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# Research on High-speed Railway Station Ticketing System Based on Queuing Theory

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## Abstract

**In order to solve the problem of rational utilization of railway station resources, performance index and model of Railway Station Ticketing and queuing system are analyzed by using queuing model theory. It is found that there are some problems in Railway Station Ticketing system, such as unreasonable number of ticket machines and inconvenient placement of ticket machines at different times. By comparing the simulation results of MATLAB and the actual data of Nanchang West Railway Station, it is concluded that the ticketing system is suitable for that kind of model, and some suggestions for improving the automatic ticketing system are given to make the best service effect of the system and maximize the utilization of resources.**

## Keywords

**Ticketing system,queuing theory,MATLAB,operations research.**

## 1. Introduction

People in daily life will often encounter queues, such as to the store to buy queue check-out, car in the gas station refueling, even students out of the classroom to queue. The reason for queuing is roughly composed of three aspects, one is too large traffic, the other is the number of service desks is too small, and the third is because the overall service efficiency of the system is too low, so there is a queue phenomenon.

From the perspective of mathematical probability theory, the analysis of why there will be queuing, mainly the time when the customer arrives is random, belongs to the Poisson distribution model. The service desk for customer service time is also uncertain, the combination of various reasons will produce queuing phenomenon. So what are the measures to reduce the queue? If you add the number of service equipment, you will have to increase the cost of investment or too many will be wasted; if the number of service equipment is too small, the queue will be very serious, the big aspects of the small aspects of society will be a waste of time for individuals.

## 2. Characteristic Model and Solution of High Speed Railway Station Queuing System

### 2.1. Queuing System Classification

There are many branches of operations, one of which is called queuing theory. Queuing theory also has other calls, such as some people call it a random service system theory, some people call it waiting for linear theory, is a special study of queuing law of a science. In the early 20th century, a Danish scientist named Erlang came up with the theory of queuing when he studied the problem of wire telephone call busylines.

Queuing systems can be broadly divided into three broad categories, not the queuing loss system, the queuing system and the queuing hybrid system.

(1) Loss system: When the customer arrives at this service system, every service desk in the service system is serving other customers, there is no idle service desk, at which time the customer will leave the service system and cause the loss of this customer.

(2) Queue waiting system; the core of this mechanism is a first-served, then-service-by-arrival order.

(3) Queuing hybrid system; there are both queuing loss systems and queuing waiting systems in a queuing system.

## 2.2. Queuing Model and Solution

D.G.Kendal In 1953, a classification method was proposed for the queuing model, which is indicated by a certain symbol, based on the characteristics of the queuing service system: the distribution of the customer's time of arrival, the distribution of service time and the number of service desks. Named Kendall mark the specific representation is:

X/Y/Z

Where: X indicates the distribution of customer arrival interval; Y represents the distribution of service time; Z represents the number of service desks.

A service system consists of customers and service agencies. For customers, of course, do not want to queue, but hope to be able to easily get service at any time. Service system want stoic to meet customer needs, in general can increase the number of service desks in the system, which will inevitably increase the burden of the service system, the use of service machines less efficient, human and material costs correspondingly increased, resulting in unnecessary waste. From the service agencies, it is hoped that the service equipment provided is the most efficient, so that each desk does not appear idle, which will inevitably lead to customer queues, affecting the interests of customers.

The application of queuing theory in the passenger ticketing system: Queuing theory in the passenger ticketing system is usually in parallel arrangement of multiple ticketing services, each passenger can be selected after the arrival of the existing queue after any queue, so on the whole, the last captain is basically equal, A change in the length of a queue can reflect changes in the overall queue. So for the sake of analyzing problems and statistics, we're here to count and analyze the queues for a queue.

# 3. Data statistics Calculation and MATLAB Simulation

According to the available statistics, customer service time is related to whether the holidays, weekends and train departure time schedule, for Nanchang West Station, we investigated the holiday and peace time of the two time periods of Nanchang West Station system operation status, that is, 8:30 a.m. to 9:30 a.m., respectively, representing the general situation and the busiest time, respectively, As in Table 1, Table 2.

