Frontiers in Traffic and Transportation Engineering (2019) 1: 1-5 **DOI: 10.23977/ftte.2019.11001**
Clausius Scientific Press, Canada **ISSN 2616-2334**

Optimization of Express and Local Train Stop Scheme for Urban Rail Transit

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Keywords: *urban rail transit; express and local train pattern; overtaking; integer programming; genetic algorithm*

Abstract: *Express and local trains can meet passengers' various travel needs effectively, reduce transport operation costs, and promote the service level of urban rail transit. For a train system to be effective, it is crucial that reasonable stop schemes be created. First, the study examines, in detail, the feature of overtaking between express trains and all-stop trains. The overtaking of local trains by express trains not only results in increased passenger travel time and train turnaround time, but also reduces carrying capacity. This study puts forward a scheme wherein express trains overtake all -stop trains at slow stations, without stopping, to reduce the adverse impact of overtaking. We then analyze passenger trave1 time and the operation costs of express and local trains, we establish an optimization model for the stop scheme of express and local trains, and use a genetic algorithm to solve it. Our results indicate that this scheme saves passengers 3,976,815 seconds of travel time, and train operators one set of train stock and a 12,OOO-yuan stop cost during the peak trave1 hour.*

1. Introduction

With the continuous improvement of the level of urbanization, the demand for passengers such as commuting between the suburbs and the central city is increasing, and the long-distance line connecting the urban center and the urban sub-center gradually forms. The passenger and passenger traffic flow of this type of rail transit line is relatively uneven, the passenger flow is obvious, and it is mainly passengers traveling in long distances such as commuting and running, and the fast and slow mode can effectively adapt to the passenger flow distribution of such lines feature.

In recent years, many scholars at home and abroad (1-71 have conducted in-depth research on the development of trains and trains, especially the train stop program. The results show that some specific fast and slow train combination stop plans meet the needs of passengers. At the same time, good social and economic benefits can be achieved. However, most of the studies have started from the difference in passenger travel time after driving fast and slow, and less consideration is given to the changes in the operating costs of enterprises. The lack of analysis is caused by passenger travel time and the number of vehicles.

In summary, based on the research results of the predecessors, this paper takes the analysis of Yuexing as the cutting point, focuses on the comprehensive benefit analysis of passengers and enterprises, constructs the mathematical model of the combination scheme of the express and slow trains, and designs the genetics. The algorithm performs model solving [1].

2. Analysis of the speed stop and stop plan

2.1. Stations and crossings

Combined with the previous research, this paper defines the adjacent area of the urban comprehensive transportation hub as: the urban area adjacent to or close to the urban comprehensive transportation hub, which is the closest urban environmental carrier of the hub. The hub carries out material, energy, information, etc. through the adjacent area and the city and the area. Exchange. The range of the adjacent area of the hub can be preliminarily defined within the radius of 1500m around it, and because the traffic function of the road above the secondary trunk road is obvious, and the branch road is mainly based on the life service function, the integrity of the block can be considered comprehensively. On the basis of natural conditions and other factors, the roads above the secondary trunk road are used as the boundary of the analysis scope, and then the adjacent area of the urban comprehensive transportation hub is delineated (Figure 1) [2].

The fast and slow mode increases the average running speed of the express train, which may cause the fast and slow cars to pass. In order to reduce the passing ability of the line, the starting interval of the fast and slow cars is increased to avoid the occurrence of the line, but in the case of tight line passing conditions, it is necessary to take the line to ensure the line passing ability. According to the position of the line, the line can be divided into two categories: the first one is the interval, which is characterized by the fact that the trains run on separate tracks, but need to add additional intervals, which requires sufficient traffic. The second type is the station crossing, requiring the forward train to be avoided at the crossing station, waiting for the express train to pass through the crossing station and guarantee a certain safety interval, and then starting from the station. In contrast, this method only needs to add a crossing line at the station, and the scheduling organization is simple and easy to implement. Therefore, this paper analyzes the model based on the station crossing mode.

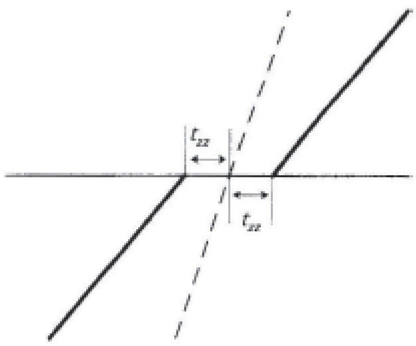

Figure1 Express train overtaking local train without stopping

2.2. Stop station position

Whether the express train stops at the crossing line mainly affects the stop time of the slow-moving passengers who are being crossed, and also affects the slow-turning time and the passing ability of the line. Figure l and Figure 2 are schematic diagrams of the express train passing different speeds in different ways, and the three symbols tkl, tml and tzz respectively indicate the express stop time, the slow stop time and the system tracking interval [3].

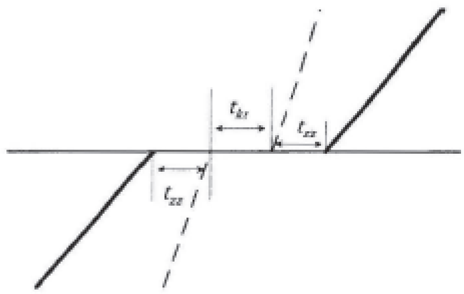

Figure2 Express train overtaking 1oca1 train with stopping

Comparing the analysis chart 1 and Figure 2, the minimum stop time of the slow-moving passengers is 2, and the maximum stop time is 2tzz+tkl'. The difference between them is tkl. In order to shorten the total time of passengers traveling, speed up the vehicle turnaround time of the passing train, and minimize the loss of the line passing ability caused by the train crossing, so this paper analyzes the model based on the scene of Figure l.

