A Multi-Objective Particle Swarm Optimization for Web Service Composition

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Abstract. The main advantage of the web services technology is the possibility of preparing a compound web service with the existing to perform a proper task, but a service may be presented by several producers which one different in the quality of services. An adaptive process should select the elements of a compound web service in a way to answer effectively the user's needs in the quality of the services. There may be contrast in the optimization of the services qualities for some of them and against the others so we are involved with a multi multi-objective optimization. In this paper a web service composition model based on the Discrete Multi-Objective Particle Swarm Optimization is presented at which besides using the main advantages of standard PSO namely simplicity and speed a Pareto optimal set is presented as solutions.

Keywords: Web Service Composition, QoS, Multi-Objective Particle Swarm Optimization (MOPSO).

1 Introduction

Currently increasingly Web services, as possible instrument of accessing web-based applications, have been adopted [1]. Web service technology devotes more flexibility and adaptability to applications because a number of loose coupling components, namely Web services, corporate to obtain a common goal. Now, most companies motivate towards deploying business processes as web services compositions [3]. Also, the composition of web services has received much interest to support B2B or enterprise application integration [4].

With the improvement of the net and growth of web users, simple services are no longer suitable for web users and in order to give more complex services, we need combine simple services but there are different services which have the same functionality and can replace one another. These services are of course different with regard to quality factors such as response time, availability, throughput, security, reliability, execution cost and etc. Therefore web service composition problem leads to quality engineering problem, because these services should be chosen in such a way that the best QoS is prepared for the total composition.

Therefore, at the step of service composition it is very important to select services which are relied on non-functional QoS (Quality of Service) attached to each service, where Web Services selection based on QoS is a NP problem [6]. Effective strategies
based on evolutionary algorithms (EA) are introduced to overcome this problem. The majority of these approaches [7-12] on Web Services selection are almost QoS locally optimal or single-objective. In ref. [7-9] the authors introduced a Genetic Algorithm with a penalty technique to handle infeasible solutions. Difference between them is in coding scheme and in the design of penalty functions. Ref. [10] takes advantage of simulated annealing algorithm to avoid premature convergence of Genetic Algorithm. Ref. [11] proposed a service selection optimization method based on particle swarm optimization. But in all of these approaches the multiple QoS indexes optimization problem is turned into a single-objective problem using a weighted method, which will inevitably miss some feasible solutions.

To solve these problems, in this paper we proposed a discrete multi-objective particle swarm optimization (MOPSO) for the optimal web service composition. The main objective of the Multi-Objective Optimization (MOO) is finding the set of acceptable (trade-off) Optimal Solutions. This set of accepted solutions is called Pareto front. These acceptable trade-off solutions give more ability to the user to make an informed decision by seeing a wide range of near optimal solutions that are near optimum from an “overall” standpoint. Single Objective (SO) optimization may ignore this trade-off viewpoint [12], which is crucial.

This paper is organized as follows. In the next section we present preliminary introduction to Multi-objective optimization. The general PSO algorithm is reviewed in section 3. Section 4 describes the web service composition problem. We will introduce our proposed multi-objective PSO in Section 5. A comparison with a genetic algorithm and experimental results are given in Section 6. Finally, we conclude the paper in Section 7.

2 Multi-Objective Optimization

Many optimization problems the aim is to find solutions that are best with regard to various objectives. These optimization problems are named multi objective and they are usually hard computing. Evolutionary based algorithms have been successfully used for these types of problems because they simultaneously work with a population of points that is crucial to find the non-dominated solution set [13]. The concept of no dominance [14] is one of the basic concepts of multi objective. For a problem having more than one objective function to optimize any two solutions \( x_1 \) and \( x_2 \) can have one or two possibilities: one dominates the other or none dominates the other. A solution \( x_1 \) is said to dominate the other solution \( x_2 \) if both the following conditions are true:

a) The solution \( x_1 \) no worse than \( x_2 \) in all objectives.
b) The solution \( x_1 \) is strictly better than \( x_2 \) in at least one objective.

If \( x_1 \) dominates the solution \( x_2 \), it is also customary to write \( x_2 \) is dominated by \( x_1 \), or \( x_1 \) is not dominated by \( x_2 \), or simply, between two solutions, \( x_1 \) is the non-dominated solution.

A solution is said to be\textit{ Pareto optimal} if and only if there is no other solution in the search-space that dominates it. This set of Pareto optimal solutions is called the Pareto optimal set.