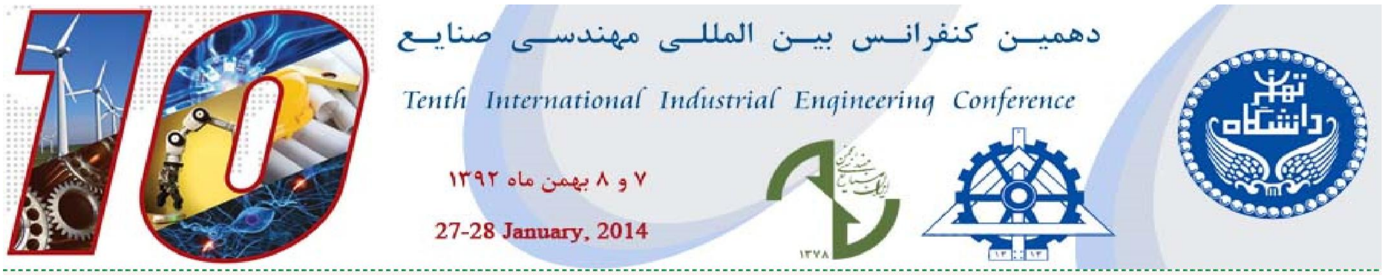

Auxiliary Public Transportation Network Planning

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***Abstract*—This paper proposes a new covering-routing problem application for the public urban transportation network called Auxiliary Public Transportation Network (APTN) and uses to help the conventional network to cover the additional demands during peak period traffic. Our objective is to design an APTN so that additional demand coverage is maximized while APTN costs are minimized. The main difference between this problem and other covering-routing applications use for commodities transportation networks is that each bus station can be the origin or destination of each passenger. The solved model and computational results have been presented for a public transportation company using goal programming approach based on different scenarios.**

Keywords-Covering-routing problem; Auxiliary Public transportation network; Multi-objective optimization

I. INTRODUCTION

This is obvious that in an urban transportation network, there are more travel demands in demand centers (bus stations) during peak period traffic. Therefore this paper attempts to develop an Auxiliary Public Transportation Network (APTN) in order to help the conventional public network and to cover the additional travel demands as much as possible. Since APTN development and maintenance costs are significant in an urban transportation network, in order to design an APTN, This work considers all of the related costs in a certain time horizon and develops a model to maximize the additional travel demand coverage and minimize the present value of the APTN costs simultaneously. However, residual passengers are not covered through APTN or conventional transportation network and will use other modes to travel.

Covering-routing problem (CRP) is defined through vehicle routing problem (VRP) and covering problem (CP). VRP refers to a general class of combinatorial optimization problems in which customers are served by a number of vehicles [1]. Suppose a transportation company wants to serve a number of customers. A fleet of vehicles with limited capacity is used to transport the products from positions called "depot" to customers. In many VRPs, each vehicle finally returns to the depot started at it, while in others, vehicles do not return to any depot (open VRP) [2].

In general, the problem output is the design of a routes set for a vehicle fleets starting and ending at a depot in order to serve customers with known demands to minimize the total delivery distance or time spent in serving all customers.

CP is one of the most popular models among facility location models [3]. For the first time, Hakimi [4] developed a CP to determine the minimum number of police needed to cover nodes on a highways network.

In a specific class of CPs called "set covering problems", demand of a customer should be satisfied by at least one facility within a given critical distance called coverage distance or coverage radius. While in others, allocated resources are not sufficient to cover all of demand nodes and therefore maximal covering problem maximizes the amount of demand covered within the acceptable service distance by locating a given fixed number of new facilities [3].

In CRPs, the size of facilities like paths and trees is large in proportion to their cover set, and therefore cannot be assumed as points [3]. The main difference between CRP and VRP is that in CRP there is not necessity to cover all of demands. In CRPs, a path covers a site, if it passes within a distance S (the service distance) of the site. It is worthy to mention that in some CRPs, there is an existing network, whereas in others, the network should be constructed [5].

This paper solves the APTN model using data of an urban transportation company under various scenarios by goal programming technique, and then compares the computational results together. The contributions of this work to the literature are:

- Developing the covering-routing problem for urban public transportation network.
- Incorporating the interaction between passenger's pick-up and delivery. It means that passengers getting into a bus can land in each bus station. In fact, a delivery of node *i* consists of passengers get into a bus in previous bus stations and their destination is bus station *i*.
- Presenting multi-objective model in which one of objective functions minimizes the present value (PV) of the APTN costs for the first year.
- Considering some of financial factors such as budget limitation and maintenance costs.