3. Mathematical model of fast and slow stop plan

3.1. Model hypothesis

To simplify the model, the following assumptions must be set:

All stations have the conditions for crossing the line, and the trains are handed over and grouped individually;

Consider only one-way train operation, the technical parameters of fast and slow vehicles are the same;

The ratio of the speed of the fast and slow cars is 1: p, where p is an integer, and only the case of simple crossing [5) is considered;

There are only two types of trains, fast and slow, and the train travel time is only affected by the number of train stops;

Passengers travel by direct mode. When passengers can reach the destination station by fast and slow trains, the express train is preferred. This article does not consider the transfer between fast and slow trains.

3.2. Basic parameters and decision variables

Xj is whether the express train stops at the station t, and the parking value is 1; otherwise, it takes 0; Yk is the slow train at the crossing station k. If it is crossed, take 1; otherwise, take 0; i, j, k is the station serial number, There are a total of n stations q'j for the traffic of stations i to j; also the stop time of the train at station i); t island is the time when the train starts and stops at station i [Sl; IL is station i to j Interval pure running time division; tzz is the system minimum tracking interval time T is the optimization period length; a, is the fixed cost of the vehicle a2 is the cost of one train stop station v is the number of passengers rated by the train; ~> is converted into the train return time (including the terminal station) 11 stops for the express passengers to save the total travel time 111; waiting for the increase of the total waiting time for the slow passengers; 11 7; the more behavior is increased by the passengers in the car time, known as the crossing station quantity.

3.3. Problem analysis and modeling

Express passenger travel time savings. In the fast and slow mode, the express train can improve the average speed of the train by stopping some stations in the middle of the stop. The express passengers can also save the stop time of the jump stop and the additional time of the train start and stop. Therefore, the total time saved by express passengers can be calculated by the following formula: $\sum_{i=1}^{T}\left(w_i^t - w_i^{t-1}\right) \le 1$.

Increase in waiting time for local passengers. In the station stop mode, all trains stop at the same station in the same way, the average speed of the train is equal, so the running lines of the train map are parallel. In the fast and slow mode, the speed of the trains is different, resulting in a difference in the speed between the trains. Therefore, the trains in the train map are operated in tracking mode. The running map is the tracking operation map. Figure 3 is a schematic diagram of the departure interval of the following vehicles in different modes. Among them, thi is the waiting time of the slow passengers at station i, z is the stop time of the slow train in different modes; seven is the following train departure interval for station stop mode; tm is the slow train departure interval for fast and slow mode, and is L l Integer multiple.

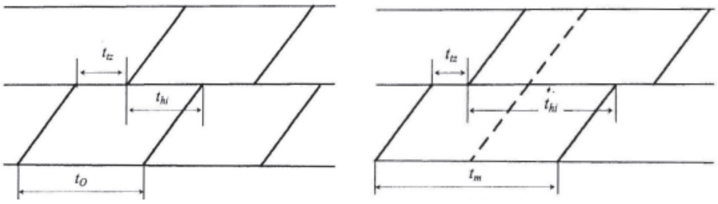

Figure3 Train headway under different modes

Compared with the stop mode of the station, the waiting time of the idle passengers in the fast and slow mode can be calculated by the following formula. The total waiting time of all the slow passengers can be calculated by the following formula: $\sum_{i=1}^{T} c_i\left(w_i^t - w_i^{t-1}\right) \le c_{max}$.

Increased in-car time by the slower passengers. The number of crossing stations affects the in-vehicle time of the local passengers and the detour time of the slow-moving vehicles. Compared with the station-stop mode, the time of the in-vehicles of the slow-moving passengers will increase. If the number of slow trains is p times that of the express train, and the trains are simple and the passengers are evenly distributed on each train, the probability that the slow passengers will be crossed by the express train in the passenger zone is IIp. The increase in the stop time increase value AJLT can be calculated by the following formula: $\sum_{i=1}^{T} c_i\left(w_i^t - w_i^{t-1}\right) \ge c_{min}$.

4. Conclusions

This paper fully considers the impact of Yuexing on passenger travel time and vehicle turnaround time. The choice of express stop and the setting of the crossing station are the decision variables, and the passenger travel time and the cost savings of the operating enterprise are the maximum optimization goals. The vehicle combination stop station model, design genetic algorithm and use

MatabR2014b software version to find satisfactory solution. The research results show that a reasonable fast and slow car program can not only save passengers' travel time, improve passenger satisfaction, but also enhance the attraction of rail transit. At the same time, it will reduce the number of vehicle bottoms and reduce the energy consumption of train stops. It will save the company's operation costs, improve the income and expenditure of the operating enterprises, improve the competitiveness of urban rail transit, and obtain good comprehensive benefits. This paper only considers the scheme of speeding and slowing down the bus under single line and single traffic conditions. In the future, it can focus on the network coordination optimization of the fast and slow vehicle stop station scheme based on multi-transit and transfer conditions.

Acknowledgements

This article was specially funded by Dalian University's 2019 Ph.D. Startup Fund (20182QL001) and 2019 Jinpu New District Science and Technology Project.

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