Chapter 6

Conclusions and Future Work

This chapter intends to expose the main conclusions that can be taken from this Master Thesis and the work that can be realized in the future.

6.1 Conclusions

The problem approached during this work was a MCARP (Mixed Capacitated Arc Routing Problem). This kind of problems is described by a mixed graph where some of its arcs have a demand associated to it (required arcs). This type of problems aims the obtention of a solution minimizing its cost and containing all the required arcs.

The biggest obstacle verified during this project was the approaching of the problem as a MCARP, since in the literature most of the works are solved as a NRP (Node Routing Problem). One approach used by a large number of authors is the transformation of an Arc Routing Problem into a Node Routing Problem.

To solve the problem proposed in this work two different Optimization Models were studied. These models were focus in the work developed by [18]. The model used in this work was built based on these two different models. Through the study of these models were obtained a better knowledge and sensitivity about the restrictions associated with this kind of problems. This knowledge allowed to the author a deep comprehension about the difficulty of solving this type of problems in real life situations due to its complexity and its possible different characteristics.

The methodology used was developed in three different stages where each one has a different aim.

The approach developed is composed by different methods used in optimization problems. The first phase uses CPLEX to apply Exact Methods providing an infeasible optimal solution that is used as an input in the next phase. The second stage uses Heuristic Methods in order to give other different solution, a feasible one, with different characteristics and a higher value of the objective function. In the last phase a Metaheuristic is applied that intends to increase the quality of the solution obtained by the previous stage.

After the development of the aforementioned approach, it was applied to two different set of instances.

To the first set, the *mval* instances, the results obtained were not much near to the best known values but the time needed to obtain that solution were not very high.

Concerning the second set, *lpr* instances, this approach will take much more time than to the *mval* instances. That happens due to the complexity of this group of problems. The time needed to obtain a final solution will increase with the complexity of the problem under study. Despite this inconvenient the final results obtained to this second set of instances were better than the ones attained to the previous set.

Despite the time demanded to obtain a solution is an important parameter to evaluate this quality index of a routing problem solver, is not absolutely required that this time should be low, but since the real life routing problem does not need to be changed in a regular way, the weight of this parameter can be minimized.

The greatest contribution of the work developed during this Master Thesis lies on the development of a new approach to solve similar problems to the one solved in this work since the adopted methodology was capable of providing satisfactory results to a large number of tested instances in an acceptable computational time.

6.2 Future Work

To continue this work will be interesting the application of two different procedures. Next will be exposed this two possible modifications to the applied approach.

To obtain better results to the tested instances would be interesting to implement a Hybrid Method in the last stage of the methodology and compare the results attained by the one implemented in this Master Thesis.

A Hybrid Method is a combination of Exact Methods and Aproximative Methods. This combination intends to gain with the advantages of these two different methods.

Concerning the work developed by the author, a hybrid method should be applied during the Metaheuristic phase. The exact methods are used by CPLEX when the reconstruction of a route is performed. This procedure will be performed in each iteration of the method since the improvement heuristic, heuristic 2-opt, is used to change the disposition of the required arcs that composes the different routes of a solution. Applying it the solution obtained to the changed route could be better than the one that is actually obtained since this last one may or may not be the optimal one. If this was the procedure followed in this work would be interesting verify the following actually happens:

- Results would be obtained faster since the algorithm already developed takes too long to reconstruct the changed routes;

- In many of the realized iterations, the solutions obtained would be better than the ones now attained since to all of them the routes that compose them were constructed by exact methods that provide the optimal solution.

Other modification that may be performed in order to verify the results that could be obtained is the using of multi-tasks in the algorithm developed. This modification could be applied in the way that the routes were constructed, since the algorithm is applied to each route at a time. This would enable the construction of all the routes that forms the solution at the same time. If this was implemented could be done more tests in the instances with a large number of iterations without increase significantly the computational time needed to obtain the final solution.