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Planning the departure of vacant transit vehicles to the median stops in a single line

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Abstract

In transit lines planning, a common issue is that transit vehicles get overcrowded as they arrive at some intermediate stops. Dispatching a portion of vacant transit vehicles to the intermediate stops may seem to be a suitable solution for this problem. This study aimed at explaining whether or not this solution can assist in enhancing the system performance in terms of the total discomfort of transit users. A mixed integer nonlinear model was proposed by adopting some simplifying assumptions. The vehicles' headway and the first boarding stop for each vehicle were the decision variables in the proposed model. The solution algorithm was a kind of hybrid algorithm consisting of a convex programming solver and a Tabu search algorithm. The results, interestingly, indicated that the total discomfort of transit users increased after dispatching vacant vehicles to the intermediate stops, although some transit users in intermediate stops may profit from dispatching vacant vehicles.

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Keywords:public transportation; scheduling; total discomfort of passengers

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1. Introduction

Transit vehicles operations in transit lines have some complexities in scheduling and timetabling particularly in various stop of transit lines with variable demands. Transit lines are expected to have a fixed schedule, whereas the demand often varies significantly in different stop along a route. While many stops may have low amounts of boarding/alighting passengers, some may have relatively large amounts of passengers. Short turn trip, stop skipping, zone scheduling and deadheading trip are the main strategies considered in previous studies to enhance transit lines performance.

There are two major policies for a deadheading strategy. The first policy applies this concept to transit lines with unbalance demand between directions while the other policy considers deadheading for vacant vehicles that start boarding passengers of a specific stop. The latter was adopted in this paper. In other words, we focused on dispatching vacant vehicles to intermediate stops in order to provide specific services. Such strategy has been the topic of limited studies in the research background. Furth (1985) applies a deadheading strategy for lines with unbalanced demand between directions. The deadheaded vehicles run empty in the direction with low demands and start boarding passengers in the other direction. Applying this strategy led to a reduction in operator cost and user cost through reducing the fleet size and waiting times, respectively. Ceder (2003, 2004) considers deadheading vehicles between two terminals to reduce fleet size by setting a specified scheduling. Eberlein et al. (1998, 1999) formulates a mixed integer non-linear problem and determines the stop that deadheading vehicle should start boarding passengers. All these vehicles are considered to have normal services along their routes. The objective function, in this study is minimizing the waiting time. Due to their results, much time is saved and the headway between vehicles is reduced. Finally, the authors propose a complicated problem in the context of real-time transit controls. Cortés et al. (2011) propose a combined model of short turning and deadheading. They consider the profile demand of a single transit line and design short turn trips and deadhead trips in high demand zones. The decision variables are frequencies, vehicle capacity and the starting and ending stop. Fu et al. (2003) assume that if some stop are skipped by a vehicle, necessarily the next vehicle will serve the entire route. They simplify their model and show that the service level is enhanced for passengers in skipped stop. Leiva et al. (2010) study expressing services. They consider a public transport corridor divided into segments. They assign a portion of the vehicles with special scheduling to each segment.

This study focused on a deadheading strategy in which the departure of vacant transit vehicles to intermediate stops is carried out in a single transit line in order to minimize the total discomfort of transit passengers. The problem was formulated as a mixed-integer mathematical model including both integer and continuous decision variables. The integer-type decision variables determine the optimal intermediate stops for departing vehicles from which loading passengers must be fulfilled. Also, continuous decision variables determine the headway between departures of vehicles.

The remainder of this paper is organized as follows: section 2 generally describes the problem and notations while section 3 presents mathematical formulation of one-way and two-way optimization model. Section 4 explains solution method. A numerical example is presented in section 5 and the paper is concluded in section 6.

2. Problem description

The problem in this paper was concerned with a deadheading strategy that could be applied to control the operation of transit vehicles over the stops. The strategy considered a route with two directions, stops ($i = (1, \dots, N)$) and vehicles ($k = (1, \dots, K)$). Naturally, it was assumed that some of intermediate stops in both directions are more crowded than the other ones. Some vehicles were assumed to run empty from first stop and start boarding passengers in intermediate crowded stops.

In this case, deadheading strategy can reduce waiting time of passenger in intermediate crowded stops and increase the passengers' satisfaction. The deadheading problem considered in this paper attempted to find (1) the optimal stop number in which each vehicle starts boarding the passengers, and (2) the optimal headway for dispatching vehicles.

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