Comparing Static and Dynamic Policies for Vehicle Routing Problems with Backhauling and Dynamic Customer Demands

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ABSTRACT

Dynamic vehicle routing problems with backhauling (VRPB), although important, have attracted little attention in the literature. Dynamic VRPB is more complex than dynamic vehicle routing problems (VRP) without backhauling, and since VRP without backhauling is a special case of VRPB, models and algorithms for dynamic VRPB can easily be adapted for dynamic VRP. In this paper, the author compared between static and dynamic policies for solving VRPB with dynamic occurrences of customer delivery and pickup demands. They developed heuristic algorithms for medium-sized problems under static and dynamic policies. Although dynamic policies are always at least as good as static policies, the author observed from numerical experimentations that static policies perform relatively well for low degrees of dynamism (dod). On the other hand, dynamic policies are expected to perform significantly better than static policies for high dod and early availabilities of dynamic customer delivery and pickup demand information. The author concludes the paper by providing directions for future research on dynamic VRPB.

Keywords: Backhauling, Degree of Dynamism, Dynamic Demand, Split Deliveries and Pickups, Static vs. Dynamic Policy, Vehicle Routing Problem

INTRODUCTION

In the traditional vehicle routing problem (VRP) without backhauling, a depot has to serve the linehaul demands of a set of customers with a fleet of vehicles. The objective is to determine the vehicle routes in order to minimize the total travelling time/cost of the vehicles. There is a vast literature on the VRP, which describes the problem as NP-Hard. A number of variants of the basic VRP exist such as multiple depots, multiple time periods, time windows, service times, maximum route time limitations on vehicles and so on. An even more difficult problem is the vehicle routing problem with backhauling (VRPB) where a customer may have both linehaul and backhaul demands (In case a customer has either linehaul or backhaul demands, this can be achieved by equating backhaul or linehaul demands, respectively, of

DOI: 10.4018/jal.2013040101
the customer to zero). It is intuitive that VRP is a special case of VRPB where the backhaul demands of customers are zero. Therefore, the problem considered in this paper is more general in nature. Since both VRP and VRPB are NP-Hard, the solution approach in the literature so far has been the development of exact or mixed integer linear programming (MILP) formulations for solving small-sized problems and approximate or heuristic algorithms for solving medium to large-sized problems. For the different variants of VRP/VRPB and their solution methodologies, readers are referred to Goetschalckx and Jacobs-Blecha (1989), Laporte et al. (2000), Ropke and Pisinger (2006) and Mitra (2008). Recent references on VRPB include Paraphantakul (2011), Zachariadis and Kiranoudis (2011, 2012), Tasan and Gen (2012), Goksal et al. (2012), Karaoglan et al. (2012), Tarantilis et al. (2012) and Wassan et al. (2012). Also, see Huang and Xu (2013) for new methodologies (such as auctions) to address VRPB.

The basic VRP/VRPB is static in the sense that all the information on customers, their demands, distances between locations, travelling times/costs and so on are available with the decision maker in the beginning of the planning period so that the solution to the problem, i.e. the vehicle routes remain static until the end of the planning period. However, in practice, most of the information may not be available at the time of decision-making, which may be revealed dynamically over time such as customer demands, travelling times and so on. This set of problems is referred to as dynamic VRP/VRPB, which has produced a significant amount of research since about the last one-and-a-half decades. Dynamic VRP may consist of customers with delivery-only or pickup-only demands, dynamic customer requests and/or dynamic travel/service times, real-time diversions of vehicles en route to a customer or replanning of vehicle routes only when vehicles reach their next destinations, capacitated or uncapacitated vehicles, single time period or multiple time periods, single objective or multiple objectives, and so on. The solution approach for the different variants of dynamic VRP has been re-optimization, i.e. the updation of vehicle routes as and when new information becomes available. Larsen et al. (2002) defined an index called the degree of dynamism (dod) depending on the number of dynamic customer requests in comparison to the total number of customer requests for a setting with delivery-only customers, unknown service times, single objective function and updation of vehicle routes only at customer locations, and compared the performances of several routing policies with respect to the dod. Angelelli et al. (2009, 2010) compared the performances of static and dynamic policies, and of collaborative and individual dynamic transportation policies, for a dynamic VRP with pickup-only and postponable or unpostponable customer requests, uncapacitated vehicles, multiple time periods and multiple objective functions allowing real-time diversions of vehicles en route to a customer. Wen et al. (2010) developed an MILP formulation and a three-phase heuristic for a multi-period dynamic VRP with delivery-only customer requests, capacitated vehicles, service time and maximum route time restrictions, and multiple objectives. The problem was solved on a rolling plan basis, and no real-time diversions of vehicles or updation of vehicle routes were allowed. Sensitivity analyses were carried out for the different parameters of the problem under consideration. Lorini et al. (2011) extended an earlier model (Potvin et al., 2006) for a dynamic VRP with pickup-only customer requests, dynamic demands and travel times, uncapacitated vehicles, real-time diversions of vehicles and multiple objectives. They showed that real-time diversions of vehicles produced better results than the situation when updation of vehicle routes can only take place at customer locations (Potvin et al., 2006). For a detailed understanding of the different issues of dynamic VRP and more comprehensive reviews of the related literature, readers may refer to Psaraftis (1995, 1998), Gendreau and Potvin (1998), Ichoua et al. (2000), Ghiani et al. (2003) and Larsen et al. (2008). Recent references on dynamic VRP include Liao and Hu (2011), Hong
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