Chapter 11

POPULATION LEARNING ALGORITHM FOR THE RESOURCE-CONSTRAINED PROJECT SCHEDULING

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Abstract The paper proposes applying the population-learning algorithm to solving both the single-mode and the multi-mode resource-constrained pro-ject scheduling problems (denoted as RCPSP and MRCPSP, respectively) with makespan minimization as an objective function. The paper contains problem formulation and a description of the proposed implementation of the population learning algorithm (PLA). To validate the approach a computational experiment has been carried out. It has involved 1440 instances of the RCPSP and 3842 instances of the MRCPSP obtained from the available benchmark data sets. Results of the experiment show that the proposed PLA implementation is an effective tool for solving the resource-constrained project scheduling problems. In case of the RCPSP instances the algorithm in a single run limited to 50000 solutions generated has produced results close to the results of the best known algorithms as compared with average deviation from critical path. In case of the MRCPSP instances the proposed algorithm in a single run has produced solutions with mean relative error value below 1.6% as compared with optimal or best known solutions for benchmark problems.

Keywords: Project scheduling, RCPSP, MRCPSP, Population Learning Algorithm.

11.1 Introduction

The paper proposes applying the population-learning algorithm (PLA) to solving instances of the single-mode and the multi-mode resource-con-strained project scheduling problems (denoted as RCPSP and MRCPSP, respectively) with makespan minimization as an objective function. In the single-mode case a project consists of a set of activities, where each activity has to be processed

in a single, prescribed way (mode). Each activity requires some resources, availability of which is constrained. The discussed problem is computationally difficult and belongs to the NP-hard class. Because of its practical importance RCPSP has attracted a lot of attention and many exact and heuristic methods have been proposed for solving it (see for example Davis and Heidorn (1971), Hartmann (2001), Hartmann and Drexl (1998), Hartmann and Kolisch (2005)). In the multi-mode case activities can be executed in one out of several modes. The modes reflect alternative combinations of resource quantities employed to fulfill the activities. As it was observed in Sprecher and Drexl (1998), in such a case the activity duration is a discrete function of the employed quantities, that is, using this concept e.g. working-off an activity can be accelerated by raising the quantities coming into operation (time/resource trade-off). Moreover, by raising the quantities of some resources and reducing the quantities of others resource substitution (resource/resource trade-off) can be realized.

Exact algorithms seem suitable only for solving relatively small instances of the RCPSP and MRCPSP. For larger and more realistic instances an approach based on approximate algorithms is required. Such algorithms can be evaluated experimentally. Usual approach is to use the existing set of benchmark instances with known lower bounds, optimal solutions or upper bounds. Criteria for such an evaluation include, usually, two factors - quality of solutions obtained and computational effort required. Interesting evaluation of the heuristic and meta-heuristic algorithms for the resource-constrained project scheduling problem can be found in Hartmann and Kolisch (1999), Hartmann and Kolisch (2000) and Hartmann and Kolisch (2005). Some recent approaches based on hybrid algorithms and metaheuristics yield a very competitive solutions Jozefowska et al (2001), Nonobe and Ibaraki (2002), Debels et al (2004), Debels and Vanhoucke (2005), Valls et al (2004).

In this paper an approach based on implementation of the population-learning algorithm belonging to the class of population-based methods is proposed. The PLA has proven quite successful in solving some other difficult scheduling problems (for example see Jedrzejowicz and Jedrzejowicz (2002)). The paper is organized as follows: Section 11.2 includes problem formulation. Section 11.3 presents main features of the population-learning algorithm. Section 11.4 contains details of the proposed implementations of PLA designed to solving both - the single-mode and the multi-mode resource-constrained project scheduling problems. Section 11.5 presents validating experiment and its results. Section 11.6 includes conclusions and suggestions for future research.

11.2 Problem formulation

A project that belongs to the class of the single-mode resource-con-strained project scheduling problem consists of a set of n activities, where each activity