The Improvement of Passenger Throughput Capacity for Airport's security system

January 24, 2017

Abstract

While airport security is one of the most significant preventive measures against terrorist attacks and other events,it is also a crucial psychological factor that influences travel experience of passengers.Around this problem,we come up with three models to find out the bottlenecks of the system and how we can solve the problem. To find where the bottlenecks lie,we establish a stochastic Petri net model to refine the whole security procedure.The specific process in the 4 zones are represented by Transitions.Some significant point are regarded as Places in the model.Then we establish a isomorphic Markov chain from reachability identification list that has been constructed.Equipped with analysis of raw data,we arrived at the conclusion that too much potential time consumption in the zone D to detect the passengers and the time it takes to do millimeter wave scan is a little bit long.

Then we regard the check points as a whole system, and focus our attention on reducing lining up time.Based on the data we have already analyzed, we establish a queuing model: M/M/s/FCFS/N/∞. The result comes that with the number of security groups increasing in the system, the number of the processing people increases linearly, but the length of the waiting queue is decreased and then increased. Meanwhile, the overall efficiency is gradually increase slowly and finally tend to be stable. It can be observed that when we have three of the pre-check channel open, we can achieve high efficiency and the waiting time can reach the lowest value at this time.

However,the queuing model cant suit the real situation best.Using PID algorithm,we put forward the closed-loop feedback control model.In our models,passengers can be analogous to industrial items in other situation.The cores of our model are systematic dynamic regulation indicators,as a result of which,we can improve the flexibility and stability of the security system and effectively alleviate the queuing delay.Also can we optimize the existing rigid operating mode and make the whole security process efficiency.

key word: airport security, Petri net, queuing theory, PID algorithm

Contents

1 Introduction

Security checkpoint is where travelers from the public area of the terminal enter the isolation area, the key step of the transferring from the land side to the empty sideIt concerns the efficiency of the entire airport service. The main purpose of the security is to prevent the passengers to carry objects which may endanger the safety of flight.

In the terminal security personnel include usher, checkers , X-ray machine operator, personnel who open bags etc. passengers and commonly used the carry-on baggage synchronization, with check. During the security, passengers put their id card, boarding pass, luggage and belongings in the laundry basket, and let them go through the X-ray machine. while passengers go through security inspection. If the security alarmed, passengers would be inspected by security personnel with a detector. After security personnel's checking, if there were still a problem, passengers would be brought to the isolation area to have a body frisking. After that, if there were no problem with passengers and luggage, passengers could get their item and wait in the waiting area. If the X-ray machine found suspicious items, they still need to open and check the trunk.

Security system analysis aimed at analyzing the security system of airport and finding deficiency in the system in order to design a better security system.

The core of Security system is about screening equipment allocation and scheduling of personnel, through the establishment and analysis of the model, we hope to find out a better security system, making the airport security part more efficient.[1]

2 Assumption and Symbol Description

- Passengers need to check-in first.
- Passengers carry small pieces of luggage without consignment.
- Luggage is provided with prohibited items at the airport.
- There are suspicious items on the passengers.
- The efficiency of the safety inspector is the same.
- Security checking machine works fine, without any problem.
- The number of passengers who can't pass the security checkpoints is far less than who can.

Tab 1: The meaning of each symbol in the model

symbol	meaning
μ	the working efficiency of a single inspect team
λ	the number of arrival people per minute
ρ	refers to λ/μ,indicate the efficiency of the system
L_s	the avenge length of the serve line
L_q	the avenge length of the waiting line
λ_e	effective arrival rate
W_s	to sign the time the customers spend in the system
W_q	to sign the time the customers spend in the waiting line
A	mean of the datas
σ^2	variance of the data
σ	mean square error of the data
Y	security time for a check or total check time
X	the sequence of people
λ_i	incidence of transition

3 Data Analysis

According to the data table provided ,we can extract some important information,which will help us in building models and solving problems.

As we know,the data was collected in different situations,its character of randomness makes it qualified to regarded as typical data to some extent.

Out of concision concernswe analyze the columns respectively.

