Simulation of Queuing process of Airport passenger at security check-in by using Simulink - MATLAB

Deepmala Sharma*, Dr Saurabh Tege, Deepti Mehta

Department of Mechanical Engineering, Geetanjali Institute of Technical studies, Udaipur, Rajasthan, India

ARTICLEINFO

ABSTRACT

This paper shows a Simulation Model of queuing process at airport security check-in system in Udaipur Airport using Simevent toolbox in Simulink MATLAB for implementing analytical Models. The queueing model is implemented in Simulink-MATLAB and is used to optimize the number of security servers. The model is used to simulate different scenarios with different arrival rates and number of servers. The input for simulation is inter-arrival time, service time and number of servers. The inter arrival time of passengers follows the Poisson distribution, and the service time follows Exponential distribution The results of the simulation shows that the optimal number of servers depends on the arrival rate of passengers. For low arrival rates, a smaller number of servers is sufficient. However, for high arrival rates, a larger number of servers is needed to avoid long queues. Simulation is scholastic process of events in which the times between events are random variables. The Simulation model is stochastic in behaviour which shows reality hence produces more reliable results. Stochastic analysis methods are recommended for queuing analysis to get accurate results. The Simulation model is therefore recommended to give Airport managers prior knowledge of system performance for planning and improved level of service (LOS) at airports. Additionally, the model could be extended to consider other factors that affect the security check-in process, such as the number of security lanes and the type of security equipment used. This document provides some minimal guidelines (and requirements) for writing a research paper. Issues related to the contents, originality, contributions, organization, bibliographic information, and writing style are briefly covered. Evaluation criteria and due dates for the research paper are also provided.

Keywords: Airport security, M/M/C queueing system, Simulation Modelling, Simulink, Optimization.

I. INTRODUCTION

Airports are complex systems that involve a variety of processes, including passenger check-in, security screening, baggage handling, and boarding. One of the most important processes is security screening, which is designed to prevent dangerous items from entering the aircraft. The security screening process can be a bottleneck in the airport system, as it can cause long queues and delays. The number of servers at the security checkpoints is a key factor in determining the length of the queues. If there are too few servers, the queues will be long, and passengers will have to wait a long time to be screened. If there are too many servers, the resources will be underutilized. The optimal number of servers at the security checkpoints depends on a number of factors, including the arrival rate of passengers, the service rate of the servers, and the desired level of service. This paper presents a modelling and simulation approach to optimize the number of servers at the security checkpoints.

The model is developed in Simulink-MATLAB, and it is based on the M/M/c queueing system. The M/M/c queueing system is a common model for describing queues in service systems. It is characterized by the following assumptions:

- The arrival pattern of passengers is a Poisson process.
- The service time of each passenger is exponentially distributed.
- There are c servers at the security checkpoints.

MATLAB SIMULINK R2023a is a product of MathWorks. The student version can be downloaded from MathWorks website for free. Simulink provides a block diagram environment for simulation. It is a simulation and model-based design environment for modelling, simulation, and analysis of multidomain system in graphical way. Simulink has graphical blocks of physical system. It provides a graphical editor, customized block libraries and solver for modelling and simulating systems. It is integrated with MATLAB and simulation result can be exported to MATLAB for further analysis. Simulink has Library browser which contains blocks. Blocks can be added to the model by just drag and drop them to the model. Discrete event simulation is provided by Simevent and component library for analysing model and optimizing performance characteristics.

Event sequence in Simevent model is

1. An entity is generated in entity generator block.
2. Entity enters the queue block.
3. Entity server block competes the service of an entity.
4. The entity exits entity server block and enter the entity terminator block.
5. The entity is destroyed.
6. Scope block is used to see the result after the simulation run.

Simulation is the process of designing a model of a real system and conducting experiment with the model for the purpose of understanding the behaviour of the system operation. Simulation results try to identify bottlenecks in the process, characterize deadlock condition and get a clear picture of Latency throughput the system. This information enables us to make a decision about optimizing the system. Different computer software can be used for simulation. Here MATLAB is used for simulation.

