capacity situations and traffic congestion. Large delays are suffered by airlines, passengers and airport authorities alike. When a rough estimate is needed, the results of queuing theory can be used to analyse airport runway systems, but when airports are too congested or a more realistic description of the system behaviour is necessary, Careful analytical planning is needed in advance of facilities and systems design, as the results of congestion could be both serious and expensive to travellers, airlines, and airports.

1. INTRODUCTION

Air line passengers are subjected to increasing levels of congestion in airport environments. This congestion is caused by three interrelated problems. The first is fluctuations of demand. Variations of demand occur at various time frames ranging from days to months. Sometimes special events create demand spikes. The second cause of congestion is related to network issues. The third cause of congestion in check is related to flight scheduling. Here, the congestion is caused by arrangement of scheduled departure times of aircraft. The congestion is caused by overlapping passenger arrival periods of the chosen aircraft. It can be seen that overlapping passenger arrival distributions concept assists in estimation of the period of congestion.

Nuhu A. Ademoh and Anosike, Esther Nneka[1] has developed a mathematical model to solve problem of queuing of air transport passengers at the Nnamdi Azikiwe International Airport (NAIA), Abuja, Nigeria’s capital city.

M.E. El-Naggar[2] described a methodology designed to support the decision-making process by developing seaport infrastructure to meet future demand. In order to determine an optimum number of berths at a sea port using queuing theory, the optimum number of berths that minimizes the total port costs can be decided.

S. Vijay Prasad and V. H. Badshah[3] has suggested a Alternate queuing system for tatkal railway reservation system to decrease Customer's waiting time.

Ronald R. Gilliam[4] decribed an application that can help the organization design passenger screening facilities to reduce the waiting time of customers.

2. METHODOLOGY

We will make the following assumptions for queuing system in accordance with queuing theory.

1. Arrivals follow a Poisson probability distribution at an average rate of λ customers per unit of time.

2. The queue discipline is First-Come, First-Served (FCFS) basis by any of the servers. There is no priority classification for any arrival.

3. Service times are distributed exponentially, with an average of μ customers per unit of time.

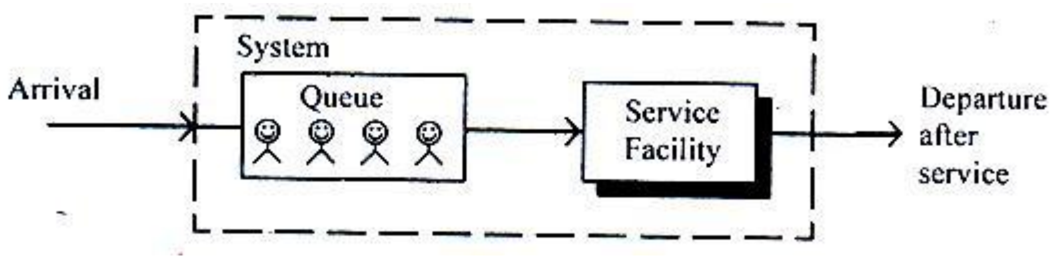
4. There is no limit to the number of the queue (infinite).

5. The service providers are working at their full capacity.

6. The average arrival rate is greater than average service rate.

7. Service rate is independent of line length; service providers do not go faster because the line is longer.

2.1 M/M/1 queuing model:



M/M/1 queuing model means that the arrival and service time are exponentially distributed (Poisson process) λ: The mean customers arrival rate

μ: The mean service rate

$\rho = \frac{\lambda}{\mu}$: utilization factor

Probability of zero customers in the system:

$P_0 = 1 - \rho$

The probability of having n customers in the system:

$P_n = P_0 \rho^n$

The average number of customers in the system:

$L_s = \frac{\rho}{1-\rho} = \frac{\lambda}{\mu-\lambda}$

The average number of customers in the queue:

