Minimizing the total cost in the real time vehicle routing problem with the traffic factors

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1 Introduction

There is a lot of uncertainty existing in the Vehicle Routing Problem (VRP), such as the customer needs, the transportation needs, the traffic condition and the vehicle condition, all of the above need the schedule administrator to make a correct response on the updated information in a short time with the scheduling system. This kind of VRP is called the Real Time Vehicle Routing Problem (RTVRP). In this work, we study the transport problem based on the RTVRP with dynamic customers and traffic factors, which takes into account the reception of the new requests, and the variation of the cost between two locations. According to the characteristics of this problem, we use a new strategy based on the hybrid genetic algorithm to solve it.

2 Resolution principle of the RTVRP with dynamic customers and traffic factors

To solve the RTVRP with dynamic customers and traffic factors, the working day is decomposed into many time slices. Each time slice represents a partial static VRP, where the vehicles must serve all known customers. The proposed approach runs on each time slice, then from the solutions provided by the algorithm, we decide about commitments within an advanced commitment time, thus we allow a driver to react to new orders prior to the time of processing the order itself.

The first static problem created for the first time slice consists of all orders left over from the previous working day. This means that the optimization starts with customers who would have missed servicing yesterday. The time cut-off parameter controls the time in which new orders may arrive and thus may leave some customers unserved. All the orders received after the time cut-off are interpreted as being customers that were not serviced the day before. This means that the optimization starts with customers who would have missed servicing yesterday because of the time cut-off. The next static problem will consider all orders received during the previous time slice as well as those which have not been committed to drivers yet. In our simulation, each vehicle starts from the location of the last customer committed to it, with a starting time corresponding to the maximum between the beginning of the next time slice and the end of the serving time for this customer, and with a capacity equal to the remaining capacity after serving all customers previously committed to vehicle. To take into consideration the traffic factors, we modify, at the end of each time slice and before the time cut-off, the distance d_{ij} between customers v_i and v_j as follows: $d'_{ij} \leftarrow d_{ij} \times t_{ij}$ (1)

Where t_{ij} represents the change on the link between nodes v_i and v_j, which is generated as follows:

$$t_{ij} \leftarrow \begin{cases} t_{ij} \leftarrow 1 + r \quad r \in [F_L, F_U] & \text{If } q \le m \\ t_{ij} \leftarrow 1 & \text{Otherwise} \end{cases} \qquad (2)$$

Where r is a random variable uniformly distributed in $[F_L, F_U]$, where F_L and F_U define the lower and upper bounds of the change respectively, q is a random variable uniformly distributed in [0, 1], and m defines the magnitude of change that satisfies $0 < m \le 1$. The frequency of change defines how changes will occur. For our problem, a change occurs as defined in the equations 1 and 2 at the end of each time slice and before the time cut-off. For each time slice, the solution approach is executed for each problem created at each time slice [2]. The procedure of our solver based on a hybrid genetic algorithm is given as follows:

1. Set N=1. Generate M solutions to form the first population P_1
2. Evaluate the fitness of solutions in P_1 based its objective function value
3. Apply the crossover operator, which combines two solutions (parents) to produce a new solution, on a set of individuals selected from P_N randomly
4. Apply the mutation operator, which makes small random changes in the population, on a set of individuals selected from P_N randomly
5. Evaluate and assign a fitness value to each solution in the population P_N based its objective function value
6. Apply the replacement to select M solutions, from P_N and the new solutions resulting from the crossover and the mutation, based on their fitness and assigned them P_{N+1}
7. Apply the hybridization phase on the best solution of the new population
8. If the stopping criterion is satisfied, terminate the search, else set $N=N+1$ and go to step 3

The proposed algorithm has been implemented in C++, and the experimental tests were carried out on « MacBook Pro-Core i5/ 2.4 GHz - MacOS X 10.7 Lion » using the benchmark instances proposed by Kilby et al. [1]. The cut-off time and the advanced commitment time are set to T/2 and 0 respectively. The total length of the working day T is simulated by a very short time which corresponds to 200 seconds. A comparison of the solution quality in terms of minimizing travel costs is done between the cases where the degree of environmental changes from small to large. From this comparison, we can see that, as the degree of environmental increases, the maximal and the average of the total cost increase, which can be explained by the traffic jams which lead to increase travel times on certain roads, which implies that the total cost of the solutions increases.

3 Conclusion

This paper suggested a new kind of the real time transport problem based on the vehicle routing problem with dynamic customers and traffic factors, where we proposed our idea of the resolution principle to solve this type of real time problem.

References

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