A summary of research on customized bus route optimization for commuter needs

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Abstract. In order to solve the problems of inadequate existing road resources, rapid development of motor vehicles, and low comfort of traditional buses, a humanized customized bus is proposed, in which the network of customized buses is a key part of its operation. This article mainly summarizes the optimization of the customized bus line network at domestic and abroad, and finally draws the conclusion of this article.

1. Introduction
Due to the rapid population development, the blowout of motor vehicles, the shortage of oil resources, and insufficient land resources, the road utilization rate is low and the energy consumption is too large. Against the backdrop of the rapid development of motor vehicles and insufficient resources, there is a great need to enrich the urban transportation system and inject new blood. Among them, public transportation is the transportation method with the highest road utilization rate. Secondly, public transportation can effectively use energy. According to a study in Canada, the energy consumption of various transportation methods in cities is calculated in terms of person kilometers at peak hours. Buses account for 8.4% of the total number of cars. In terms of ecological environment, the emission of hydrocarbons (CH), carbon monoxide (CO) and nitrogen oxides (no or NO2) from passenger cars accounts for 17.1%, 6.7% and 17.4% of the total emission of automobiles, respectively, based on the peak hour man kilometers. According to a French research report, the social cost of car pollution is more than 10 times that of public transportation based on one trip.

With the development of society, more and more cities are planning to separate the work and residence. In this case, the travel time for commuters increases, coupled with the lack of road resources and the comfort of conventional public transportation, and the phenomenon of small capacity of cars and excessively congested rail transit. This paper proposed an "Internet +" urban customized public transportation mode to supplement the urban public transportation system.

As an important part of diversified public transportation, the customized public transportation provides a customized medium-to-high-end public transportation service for people with the same or similar travel start and end points, travel time, and service needs through centralized integration of individual transportation needs[1].

The optimization of customized bus routes is a key part of the entire customized bus operation. Optimizing the customized bus line network is helpful to improve the efficiency of commuters, shorten unnecessary waste of time and reduce the operating costs of customized buses. Based on this, this article summarizes the domestic and abroad research on the optimization of customized public transportation network.
2. Customized bus operation process

The operation of customized bus operation is based on the Internet mode, which is mainly divided into passenger and bus operation modes. Passengers apply on the APP, and the bus serves passengers from the picking up area. After a period of operation, the bus will serve the passengers at the dropping off area.

2.1. Advantages of customized bus operation

Traditional customized bus vehicles have the disadvantages of fixed location of bus stop, fixed line of vehicle operation and crowded environment. The customized bus has the following advantages:

1. It uses a one-stop direct bus service model, which has the characteristics of "fixed point, fixed line, fixed car, fixed timing, fixed pricing, and fixed person" [2-3];
2. Customized bus can attract commuters who take taxis, thereby reducing the use of cars and alleviating traffic congestion;
3. A customized bus is equivalent to 9-10 cars in the morning rush hour, thereby improving road use resources;
4. Compared with taxi, the vehicle cost is lower;
5. Compared with traditional bus vehicles, the ride comfort is higher;

The mature operating experience abroad provides a reference for China. At present, the cities that have adopted this method in China are Beijing, Harbin, Qingdao, Chengdu, Shenzhen, Tianjin, etc. For example, in the United States, bus capacity can be increased by 41% per day, reducing bus mileage by 24%. After Shakopee, Minnesota adopted responsive custom buses, the daily passenger capacity increased by nearly 3 to 5 times [4].

2.2. Passengers’ application process on the APP

Passengers’ applications mainly include advance appointments and timely requests. The passenger first sends a ride request on the APP. After the background analysis and judgment, if the request meets both the bus operation revenue requirements and the passenger travel time window, the passenger who made the request is served.

