The Landscape of the Quadratic Assignment Problem and Local Search Methods

V. Bachelet* P. Preux† E-G. Talbi‡

February 28, 1997

Keywords: Landscape, Quadratic assignment problem, Hill-climbing, Tabu search, Genetic algorithms, Hybrid meta-heuristic, Parallel algorithm.

The Quadratic Assignment Problem (QAP) represents an important class of combinatorial optimization problem with applications in many practical problems. The QAP consists in finding the best assignment of n units to n different locations while the evaluation of a layout is a quadratic function of the distances between the locations and the flows between the units [1]. As the QAP belongs to the NP-hard class, non exact algorithms must be used to solve large instances (over 20). We have applied different kinds of meta-heuristics: genetic algorithms (GA), tabu search (TS), hill-climbers (HC), and hybrid methods [2].

In the design of a heuristic search strategy, two contradictory criteria should be considered: the exploration of the search space and the exploitation of the solutions that have already been found. Many efficient modern heuristics balance the two criteria but the experimental results show that each meta-heuristic explores and exploits the search space in its own way and the efficiency of a method depends on the type of the QAP instance to solve. Therefore, no heuristic can be better than any heuristic on a wide spectrum of problems and to build more efficient and robust search methods, combination (hybridization) of heuristics has been investigated and parallel hybrid algorithms have been proposed. The use of parallel models is not restricted to the use of the "brute-force" of parallel computers. Rather, we think that a real cooperation of several search methods will lead to better solutions, making different types of heuristics compensate themselves and federate their complementary behaviors.

To evaluate the difficulty of an instance, its size is an important parameter, but it is not enough. The QAP can be divided into several groups depending on the intrinsic nature of the instances, from real world instances to fully randomly generated ones. The values of the flow dominance and the distance dominance are strongly correlated to the nature of an instance and provide a good help to select a relevant heuristic for the specific instances to be solved. According to the results obtained, we observe that the TS is well fitted to instances with low dominance but its performance decreases in other cases. Unlike the TS, the GA performs well on instances with high dominance. The GA is able to realize a good exploration, while the TS is powerful in the exploitation task. The experimental results confort our intuition of landscapes of the different instances. High dominance implies, for the landscape associated to the instance, a collection of rugged plateaus at different levels of fitness. Low dominance corresponds to a rugged landscape without any dominating peak. Consequently, it is expected that the hybrids perform better than both GA and TS on instances with medium flow dominance as long as their landscape is intermediate and the hybrids combine the advantages of this two algorithms.

References

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*Ecole des Mines de Douai, 941 rue Charles Bourseul, BP 838, 59508 Douai Cedex, France, bachelet@lifl.fr

†Laboratoire d'Informatique du Littoral, BP 719, 62228 Calais Cedex, France, preux@lil.univ-littoral.fr

‡Laboratoire d'Informatique Fondamentale de Lille, URA CNRS 369, Cité scientifique, 59655 Villeneuve d'Ascq Cedex, France, talbi@lifl.fr

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