Multi-project scheduling using an heuristic and a genetic algorithm

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Abstract Managing multiple projects is a complex task. It involves the integration of varieties of resources and schedules. The researchers have proposed many tools and techniques for single project scheduling. Mathematical programming and heuristics are limited in application. In recent years non-traditional techniques are attempted for scheduling. This paper proposes the use of a heuristic and a genetic algorithm for scheduling a multi-project environment with an objective to minimize the makespan of the projects. The proposed method is validated with numerical examples and is found competent.

Keywords Genetic algorithm · Heuristic · Multiproject scheduling · Project management · Resource allocation · Resource constraints

1 Introduction

New product development, variety product manufacturing, maintenance of systems, infrastructure constructions are few vital areas of multiproject environment. In a multi project environment problem a number of projects must concurrently share limited resources with in the equivalent precedence constraints. Each activity in a project must be performed in a particular mode with specified duration and resource requirements. Most of the techniques developed in the past favored scheduling a single project or multiproject represented as a single project [1]. Mathematical techniques for scheduling project activities with constraints are extremely cumbersome [2] and become seldom possible for multiproject. Efficient and effective scheduling for multiproject environment needs attention.

1.1 Heuristics in project scheduling

Heuristic refers to a particular approach to decision-making that is rapidly growing in application and importance [3]. Heuristic procedures and scheduling rules are aimed at the development of good solutions [4]. Researchers have contributed many such heuristics for project scheduling [5–10]. The heuristic approaches are discussed in the recent survey by Kolisch and Drexl [11], in which extensive experiments are carried out on a set of 536 test problems [12] and four different heuristic methods [13, 14], and are compared with the optimal solutions and are found to be a viable solution, but very inconsistent.

1.2 Genetic algorithm in scheduling

The ideas involved in genetic algorithms (GAs) were originally developed by Holland [15] and described in greater detail by Goldberg [16]. Genetic algorithms are search techniques for global optimization in a complex search space. As the name suggests, they employ the concepts of natural selection and genetics. Using past information they direct the search such that the expected performance will be improved. Although genetic algorithms have already been applied to a wide range of different problem domains, only a few approaches have tried to apply them to scheduling problems until now and, moreover, most of them have been restricted to job shop, flow shop scheduling problems [17, 18] or production scheduling problems [19]. Portmann [20] has presented a detailed survey on GA’s in the area of scheduling with analyses of the effects of various operators like encoding, crossover, and mutation. Maso and Ching [21] proposed a genetic algorithm for a multi-mode multi-resource constrained scheduling problem but with an assumption of non-pre-emptiveness. Leu and Yang [22] proposed a GA based multicriteria optimal model for construction scheduling. Hegazy [23] proposed a genetic algorithm in optimization of resource allocation and leveling. Latter Reddy et al. [24] proposed a genetic algorithm approach to multi-mode multi-
resource constrained project scheduling with pre-emption and decision nodes. Most of the researchers have mentioned single project scheduling with resource constraints using heuristic and non-traditional techniques. Attention is needed for scheduling multiproject with resource constraints using non-traditional techniques.

2 Problem definition

The problem consists of the number of projects P.

- Each project consists of N activities; activities are labeled form 1 to N, with activity N being the unique terminal job without successors.
- Activity i may be performed in any one mode j = 1. Each job will have a specific mode and must be finished without changing mode.
- Scheduling activity i in mode j takes $d_{ij}$ time units (duration).
- Activity i cannot start unless all of its predecessors have been completed.
- Activity preemption is not allowable.
- There are K kinds of the resources, where resource k is available in quantity $Q_k$ per period. Scheduling activity i in mode j use $q_{ijk}$ resources units per period from resource K.

3 Proposed methodology

The proposed methodology for multiproject scheduling is given in Fig. 1. The details of the genetic coding, evaluation, crossover and mutation for the proposed algorithm are as follows.

Fig. 2 Genetic coding for the proposed methodology