3.1 Millimeter Wave Scan Times

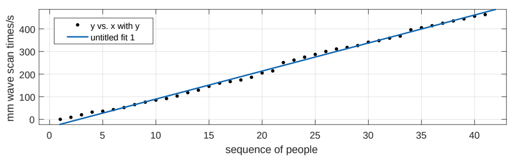

Fig 1: Millimeter Wave Scan times

The figure 1 shows the relationship between the sequence of people and the time they finish mm wave scan,and the blue line is the first order linear fit of raw data,from slop (Am=12.39s) of the curve fitting,we can come to the period of time people pass the mm wave scan ,but the variance of the fitting is quiet large $\sigma_m^2 = 6.63e + 5$,so we need to examine each person's data.

The figure 2 show the time required for the millimeter wave scan to detect each person.The mean and mean mean squared error of these data is Am=11.5750 and ,which σ = 1.1313e + 3, are close to the result of curve fitting in image 1.As can be seen from the figure 2,most people concentrate on completing in 5-15s.There are two exception points(21,37)and (33,28),When we exclude the two points and calculate again,whe results are Am =10.4737 and σ =9.4452 ,the stability of the data has been significantly improved.Then we can speculate that there was no significant difference in the time for mm wave scan examination between pre-check passengers and regular passengers,but in this link, there is a probability of about 5% of people to spend longer time.

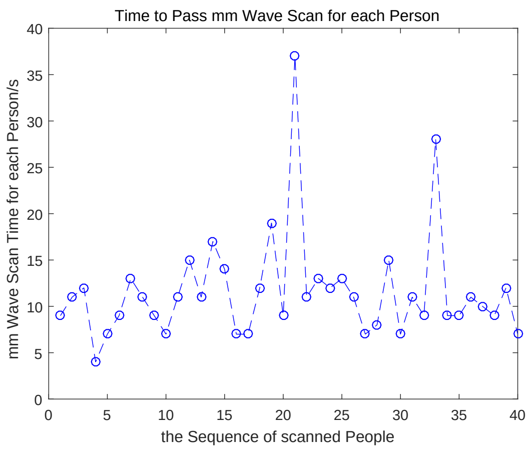

Fig 2: the time required for the millimeter wave scan to detect each person

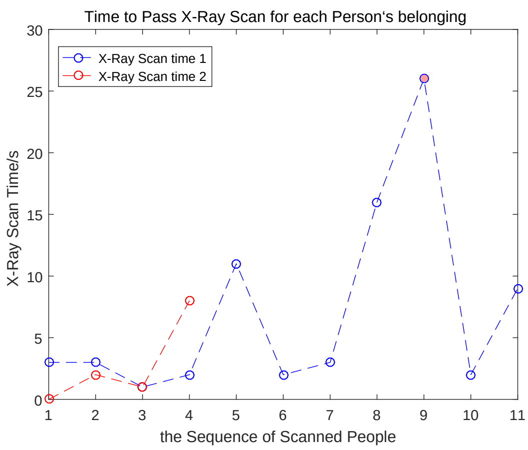

Fig 3: the time it takes for belongings to pass the X-Ray Scan

3.2 X-Ray Scan

The figure 3 show us the relationship between the sequence of Scanned people and the time it takes for their belongings to pass the X-Ray Scan. From the two sets of X-Ray scan time,we can do the following judgments: for the the security procedures of regular passengers, it is necessary to carry out security check of clothes,so it is impossible for the X-Ray check time to be zero,while it is possible for pre-check passengers.As we can see,there exits a point(0,0),in the X-Ray Scan time 2.It can be judged that curve 2 is the X-Ray inspection time statistics for the pre-check passengers,and the curve 1 is for the regular passengers.If we are concerned about the statistical characteristics of the data,the mean of two line is respectively Ax_1=7.0909 and Ax_2=2.7500,which is In line with our judgments.

