Optimizing the Passenger Throughput at an Airport Security Checkpoint

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Abstract: We consider the problem how to optimize the passenger throughput at an airport security checkpoint. Generally speaking, for an arrival passenger to board the flight, she/he must receive security check. First, check his/her identification and then check his/her baggage and body in a queue according to the FIFO rule. By applying the queue theory we model the security check process as a two-chase multi-server series and parallel queue model with two input queue and use the computer simulation to evaluate the performance of current queue system. Furthermore, we obtain the improved queue system by modifying the parameters of current queue system.

Introduction

It is well known that the aviation security check plays a very important role in protecting the airports, airlines and passengers from terrorist threats. However, the aviation security check process may carry the additional expense of longer processing times, increased screening device operational costs , increased waiting times for passengers, and a larger taskforce of security staff. Thus, a key challenge is how to balance the tradeoff between maximizing security and minimizing the expected amount of waiting times and variance for passengers to improve the passenger throughput. In this paper, we consider the above problem on how to optimize the passenger throughput at an airport security checkpoint. Therefore, we present a two-phase multi-server series and parallel queue system to model the airport security checkpoint process, and we use the computer simulation method to solve this problem.

US Airport Security Checkpoint Process

US airport security inspection is divided into pre-inspection and general security in two forms. Passengers through the specific process of security is shown in Figure 1.
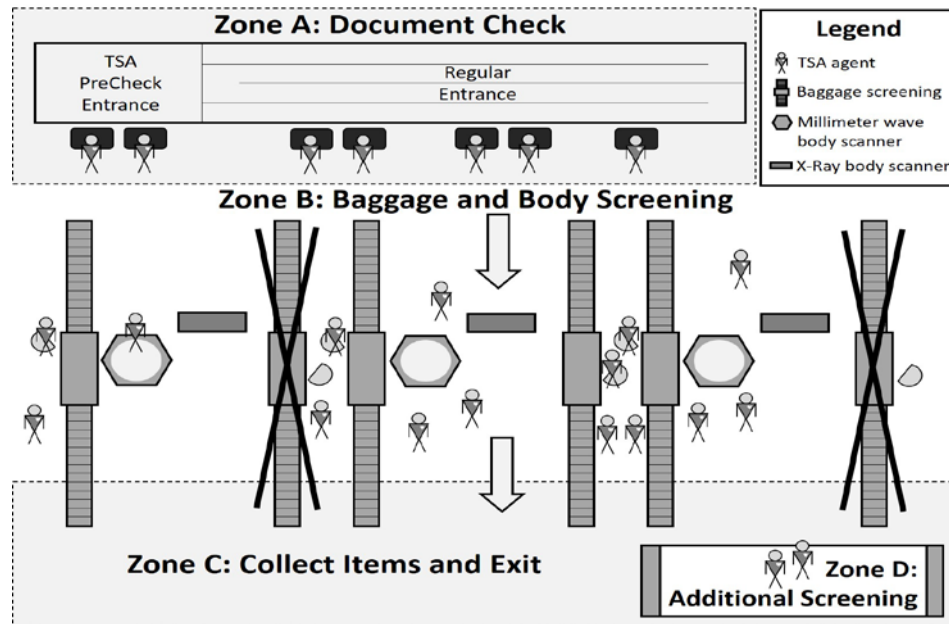
Figure1:Illustration of the TSA Security Screening Process

STEP1 All passengers arrive at the checkpoint area A and wait in the queue until the security personnel can check their ID and boarding documents.

STEP2 Passengers move to zone B and enter a subsequent queue for an open screening. In area B, once passengers arrive at the front of the queue, all their items are checked for X-rays. At the same time, passengers through the millimeter wave scanner or metal detector to check, not through this inspection of the passengers to accept the D area security officer's search checks.

STEP3 The passenger goes to the conveyor on the other end of the X-ray scanner, collects their items in area C and leaves the checkpoint area.

Modeling the Airport Security Checkpoint Process

It is well known that the general queuing system has three basic components: input process, queuing rules and service organization. The indexes that describe the performance of a queuing system are the average queue length, the average waiting time for the customer, the average stay time for the customer, and the service desk utilization rate.

The basic elements of queuing service system are as follows:
●Arrival mode: such as fixed-length distribution, Poisson distribution, Irish distribution, exponential distribution and super-exponential distribution;
●Queuing rules: FIFO rule, i.e., first-come-first-served rule, LIFO rule, i.e., later-come-later-served rule, priority, random, and others;
●Service agencies: parallel(one-to-many), serial(single-to-single-service), or others;
●Service process: fixed-length distribution, negative exponential distribution, Erlang distribution, general random distribution, and other distribution;
●Performance indicators: average waiting time, the number of service per unit time, the average waiting time variance, the average length of stay, and others.