**Table 1.** Nanchang West Station Holidays 8:30-9:30 Service Time Frequency Distribution Table

| Service time(min) | 1 | 2 | 3 |
|---|---|---|---|
| frequency of occurences | 44 | 13 | 1 |

Source: spss software

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**Table 2.** Nanchang West Station Holidays 8:30-9:30 Service Time Frequency Distribution Table

| Service time(min) | 1 | 2 | 3 |
|---|---|---|---|
| frequency of occurences | 48 | 5 | 0 |

Source: spss software

From the data in Table 1, we can conclude that the average service time per automatic ticket pick-up during the holidays is 1 / s 73/58 s 1.26 (min/person); From the data in Table 2, we can conclude that the average service time per automatic ticket pick-up on a normal day is 1 / s 58/53 s 1.09 (min/person);

**Table 3.** Nanchang West Station Holiday 8:30-9:30 Frequency Distribution Table

| | Waiting time | service time | interval time |
|---|---|---|---|
| Number of cases | 58 | 58 | 58 |
| average | .78 | 1.26 | .90 |
| median | 1.00 | 1.00 | 1.00 |
| mode | 0 | 1 | 1 |
| minimum value | 0 | 1 | 0 |
| max value | 3 | 3 | 4 |
| total | 45 | 73 | 52 |
| Percentile 25 | .00 | 1.00 | .00 |
| Percentile 50 | 1.00 | 1.00 | 1.00 |
| Percentile 75 | 1.00 | 1.25 | 1.00 |

Source: spss software

**Table 4.** Nanchang West Station 8:30-9:30 Frequency Distribution Table

| | Waiting time | service time | interval time |
|---|---|---|---|
| Number of cases | 53 | 53 | 53 |
| average | 1.62 | 1.08 | 1.15 |
| median | 2.00 | 1.00 | 1.00 |
| mode | 0 | 1 | 1 |
| minimum value | 0 | 1 | 0 |
| max value | 4 | 2 | 4 |
| total | 86 | 57 | 60 |
| Percentile 25 | .00 | 1.00 | .00 |
| Percentile 50 | 2.00 | 1.00 | 1.00 |
| Percentile 75 | 3.00 | 1.00 | 2.00 |

Source: spss software

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From Tables 3 and 4 we can see that the average service time between holidays and normal days is not much different, but the average wait time difference is quite large. The following is the operation of different models using MATLAB simulation.

Mode one M/M/1/∞/∞mode (λ=0.88, μ=0.91)

```
function x=f1(lambda,mu,s)
ro=lambda/mu;
end
p0=1-ro;
p=1-p0;
Lq=ro*lambda/(mu-lambda);
L=Lq/ro;
W=Lq/(lambda*ro);
Wq=Lq/lambda;
x(1)=p0;x(2)=p;x(3)=Lq;x(4)=L;x(5)=W;x(6)=Wq;
End
```

**Table 5.** Results of single service desk quantity indicator calculation

| norm | Idle chance p0 | Waiting chance p | Average Waiting Captain Lq | queue length L | Average Staying time W(min) | Average waiting time Wq(min) |
|---|---|---|---|---|---|---|
| S=1 | 0.3481 | 0.3152 | 0.2951 | 1.2621 | 1.4342 | 0.3353 |

Source: matlab

Mode two M/M/S/∞/∞mode (λ=0.88, μ=0.91)

```
Function x=f1 (lambda,mu,s)
ro= lambda/mu;ros=ro/s;
sum1=0; for i=0: s-1
sum1=sum1+ro. ^i/factorial (i);
End
sum2=ro. ^s/factorial(s)/ (1-ros);

p0=1/ (sum1+sum2);
p=ro. ^s.* p0/factorial(s)/ (1-ros);
Lq=p.*ros/ (1-ros);
L=Lq+ro;
W=L/lambda;
Wq=Lq/lambda;
x(1)=p0;x(2)=p;x(3)=Lq;x(4)=L;x(5)=W;x(6)=Wq;
End
```

