Chapter 10

VLSN Search Method Based Hubs Location and Service Frequency Determination for the Intermodal Freight Transportation Network

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This chapter attempts to study the hub location problem as well as the service frequency determination for the intermodal freight transportation network. The objectives consist of two related parts: (a) determining the optimal number and locations of the hub nodes; (b) determining the service frequencies for different transportation modes between the hubs. Nodes of the freight transportation network are classified into hubs (or hub nodes) and feeding nodes, correspondingly, the arcs consist of feeding arcs and spoke arcs. The topology of the original network is changed to convert the hub location problem to a capacitated minimum spanning tree problem (CMST) and employ the very large-scale neighborhood search (VLSN) approach to solve it. After ensuring the optimal hub number and their locations, the cumulative freight demand matrix between hubs is calculated and then an all-or-nothing transportation assignment algorithm is executed on the hubs-spokes network. The service frequencies of rail and truck modes are determined based on the assigned flows of spoke arcs. The proposed formulations are tested by an experimental rail and truck freight transportation network with 89 nodes and 142 arcs. The results indicate the robustness of the VLSN algorithm, and the optimal hubs and service frequencies on spoke arcs are determined efficiently.

10.1 Introduction

With the rapid development of national economy in China, express operation in delivery of goods has gotten more attention than before. Each department claims at the exact time and place to deliver goods with accurate and precise services. Traditional goods transportation operations cannot meet today’s requirements. The rapid and continuously enhanced constructions of highways, railway lines, airport hub, and international shipping centers
have greatly improved the conditions of transportation facilities. These laid the foundation of the rapid progress of express shipment industry. With the accelerating development of express shipment industry, it is a great significance to optimize the transportation resource allocation, increase economic efficiency and promote transportation enterprise development. Consequently, intermodal operation in freight transport has been the main trend of the future. Designing a flexible, economical, reliable and efficient intermodal transportation system is exigently required by both the freight companies and the customers. The freight transportation operation planning (FTOP) has been a hot researching issues and attached many attentions in the last two decades (Mahmassani et al. 2007).

During intermodal freight transportation operation, determining the freight transfer facility’s (or the hub’s) location has been a key issue. In the intermodal context, the cargoes are not always directly door-to-door delivered, but handed in the hubs. Via the hubs, cargos are assembled, classified and finally dispersed to the demanding destinations. The hub plays an important role in the integration of technical and economic advantages during cargo transporting. It makes to speed up the transport of goods and service, reduce transportation costs and so on. Moreover, in the process of building an intermodal freight transportation network, hub location directly inflects the efficiency of the entire network. The hub location problem is to determine the position of hub facilities. Determining the freight transfer facility’s (or the hub’s) location has been a key issue in intermodal FTOP. In the intermodal context, the cargoes are not always directly door-to-door delivered, but handed in the hubs. Via the hubs, cargos are assembled, classified and finally dispersed to the demanding destinations. The hub location problem for the freight transportation has been substantially researched and applied in practical operations. The total characteristics of freight hubs have been described by McCalla et al. (2001). Detailed reviews of different types of hub location problems have been done by Campbell (1996) and Campbell et al. (2002). Alumur and Kara (2008) classified and surveyed network hub location models. O’Kelly and Bryan (1998) considered the hub location problem with economical network flow model. Marianov et al. (1999), Shimizu and Wada (2003), Racunica and Wynter (2005), Cunha and Silva (2007) also finished the hub location researches for the freight transportation networks. They considered different objective functions with various constraints.

Few of the previous researchers studied the hub location problem in the condition when both the number and the location of hubs are unknown. In the intermodal freight transportation context, decision makers concern not only where to construct hubs but how many