An approach based on multi agents system and genetic algorithm for a dynamic dial a ride problem

O. Bensouilah , O. Lekadir and D. Boukredera

Research Unit LaMOS (Modeling and Optimization of systems)
Doctoriales of Operation Research, 12th and 13th December 2018

Abstract

To reduce the traffic congestion and strengthen the regular transport system, the Dial a Ride services represent a good choice according to the flexibility of its vehicle routes and its adaptation to the particular users' needs. The purpose of this work is to review a solution for a dynamic Dial a Ride problem based on multi-agent systems (MAS) and genetic algorithms. The aim is to satisfy customer requests as much as possible by using a set of minimum cost vehicle routes. The schemas of the system and the used methods are described.

Keywords: Dial a Ride Problem, Multi-agent systems, Genetic algorithms, Transport services.

Introduction

Here in Algeria, after more than five decades from the independence, the transport system can't cover the needs yet, which made the big cities suffering from traffic congestion, and many small cities still have a lack of permanent transport services. To resolve this problem while considering the current economic crisis experienced by our country, the attention must be given to the modern transport modes, which improve the transport system quality and extend its range without requiring new infrastructures to be built or the use of new type of vehicles. One of the most known modern transport mode in the world is the Demand Responsive Transport (DRT) which is also known as Dial-a-Ride and Paratransit.

In Dial a Ride Problem (DARP), we study a public shared transport mode, where the customers specify their pick up and drop off points, and limit their availability in these points by a time range. The aim is to satisfy as much as possible the customer's requests by using a set of minimum cost vehicle routes [1]. This makes the demand responsive transport a good choice for less developed countries to reinforce their regular transport systems, by using it to feed the low-density areas and to offer customized services for peoples whose needs are not been met by regular transport system, like people with reduced mobility: elderly and/or disabled (see Figure 1) [2].

Figure 1: Examples of beneficiaries of demand responsive transport services

There are two operating modes for the dial a ride services: the static mode and the dynamic mode. In the first mode there is a separation between the reservation and the execution phases, while in the second mode the requests received throughout the day and vehicle routs are adjusted in real-time to meet demand [1]. To resolve a dial a ride problem in real time a lot of solutions are proposed in the literature, and a bunch of them are adaptation of the existing solutions for other transport problems like pickup and delivery problem and vehicle routing problem.

Methodology

In our research, we tackle the transport problem and propose a solution based on multi-agent systems (MAS). Firstly, we decompose the problem in different tasks in order to reduce its complexity, then we assign each of these tasks to one or more agents in the system. Basically, the problem is composed of three main tasks:

1. the interaction with the user accomplished by two types of agents: the interface agent and N user agents.
2. the creation of the vehicle routes performed by m vehicle agents.
3. the management of the whole system which is ensured by the manager agent.

❖ **The agents used in the system :**

1. **Interface agent:** this agent represent the communication channel used by the users of the system to specify their needs, and it can be via an application or a website.
2. **User agent:** it represents the applicant user within the system which can update his request or cancel it. This agent is created by the interface agent each time it receives a new request.
3. **Vehicle agent:** each agent of this type represents a real vehicle in the system, and each time it receives a new request, it generates and adapts the vehicle route for the real vehicle to meet the new demand. By solving the travelling salesman problem with time windows, these agents find the best vehicle routes for their vehicles, and send it to the manager agent as a proposal. When all the proposals are received, the manager decides which is the best proposal and who serves the request.
4. **Manager agent:** this agent is responsible of sorting the received requests and assigning them to the most appropriate vehicle agents for processing, as well as receiving the proposals and choosing the best one. In addition to that, it resolves the conflicts when it occurs.

In the figure 2 we illustrate what happens in the system when a new request occurs.

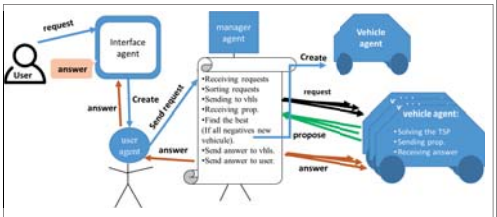

Figure 2: what happens in the system when a new request occurs ?

