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# Research on Optimization for Passenger Streamline of Hubs

Yuting Zhu*, Chunping Hu, Dejie Xu, Jimeng Tang

*MOE Key Laboratory for Urban Transportation Complex Systems Theory and Technology, Beijing Jiaotong University, Beijing 100044, China*

**Abstract**

This paper proposes an optimization model for passenger streamline to promote the organization of hub management. Passengers are divided into two different categories, namely familiar type and unfamiliar type. Then the different route choice behaviors of these two types are analyzed. The graph theory is employed to abstract the hub network. The system cost is taken as the optimization objective, and then an optimization design model for passenger streamline is built. To find a solution, we adopt a traversal search algorithm to enumerate all the possible schemes, and then choose the scheme with the minimum system cost. Finally, a simple case is taken to verify the validity of the proposed model.


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*Keywords:* passenger hub; passenger streamline; travel behavior; optimization model

## 1. Introduction

With the expansion of Chinese transportation network, passenger demand in hubs has becoming more and more diversified, especially in integrated passenger hubs. The functions and internal structures of hubs also become more complicated, which brings much trouble to the organization and operation of hubs. Therefore, an optimization model for passenger streamline is proposed to provide a safe, convenient and efficient service in hubs.

Over the past few decades, many researchers have pay attention to passenger hubs (Odoni, 1992; Lemer, 1992; Takagi et al., 2003; Hsu, 2010; Zhao et al., 2011). As one of the most effective way to improve the efficiency of hub operations, the optimization problem of passenger streamline has been widely considered in studies. Daamen (2004)

* Corresponding author. Tel.: +086 10 51682264
*E-mail address:* 10121094@bjtu.edu.cn.


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proposed a utility model to describe passengers' route choice behavior in hubs, and then gave some strategies to the organization of streamline. Cui and Jia (2006) analyzed the characteristic of passenger streamline and proposed design principles for streamline in integrated traffic terminal. Kaakai et al. (2007) evaluated the streamline of railway transit station with a hybrid Petri nets-based simulation model. O'Kelly (2010) outlined an analytical framework of flow optimization and discussed several variants of the problem. Zhu and Cha (2011) explored the key factors, which effect passengers' efficiency in hubs through analyzing passenger streamline. Although the above studies can assist us in recognizing how the passenger streamline affects the efficiency of hub operations, however, these studies have not introduced available methodologies that can quantitatively optimize the passenger streamline.

Feng (2010) proposed a doubly restricted model for the streamline design problem. The minimum transfer cost and shortest transfer time were taken as optimization objectives. Qi (2011) introduced a concept of measurement entropy of passenger line optimization. The optimization problem was abstracted into a nonlinear constrained problem, which aims at maximizing the measurement entropy. Hu et al. (2012) expanded the study area of passenger streamline into the whole activity process of passengers in hubs. Jiang et al. (2013) proposed a cross entropy method to select passenger streamline from a number of available streamlines. The above-mentioned studies provide valuable methods to optimize passenger streamline. However, their models neglect the different choice behaviors between different types of passengers, which will have a strong effect on the optimization result.

The objective of the paper is to propose an optimization model of passenger streamline with differentiate the route choice behaviors between familiar and unfamiliar passenger. The method of graph theory is employed to abstract hub networks. In the network, nodes represent active points and links represent walkways between nodes.

The remainder of this paper is organized as follows. In Section 2, the different route choice behaviors of familiar and unfamiliar passenger are analyzed. Section 3 describes a modeling approach to optimize passenger streamline. To illustrate the effect of the model, Section 4 presents a numerical result from a simple hub network. Finally, Section 5 concludes the paper.

## 2. Route choice behavior

In passenger hubs, there have many factors that affect passengers' route choice behavior. Existing researches usually considered some factors such as walking time, crowding penalty and so on. However, in order to judge these factors, passengers must have a long-term travel experience and very familiar with the hub. In fact, there have some passengers who are unfamiliar with the hub, such as tours and shoppers. They usually select the route in a random way. Therefore, it is necessary to classify the passengers, and then analyze their choice behavior respectively.

Based on the description above, passengers can be divided into two types, namely familiar type and unfamiliar type. Familiar passengers have multiple travel experience and can select route by experience. Unfamiliar passengers rarely travel through the hub and select route random.

### *2.1. Route choice behavior of unfamiliar passenger*

Unfamiliar passengers can hardly estimated the general cost of each route. Thus, they will make a random choice in each crossing node, which means the probability that each feasible route, which traverse through node $i$, selected by unfamiliar passenger will be the same at node $i$. The probability will equal to the reciprocal of the number of feasible routes:

$$\pi_i^{rs} = 1 \Big/ \sum_{k \in K_{rs}} h_{i,k}^{rs} \tag{1}$$

where $K_{rs}$ denotes the set of available routes when passenger located at origin node $r$ need to walk to destination node $s$; $h_{i,k}^{rs}$ shows the relationship between node $i$ and route $k$, let it be one if route $k$ traverses through node $i$, zero otherwise.

The probability that route $k$ ($k \in K_{rs}$) selected by unfamiliar passenger, who located at origin node $r$ and need to walk to destination node $s$, can be denoted as: