A Decentralised Approach for the Transportation On Demand Problem

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Summary. Public transport systems are generally organized in a static, a priori way. In such systems, the demand must be adapted to the offer. In this paper, we propose a model based on self-organization in order to dispatch a fleet of vehicles in a purely dynamic Transportation On Demand system (TOD). Our proposal consists in a decentralized approach and a multi-agent system (MAS) to model the environment. This will tackle the problem of vehicles over-concentration or the lack of service in certain areas of the city. We demonstrate that our model addresses these problems by providing vehicle agents, for a given request, to make the final decision thanks to a negotiation process and to calculate overcosts according to an original insertion heuristic.

Keywords: transportation on demand, vehicle routing problem, collective intelligence, self-organization.

1 Introduction

Growing environmental concerns are linked to the difficulties of management of urban traffic. They lead to the creation of new solutions improving mobility in agglomeration. Current public transportation systems are determinist and based on frequencies and routes fixed in advance. They are built starting from opportunity studies and are not very adaptive to a request that can change in time: the demand has to adapt to the offer. It is thus advisable to complete the urban transportation services by flexible systems being more adapted to the individual needs. We propose a Transportation On Demand (TOD) system which must adapt to users need in real time. It must allow to generate an important reduction in the traffic and to offer a maximal quality of service to reduce the cost of exploitation. Lastly, it will be the basis for a decision support system, computing vehicle tours in real time, a service which is not offered by the traditional transportation systems. The stake of this article is to study the possibility of the installation of a TOD system to satisfy the requests of the customers at any moment, by distributing the load inside the fleet of vehicles in order to achieve the goals mentioned previously. This system will adjust dynamically to the customers demand. The scenario of the execution starts with the first customer request which appears randomly in a place of the city. It
sends a request indicating his departure point and his destination. The resolution consists in choosing the best located vehicle to satisfy the passengers already on board this vehicle as well as the new request by optimizing its rate of filling with respect to the maximal capacity, its time and cost of travel.

First of all, we will present some previous work of similar problems. Then, we will define the data of our problem. We will present our approach and the preliminary results related to the initial tests to finish by a conclusion and some perspectives.

2 Previous Works

The general problem of the construction of vehicles routes is known under the name of Vehicle Routing Problem (VRP) and represents a combinatorial problem of multi-objective optimization which was the subject of many works and many alternatives in the literature. It belongs to the NP-hard category [2][10]. In its basic version, the VRP problem (see figure 1) models a well known transportation problem which consists of pickup (and/or collect) products to serve a set of customers using a fleet of vehicles. The resolution consists in determining a set of routes which minimizes objectives as well as possible as the total traveled distance, the number of vehicles used and the sum of customers delays [8].

![Vehicle Routing Problem](image)

**Fig. 1. Vehicle Routing Problem**

A complete state of the art of the VRP problems in the static context, and in particular, the dynamic one and their applications is given by [9]. In [13], the Dynamic VRP (DVRP) problem was treated. The resolution consists in dividing time execution into slices. The DVRP problem will be a succession of VRP static problems. An ant colony algorithm was developed to solve these static problems. When it is about the problem of VRP with pickup and delivery of goods, one speaks about PDP (Pickup & Delivery Problem). The Dynamic PDP problem was studied by [6]. The authors adopted a multi agent approach. The conversation between agents was based on the Contract Net Protocol. The clients demand arrival was calculated with basis on Poisson distribution. A Dial-A-Ride Problem (DARP) is an extension of the PDP in which the transportation of goods is replaced by the transportation of people [4][7]. Since we talk about people transportation, the