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**Table 6.** Results of single service desk quantity indicator calculation

| norm | Idle chance p0 | Waiting chance p | Average Waiting Captain Lq | queue length L | Average Staying time W(min) | Average waiting time Wq(min) |
|---|---|---|---|---|---|---|
| S=1 | 0.3492 | 0.3162 | 0.2964 | 1.2635 | 1.4358 | 0.3365 |

Source: matlab

From Table 5, we can see that the automatic ticketing system in the case of S-1, the two models run results basically no difference, indicating that the program has a certain degree of correctness, indicating that the single service desk indicator calculation results have a certain degree of credibility. Combined with Table 3, we can conclude that the single service desk queuing model cannot be applied to the high-speed rail station ticketing system, because the average waitime time calculated under the M/M/M/1/s/s/model is 0.3353min, and the average wait time calculated by the M/M/S/S/T model is 0.3365min and the actual measured waiting time of 0.78min (holiday) and 1.68 (holiday) data is too large.

## 4. System Analysis and Optimization

### 4.1. System Operation Analysis

The main factors affecting the queue are the time between the arrival of customers, the service efficiency of the service desk and the number of open service desks. The former factor is random, and the latter two factors can be artificially controlled. Therefore, it is difficult to predict the number of customer arrivals over a period of time. Only through a large amount of data collection, the analysis of data to the unit time customer arrival of the number and average service time of the two random variables for spss data fitting.

In this system, the holiday Nanchang West Station has a total of 8 plus 8 plus 8 x 24 automatic ticket ingress and 2 temporary population ticketing windows, which can save the passengers to a certain extent, a total of three places, reducing the time of different passengers walking. However, when the average wait time exceeds 2min, the system efficiency is considered inefficient, and the average wait time is less than 2min, the system is considered idle. The usual time is only 8 plus 8 x 16 automatic ticket machines, although the number of passengers decreased, but the number of automatic ticket collection machines reduced more resulting in the service quality on weekdays is not as good as holidays, so the high-speed railway station ticketing system has different times high-speed rail station ticket machine opening number is unreasonable and ticket machine placement is not convenient and so on.

### 4.2. System Optimization Measures

Through the above analysis, in the 8:30 to 9:30 time interval, holidays have idle image, waste some human and material resources, but in the ordinary days of resources are not fully utilized. In reality, it is difficult to reasonably keep the waiting time within (1 - s, 1 , plus) ( a very small number). In order to improve the efficiency of the system, the following recommendations are made:

1) The ticketing system should be flexible in adjusting the number of vending machines according to different times. For example, the number of holidays open to more, weekday can be appropriately reduced. And the opening time is accurate to the daily hours, the daily afternoon passengers are certainly less than in the morning, and the evening passengers than the afternoon less, can be reasonably open according to the time of the number of machines.

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2) Improve the environment where ticket-picking machines are placed, where the three ticket machines are placed in a place to be subject to high winds, where staff can put something to keep the wind out.

3) Several automatic ticket-picking machines can be mobilized to the West Station subway exit, which can greatly save the time of passengers who come to the West Station by subway, because these passengers can no longer have to go to the ground to collect tickets. In fact, many large high-speed rail stations outside take this form, such as the Shanghai Hongqiao high-speed railway station.

4) Improve the level of work of automatic ticket-picking machines, adopt high-tech achievements, speed up the speed of ticketing. It can reduce the service time of passengers, but also reduce the waiting time of passengers in line, thus greatly improving the service level of the system.

5) With the development of information technology, it is hoped that the ticketing system can also be modelled on the bus to launch electronic tickets, so that passengers can not pick up tickets, with electronic tickets to check the station. This is also in line with the development of the information age.

## 5. Epilogue

From the above analysis, we can conclude that: Nanchang West passenger station automatic ticketing system overall service effect is still good, the average waiting time for passengers is not long, but there are many areas for improvement. In order to improve the service levelof high-speed railway stations, railway stations should not only focus on the waiting time of customers, but also consider how to improve the service level. Combined with the behavior characteristics of the customers of high-speed railway stations and the spatial layout of high-speed railway stations, a scientific, uman-friendly and efficient high-speed rail ticketing system is established.

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