In the airport security checkpoint process, the input is the pre-check passenger arrival and the regular passenger arrival; the queuing rule obeys FIFO rule, i.e., first-come-first-served rule; and

the service organization studied in this paper can be abstracted as a two-phase multi-server series and parallel queue model, as shown in Figure 2 below. Because the queuing model is complex , it is difficult to compute the exact analytic solution. We resort to consider the computer simulation method to model and solve it. The specific process of computer simulation will be discussed later. The performance indexes are the waiting time and variance.
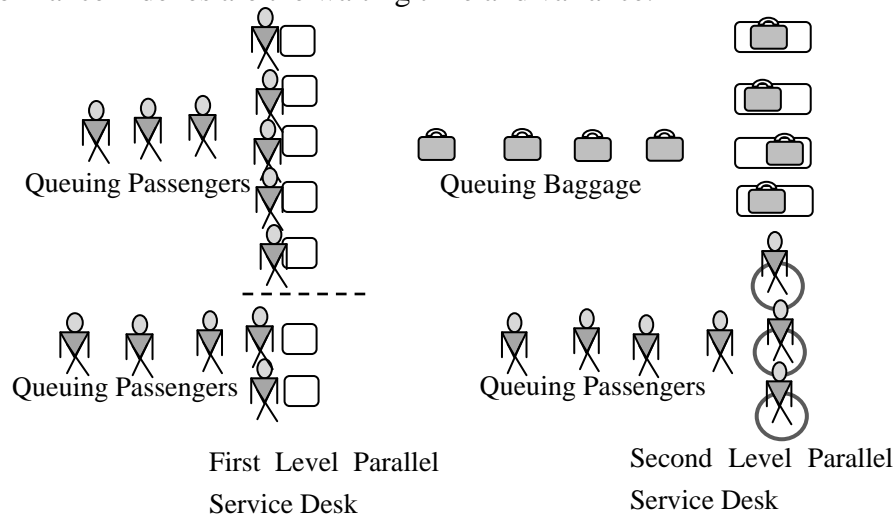

Figure2: Two-level Multi-service Queue Model

In the airport security checkpoint process, it is a queuing system and there are many random variables about the times. The first task is to determine the specific distribution functions about the arrival time, the total time for checking the identification and boarding documents, the total time for X-ray scanning check and the total time for the millimeter-wave scanning check by using the given data.

In order to better reflect the US airport security process, we draw the flow chart of the problem analysis, as shown in Figure 3 below.
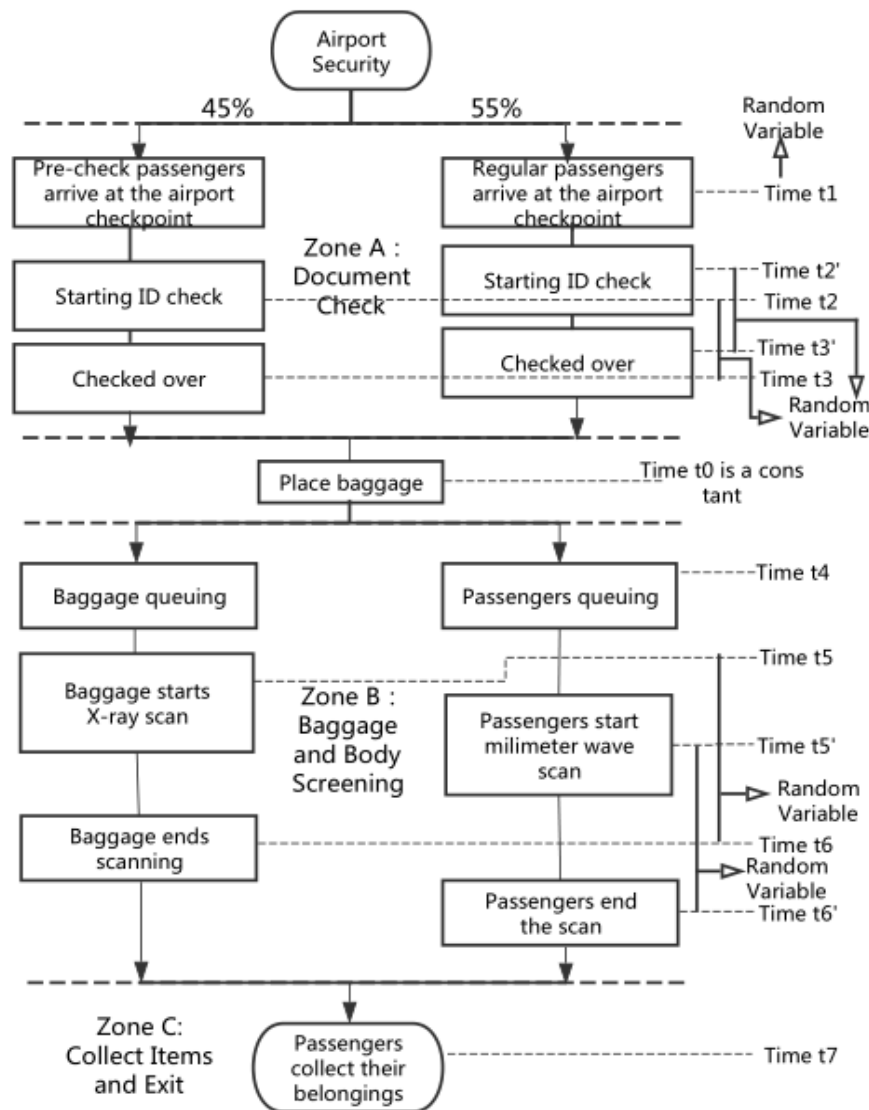
Figure3: A Brief Introduction of TSA Security Screening Process