3.3 Total Security Time

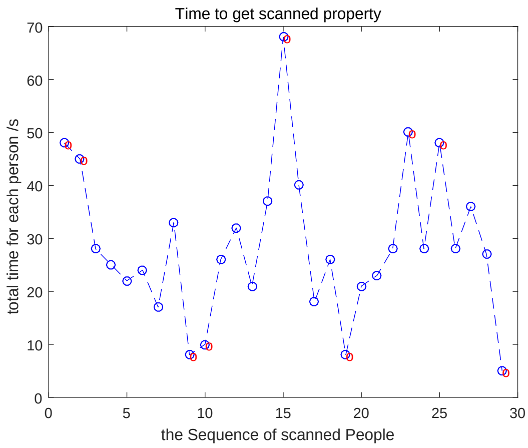

Fig 4: total security time

The data in the figure 4 correspond to the data in the H_2 column of the original table.As the second inspection time in the D area for the goods or people is random,and according to the preceding analysis,we deal with these data as follows: several sets of data withY_t¡15 are considered as samples for pre-passengers,and the portion of Y_t ¿41 is treated as a sample of ordinary passengers(the red circle marks the point in the figure above),these samples are called definite samples.The point with $Y_t \in [15,40]$, is called the uncertainty point,and reconstructed $\{(x_i,y_i), i = 0,1,2...20\}$.the mean of the new set is $A_t = \sum_{i=1}^{20} \frac{y(i)}{20} = 28$

Screening was performed with At as the decomposition and comes to the mean for regular passengers is$A_{t1} = 43.7$ and for Pre-check passengers is$A_{t2} = 20.68$.

3.4 Passengers Flow Analysis

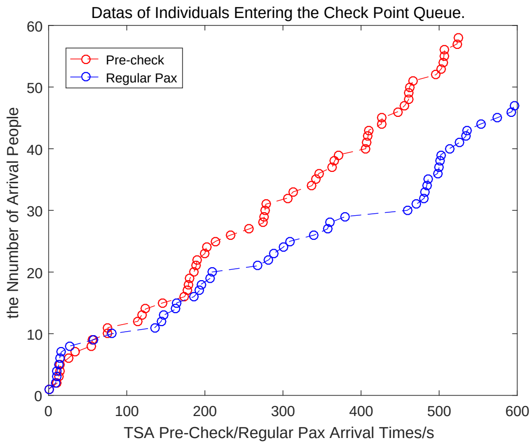

Fig 5: Passengers flow analysis

In the Figure 5, for pre-check passengers data,we can see that some of the distribution of points, not strictly in accordance with the uniform arrival time.If investigate the data as a whole,we can get an average of 1 minute with 6.6 people.When investigating the regular person's data,it can be observed that the data are clearly divided into four segments which are more concentrated.To separately study each section,we comes to four peak flow time:(17,7,4,7) persons / min.If the first observation area is extended, the two independent points (57, 9) and (81, 11) are classified as the first stage,and the average flow rate is 7 persons / min.

4 Petri Network Analysis

4.1 Petri Net Introduction

Petri net was first proposed by the German scientist Carl Adam Petri in his doctoral thesis in 1962,it can be used for system modeling and analysis.We can use Place, Transition, Token, and the arc as the main analysis tool to anylize the security process,show the process in a graphical format, and through the mathematical model of performance analysis, making the model with the basis of optimization.[3]

4.2 Model Construction and Reliability Verification

Petri net elements and security system elements corresponding relationship is as follows

Based on our analysis of the security process, the establishment of the model are shown below

Tab 2: Petri net elements and security system elements corresponding relationship

Petri net elements	security system elements
Place	specific location in Security process
Transition	Certain security process
Token	Passenger
M_0	Location that passenger enter the security system

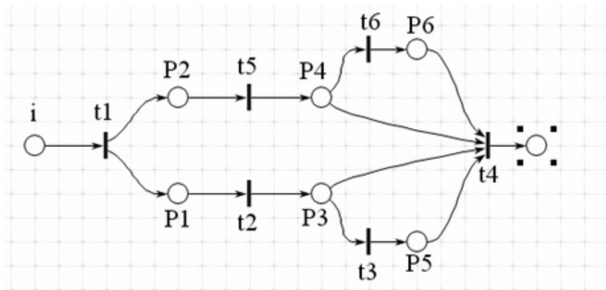

Fig 6: petri net model of security system

Tab 3: The meaning of each element in the model

Place	meaning	Transition	meaning
i	id check station	t_1	id check process
P_1	Conveyor belt	t_2	X-Ray Scan
P_2	begin Millimeter Wave Scan	t_3	additional search for flagged items
P_3	X-Ray screening end	t_4	Passengers depart
P_4	End Millimeter Wave Scan	t_5	Millimeter Wave Scan
P_5	end of additional search	t_6	pat-down inspection
P_6	End of pat-down inspection		
O	Security end		

After building a good model, we need to do reliability analysis of petri net model , and come to if it is reliable.[4]

Analysis:

- reachability:For any process in the model, it can be achieved by the initial Place
- boundedness and safety:In accordance with the security rules, only one passenger is active in the security systemso meet the rule: when M(P)¡K,k=1
- liveness:For each transition,there will be a transition associated with itToken won't fall in dead transition.

