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Procedia - Social and Behavioral Sciences 96 (2013) 1322 – 1328
Procedia Social and Behavioral Sciences

13th COTA International Conference of Transportation Professionals (CICTP 2013)

The Optimize Management of Passenger Organization in Transfer Station Based on Dynamic Passenger Flow Analysis

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Abstract

How to better organize the passenger operation of transfer stations has become one of the significant challenges in recent years. Based on detailed analysis of historical passenger flow in transfer stations, this paper presents an algorithm for dynamic correction of this data using actual number of people entering and exiting the station and actual passenger volume travelling in the main channel. The main objective is to get refined data like enter and exit quantity of station, number of transfers between lines and number of transfers to each line. Passenger organization of transfer station could then be optimized according to the results obtained from this analysis. At last, Shanghai People Square Station is used as a case study to illustrate the reliability of this algorithm and find out reasonable improvements on passenger organization in this station.

Keywords: Urban Transit, Transfer Station, Dynamic Passenger Flow Analysis, Passenger Organization Management;

1. Introduction

Urban railway transit station, especially large transfer hub, undertakes plenty of internal rail technical operation of rail transport enterprise, such as the arrival and departure, passing and turn-back of train. It's also the place where passengers buy tickets, receive ticket checking, board and alight as well as transfer trains. Thus these stations become not only important nodes of urban rail transit, but also key areas of a city. Meanwhile, safe and orderly passenger operation in the station involves more than a primary part of rail transit operation management, it is now a serious issue that affects regional safety and smoothness within the city.

However, as urban rail transit networks expand in size, the growing number of track lines and passenger flow of stations increase such pressure that passenger volume of some main transfer hubs has reached close to their capacity during rush hours. This will bring potential security hazard in case of emergency, which influences the

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doi:10.1016/j.sbspro.2013.08.150

operating security of stations all the time. For this reason, how to better organize the passenger transport of urban railway transit station has become the most significant challenge. Since most previous passenger operation was handled by experienced station staff, organization quality largely depends on how the operators treat it, which means that the passenger operation of station has uncertainty. So it's very important to optimize the passenger operation of station in theoretical level. Current researches about this operation management are mostly based on static passenger flow both at home and abroad, and they at one point or another suffer from lack of flexibility.

Therefore, based on route clearing tables and passenger flow OD data of historical characteristic day derived by metro operation company, an algorithm is presented to realize the dynamic analysis of passenger flow in transfer station, according to which operation management(passenger organization) of transfer station could be optimized. The first step of the algorithm is to obtain the refined data of transfer stations in application of calculation program concerning passenger flow distribution using passenger flow OD data of days with the same Characteristic, then operate two data correction to fit the actual data, finally carry out some discussion and analysis about passenger operation of transfer station with these data, providing support for station organizers.

2. Passenger Flow Analysis of Transfer Station

The detailed historical passenger flow data in transfer stations could be computed with a calculation program developed by our research team named Passenger Flow Distribution Calculation Program. Input conditions of this program are the whole network OD passenger flow data of a day, and current routes clearing table provided by metro operation company. Output result is the transfer station detailed passenger flow data of the day.

By comparing historical passenger flow data of several major transfer stations in metro system, we could find that passenger quantity within a week shows a strong regularity. Among these, passenger quantity of Monday morning counts obviously higher than others, while evening peak of Friday lasts longer than other days. And passenger flow characteristics of working days are totally different from that of Saturday and Sunday. In order to make the data more convincing, an average of historical passenger flow data of the station in same characteristic day is used as the basic passenger flow data.

Because of the influence of network structure, weather environment and other factors, the actual passenger flow of transfer station differs from historical one. Thus we have to adjust the historical passenger flow data to obtain a more accurate dataset than the actual one. Here we propose two passenger flow data correction method to do this work. The first is to adjust the total amount of the historical data using enter and exit quantity of station within a period of time. That is to say, a decrease or increase coefficient is able to be calculated after comparing these data with actual data. The second is to adjust the proportion of historical passenger flow data in each portion (enter and exit quantity of station, different direction transfer quantity, etc.), depending on passenger quantity in key channels collected by thermal probe, video and so on. From this way we could get a proportion adjustment coefficient after comparing these key channels data. It is feasible to achieve the purpose of dynamic passenger flow prediction through historical passenger flow modification with the two adjustment coefficients.

