The Finding of Airport Security's Bottleneck

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Abstract. This paper establishes security process optimization model based on GSPN and use average token to make performance analysis of each step in security process to identity bottlenecks and put forward some optimization suggestions.

Based on the theory of Petri Net, we divide the whole security process into several steps and set up the security process optimization model. Under the premise of validating the structural reliability of the model, we analyze the tangible state and vanishing state of the GSPN and transform the generalized stochastic Petri net into the isomorphic Markov chain to get the probability of each state and get the average token. Thus, we find that the bottlenecks in the security process are ID check and luggage collection.

Introduction

In order to ensure the safety of the airport and personnel, security check at the terminal has become the key process of flying experience. As the aircraft isincreasingly becoming a convenient way for people to travel long distances, the amount of air traffic has a substantial increase and airport passenger throughput also increases significantly. However, airlines have a vested interest in maintaining a positive flying experience for passengers by minimizing the time they spend waiting in line at a security checkpoint and waiting for their flight. During 2016, the U.S. Transportation Security Agency (TSA) came under sharp criticism for extremely long lines due to the long waiting time. Although TSA invested in several modifications to their checkpoint equipment and procedures and increased staffing in the more highly congested, these optimization plans cause a lot of expenditure to maintain the passenger throughput.

Security Process Decomposition

Through the description and analysis of the security process in the background, we divide the whole security process into the following steps：

The passengers arrived at the terminal wait in a queue until a security officer can inspect their identification and boarding documents

The passengers prepare all of their belongings for X-ray screening and meanwhile the passenger process through either a millimeter wave scanner or metal detector.

All of the belongings, including the bins containing the aforementioned items, are moved by conveyor belt through an X-ray machine, where some items are flagged for additional search or screening by a security officer. Passengers that fail this step receive a pat-down inspection by a security officer.

After inspection, the passengers collect their luggage and exit.

Model Establishment

Through the decomposition of the security process, we regard the whole process as a collection of discrete events. The security process has the characteristic of synchronization and concurrency. Therefore, we introduce the time parameter to analyze the time behavior of the model and establish the security process optimization model based on generalized stochastic Petri net.

In the model constriction, we utilize place to express the state before the security process

execution, utilize transition to express activities in various executions in the security process and utilize connections to express the location of service objects during the security process. Eventually, we get the security process optimization model based on generalized stochastic Petri net as following:

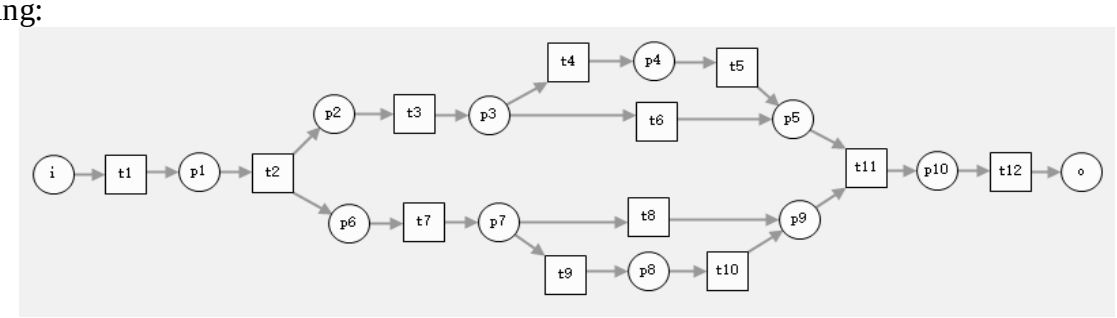

Figure 1. The security process model based on GSPN

The definition of symbols are interpreted as following:

Table 1 the definition of place

Place	Definition
i	Prepare for ID check
p_1	Passengers after ID check
p_2	Luggage to be X-ray scanned
p_3	Luggage after X-ray scanner
p_4	Luggage need to have open-package inspection
p_5	Luggage after open-package inspection
p_6	Passengers to be millimeter wave scanned
p_7	Passengers after millimeter wave scanner
p_8	Passengers need to have personal examination
p_9	Passengers after personal examination
p_{10}	Passengers intend to collect luggage
o	Passengers who have collected their luggage

Table 2 The definition of transitions

Transition	Definitions
t_1	ID check
t_2	Prepare for security check
t_3	X-ray scan
t_4	Passenger's luggage with suspicious objects
t_5	Open -package check
t_6	Passenger's luggage without suspicious objects
t_7	Go through either a millimeter wave scanner or metal detector
t_8	The millimeter wave scanner alarms
t_9	The millimeter wave scanner doesn't alarm
t_{10}	Personal check
t_{11}	Transmission of luggage on the belt
t_{12}	Luggage collection

Model Solution

Data Interpretation. Dataset, each column of data, is independent of others as several groups of people were coming through the screening process.

Before the simulation of the model, we process the data by the following steps:

Find the mean value and variance of the consumption time of each transition.

We assume that data with large deviation degree is invalid and get more efficient data.

Simulation Results

Using the processed data, we establish the security process optimization model based on GSPN and evaluate its performance. we calculate the density matrix X:

$$\begin{cases} -5.6604x_1 + \lambda x_{11} = 0 \\ 5.6604x_1 - 24.0688x_2 = 0 \\ 2.4631x_2 - 6.1216x_3 = 0 \\ 16.4841x_2 + x_3 - 5.1216x_4 = 0 \\ 0.2561x_2 - 21,9472x_5 = 0 \\ 4.8655x_2 + 3x_5 - 18.9472x_6 = 0 \\ 0.2561x_3 + 2.4631x_5 - 4x_7 = 0 \\ 0.9473x_4 + 16.4841x_5 + x_7 - 3x_8 = 0 \\ 4.8655x_3 + 2.4631x_6 + 3x_7 - x_9 = 0 \\ 4.8655x_4 + 164841x_6 + 3x_8 + x_9 - 2.0964x_{10} = 0 \\ 2.0964x_{10} - \lambda x_{11} = 0 \\ \sum x_i = 1 \end{cases} \quad (1)$$

Solving the function $X \cdot Q = 0$, we get the probability distribution and obtain the average token of each place of the security process model based on GSPN.We can get the result that places (i, p_{10}) are the bottlenecks of the security process. i represents the process of ID check and p_{10} represents the process that passengers intend to collect luggage.

Summary

Based on GSPN and the theory of Petri Net,this papaer establishes a security process optimization model.Then we calculate the density matrix and get the result is that the bottlenecks of the security process are represents the process of ID check and represents the process that passengers intend to collect luggage.If we want to increase the efficiency of security,we need to improve the speed of this two processes.

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