So we can comes to the conclusion that the model is reliable.

4.3 Performance Analysis and Conclusion

In the performance analysis, we take the following approach:

We use stochastic Petri net's reachability identification list to build isomorphic Markov chain,and based on the probability of stability of isomorphic Markov chain,we can do the performance analysis.[5]

The stochastic Petri net's reachability identification list is shown below.

Tab 4: Security model's reachability identification list

	i	P1	P2	P3	P4	P5	P6	O
M_0	1	0	0	0	0	0	0	0
M_1	0	1	1	0	0	0	0	0
M_2	0	1	0	0	1	0	0	0
M_3	0	0	1	1	0	0	0	0
M_4	0	1	0	0	0	0	1	0
M_5	0	0	1	0	0	1	0	0
M_6	0	0	0	1	1	0	0	0
M_7	0	0	0	1	0	0	1	0
M_8	0	0	0	0	1	1	0	0
M_9	0	0	0	0	0	1	1	0
M_10	0	0	0	0	0	0	0	1

Then we can come to the isomorphic Markov chain.[3]

The results are shown in the figure 7:

The vector $\lambda(\lambda_1,\lambda_2,...\lambda_6)$represent a set of average The incidence of transition per unit time,ti and λi are reciprocal.[6]

Because the Markov process satisfies the following linear equation[6]:

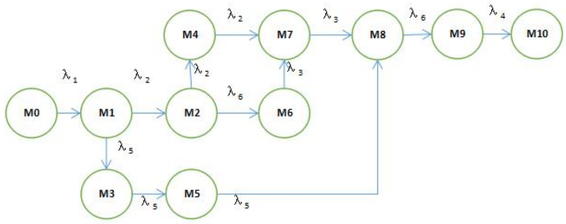

Fig 7: isomorphic Markov chain compared with petri net

$$\begin{cases} XQ = 0 \\ \sum_{i=1}^{n} x(i) = 1 \end{cases}$$

Q represent Transition rate matrix,with building the Q matrix from isomorphic Markov chain and the solving the liner equations,we can get the result in the Table 6[6].

Now we can come to the conclusion:

The number of token is biggest in the id-check and exit, and that there is indeed the problem, said security and waiting for the security check takes too much time. Token numbers of P2 P1 point is relatively large, but numbers in

Tab 5: The incidence of security process transition

incidence of transition	times/unit time
λ_1	4.7
λ_2	8.45
λ_3	5
λ_4	0.5
λ_5	5.77
λ_6	3

Tab 6: Average number of Token in the places and utilization rate of transitions

Place	Token	Transition	Utilization Rate
i	0.35620	t1	0.28780
P1	0.11980	T2	0.07945
P2	0.17500	T3	0.04510
P3	0.07840	T4	0.23600
P4	0.10815	T5	0.15290
P5	0.06535	T6	0.11660
P6	0.04934		
O	0.29440		

P2 is more, this reflects the main bottleneck within the system is the passengers' body security longer lead to the security system congestion. Millimeter Wave Scan takes a little long time, and the pat-down inspection's Utilization Rate is low but is inclined to make the system enter a state of low efficiency. When we focus on utilization rate, we can find that in addition to the id-check procedure and exit procedure, the highest utilization rate is the process of the personnel Millimeter Wave Scan and This information is in good agreement with the previously discussed security issue.

5 Improve the Model by Using Queuing Theory

5.1 Introduction of the Queuing Theory

Queuing theory is also called stochastic service system theory.It can find out the statistical law of some index like waiting time, queue length through the statistical study of the aimed object and their arrival time. Then according to these rules,the structure of the service system can be improved or those object which are served can be reorganized.These can make the service system not only meet the the needs of the serviced object, but also can save the agency cost or make some optimal index as perfect or effective as possible.There are three aspects in the research of queuing theory: statistical inference, the establishment of the model based on the data, the state of the system, which means the regularity of the number of indicators related to the queue. The purpose is to design the system correctly and operate the service system efficiently, also, to make the best benefit for the actual event.

5.2 Restatement of the Improving Problem

We are asked to develop two or more potential modifications to the current process to improve passenger throughput and reduce variance in wait time. Model these changes to demonstrate how your modifications impact the process.