II. METHODS AND MATERIAL

The airport passenger security screening process is designed to prevent dangerous items from entering the aircraft. The process involves the following steps:

1. Passenger identification. Passengers present their boarding pass and identification to a security officer.
2. Baggage screening. Passengers' carry-on baggage is screened by X-ray machines.

3. Personnel screening. Passengers walk through a metal detector or are scanned by a millimeter wave scanner.

4. Hand search. Passengers may be selected for a hand search, which involves a security officer physically searching their person and belongings.

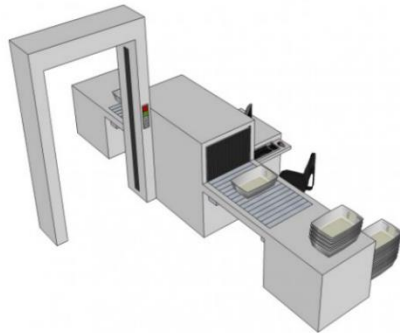5. Explosive trace detection. Passengers may be swabbed for explosives.

Figure 1 : DFMD for passenger and X-Ray screening for items

The figure 1 shows the process of passenger security screening at security check in. The passengers have to remove their specified belongings and hand bag on the tray. This tray will pass through x-ray machine on belt. Passengers have to pass through DFMD than frisking by CISF officials.

For building the queueing model in Simulink the input data required is inter-arrival time and service time of passenger at Udaipur airport. The inter-arrival time is the reciprocal of arrival rate of passenger. Arrival rate of passenger is obtained from official data. Service time is calculated by the observation method. Analytical queueing model is based on the formula. The performance measure is obtained using these formulas. Simulation of the queue model will give the better understanding of queue parameters such as waiting time, queue length, utilization. It is represented in graphs.

Data collection

For the analysis of passenger queue at security screening using Queueing theory, We need the input data like Arrival rate, service time and number of servers. First, we collect data of passengers embarked from the Udaipur airport during the year 2022 (January to December). These data are taken from official website. These are the data of passengers enters the terminal building. The arrival rate can be calculated with these data.

The average number of passengers arrivals per hour (λ) =passengers departed per day/number of hours per day
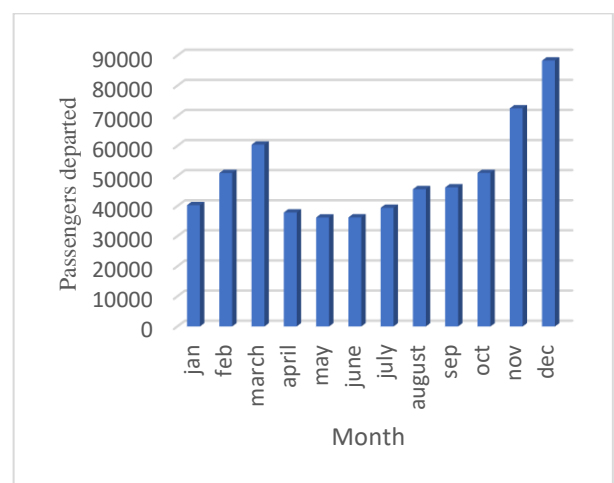

Figure 2 : Passenger departure data during the year 2022 (January to December).

Observation was taken randomly for 100 passengers per day of a week during the time period from 2:00 pm to 7:00 pm at the passenger security screening. It is the time when maximum flight departure is scheduled. It is concluded that the standard service time per pax at passenger screening is 22 seconds.

III.RESULTS AND DISCUSSION

After applying the queueing theory, the result observed are as follows:

Standard service time = 22 sec

Daily operating hours=12 hrs.

1. The average number of passengers served per hour μ

= hour/service time = 3600 sec/22 sec per passenger

(standard service rate) μ = 164 passengers per hour

The number of passengers served per hour is 164 passengers.

2. From Figure 2 it is seen that the maximum arrival of passenger at airport is in month December. The **busy month** of year is December.

Daily operating hours=12 hrs.

