Using a Large Set of Low Level Heuristics in a Hyperheuristic Approach to Personnel Scheduling

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Summary. A hyperheuristic is a high-level search method which manages the choice of low level heuristics, making it a robust and easy to implement approach for complex real-world problems. We only need to develop new low level heuristics and define the objective functions in order to apply a hyperheuristic to an entirely new problem. Although hyperheuristic methods require limited problem-specific information, their performance for a particular problem is determined to a great extent by the quality of low level heuristics used. This chapter addresses the question of designing the set of low level heuristics for the problem under consideration. We construct a large set of low level heuristics by using a technique which allows us to “multiply” partial low level heuristics. We apply hyperheuristic methods to a trainer scheduling problem using commercial data from a large financial institution. The results of the experiments show that simple hyperheuristic approaches can successfully tackle a complex real-world problem provided that low level heuristics are carefully selected to treat various constraints. We examine experimentally how the choice of different sets of low level heuristics affects the solution quality.

1 Introduction

Given its economic importance, there is continuing research interest in solving real-world personnel scheduling problems. The purpose of personnel scheduling is to allocate the available workforce to timeslots and locations and to assign particular tasks to each member of staff optimising...
various measures such as worker quality of life, workforce utilisation and service quality. However, real-world scheduling problems require increasingly complex models and finding optimal solutions may require prohibitive amounts of computer time. Heuristic methods are often used in practice, which produce solutions of acceptable quality in reasonable time. Various metaheuristic approaches have been developed and successfully applied for different personnel scheduling problems. Recent examples include fast local search and guided local search algorithms applied to British Telecom’s workforce scheduling problem [24]; a simulated annealing approach for shift scheduling problems [23]; tabu search applied to audit staff scheduling [10]; different approaches to tackle a nurse rostering problem, specifically tabu search with strategic oscillation [11], genetic algorithms [1], and memetic algorithms and their hybrids with tabu search [2].

Although metaheuristics and especially their hybrids have proved to be quite efficient for solving some real-world scheduling problems, their application is usually dependent on the problem domain. Specific metaheuristic approaches designed to effectively solve a particular problem may not be applicable or may produce very poor solutions for other problems or even for the other instances of the same problem. Metaheuristics incorporate information specific for the problem and require expertise both in the problem domain and in heuristic methods. Therefore, metaheuristics are often quite expensive to implement [7]. For that reason, development of general domain-independent heuristic search techniques has received increased attention from researchers. These new approaches have recently become known as hyperheuristics and their development is described by Burke et al. [3] as “an emerging direction in modern search technology”.

The term “hyperheuristic” was introduced in [7], as an approach that manages the choice of which low level heuristic method should be applied at any given time, depending upon the characteristics of the region of the solution space currently under exploration, and the history of each low level heuristic. This means that a hyperheuristic does not search directly for a better solution of the problem but instead it looks for a method by which a promising solution can be obtained. A hyperheuristic requires limited domain-specific information which is concentrated in the set of low level heuristics and the objective function(s). Low level heuristics usually represent simple local search neighbourhoods or the rules used by a human expert for constructing solutions.

Several hyperheuristic approaches have been presented over recent years. Gratch and Chien in [14] develop a general adaptive problem-solving approach which automatically acquires domain-specific information and selects well-suited heuristic method from a given set. In [20], Randall and Abramson develop a general metaheuristic based solver for