We can use the queuing theory to build a model to find out the potential modifications to the current process through the data which is given in the subject.

5.3 Establish the Model Based on Queuing Theory

We can establish a queuing model for $M/M/s/FCFS/N/\infty$, which means both the customer arrival time and the serve time follow Poisson distribution and this security system has s inspection teams. The system capacity is limited but the source of the people isn't limited. We can make assumptions that each team work is independent, and every single table's working efficiency is equal.

We can get We can assume that the working efficiency of a single inspect team is μ,and the number of arrival people per minute is λ. We can infer that when the system reaches a steady state, the average number of people entering the system per unit time will be equal to those who leave. We use P_N to illustrate the probability of when there is no one in the system.These parameters have already listed in the previous table.

We assume those things above and use Little equation[2]:

$$L_s = \frac{\rho}{1-\rho} - \frac{(N+1)\rho^(N+1)}{1-\rho^(N+1)} \tag{1}$$

$$L_q = L_s - (1 - P_0) \tag{2}$$

$$\lambda_e = \mu(1 - P_0) \tag{3}$$

$$W_s = \frac{L_s}{\lambda_e} \tag{4}$$

$$W_q = \frac{L_q}{\lambda_e} \tag{5}$$

According to the formula above, as well as the previous analysis of the data, we can assume the arrival time of the customer follow the Poisson distribution.[2]

In the picture of the subject, we know that pre-check people and regular people are not only separated from the ID check channel, but also the baggage check ways. So we can be discussed them separately. The whole people can be divided into three group: pre-check people, regular people in peak period, regular people in low peak period. To solve the differential equations in our model, we use the analyzed data in MATLAB on the formula we already mentioned above to find the results in Table 7.

Tab 7: analyzed data

	number of arrival people/min(λ)	working efficiency/team(μ)
pre-check	7	2.9
regular	7(high peek)/4(low peak)	1.37

According to the above data, we can see that the average arrival rate of a single checkpoint is more than one, so it will be a model which can never be stable, to be more specific, there will always be people waiting in the line and if the coming source of people does not limit, the queue number will continue to increase. We calculated these three cases in the above sheet using the equations mentioned above. The calculated data is shown in the Table 8.

Tab 8: calculated data

	pre-check	regular of high peak	regular of low peak
L_s	0.695	1.49	1.6
L_q	1.971	0.525	0.684
W_s	0.345	1.12	1.26
W_q	0.979	0.395	0543
λ_e	2.014	1.33	1.26

A conclusion can be drawn from the above data: because only when three regular channels are open to the customers, a pre-check channel can be open. So we can see from the data above that pre-check people using longer time than regular people waiting in line, and the processing efficiency is also less than those regular people. However, the processing time of pre-check people and the stay time is shorter than that of regular people. So the next step we try to increase the number of pre-check channels so that the system can handle more people each time, and then analyze the data to see how it will change.

To demonstrate better the change in flow rate with the capacity of the system, when the number of the pre-check channels increase, we plot over a shorter range of rate in five Figures from 8 to 12.

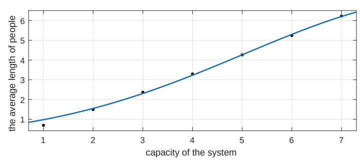

Fig 8: avenge length of the serve line

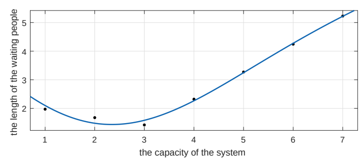

Fig 9: avenge length of the waiting line

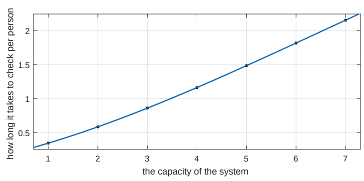

Fig 10: the time spend in the system

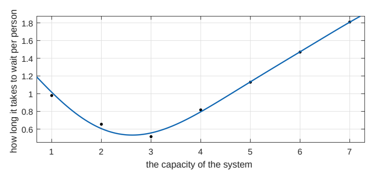

Fig 11: the time spend in the waiting line

It can be safely concluded that with increasing number of channels in the system, each processing number increases linearly, but the length of the waiting queue is decreased and then increased. And at the corresponding time, the processing time has a linear growth,which means more people can get the service in the system per unit time. And the waiting time is decreased first and then increased, that is the same flow as the length of the waiting queue. The overall efficiency is gradually increase slowly and finally tend to be stable. It can be observed that there is a best way we can choose, that is, when we have three of the pre-check channel open, we can achieve high efficiency and the waiting time can reach the lowest value at this time.

