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Airport Security Process Analysis

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Abstract. At present most of the airport security cost a very long time. To relieve the tension between security maximization and positive flying experience, we describe the current security checking process by analyzing the time distribution of each step. We ignore those delay caused by happenstance to simplify the problem solving, and make several assumption to fill up the lack of the given data, so that we can apply Service Model Simulation to achieve a visual representation of the security checkpoint process and identify the bottlenecks further by means of Monte Carlo algorithm. By additional analysis, we find the bottlenecks of current security checkpoint are the skill level of TSA staff and the time spent by passengers in preparing belongings to be X-rayed.

Introduction

At the airport security check is a very important step. Following the recent threats to aviation security over the world, such as the Christmas Day 2009 bombing attempt, the Richard Reid shoe bomb attempt 2002, and the 9/11 hijackings, airport security has been significantly enhanced along with a relatively longer time needed to finish a security examination. However, airline company have a vested interest in maintaining a positive flying experience for passenger, in which the time they spend waiting in line at a security checkpoint plays an important role.

Figure 1. A picture of Security Checkpoint

Based on the situation above, while the TSA invested in several modification to their security checkpoint, which were some what successful in reducing waiting tine, a creative solution to address the problem is in especially need.

The Security Checkpoint Model

Security Checkpoint Process. The current process for a US security checkpoint is display as follow:

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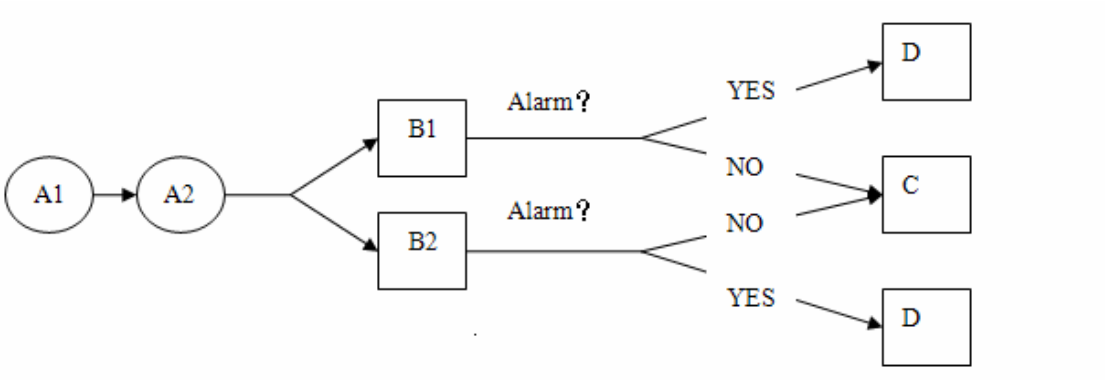

Figure 2. Illustration of the TSA Security Screening Process

Where:
Arrows represent the movement of passengers;
A1-passenger enter the line waiting for document check;
A2-document checkpoint[step 1];
B1-baggage screening[step 2];
B2-body screening[step 3];
C-collecting items and exiting[step 4];
D-additional screening.

Data Analysis. Based on the given data, we get the mean and standard deviation of time spent in each step of the security screening process in Table 1, details as per attached tables.

Table 1 time distribution of security checkpoint process

Step	ID Check 1	ID Check 2	X-ray Scan 1	X-ray Scan 2	Millimeter Wave Scan	Time to Get Scanned Propert
Mean[s]	**10.2**	**12.6**	**7.5**	**3.7**	**11.9**	**28**
Variance[s]	**3.0**	**5.0**	**8.2**	**3.4**	**5.9**	**845**

We use MATLAB to simulate the arrival of regular and Pre-Check passengers, and determine the distribution of their arrival moment as Fig. 3 and Fig. 4, which are follow negative exponential distribution approximately.