Per day arrival in December = 88342/31 =2850

Daily per hour arrival of passenger = 2850/12

=238 passenger per hour

The mean arrival rate of passenger in December

λ = 238 passenger per hour

μ = 164 passenger per hour

C = number of server

Utilization $\rho = \lambda/ c\mu$

We can find the difference between performance of queue, how they can perform potentially with using analytically and MATLAB simulation. We can analyse the difference between channels with respect to Length of passengers in queue(Lq) and in system (Ls),Waiting time in system(Ws) and in queue(Wq.)

Table 1: Performance measure of passenger queue

C	2	3
ρ	0.72	0.48
P_0	15.9%	22.26%
L_q	1.61	0.20
L_s	3.06	1.65
W_q (Min)	0.40	0.518
W_s (Min)	0.76	0.41

We will take December month data for simulation with three number of server.

λ = 237 passenger per hour

μ = 164 passenger per hour

C=3

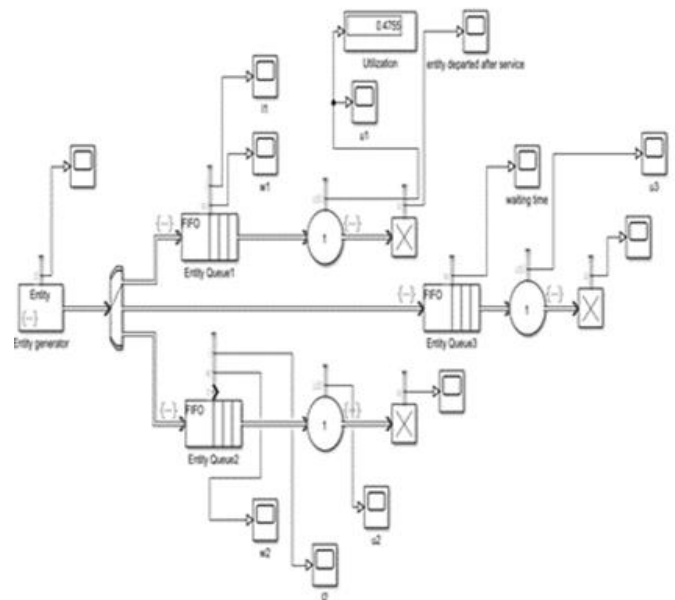The following Simulink queue model was developed to represent the queueing process.

Figure 3 : Simulink model for 3 servers for month of December

The above multi server model run in Simulink. It will give the following results which can easily be seen in scope in graphic form.
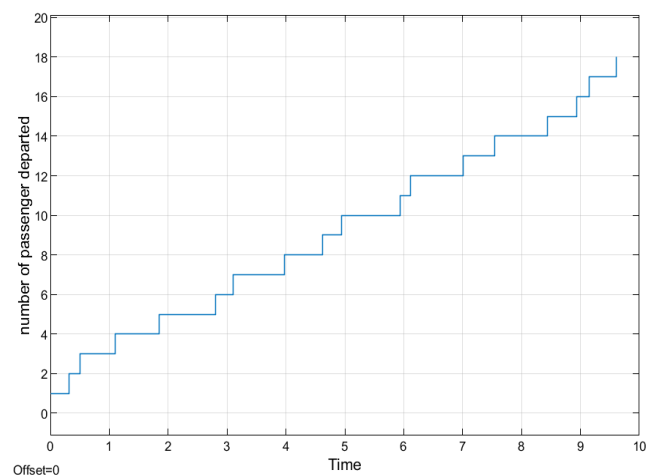

Figure 4 : Passenger Arrival pattern random (exponential)

In the Figure 4 the random behaviour of arrival of passenger can be seen easily. The passenger arrive in a random manner so the exponential distribution is selected with random variable. This graph is seen in scope of entity generator block. It shows the arrival pattern of passenger randomly.
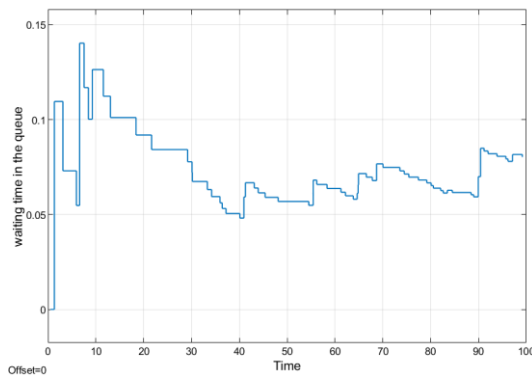
Figure 5 : simulated waiting time in queue

In the above Figure 5 the waiting time of queue for server is seen in scope of queue block. The simulated waiting time is same as the waiting time obtained from queueing formula analytically, which is 0.0518 min from Table 1.
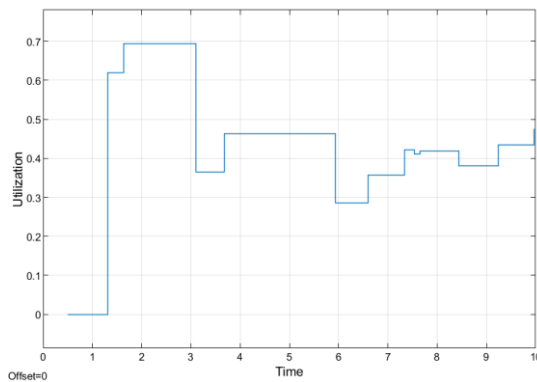

Figure 6 : Server utilization simulation

The server utilization obtained from the analytical model for three server is 0.48, is similar to the simulated model shown above Figure 6.
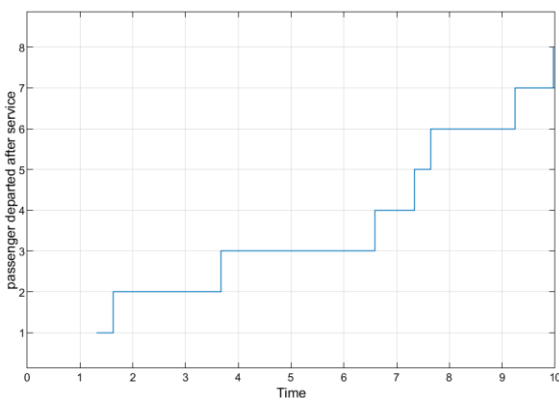

Figure 7 : Passenger departed after service

The above Figure 7 shows the passenger departure pattern after getting the service at security check -in. By changing the input of inter-arrival data and service time, the behavior of the queue performance can be seen easily. Number of passengers in the queue can be seen in the scope and additional server can be used to reduce the waiting time of passengers.

The management of queues may include many aspects, from physical settings and structures to the estimation of key parameters and predictability of various quantities. we should observe and estimate the number of customers, queue length, waiting time, service time, and other quantities so as to be prepared for queueing management. Then, the number of servers should be able to vary so as to minimise the waiting time and queue length. Customers' rating and satisfaction can be influenced by the waiting time. Monitoring of queues and communications about the queue status, comfortable waiting environment, engagement and interactions with customers, and effective service mechanism are all part of queue management systems.

IV.CONCLUSION

In this paper, a simulation model of the queuing process at the security check-in of an airport was developed using MATLAB's SimEvents toolbox. The model was validated using real-world data from the airport, and the results showed that it was able to accurately predict the queue length and waiting time at the security check-in. The study also found that the arrival rate of passengers and the service time of the security officers also had an impact on the queue length and waiting time. The study concluded that the simulation model can be used to evaluate the performance of the security check-in system and to identify potential bottlenecks. The model can also be used to test different configurations of the security check-in system in order to improve its efficiency. Simulations can help managers to better understand how queue systems work by providing them with a visual representation of the system's behaviour.

Simulations can be easily modified to reflect changes in the real world.

The study has several limitations. First, the study only considered a single airport. Second, the study only considered a single type of security screening equipment. Third, the study did not consider the impact of other factors, such as the layout of the security check-in area, on the queue length and waiting time.

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Cite this article as :