$L_q = L \times \rho = \frac{\rho^2}{1-\rho} = \frac{\rho\lambda}{\mu-\lambda}$

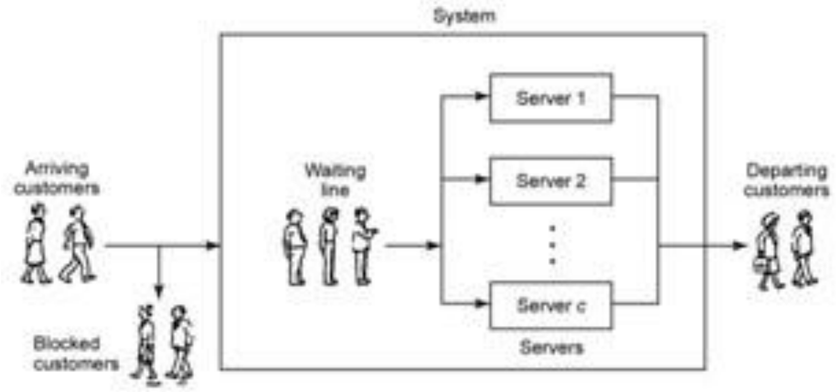
W_q: The average waiting time in the queue:

$W_q = \frac{L_q}{\lambda} = \frac{\rho}{\mu-\lambda}$

W_s: The average time spent in the system, including the waiting time

$W_s = \frac{L}{\lambda} = \frac{1}{\mu-\lambda}$

2.2 M/E_K/1 queuing model:



λ: The mean customers arrival rate

μ: The mean service rate

The average number of customers in the queue:

$L_q = \left(\frac{k+1}{2k}\right)\left(\frac{\lambda^2}{\mu(\mu-\lambda)}\right)$

The average number of customers in the system:

$L_s = L_q + \frac{\lambda}{\mu}$

W_q: The average waiting time in the queue:

$W_q = \frac{L_q}{\lambda}$

W_s: The average time spent in the system, including the waiting time

$W_s = W_q + \frac{1}{\mu}$

2.3 Analysis of data

2.3.1 Present Scenario:

Passengers are standing in the queue thrice for the whole process which includes the first queue for check-in, Second for Security check and the last for boarding.

Performance measures:

It was observed in an XYZ airport that the arrival rate was λ= 70 customers per hour and the service rate was μ = 75 customers per hour.

The performance measures are:

The average number of customers in the system: L_s = 35

The average number of customers in the queue: L_q = 34.027

The average waiting time in the queue: W_q = 0.5 hr or 30 min

The average time spent in the system, including the waiting time W_s = 0.4861hr or 29 min

2.3.2 Proposing Model:

Here, we are using our $M/E_k/1$ queuing model in e first phase, in which there are three phases.

<u>Phase 1:</u>

Web check-in with baggage

Customers (or passengers) can do web check-in by their smart phone or laptop whenever they are free.

Phase 2:

Web-Security

Security screening consists of two distinct operations: Inspecting the passenger's cabin bags and inspecting the passenger himself. Both of these operations can be automated by using electronic equipment. Carry-on bags may be inspected by a visual scan in an x-ray device. Door-way type walk through metal detectors detect weapons.

Phase 3:

Mobile bar-coding for boarding

Once a passenger has done web check-in, boarding pass generates in his smart phone. After he is through security check, the update is done in his boarding pass, which contains a bar code. And through that he can board with the smart boarding pass.

Performance measures:

It was observed in an XYZ airport that the arrival rate was λ= 70 customers per hour and the service rate was μ = 85customers per hour,

Service time per phase = 5 min, k = 3

The performance measures are:

The average number of customers in the system: L_s = 9.33

The average number of customers in the queue: L_q = 2.56

The average waiting time in the queue: W_q = 0.036 hr or 2 min

The average time spent in the system, including the waiting time W_s = 0.047hr or 3 min

3. CONCLUSION

This proposing model is a small step towards easing out the life from the long queues in the airports. The problem of waiting for ones turn to come in a long queue could be easily overcome by this project. It reduces queue length and actual waiting times, thus improving customer satisfaction. It upholds the image of the firm as the queue system ensures discipline at the premises.

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