After the distribution function is obtained, the five distribution functions are used to simulate the entire security check process. In the simulation, the basic principle of the whole simulation process is to use the arrival time and service time to obtain the mean waiting time and variance in the queuing system, that is, using random variables for five known test data to simulate the queuing. It is of course possible to compare the time taken by passengers to baggage in area B and to compare the known time intervals to verify the reasonableness of the simulation. Specific simulation process is shown in Figure 4 below.

When the entire computer simulation is finished, all passengers arriving at the checkpoint pass the security check. We can compare the obtained random variables (that's w_p, w_r, w_b, w_h) with the waiting time to find out the bottleneck point. On a best-effort principle $w_p \leq w_r, w_b = w_h$, two or more potential modifications to the current process are developed to increase passenger throughput and reduce the waiting time.
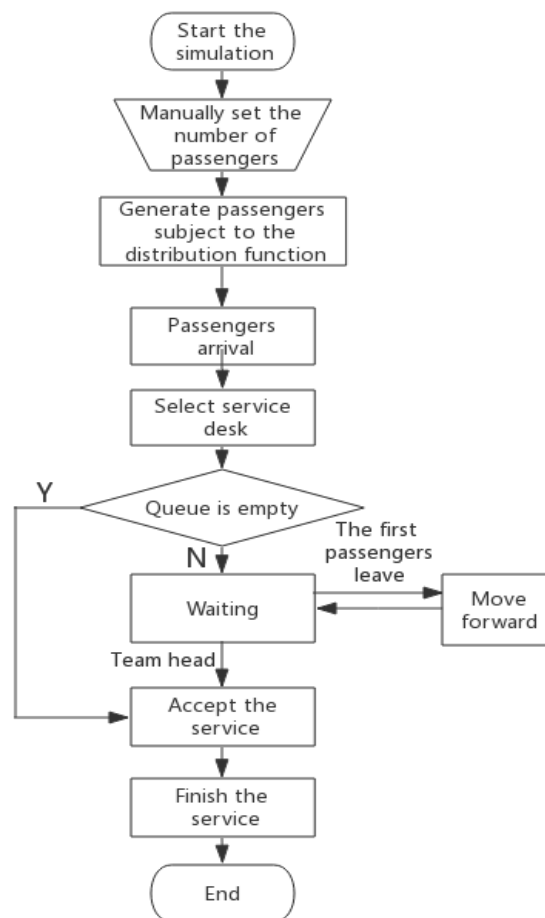
Figure 4 : Specific Simulation Process

Improved Queue System

In this problem, data has been collected about how passengers proceed through each step of the security screening process. Therefore, according to a two-chase multi-server series and parallel queue model and computer simulation model, we can explore the flow of passengers through a security check point and identify bottlenecks. Then clearly identify where problem areas exist in the current process. Through the above analysis, we can get the result that one bottleneck is the unbalance on the number of service desks for pre-checking passengers and regular passengers and the other bottleneck is the unbalance on the number of service desks for baggage X-ray check and millimeter microwave check.

In response to the problem with the model, we develop improved queue system to the current process to improve passenger throughput, reduce the waiting time difference, and simulate these changes to demonstrate how our changes affect the process. Specifically, taking the bottleneck found in this question into account, under the premise that don't change the number of service desks, we re-propose two arrangements of service desks, which are shown in Table 1 below.

Table1:The Specific Distribution Plan of service desks

Scheme name	Original Scheme	Improved Scheme 1	Improved Scheme 2
Pre-check Entrance (Security personnel)	2	3	3
Regular Entrance (Security personnel)	5	4	4
Baggage Screening (instrument)	4	3	2
Body Screening (instrument)	3	4	5

Combined with the mean and variance of the waiting time of each service station, the improvement of scheme 1 is about 0.6 second longer than scheme 2, but it's fluctuation of waiting time is small, which will bring passengers better experience. However, compared with the original program security time which has the mean 29.1695 seconds, variance 0.9100, waiting time and stability have a more significant improvement.

Conclusion

Queuing service system and computer simulation are important to optimize the passenger throughput at an airport security checkpoint. In this paper, we give the model of the airport security checkpoint process and obtain the improved queue system by modifying the parameters of current queue system. By comparison, our improvement makes sense for the passengers.

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