However, as the actual passenger flow data of getting in and out of station and travelling through key channels cannot be obtained immediately until after a certain period of time, we present a dynamic passenger flow analysis algorithm. First, 5 min and 30 min historical passenger flow data of a station at a time point are got from the database, then it could figure out a decrease or increase coefficient after comparing with 5 min actual passenger flow data collected by AFC (Auto Fare Collection), and also a proportion adjustment coefficient by comparing with the data collected by thermal probe, video and so on. Second, 30 min historical passenger flow data of a station is revised into approximate real 30 min passenger flow data of the station with these two adjustment coefficients. And then dynamic analysis of all-day passenger flow can be done by this algorithm. Below is algorithm flow chart.

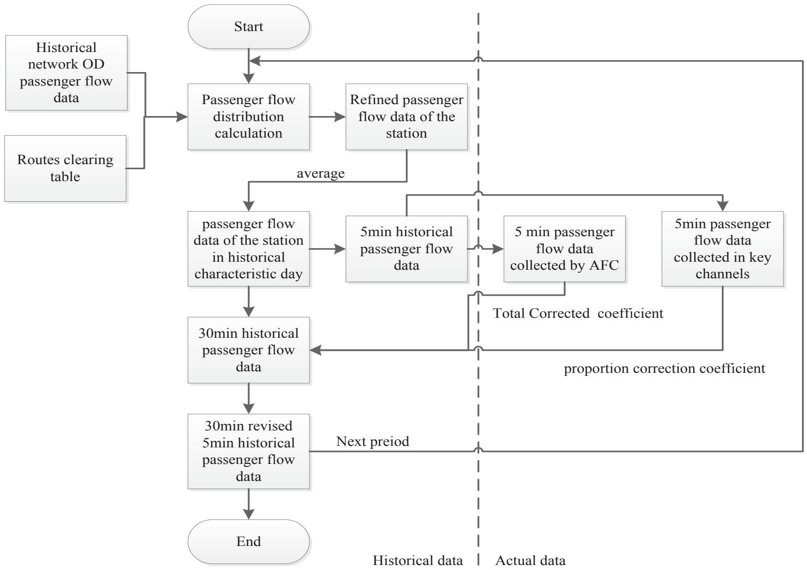


Fig. 1. Algorithm Flow Chart

3. Passenger Operation in Transfer Station

Rational layout of the station (station hall and platform), together with effective use of facilities and equipment (ticket system、access gate、escalator、staircase etc.), is foundation and prerequisite to a well operated station. Again, much uncertain factors constrain that work since traffic organization quality largely rests with the proficiency of station staff. Thus a further analysis on passenger flow trend of transfer hub in specific period exerts a good supporting effect on organizing work.

All-day volume on entrance and exit can be acquired from the analysis results of traffic flow in transit hubs, according to which operators are able to set number of gates that should be selectively opened. When the station enter flow is much greater than exit amount, these gates can be set to most of entry gates and a small part of exit gates. Station staff can take security check selectively at traffic peak time to speed up as passengers get into the station. Conversely, part of entry gates need to be switched to exit ones if there's more out-of-station traffic. Meanwhile, the station should open additional channel of ticket collecting by manual work for passengers with single ticket when it's necessary to evacuate the stream as soon as possible. Furthermore, marked guardrail and guide signs are also needed when station workers design passenger flow lines that enter and exit the station in the light of traffic volume, using PDP and LED screens in the station as a supplement. Of course, streamline of pedestrian must be simple and clear in order to reduce traffic crossing as well as convection.

The primary purpose of passenger flow analysis is to obtain the amount of transfer passengers between lines of the station within a day, through which we are able to roughly draw a streamline of passengers at the station, and then get the main traffic direction in a period of time, so that station staff can set passenger guidance signs in advance, arrange the direction of stairs, escalators, and channels, removable impediments(guardrail), conduct passengers to transfer in order and evacuate rapidly. These actions will help to avoid cross interference or overcrowding among traffic lines, disorder as well as unnecessary accidents. When there is a distinct directional flow among transferring passengers, station staff are supposed to set clear guide signs, separate path of travellers in this direction with guardrail. In the meantime, priority should be given to adjust the direction of escalator in the transfer path, facilitating passengers to evacuate. This phenomenon is not uncommon in some transfer stations with remarkably tidal characteristic, which is to say, passengers leave their home to work in early peak and return home after work in late peak. In such a case, evacuation of interchange passenger flow should be organized in a flexible way, for instance, by expanding guardrail in the morning rush hours with escalator set towards the direction of larger transfer flow and travel corridor pressed to smaller side, keeping other passenger work simultaneously well operated. On the contrary, station staff should contract guardrail, turn escalator to the opposite side to make full preparation for passengers in reverse in evening peak.