Therefore, the fine adjustment of the number of security checkpoints and the functional distribution of each security port can help to eliminate bottlenecks in the security process, which can laso improve security process performance and efficiency.Of course, this is the ideal situation, but does not necessarily meet the truth of an actual Airport. In the design of the system, other factors should also be welled considered, such as the size of the airport, the design speed of conveyor, the price of the equipment and so on. And we finally want to achieve the goal which is the system can achieve maximum economic benefits in operation.

6 Task Solution Establishing

6.1 Task A : Based on the Idea of Feedback Regulation in Automatic Control Theory, the PID Algorithm Model is Established

6.1.1 Introduction of Closed Loop Feedback Regulation

Feedback control system is an automatic control system based on feedback principle. The so-called feedback principle is based on the output of the system to change the information to control, that is, by comparing the system behavior (output) and the expected behavior of the deviation, and eliminate bias to achieve the desired system performance. In the feedback control system, there is not only the signal forward path from input to output, but also the signal feedback path from the output to the input. Therefore, the feedback control system is also called closed loop control system. Feedback control is the main form of automatic control. In engineering often to run the output and the expected value of consistent feedback control system called automatic control system, the feedback control system to accurately reproduce or follow a process known as servo system and servo system.The elements of feedback theory include three parts: measurement, comparison and implementation.The key of the measurement is the actual value of the controlled variable, which is compared with the expected

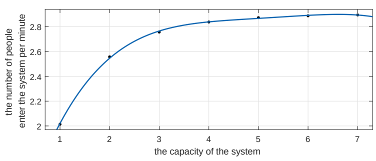

Fig 12: effective arrival rate

value and use this deviation to correct the system response and perform the regulation control.In engineering practice, the most widely used regulator control law is proportional, integral, differential control, referred to as PID control, also known as PID regulation[8].

PID algorithm is one of the most widely used algorithms in closed loop feedback control, which can be divided into three parts: PID controller is composed of I, P and D. The relationship between its input e (T) and output U (T) is:

u(t)=kp[e(t)+1/TI∫e(t)dt+TD*de(t)/dt][9]

The upper and lower limits of the integral are 0 and T, so the transfer function is G (s) =U (s) /E (s) =kp[1+1/ (TI*s) +TD*s][9] where KP is the proportional coefficient; TI is the integral time constant; the differential time constant.

The PID control is based on proportional control; the integral control can eliminate the steady-state error, but it may increase overshoot. Differential control can speed up the response speed of large inertial system and reduce the overshoot.The key to this theory and application is to make a correct measurement and comparison of how to better correct the system.

6.1.2 Task Restatement

Develop one or more models that allow you to explore the flow of passengers through security checkpoints and identify bottlenecks. Identify the problem areas in the current process.

This group will be possible to the problem area is divided into four parts: A (document check), B (baggage and screening), C (collect items and exit) and D zone(additional screening).

6.1.3 Task Analysis and Results

A zone:

It can be seen from the figure given by the test, Pre-check channel and Regular channel are separated, a group of people that did not apply for Pre-Check services, then they can only go Regular channel, Pre-check channel is idle waste, wasted by efficiency. Or only a small number of people take the Pre-check channel, but in accordance with the provisions of each three Regular channel has a Pre-check channel, then it will reduce the channel usage.

B zone:

As shown by the test, the belt is stopped or can use a period of time, assuming the number of transmission belt, microwave scanner opens is certain that, if less was a waste of costs, so many people will cause congestion, delay.

C zone:

just export, so do not have to C area analysis

D zone:

D itself is not a big problem, but it is necessary for us to analyze the process of passengers checked and transferred to the D region, assuming one of the passengers suspected in security have prohibited items, and then click to accept the check, this process will no doubt cause delay of normal security checks.

