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Coalition-based metaheuristic: a self-adaptive metaheuristic using reinforcement learning and mimetism

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Abstract We present a self-adaptive and distributed metaheuristic called Coalition-Based Metaheuristic (CBM). This method is based on the Agent Metaheuristic Framework (AMF) and hyper-heuristic approach. In CBM, several agents, grouped in a coalition, concurrently explore the search space of a given problem instance. Each agent modifies a solution with a set of operators. The selection of these operators is determined by heuristic rules dynamically adapted by individual and collective learning mechanisms. The intention of this study is to exploit AMF and hyper-heuristic approaches to conceive an efficient, flexible and modular metaheuristic. AMF provides a generic model of metaheuristic that encourages modularity, and hyper-heuristic approach gives some guidelines to design flexible search methods. The performance of CBM is assessed by computational experiments on the vehicle routing problem.

Keywords Combinatorial optimization · Metaheuristic · Multiagent system · Hyper-heuristic

1 Introduction

Several recent frameworks of metaheuristics such as I&D Frame (Blum and Roli 2003), Adaptive Memory Programming (AMP) (Taillard et al. 2001) and MAGMA

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(Milano and Roli 2004) tend to put the emphasis on simplicity, flexibility and modularity of metaheuristics. These features constitute important criteria for an effective use of metaheuristics, and have been put forward in several articles and surveys (Voss 2001; Blum and Roli 2003).

In Cordeau et al. (2005), the authors defined the simplicity and flexibility criteria in these terms: "Simplicity relates to ease of understanding and coding of an algorithm" and "Flexibility measures the capacity of adapting an algorithm to effectively deal with additional constraints". In addition, robustness can be viewed as the ability to solve different instances of a same problem while maintaining computational performance. Finally, modularity is the capacity of an algorithm to be reused, hybridized or parallelized.

Distributed Artificial Intelligence (DAI), particularly multiagent systems, seems to be a promising field of research to tackle these new issues. Multiagent approach is tightly linked to metaheuristics considering that both approaches can exploit the social metaphor and self-organization paradigm. Thus, multiagent concepts are widely used in metaheuristics, particularly for population-based, hybrid and distributed metaheuristics. For instance, the concept of agent is explicitly used in Co-search metaheuristic (Talbi and Bachelet 2004) or MAGMA's metaheuristics architecture (Milano and Roli 2004). The advantages of using multiagent approach for metaheuristics may be justified by the distribution and robustness inherent to multiagent systems and the need of flexibility and modularity.

The aim of this work is to explore how DAI methods and tools might be exploited to conceive efficient, flexible and modular metaheuristics. To do so we present in this article a Coalition-Based Metaheuristic (CBM). This method, introduced in Meignan et al. (2008a), is based on the Agent Metaheuristic Framework (AMF) and hyperheuristic approach. In CBM, several agents organized in a coalition concurrently explore the search space of an optimization problem. These agents cooperate to perform a better search of solutions. The cooperation consists in exchanging information about the search space and sharing experiences to improve the agents' behavior. The main features of this approach are the use of a heuristic decision process, the introduction of unsupervised learning mechanisms and the exploitation of cooperation between agents. This metaheuristic is then applied to solve the Vehicle Routing Problem (VRP). Computational results are reported to confirm the effectiveness of learning mechanisms and to compare our approach with existing metaheuristics.

This paper is organized as follows. Section 2 introduces the Agent Metaheuristic Framework. Section 3 presents the Coalition-Based Metaheuristic. Then, Sect. 4 is devoted to the application of the metaheuristic to the VRP. The last section gives some conclusions and perspectives.

2 The agent metaheuristics framework

The Coalition-Based Metaheuristic presented in the next section is build from Agent Metaheuristic Framework (AMF) (Meignan et al. 2008b). This framework aims at analyzing existing algorithms, and facilitating the design of hybrid or new metaheuristics. It proposes an organizational model of metaheuristics that can be used