It is the volume we need to obtain, in exceptional circumstances like delay, large flow or some other cases, from the analysis results of traffic flow in transit hubs that how many passengers interchange into or out of stations. When a train is delayed, passengers backlogged on the platform suffer growing security risk, the station organizer can figure out where the sequential enter flow comes from by checking the influx of traffic on that line to take appropriate measures, such as set serpentine channel to extend the arrival time of passengers, deploy work force to evacuate travellers that transfer to the platform and so on. If there is a prolonged train delay, passengers on the platform have been so severely backlogged that large scale passenger flow situation occurs, at this moment station staff should report to dispatcher to enforce passenger operation control, like seal the station without allowed enter volume, jump trains without stopping on adjacent line, operate reserved vehicles etc.

From the above, understanding the general trends of passenger flow in transfer stations is of great benefit for station operators to decide the proportion of entry and exit gates, change the direction of escalators, staircases, and also set clear guide signs. In addition, station organizer is able to arrange or assign workers on the basis of traffic trend in different period of time, engage in commercial development and other work of subway station. Thus analysis of passenger flow plays an excellent supporting role in passenger organization of transfer hubs.

4. Case Analysis

At the part, People Square Station of Shanghai Metro is set as an analysis case to illustrate the algorithm and method mentioned above. Shanghai rail transit network now is “cross with ring” based frame. Shanghai People Square Station locates in the middle of the city, and is converged by three lines, Line 1, Line 2 and Line 8, which makes it a central point of Shanghai rail transit. Because of its large passenger flow and its heavy operation, the station is of great significance. In addition, People Square Station is a transfer station, passengers from Line 1 could reach Line 8 platform easily within just a few minutes. But passengers who transfer to Line 1 and Line 8 from Line 2 have to pass through the “Huge Triangle” transfer hall, the long travel distance makes it more inconvenient for passengers in transfer.

This case employs 2012-06-11, Monday as an example to calculate the whole passenger flow of People Square Station. And in order to make the result more accurate and authentic, the OD data adopts those passenger flow volume data of Monday in November, 2011 and March, 2012, while eliminates those abnormal data of the day when metro trains delay 20 minutes or more. That is to say, 20111114、20111128、20120305、20120312、20120319、20120326, these six days data is selected to carry on the calculation based on the program mentioned above. As a result of the program calculation, we could achieve all kinds of passengers flow data of People Square Station in those six days. Furthermore, we take the average value of the six days’ data as the station data of characteristic Monday. The delicate data mentioned below, such as passenger enter and exit quantity of station and transfer quantity, is revised by the algorithm to realize the dynamic prediction. As is shown in figure 2, the total amount of historical passenger flow of People Square Station reaches more than 560 thousand person-time, among which there are 240,000 people who enter or exit the station and 230,000 ones that transfer in the station. We could also find the general trend across one day in People Square Station, its early peak occurs in 07:00~09:00, when passenger flow volume accounts relatively more than other period of time but dissipates rapidly. While late peak occurs in 17:00~19:00, when the volume is not large but shows a long duration.

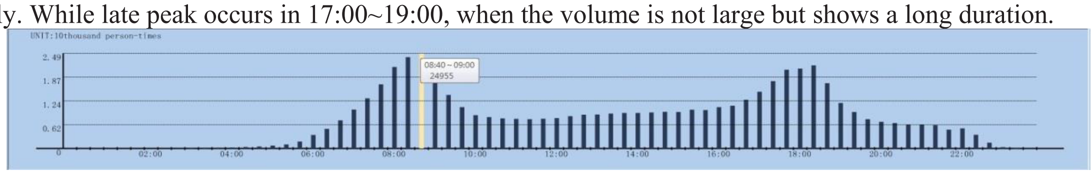


Fig. 2. Passenger Flow Quantity within a Whole Day

4.1. Enter and Exit quantity of Station

Figure 3 shows the quantity enter and exit People Square Station during morning and evening rush. The red left rectangles show passenger flow getting in the station, while the green right rectangles show exit volume. It is indicated from the left figure that travellers who get out of the station are far more than those enter during the early peak period (figure a). Thus the station could take measures to evacuate the stream as soon as possible if necessary, such as switch part of enter gates to exit ones, open additional channel of ticket collecting by manual work for passengers with single ticket and so on. But the volume of passengers who get in the station is larger than those get out of the station in late rush time from the right figure (b). Thus station operators should selectively switch some exit gates to enter ones to balance enter gates and exit gates. At the same time, they could adopt sampling inspection instead of security check for each passenger to shorten enter station time.