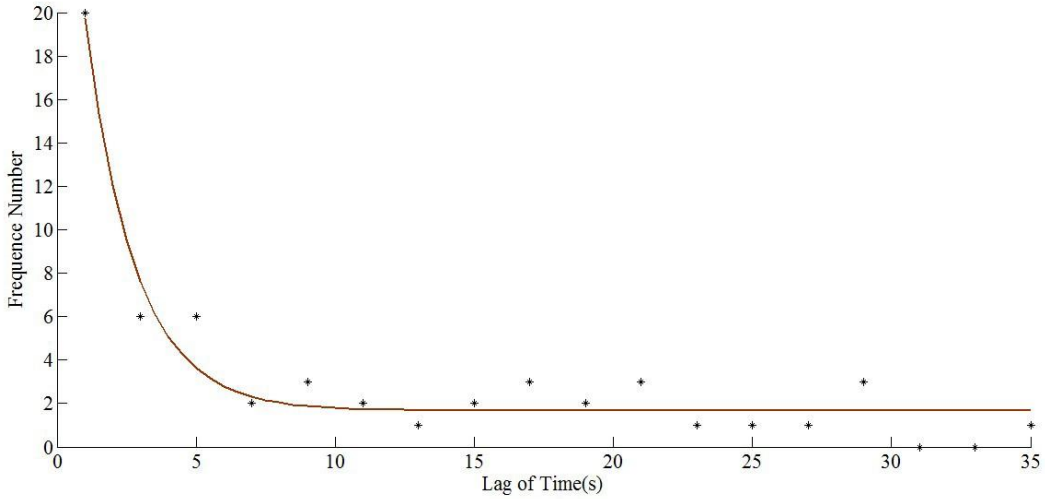

Figure 3. TSA Pre-Check arrival moment

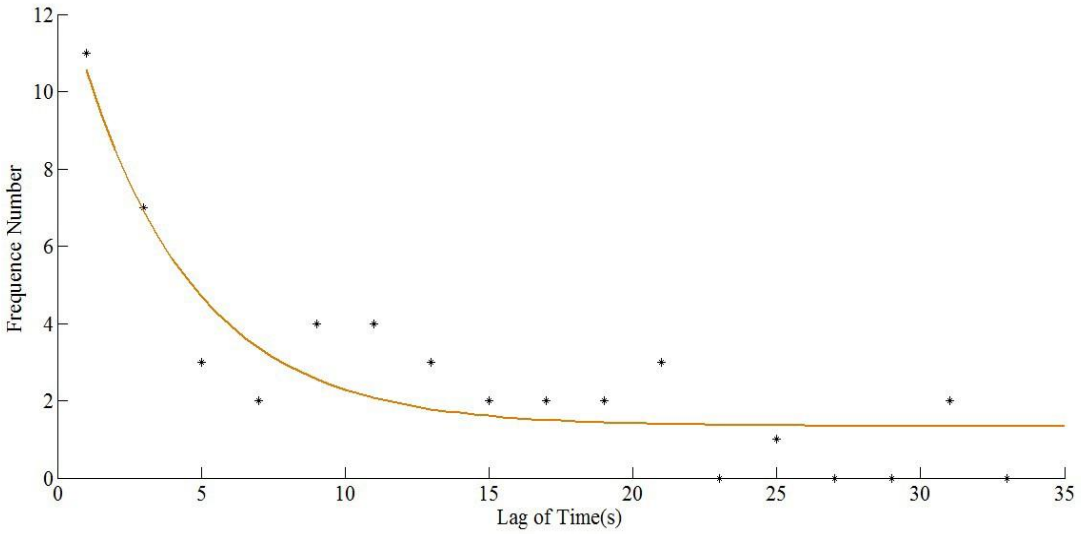

Figure 4. Regular arrival moment

Service Model Simulation. Before Service Model simulation[1,2], we need to set five main elements to describe the current security checkpoint.

- Background setting

Simulation background, which is the possible active region of passengers, include zone A, B, C, and D (Fig. 2). Specifically, there is one pre-check line open and three regular lines open, but the proportion of passengers enrolled in a Pre-Check program and common passengers is nine to eleven. Besides, the checkpoint throughput per hour is 800 passengers.

- Time spent in each step

We take the average value of the data collected as the time spent in relatively step of security screening process to describe the efficiency of the step. And we assume that the time for walk between process stations and waiting is 15min in total.

- Passenger's arrival moment

Since the arrivals of passenger are negative exponential distribution approximately (Fig. 3, Fig. 4), we take the value of passenger's arrival moment at random according to its distribution.

Given a certain circumstance as above, and the values of time spent in each step are shown in the Table 5.

Table 2 the values of the parameters

Variable	Document Checkpoint		X-ray Screening	Millimeter Wave Body	Get Scanned Property
Value[s]	10.2	12.6	7.5	11.9	28

We apply Service Model to simulate the security checkpoint process and get the waiting time of document checkpoint (zone A) and security screening (zone B) in Table 6.

Table 3 results of simulation

Elements		Maximum Time Spent In Line[min]
Document Checkpoint	TSA Pre-Check Lines	6
	Regular Line	5
Baggage and Body Screening	TSA Pre-Check Line	10
	Regular Line	15

Identification of Bottlenecks

Step Analysis Based on Monte Carlo Algorithm. The current process for US airport security checkpoint is displayed in Fig. 2. We use Monte Carlo algorithm[1,3]to model the security checkpoint process and identify where bottlenecks are.

