Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 3 (2014) 442 – 451

Transportation Research Procedia

www.elsevier.com/locate/procedia

17th Meeting of the EURO Working Group on Transportation, EWGT2014, 2-4 July 2014, Sevilla, Spain

A Flexible Transport Service for Passengers

Pasquale Carotenuto[a]*, Leonardo Paradisi[b], Giovanni Storchi[c]

[a]*Istituto per le Applicazioni del Calcolo "M. Picone", National Research Council, via dei Taurini 19, Roma - 00185, Italy*
[b]*Dipartimento di Ingegneria dell'Impresa, University of Rome "Tor Vergata" via del Politecnico 1, Roma - 00133, Italy*
[c]*Dipartimento di Scienze Statistiche, University of Rome "Sapienza", piazzale Aldo Moro 5, Roma - 00185, Italy*

Abstract

The realization of innovative passengers transport services requires more and more often a greater flexibility and inexpensiveness of the service. To answer this request in many cases the physical solution is to realize a demand responsive transportation system (DRTS). A DRTS require the planning of travel paths (routing) and customers pick-up and drop-off times (scheduling) according to received requests, respecting the limited capacity of the fleet and time constraints (hard time windows) for each network's node, and the service time of the system. By the modelling point of view a DRTS can be effectively represented with a Dial-a-ride problem (DaRP). A DaRP derives from the Pick-up and Delivery Problem with Time Windows (PDPTW) and may operate according to a static or to a dynamic mode. In the static setting, all customers' requests are known beforehand and the DaRP returns the vehicles routing and the passengers pick up and drop off time scheduling. The static setting may be representative of a phase of reservation occurred the day before the execution of the service. But, if the reservation requests must be processed on-line, even during the booking process there may be a certain level ad dynamism. In fact, if the algorithm works online, it manages each and every incoming request separately, and accepts or refuses it immediately, without knowing anything about the following. The operative program is constantly updated after each received request without refusal to carry out previous accepted services. In the dynamic mode, customers' requests arrive when the service is already running and, consequently, the solution may change whilst the vehicle is already travelling. In this mode it is necessary that the schedule is updated when each new request arrives and that this is done in a short time to ensure that the potential customer will not leave the system before a possible answer. In this work, we describe a flexible people transport system capable of managing incoming transport demand in dynamic mode, using a solution architecture based on a two-stage algorithm to solve Dial-a-Ride Problem instances. In the first stage, a constructive heuristic algorithm quickly provides a feasible solution to accept the incoming demand. The algorithm in the second stage try to improve the solution evaluated at the first stage by using the time between two consecutive transportation events. The algorithm, unlike most of the works in the literature, use an objective function that optimizes the service punctuality.

Selection and peer-review under responsibility of the Scientific Committee of EWGT2014

* Corresponding author. Tel.: +39-064-927-0926; fax: +39-064-404-306.
E-mail address: carotenuto@iac.cnr.it

Selection and peer-review under responsibility of the Scientific Committee of EWGT2014
doi:10.1016/j.trpro.2014.10.025

Keywords: Dial a ride, Heuristics, Routing algorithms, Transportation planning.

1. Introduction

The realization of innovative passengers transport services requires more and more often a greater flexibility and inexpensiveness of the service. To answer this request in many cases the solution is to realize demand responsive transportation system (Ambrosino et al. 2006). A Demand Responsive Transport System (DRTS) requires the planning of travel paths (routing) and customer pick-up and drop-off times (scheduling) on the basis of received requests (Cubillos et al. 2004). In particular, it has to tackle the problem of multiple vehicles, the limited capacity of fleet vehicles and temporal constraints (time windows). The problem of working out optimal service paths and times is called a Dial-a-Ride Problem (DaRP), which derives from the well-known Vehicle Routing Problem (VRP) (Toth and Vigo, 2002; Barrie et al., 2003; Prins, 2004), with the addition of precedence constraints between pick-up and drop-off locations (Cordeau and Laporte, 2007).

Their computational complexity makes both DaRP and VRP as NP-hard problems, so attempts to develop optimal solutions have been limited to simple and small-size problems. It can be argued that heuristic procedures are more suitable for realistic networks and demand, because they allow to obtain good solutions in a limited amount of time. In the DaRP, customers formulate transportation requests from a given origin-destination pair (i.e., from a pick-up point to a delivery point). Transportation is carried out by vehicles that provide a shared service. Due to this fact, several customers may be in the same vehicle at the same time. Since the DaRP is a special Vehicle Routing Problem with Pickup and Delivery (VRPPD) (Savelsbergh and Sol, 1995), including restrictions on the time at which each point may be visited by a vehicle, the problem of finding a feasible pick-up and delivery plan is NP-hard. Clearly, the DaRP has to take into account specific constraints as we are considering people instead of goods. As a consequence, each customer specifies a possible pickup and delivery time, as well as an upper bound on the riding time (Coslovich, et al., 2006). Furthermore, in this context, customers often formulate two requests per day, specifying an outbound request from the pick-up point to a destination and an inbound request for the return trip. A DRTS may operate according to a static or to a dynamic mode. In the static setting, all the customer requests are known beforehand, and the DRTS produces, by solving a DaRP instance, the tour each vehicle has to make, respecting the pick-up and delivery time windows while minimizing the solution cost (Bergvinsdottir et al., 2004; Uchimura et al., 1999; Jaw et al., 1986; Jorgensen et al., 2007). In the dynamic mode, the customer requests arrive over time to a control station and, consequently, the solution may also change over time (Jih and Hsu, 1999; Carotenuto et al., 2006; Beaudry et al., 2010; Berbeglia et al., 2010). This work improves on previous approaches as it operates dynamically without interrupting the optimization cycle until the end of the service, providing the best solution found each time the system is modified. We address a DRTS capable of managing incoming transport demand to solve a DaRP in-stance using a solution architecture based on a two-stage algorithm. The first one is a constructive heuristic algorithm that quickly provides a feasible solution. The second algorithm is a specialized Hybrid Genetic Algorithm (HGA). Genetic Algorithms (GA) (Goldberg, 1989), are iterative stochastic algorithms in which natural evolution is used to model the search method. We obtain the so-called hybridization by including positive features of different algorithms into the GA schema.

The paper is organized as follows. In Section §2, we describe the DaRP by introducing the assumptions to be considered when a Demand Responsive Transportation System is being designed. In Section §3, we introduce the algorithms used in solving the DaRP instances. In particular, in Section §4, we describe the heuristic algorithm to compute an initial feasible DaRP plan. Section §5 describes the Genetic Algorithm implementation, in Section §6 some results related to a real case study are reported and finally conclusions are given.

2. DaRP definition

In DaRP (Bodin and al. 1983), each transportation request is dynamically formulated and specifies a single origin and a single destination as well as the number of passengers, a time of pick-up and delivery, the related time windows defined as maximum deviation by the time agreed and the maximum time that each passenger can remain on board the vehicle. The capacity of all vehicles is limited. For brevity, we do not provide the model formulation