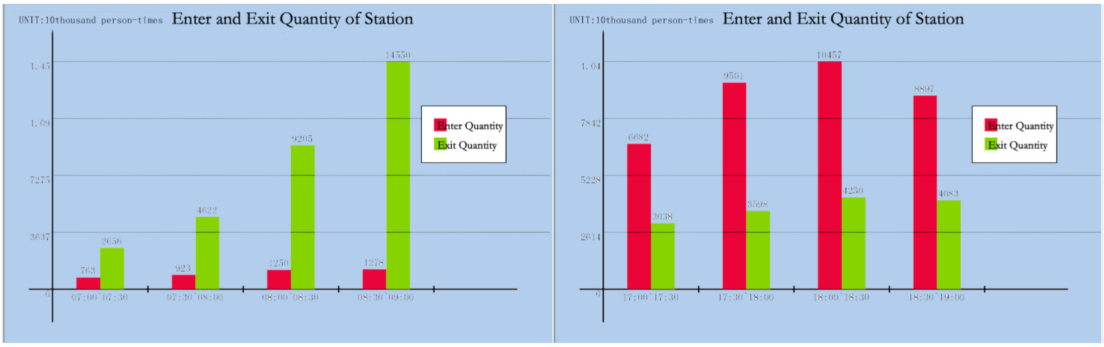


Fig. 3. Enter and Exit Quantity of Station in Early Peak (a) and Late Peak (b)

4.2. Transfer Flow between Lines

As is shown in figure4, in the rush hour around 08:00～08:30, the interchange quantity from line 1 to line 2 takes up the most part of passenger flow in People Square Station while that from line 8 to line 2 is comparatively small. However, line 1 and line 8 share the same position in station and both of their passengers need to go through the "Huge Triangle" transfer hall to switch to line 2, moreover, the interchange quantity from line 2 to both line 1 and line 8 is not that much, therefore, station operators should try their best to keep the transfer flow in the left side in early peak in order to automatically generate the clock-wise transfer flow to avoid mutual confrontation between different streamlines. On the other hand, in consideration of the large transferring volume to line 2 from both line1 and line 8, doorway E and F should be set the same direction as transfer traffic from line 1 and line 8 while doorway D should be opened toward passengers from line 2. At the same time, separation guardrail and marked guide signs should be set between doorway D and E to distinguish different routes for each passenger, reducing crossing and confrontation between flows. These arrangements are also applicable to the corridor in the "Huge Triangle" transfer hall and the 17 meters-wide transfer steps. When needed, all the stairways in the middle could be provided completely to passengers transfer to line 2 from line 1 and line 8. As for the great interchange traffic between line 1 and line 8, it is convenient for passengers to transfer directly through doorway A, B and C, yet making work much harder for station organization and obviously aggregating crossing and confrontation between flows. For this reason, it is proposed to equip removable guardrail and assign station staff to help evacuate passengers and physically eliminate crossing and confrontation.