![Figure 1. The flow of passengers are serviced by customized bus](image)

2.3. Customized bus operation process

After the public bus judges to accept the passenger’s request, it departs from the parking lot and carries the serviced passenger in the residential area. After servicing the passengers, the bus return to the parking lot. The above operating condition is that single operation accepts passengers not exceeding the maximum passenger capacity of the vehicle. The route is shown in Figure 2.
3. Research status of network optimization at domestic and abroad

Customized buses are a kind of transportation with human characteristics, which better embodies the idea of "human text". At present, due to the rapid development of customized buses, many scholars at domestic and abroad have conducted extensive research on the optimization of its network.

3.1. Current status of foreign research

Ernesto [5] established a model that targets public resource consumption and cost, with constraints on line length and departure frequency, and then used genetic algorithms to solve many-to-many line operation problems. In order to solve the problem of radioactive road network, Hugo [6] proposed a model with one bus operation and passenger ride cost as the target, and searched for the final bus line network with the constraints of the departure frequency and the size of the central area. K. An [7] studied the random theory of interval uncertainty to optimize the bus network. N. Nassir [8] used impedance access theory to optimize the customized bus network. K. Kerkma [9] proposed a multi-dimensional space combination theory of public transport network optimization. Based on the problem of minimum cost and maximum flow, WLi [10] used the minimum cost growth chain Dijkstra algorithm and the 0-1 planning model to select sites to study the many-to-many operation mode, then made reasonable arrangements to ensure the frequency of departures to achieve the shortest single route and maximum passenger attendance. In order to solve the problem of low resource allocation rate of customized bus line network, Ma [11] proposed a clustering method based on passenger OD demand, which used the OD that maximizes social benefits and minimizes operating costs to perform matching calculation. ZLi [12] aimed at passengers’ demand, studied the method based on soft time window to adjust the customized bus network, and then used Cplex software to solve. YanLyu [13] constructed the CB Planner route planning framework, and developed a heuristic algorithm considering the road network density to solve, and finally used examples to verify.

3.2. Domestic research status

Peng [14] considered minimizing passenger travel costs and company operating costs, and at the same time meet the needs of the largest passenger customization, and established a customized connection bus optimization model. Liu [15] aimed at the customized bus demand service rate, average attendance rate and the optimal total cost of customized buses, built a green customized bus line network optimization model, in which the total cost of customized bus operation includes time cost, distance cost and environmental protection cost.

He [16-17] considered the establishment of a customized bus line design model with minimum bus operating costs and passenger travel reliability and comfort requirements, where reliability is described by travel time reach rate and comfort is selected by passengers choosing different models and used...
genetic algorithm to encode, and then used a small-scale algorithm to verify, and founded that reliability has an impact on the vehicle’s driving path, and comfort has an impact on the vehicle’s operating cost.

In order to improve the operation efficiency of customized buses, Wang\textsuperscript{[18]} established a model with the minimum total operating mileage of all customized bus vehicles in the road network as the optimization goal, and built a model to satisfy multiple parking lots, multiple loading and unloading stations, and multiple customizations. The bus line was solved by an improved genetic algorithm. Finally, the case of Chengguan District of Lanzhou City was used to verify the rationality of the model and algorithm. The study concluded that the passenger occupancy rate was 91.875%.

Peng\textsuperscript{[19]} set the Q-learning reinforcement learning reward and punishment function through comprehensive traffic congestion status, passenger demand and the location of residential quarters based on the characteristics of commuters’ dense travel and regularity of passenger flow trends, and used the improved Q-learning model to optimize customize buses’ routes.

4. Conclusions
At present, most of the domestic and foreign research on the optimization of the network of customized buses are based on passenger costs and bus operating costs. Among them, the pollution cost of the customized bus operating costs is less considered. Secondly, scholars at domestic and abroad rarely optimize the existing network from the aspect of customizing bus dispatching.

Nowadays, with the rise of the Internet and the wave of 5G technology, the customized bus has been given strong technical support. In the future, the "people-oriented" transportation concept will be widely spread. Customized bus will become an important part of the urban public transportation system.

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