

Research on transfer route guidance strategy for passenger in urban rail transit

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Keywords: transfer route, guidance strategy, urban rail transit

Abstract. In order to boost the efficiency of urban rail transit operation, it is necessary to study on urban rail transit route congestion, define interval passenger congestion index, and meet the needs of network load balancing. There a series of procedure for propose a solution, including an analysis of passenger data, and calculated and verify the congestion index firstly, an method for optimization of assignment model, and completed the relevant calibration on parameters accordingly, the optional passenger flow route allocation scheme for both entering/leaving station passenger flow and transfer passenger flow finally. By doing this, the verification of the allocation scheme effectiveness would be accomplished, and technical support could be beneficial to the local urban rail transit operation company.

Introduction

There is a growing investment on urban traffic infrastructure, especially on urban rail transit in most big cities in China. Local government pay more attention on the relatively complete urban rail transit network for public travel. Based on the systematized urban rail transit network, congestion level of the network come to a major consideration of the passengers, which making them keep away from intensively crowded routes rather than only one choice. In order to enhance the overall level of urban rail transit operation service, and achieve the assignment, balance transit network load, by means of specific modern measures include that real-time releasing the congestion information in urban rail transit network, on-site guiding passengers' transfer behavior, a suitable solution for passenger transport flow assignment problem would be discussed in this paper.

T(time)-F(frequency) model for passenger in urban rail transit

An extensive survey recently found that when passengers faced the multi-route choice for travel, especially there were more than two transfer route choice in urban rail transit network, they tended to choose the most time-saving or least number of times for transfer rather than other choice. For example, once there was only one transfer opportunity, there were at least 7 segments of time to be calculate for our model. The abstract outcoming for the travel process of passenger can be easily deconstructed in the simulation model, as Figure 1 shows. By defining the OD stations virtual node, represented as r and s , and the transfer station virtual node, represented as $ai1$ and $ai2$, the T-F model demonstrated that r and s should point to the gate machine of the OD stations, and $ai1$ and $ai2$ should point to the two virtual transfer stations in different lines, respectively.

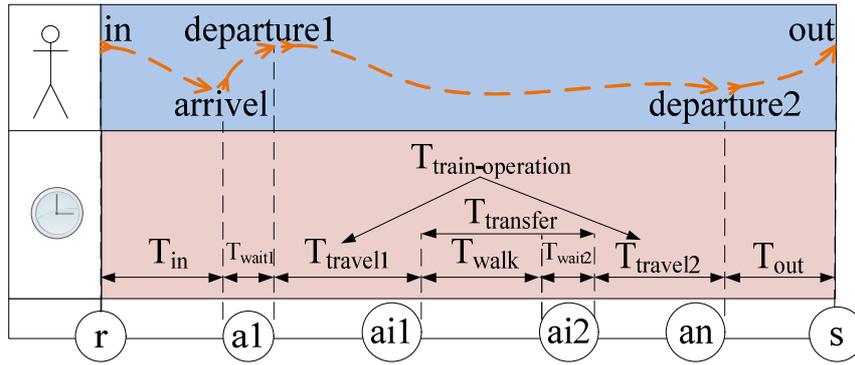


Figure 1 T(time)-F(frequency) model for passenger in urban rail transit

I(interval) T(traffic) C(congestion) index

Through the computer simulation analysis, traffic congestion of network consists of the whole interval traffic congestion, which was the dynamic passenger flow density rather than the static pedestrian density. It affected the passenger transfer route choice rather than path selection in station. In order to measure the influence on the route choice, taking B model vehicle as an example, a train consisted of 6 vehicles, full loaded volume 1440, when the real capacity went up to 140%, the volume of train would be more than 2000. In this case, the operation department would adopt the temporary scheme for passenger safety, and at this time, the value of traffic congestion index could be defined as 10. There was a relationship of piece-wise linear function between f and I_{index} , which represented the current number of passengers in the train and the ITC index respectively. The algorithm was as follows.

$$I_{index} = \begin{cases} 2.5 * \frac{f}{720}; & (0 < f < 720) \\ 2.5 + 2.5 * \frac{f - 720}{1440 - 720}; & (720 < f < 1440) \\ 5 + 2.5 * \frac{f - 1440}{1728 - 1440}; & (1440 < f < 1728) \\ 7.5 + 2.5 * \frac{f - 1728}{2000 - 1728}; & (1728 < f < 2000) \end{cases} \quad (1)$$

G(generalized) C(cost) M(model) for passenger route choice

Taking interval traffic congestion index into generalized cost model for passenger route choice, and setting certain time granularity (arbitrary discrete time snippet), the variety of interval traffic congestion could be calculated effectively, and then by defining it as the weighted constraint for the G(generalized) C(cost) M(model), the following parameters could be introduced and validated easily.