We focus on the time spent in security screening process, which includes step1,2,3,4(fig. 2). Obviously, the total time can be described as:

$$T = \sum_{i=1}^{m} T(x_i) \tag{1}$$

Where:
T is the total time;
$T(x_i)$is the time spent in step i ;
m is the number of steps.
As to every step of security screening, there are:

$$\Delta T(x_i) = T_{max}(x_i) - T_{min}(x_i) \tag{2}$$

Where:
$\Delta T(x_i)$ is the difference between the maximum and minimum;
$E(T(x_i))$is the mathematical expectation of time spent in step i;
E(T)is the mathematical expectation of total time.

A large value in $\Delta T(x_i)$ would indicate that the time spent in step i is unstable, which lead to a large influence to the stability of whole system. Meanwhile λ_i describe the weight of relatively step n the current security screening process, and the largest weight factor may point to where problem are, also call bottlenecks, exist in system.

Result. We apply Service Model to simulate the above process repeatedly. For each simulation, there are:

$$T_k = \sum_{i=1}^{m} T_k(x_i) \tag{3}$$

Where:
T_k is the total time calculated in the k th simulation;
$T_k(x_i)$ is the time spent in step i calculated in the k th simulation;
k is the times of simulation.
After the simulations, we can get:

$$T_{\min}(x_i) = min\{T_{\mathrm{k}}(x_i)\} \quad (4)$$

$$T_{\max}(x_i) = max\{T_{\mathrm{k}}(x_i)\} \quad (5)$$

Thus, we can figure out the value of $\Delta T(x_i)$ and λ_i for each step of the security screening process.

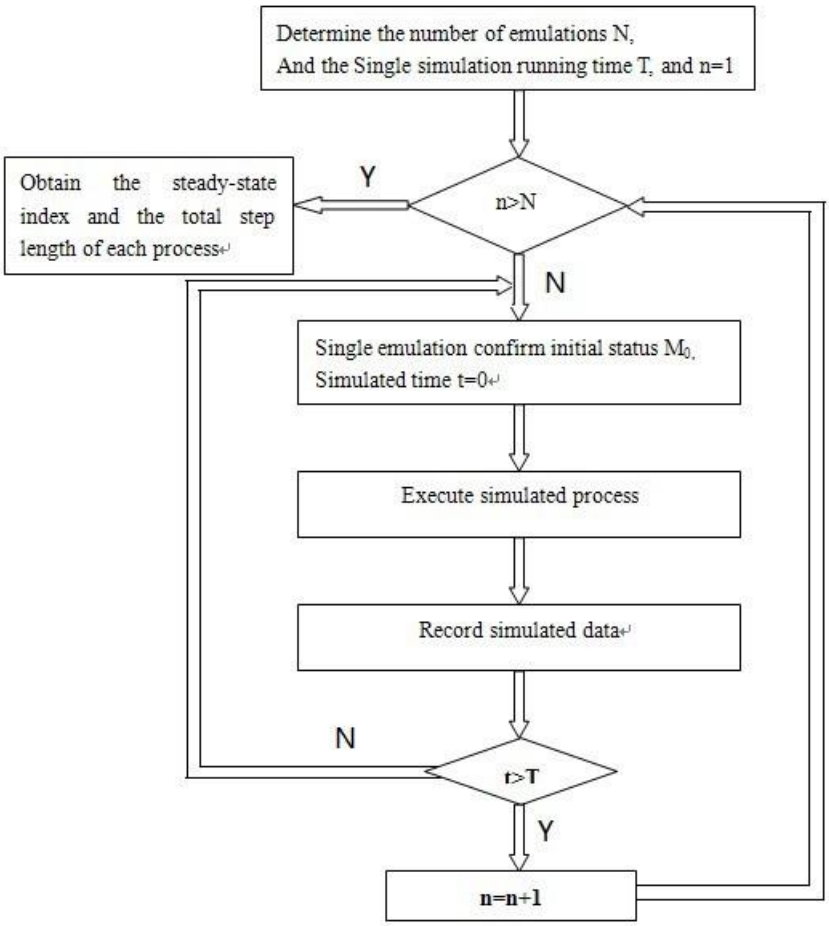

Figure 5. Illustration of Monte Carlo simulation

Base on simulations and analysis, we find the value of λ_i and $\Delta T(x_i)$ in millimeter wave scanner are large when comparing with the others, which are relatively 16s and 20s, making it the bottlenecks of the security checkpoint. In addition to this, the delay caused by collecting belongings at the conveyor belt on the other side of the X-ray scanner also somewhat impacts the throughput of checkpoint.

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