The above brief analysis, the existing model of passengers as an open-loop control model through security (open-loop control is applied to a simple system, it has no feedback, the response time is long, low cost), flow chart:

Structure of open loop control system

Input: passenger flow input

Output: passenger flow output

This model is the output without any restriction on the amount of input, when the flow of people or big or small, the overall operation of the security system is not stable, which is prone to channel the unreasonable distribution, flow uneven density and waste of airport resource costs and other issues, but the safety hidden trouble. Therefore, the specific bottleneck for the following:

- Pre-Check channel and Regular channel settings unreasonable.
- Various types of scanning equipment to detect the density of people is not flexible enough.
- The uncertainty will greatly delay the normal flow of traffic.
- Do not set up the appropriate channel for special populations.

Overall, the team analyzed the existing security system put forward constructive problems, aiming at these problems, we will be using the stability regulation of various models to improve the system feedback, and the model of flow PID algorithm to verify the optimized system flexibility and superiority, the final is to ensure the safety standard of security at the same time, improve the system throughput of passengers.

6.2 Task B : Based on the PID Model, the Solution to the Existing Problems is Put Forward

A zone: in order for the A area of the channel is fully utilized, we need to monitor the flow of people from the Pre-Check and Regular channels, but also to cancel the two channels of their ID Check, ID Check Point and then take the same measure, according to the flow of people to their own dynamic distribution channels, and each channel is three Regular the rigid form only a Pre-Check channel that, in view of this situation the establishment of PI model. As to how to detect the flow of people we will give specific measures in the following figure.

Based on the idea of PI algorithm, we considered all the channels for the same channel, set up by the total Pre-Check traffic to W_p, the total Regular flow rate is W_r and the expected flow of people is a constant β, Wp and W_r respectively with A PI operation.

PI formula:

$$u(t)=kp[e(t)+1/TI\int e(t)dt][9]$$

where KP is the proportional coefficient; TI is the integral time constant;

The output is Q_p andQ_r, and then the output value of the corresponding time to determine the corresponding number of channels.

The results are as follows:

- when the flow of Pre-Check and Regular of the large flow of people hours, open Pre-Check channel more than Regular of the channel, the specific number of results based on the PI operation.
- when the flow of Pre-Check is small and the flow of Regular large, open Pre-Check channel less than Regular of the channel, the specific number of results based on the PI operation.
- when the Pre-Check and Regular flow are relatively small, reducing the opening of the two channels, according to the specific number of Qp and Qr ratio.
- when the Pre-Check and Regular traffic are larger, increase the opening of the two channels, the specific number of Qp and Qr depending on the proportion.
- when the Pre-Check or Regular traffic are very large, beyond the existing channels to meet the amount, then you need to expand the infrastructure.

After optimization, as shown in figure 13:

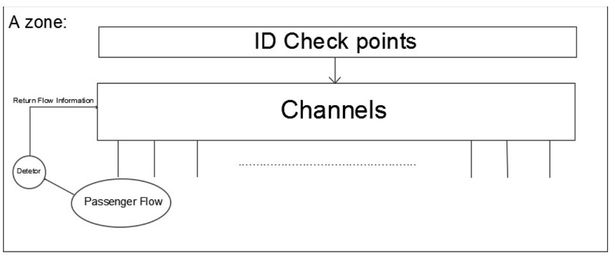

Fig 13: A zone:after get improvement

B zone: there is a close relationship between population density and equipment layout, similar to the A problem, our optimization goal is to keep the object flow stable, reasonable arrangements for the opening time of the scanner, alleviate the uneven queuing situation. Assuming that the number of devices to open a certain amount, then the flow of goods or large or hour queuing delay or waste of costs, so we build the PID model considering the most complex part of the security process. The amount of logistics can be calculated and calculated by the scanner on the conveyor belt.

PID formula:

u(t)=kp[e(t)+1/TI∫e(t)dt+TD*de(t)/dt][9]

where KP is the proportional coefficient; TI is the integral time constant; the differential time constant.

Set flow rate is $Real_f$, the expected value of Set_f, $Real_f$ and Set_f into the PID algorithm, the results as a measure of the number and time to open the device, you can get the following analysis:

- when the flow of goods is small, reduce the time to open the device
- when the flow of goods is large, increase the time to open the device
- when the flow is very large, it is necessary to control the stability range, the need to expand the number of equipment

After optimization, as shown in figure:

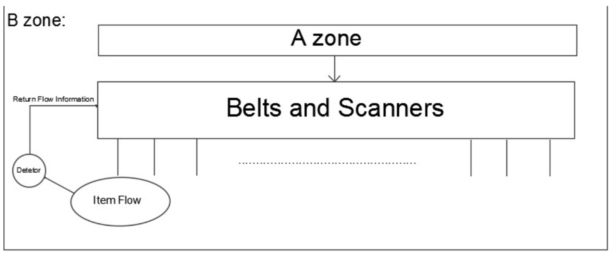

Fig 14: B zone:after get improvement

D zone: before Task A has shown that D itself is not a problem, then we'll return to the A and B regions, the establishment of PD model, this model has forecast adjustment function, can lead to the regulation effect on the flow of people, so as to maintain the stability of the system to a certain extent.