❖ **Solving the TSPTW (Travelling Salesman Problem with Time Windows) :**

when a new request arrives, the vehicle agent solves the TSPTW in order to find the best vehicle route that meets the precedent different requests and the new received request. After solving the TSPTW, if there is a least one valid solution, it sends its proposal (the best solution found) to the manager agent and wait for the answer, otherwise it sends a refuse message. When the vehicle agent receives an accept proposal message from the manager agent, it adds the new request to its assigned requests.

In a dynamic RADP, the response time is too critical since the requests received throughout the day and the vehicle routes must be adjusted in real time to meet the demands. To cope with this constraint, we propose to use, the genetic algorithms [3], to find a good solution in a short time. Theoretically, we consider the vehicle route as a genome and each of its points as a chromosome. As this algorithm is an evolutionary algorithm, the resolution of the problem starts with the generation of an initial population, then applies the operations of the algorithm several times to make the population evolve. The different phases of the algorithm can be resumed as follows (see figure 5) :

0. Data preprocessing: before starting the resolution, and as the solution is a vehicle route that contains a distinct set of points visited by the vehicle to pick up and/or drop off customers, a distinct set of points is extracted from the x precedent requests and the new request.

1.The generation of an initial population: to generate the initial population, there is two cases:

- the number of possible solutions is less or equal than the population size: all the possible solutions are generated.
- n (population size) solutions are generated randomly.

2. Evaluation of all the solutions by counting the distance of the vehicle route and check all the constraints of the problem (there is no drop off of customer before a pick up, the capacity is not exceeded, etc.).

3. In the case of a random generation, we start the evolution process for m generations:

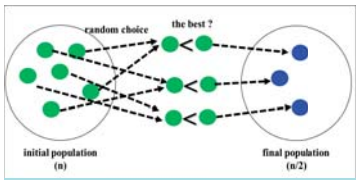

Figure 3: The selection by tournaments

- The selection: reduce the population to half by using the selections by tournaments (see figure 3).

- The crossover: get two random solutions from the new population and make a crossover with bit string to create two new solutions (see figure 4).

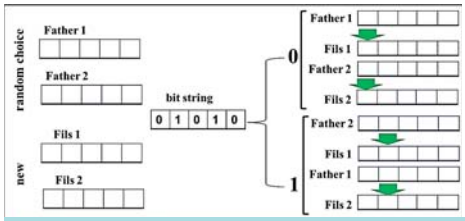

Figure 4: The crossover by bit string

- The mutation: to ensure the diversification in our method, a solution has been chosen randomly to make a change on it if the random value surpasses the mutation rate.

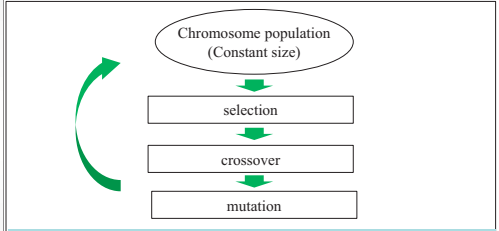

Figure 5: Genetic algorithms basic principle

Conclusion

In this work, we propose a solution based on the multi agents system and the genetic algorithm to resolve the dial a ride problem in dynamic mode. That is, we decompose the problem in three main tasks and affect each of them to different agents in the system. In our proposed model, We aim to reduce the complexity of the problem as well as the processing time of the request, which is a critical aspect in real time systems. On another side, the choice of the genetic algorithms for the resolution of the travelling salesman problem with time window in the vehicle agent leads to accelerate the problem resolution by generating more than one solution in time. This ensures also a good exploration for the solutions space.

The perspectives:

- Improve the system to handle unexpected events.
- Make a comparison with other works in the literature.
- Design another version of our approach with a decentralized decision in the MAS system.

References

[1] Cordeau, Jean-François, and Gilbert Laporte. "The dial-a-ride problem (DARP): Variants, modeling issues and algorithms." Quarterly Journal of the Belgian, French and Italian Operations Research Societies 1.2 (2003): 89-101.

[2] P. Bakker, "Large scale demand responsive transit systems –A local suburban transport solution for the next millennium," AVV Transport Research Centre, Ministry of Transport, Public Works and Water Management, Rotterdam, Netherlands 1999.

[3] S.Amédée, R. F.Gérard, "les Algorithmes génétiques" TE de fin d'année, Université Nice Sophia Antipolis, 2004.