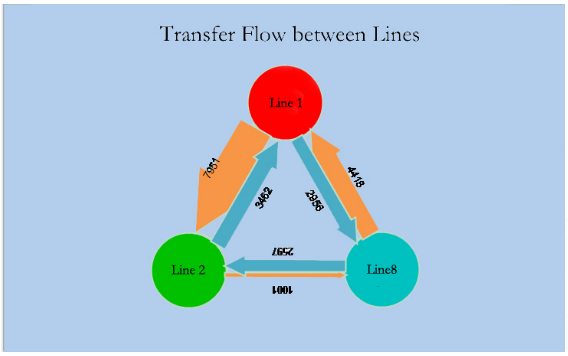


Fig. 4. Interchange Quantity between Lines

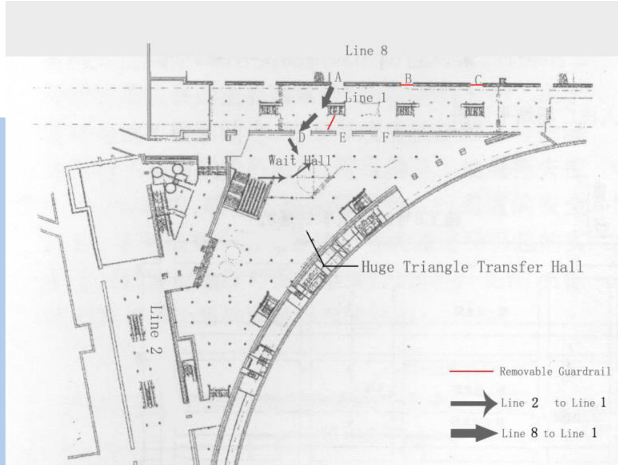
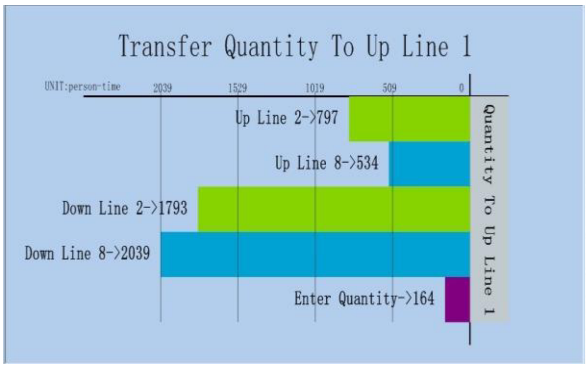


Fig. 5. Measures Taken by Transfer Station Operators

4.3. Transfer Flow to Lines

It is also important for station to calculate and analyse the transfer quantity in each direction. The most prominent problem is that an increasing number of passengers would aggregate in the platform if the train is delayed in People Square Station, so it's necessary to take measures to protect these backlogged passengers from security incidents. For example, hypothetically there is a train in delay in the up direction of line 1 during rush time 08:00～08:30. At this moment, passengers from the down directions of both line 8 and line 2 occupy the most part of transfer flow to the up direction of line 1. Then station staff could close doorway B, C and guide these passengers to the platform of line 1 through doorway A, extending transfer time for passengers from line 8 to line 1. Besides, they could also make use of broadcast, set removable guardrail and allocate workers to keep passengers wait in the "Huge Triangle" transfer hall or even guide them to walk out of the station so as to alleviate the pressure pushed onto the platform. Furthermore, station operators should report to COCC (Central Operation Cooperation Centre) to apply for contingency plans like letting trains cross in adjacent lines without stop as a response to large passenger flow when the station cannot be able to support.



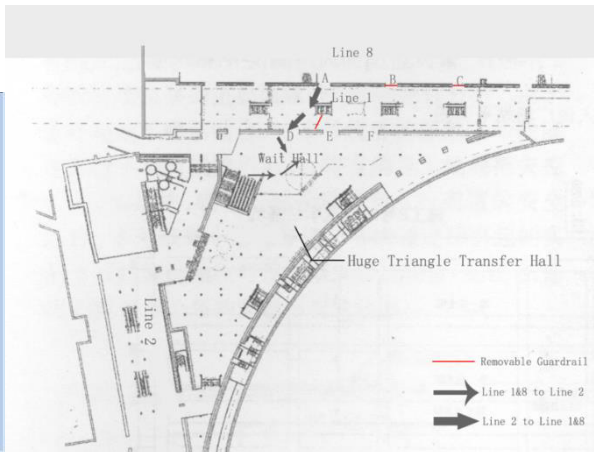


Fig. 6. Interchange Quantity to Line 1 in 08:00~08:30,

Fig. 7. Emergency Oriented Measures

5. Conclusion

To make passenger organizing operation more scientific and efficient in transfer station, the paper presented an improved algorithm about dynamic analysis of passenger flow, then proposed corresponding optimization measures of passenger organizing operation in transfer station based on those analysis results. In the end, taking People Square Station for example, this paper expounds the supporting effect of the algorithm on passenger organization based on enter and exit quantity of station, transfer quantity between lines and transfer quantity to lines. However, further research should be devoted into the selection of passenger flow correction coefficient involved in the algorithm and accuracy of traffic volume analysis.

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