

## CHAPTER VI

### CONCLUSIONS AND FUTURE WORK

The present work goal was to present a framework of the Lagrangean relaxation and implement it in order to obtain primal and dual bounds for the capacitated  $p$ -median problem, a classical location problem often used for geographical areas partition. Different approaches were presented to show how much this problem has been studied and many exact algorithms, heuristics and metaheuristics have been developed.

A Cluster Median Improvement heuristic was proposed, this particular heuristic is easy to implement and greatly improves upon the classical Lagrangean heuristic by yielding better upper bounds in almost all the instances and of way greater quality or at least equal bounds in the cases where it does not improve them. The gaps are also greatly reduced most of the times. Actually the CMI heuristic works better with harder instances as it was in those where the best improvements were observed. For lower bounds the worsening is negligible in almost all cases. All in all the implementation of the CMI is a clear improvement upon the regular Lagrangean heuristic.

For future work firstly the instances of the problem should be solved to optimality in order to prove or dismiss the theory that when the CMI cannot find better is because the optimal solution was already found by the regular Lagrangean heuristic. Also there will be further testing of the parameters  $\rho$ ,  $T$  and  $K$  (the multiplier in the step size, the amount of iterations without improvement before the multiplier is halved and the total number of iterations respectively) as different settings may yield better results.

For improvements upon the heuristic a Lagrangean/surrogate method could be used for obtaining lower bounds as it can accelerate improve the lower bound convergence, this in return may yield better medians faster which will result in having to resolve fewer generalized assignment problems. Another approach could be that for a certain number of iterations the CMI is not applied, until some better quality medians are found; the goal is the same: solving fewer assignment problems. By tackling execution time more iterations could be done in the same time and that will probably allow to find better bounds.