Chapter XIII
Evolutionary Multi-Objective Optimization for Assignment Problems*

Mark P. Kleeman
Air Force Institute of Technology, USA

Gary B. Lamont
Air Force Institute of Technology, USA

ABSTRACT

Assignment problems are used throughout many research disciplines. Most assignment problems in the literature have focused on solving a single objective. This chapter focuses on assignment problems that have multiple objectives that need to be satisfied. In particular, this chapter looks at how multi-objective evolutionary algorithms have been used to solve some of these problems. Additionally, this chapter examines many of the operators that have been utilized to solve assignment problems and discusses some of the advantages and disadvantages of using specific operators.

INTRODUCTION

The application of multi-objective evolutionary algorithms (MOEAs) to solving multi-objective assignment problems has been quite successful and continues to make strides towards solving more complex real-world problems of this type. This chapter is devoted to a wide spectrum of such multi-objective assignment problems that indicate MOEA competitive or improved results over other approaches. In discussing various MOEA applications to multi-objective assignment categories, the specific problem domain is exhibited and the selected MOEA structure illuminated. Experimental results are summarized and the impact of the various MOEA op-

erators and parameters on the results discussed. The intent is to provide insight for selection of MOEA operators and parameters values for a new variation of a multi-objective assignment problem. Multi-objective assignment problem categories addressed range from extended classical NP-Complete and personnel management problems to causality assignment and frequency assignment problems. Contemporary references provide extended details of the various MOEA applications to multi-objective assignment problems. For a discussion on assignment problems in general and their mathematical derivation, see the books by West (2001) and Garey (1979).

Specific multi-objective assignment problems are presented in Section II along with a brief discussion of the MOEA application. The assignment problem examples include the linear gate assignment problem, the multi-objective quadratic assignment problem, the airman assignment problem, causality assignment problem fixed channel assignment problem, frequency assignment problem, multilevel generalized assignment problem, and resource allocation problem. The characteristics of these assignment problems range from linear to nonlinear fitness functions with limited constraints to a multitude of constraints. Assignment problem representations, MOEA operators and their appropriate selection for assignment problems are discussed in Section III. Representations can be fixed or variable with classical and extended crossover and mutation methods discussed.

MULTI-OBJECTIVE ASSIGNMENT PROBLEMS

Researchers have used many different types of algorithms and heuristics to solve a wide variety of assignment problems. The generic assignment problem is in reality a maximum weighting matching problem in a weighted bipartite graph. In general, it can be described as assigning a number of agents to a number of tasks while minimizing the total assignment cost. Single objective variations include the linear fitness assignment problem, the quadratic assignment problem, the bottleneck assignment problem, and others with linear and nonlinear constraints. The precise variety of assignment problems is reflected in different mathematical models. Techniques for solving these single objective assignment problems include the Hungarian algorithm, the simplex algorithm, Tabu search, simulated annealing, and genetic algorithms. Instead of aggregating a multi-objective assignment problem into a single objective model, we attempt to address the multi-objective model directly and focus on the use of MOEAs.

This chapter focuses on multi-objective assignment problems with two or more competing objectives that have been solved using a variety of evolutionary algorithms. However, some aggregated fitness as well as multiple fitness functions are discussed via a variety of applications. Each subsection presents a different type of multi-objective assignment problem and briefly describes the problem domain and the algorithm used. The experimental results are also summarized. Mathematical models reflecting the exact mathematical structure of an assignment problem are found in the associated references. Such models are very useful in generating computational software and should be understood, but they are not presented in this chapter since the focus is on MOEA evaluation. The intent is to generalize in the following sections the various algorithmic approaches and operators and thus provide insight as to appropriate selection of MOEA operators within the specific problem domain.

Linear Gate Assignment Problem

The linear gate assignment problem (LGAP) is related to logic gate matrix layout and programmable logic arrays folding. The problem concerns the assignment of a set of circuit elements in a