PD formula:

u(t)=kp[e(t)+TD*de(t)/dt][9]

where KP is the proportional coefficient; the differential time constant.

Adjustment measures with the above two ways to combine, to act as a supporting role, to reduce the impact of a check.

As shown in figure:

6.3 Task C : Specificity Analysis: Probability Estimation Using Markov Chain Model for Specific Populations

6.3.1 Introduction of Markov Chain

Markov model (Hidden Markov Model, HMM) is a statistical model, which is used to describe the process of a hidden unknown parameter of the Markov process. The difficulty is to determine the parameters of the process from the observable parameters. These parameters are then used for further analysis, such as pattern recognition. In a normal Markov model, the state is directly visible to the observer. The transition probabilities of such states are all parameters. In the hidden Markov model, the state is not directly visible, but some variables affected by the state are visible. Each state has a probability distribution over the possible output symbol. Therefore, the sequence of output symbols can reveal some information about the state sequence[7].

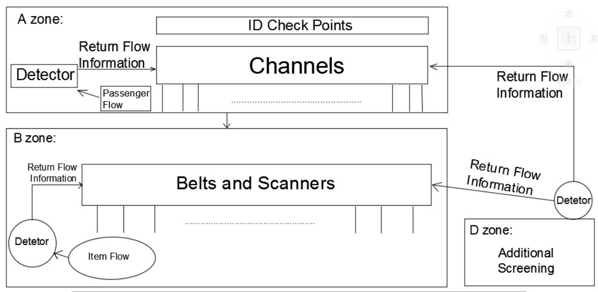

Fig 15: D zone:after get improvement

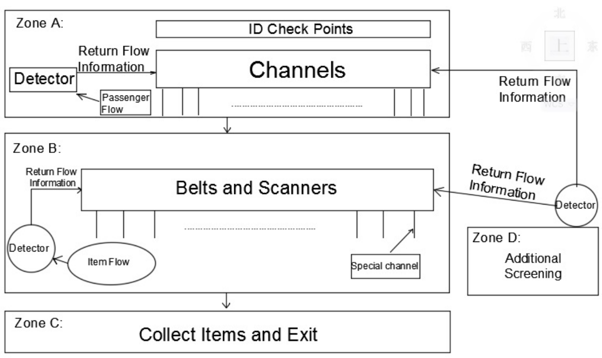

Fig 16: Final optimized figure

6.3.2 Final Optimized Figure Shown in Fig 16

6.4 Task D : Additional Recommendations Based on PID Model

According to the ABC results, the team believes in the airport security system using closed-loop feedback regulation strategy only for the system itself of the passenger flow and dynamic regulation of logistics volume, and it is clear that a person's behavior of the system is indispensable part of the specific measures for the system itself at runtime. Security personnel with the system to mobilize and transfer, for example, some open channel, the security personnel should be configured, similarly, open some testing equipment, correspondingly will also increase security personnel, as a result, people and systems cooperate with each other, can greatly shorten the total time of passengers through security, greatly improve work the system efficiency and flexibility, so as to improve passenger throughput.

Another suggestion is that the airport should be expanded, and increase the detection equipment, there is no doubt that this measure will increase the cost of the airport, but based on closed-loop feedback control principle, the PID algorithm can inhibit costs and increase passenger throughput.

7 Strengths and Weaknesses

Strengths:

- The use of feedback regulation model is a very innovative interdisciplinary approach.
- On the basis of the feedback regulation model, the open loop system is improved into a closed loop system, which greatly improves the stability and flexibility of the system, so as to improve the efficiency of the system.

Weaknesses:

- For the flow of people and traffic detection is not accurate enough.
- The limited number of channels and equipment security system would affect the sensitivity of the regulation.
- .Measures for special populations need to be improved.

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