E_k^{rs} referred to train travel time,

$$E_k^{rs} = \sum_{a \in k} t_a + \sum_{i \in k} t_i ;$$

W_k^{rs} referred to transfer time,

$$W_k^{rs} = \sum w_k^{ij}, w_k^{ij} = (w^{ij} + d^j) * f^n; (f \geq 1);$$

I_k^{rs} referred to interval traffic congestion,

$$I_k^{rs} = \left[\left(\sum_{i=1}^n \frac{i}{index} / n \right) \right]^{1/n}.$$

By defining certainty generalized cost as C_k^{rs} , which represented the OD cost for passengers in path k . C_k^{rs} could be an index of weighted sum.

$$C_k^{rs} = (E_k^{rs} + a * W_k^{rs}) + b * I_k^{rs}.$$

By substitution,

$$C_k^{rs} = \left\{ \left(\sum_{q \in k} t_a + \sum_{i \in k} t_i \right) + a * (w^{ij} + d^j) * f^n \right\} + b * \left[\left(\sum_{i=1}^n \frac{i}{index} / n \right) \right]^{1/n}.$$

Among the parameters, a referred to the weight of transfer time parameter, and b referred to the order correction coefficient from passenger congestion index to travel/ transfer time, and f referred to the weight of transfer times, and n referred to the number of transfer times or intervals.

Generally, total travel time (including train travel time and transfer time) and route congestion were the most sensitive factors. Accordingly, for the Logit model, those passengers chose the route which represented the generalized cost for this route is the least among all choices. By observation and deduction for large quantity of passengers' transfer behavior, the hypothesis that passenger would choose the k path only when the generalized cost of k path became the minimum among all possible paths would be the reality. Under normal circumstances, travel time, transfer time, and transfer times in generalized cost model were all basic constants. But in reality, passengers would change the route over time, especially in morning or evening rush hour. Passengers tend to choose the less crowded line rather than the shortest travel time route or the least transfer time route. Taking interval traffic congestion index into generalized cost model, the value of allocation could be calculated dynamically, and the regularity for passenger route choice could be described accurately.

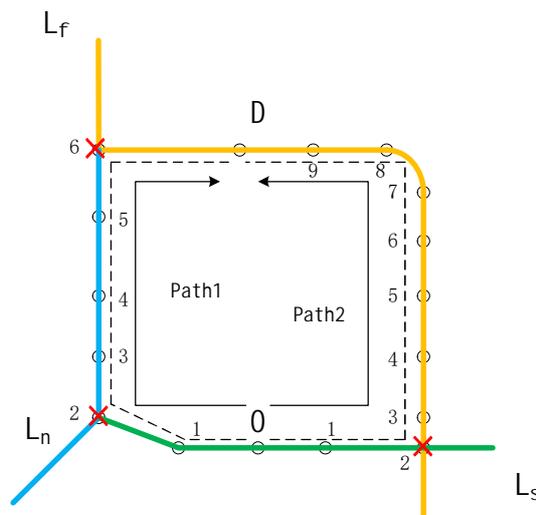


Figure2 R(route)-C(choice) strategy for passenger from O to D in urban rail transit

In simulation experiment, different route choice contribute to different experiment results, such as the route choice from node O to node D, as Figure 2 shows. On one hand, if a passenger chooses path1, that is Ls-Ln-Lf, the process needs two transfer nodes. On the other hand, if a passenger chooses path2, that is Ls-Lf, the process needs only one transfer node. Obviously, for transfer times, total number of stops, and ITC index are all key aspects for urban rail transit operation efficiency and passengers comfort. Based on the above simulation models, validated parameters, and the real time passenger flow data from urban rail transit control center, a series of passenger flow guidance strategy for different regions could be proposed and adopted to accomplished higher operation efficiency and passenger comfort. Firstly, with the public information release platform, urban rail transit operation company provide parking and transfer information for certain discount, optimizing the initial station selection, and balancing the network load. Secondly, during peak hours, making the corridors, escalators, and stairs to be unidirectional artificially, and optimizing the passengers walking streamline are also effective and commonly used measures for operation company. Finally, for the special line which was characterized by tidal effect passenger flow, operation company tend to adopt the dynamic adjustment traffic channelization strategy for morning/evening rush hours if necessary.

Acknowledgements

This work has been supported by National Natural Science Foundation of China (U1434207), Fundamental Research Funds for the Central Universities (2017JBZ001), and Beijing Chaoyang District Science and Technology Commission(CYXC1607).

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