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The model of location for single allocation multimodal hub under capacity constraints

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Abstract

In a multimodal hub network, the limited resources at the hub may cause shipment delays which will affect the service performance. In this research, hub operations is modelled as a GI/G/1 queuing network and integrates the hub operation queuing model and the hub location-allocation model, then a multimodal hub-and-spoke hub location model considering capacity limit is proposed and tested. The results show that the model can be used to solve the location - allocation problem in the design of multimodal hub network.

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Keywords: multimodal; hub-and-spoke network; hub location; GI/G/1 queuing system

1. Introduction

Multimodal transportation refers to the integrated use of two or more modes of transportation for delivering goods from origin to destination in a seamless flow [1] [2], which has become the subject and link of modern logistics network operation. Through the multimodal transportation can combine with diverse modes of transport effectively in accordance with the scientific and reasonable process, which can reduce the storage and transit time and customers can get the best transportation route, the shortest transportation time, the highest transport efficiency and the lowest transportation cost consequently. But due to the randomness of the shipping order and interference of time factor, multimodal transportation also has the following insufficient: shipment delay is common due to short of time satisfiability; lack of emergency time strain capacity due to designated transport plan workload is plenty and transport cycle is long; optimization performance is not best so that can't make full use of resources and capacity, etc.

Hub-and-spoke transport scheme can solve some drawbacks of multimodal transport effectively. Hub-and-spoke transportation network is a network (a chart consisted of nodes and connection lines between nodes) which connects most of the nodes and one or more centre hub node and then interaction (see Fig 1), in order to achieve

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the network structure which can make an integration of logistics resources and improve utilization efficiency of the logistics resource and reduce logistics cost effectively.

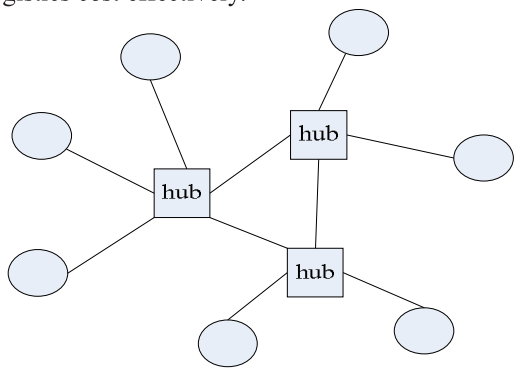

Fig.1. hub-and-spoke network schematic diagram

In a typical hub-and-spoke cargo distribution network, node firstly collects the cargos which are serviced by this node, and then shipment to the hub after assembled. In a hub, the cargo with the same destination and initial address are tidied, and redistribution path is decided according to the destination. If a shipment arrived at a hub and the destination hub link with the hub, it can direct transportation to the destination, or transport to the hub linked with the destination node, then the next step processing. So, the cargo can be concentrated effectively, and the real load rate can be improved, and then achieve economies of scale.

Due to the competitive environment in the market, the enterprise paid more and more attention to the cost and level of service, etc. The mode of multimodal is used widely because it can meet the demand, more and more domestic and foreign scholars begin to study the multimodal transportation, in which the study of multimodal transportation network design and hub location allocation problem is most widely. Arnold [3] et al. presented formulations in which a fixed number of multimodal hubs are selected among candidate locations in 2001, but they only considered the fixed cost of a single hub, ignoring the cost of shipping and storage, and they presented alternate formulations by representing each constituent network as a graph with nodes and arc in 2004, the problem is solved using a heuristic approach involving the solution of a shortest path problem for each commodity (origin-destination pair). Groothedde [4] discussed the implementation of hub-based distribution networks in the consumer goods market in 2005. A road-barge multimodal is compared with the road-only network. A heuristic solution is developed which starts with two hubs and iteratively selects a hub based on improvement in the objective function value, however, there is no specific service time requirements were used in the location/allocation decisions. Wei Zhong [5] et al. studied the model of shortest time and path with the cost of transportation for multimodal in 2006, the paper pays attention to the optimization of path of transportation instead of the selection of hub nodes. Limbourg [6] et al. discussed the location of hubs in a road-rail network. Their solution approach is based on a heuristic which solves the hub location problem completely over road the network first in 2009, but lacks the use of fixed cost and service time restrictions. Yang Youhui[7] studied the location of cargo hubs based on multimodal in 2011. He discussed the influence factors of location for multimodal cargo hubs and evaluation method of the location scheme chiefly. Rafaq Ishfaq and Charles R.Sox [8] studied the design of multimodal logistic networks with hub delays in 2012, but they paid more attention to the analysis of operation procedure of multimodal hubs, and they presented the problem of multimodal transport design, not yet considered the restriction of hub capacity.

The design of multimodal logistics network is more complicated than the design of a single transport logistics network. From the perspective of network design, hub location and allocation problem is integrated into the multimodal logistics network in this research and a multimodal logistics model considering capacity limit is proposed and tested in this paper.