Improved Methods for Scheduling Partially Ordered Jobs Under Resource Constraints

Sanjay Verma[†]

Indian Institute of Management Calcutta

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Thesis Advisory Committee:

Prof. Amitava Bagchi (thesis supervisor), Indian Institute of Management Calcutta

Prof. Subir Bhattacharya, Indian Institute of Management Calcutta

Prof. Nilotpal Chakroborti, Indian Institute of Management Calcutta

Thesis Examination Committee:

Prof. Amitava Bagchi, Indian Institute of Management Calcutta

Prof. Ashish Chaterjee, Indian Institute of Management Calcutta

Prof. M C Puri, Indian Institute of Technology Delhi

Prof. M. R. Rao (IIMB), Indian Institute of Management Bangalore

[†] sverma@iimahd.ernet.in

Thesis Abstract

One of the most widely studied problems in the area of job scheduling is the Resource Constrained Project Scheduling Problem (RCPSP). A project consists of a set of activities partially ordered by precedence constraints. An activity has a given non-negative duration and uses different types of renewable resources such as manpower and machinery. The total number of available units of each resource type is constant and specified in advance. A unit of resource cannot be shared by two activities. An activity is ready to be processed only when all its predecessor activities are completed and the numbers of units of the various resource types required by it are free and can be allocated to it. Once started an activity is not interrupted and runs to completion. The objective is to assign start times to the activities so that the total project length (makespan) is minimized. Instead of the makespan, other regular measures can also be minimized. Examples of such measures are mean flowtime, maximum tardiness, and the number of tardy jobs.

This problem can be generalized to the situation in which instead of a project, a collection of partially ordered jobs are required to be scheduled on a given number of identical parallel machines so as to optimize a specified regular measure. Another possible generalization of the RCPSP relates to the maximization of the Net Present Value (NPV) of a project. In this problem, cash inflows and outflows occur during the execution of an activity. The objective is to schedule the activities in such a manner that the NPV of these cash flows is maximized.

The primary objective of this work is to present improved exact methods that solve the above problems. Two tree-search schemes based on breadth-first search and best-first search are described which, with appropriate modifications, solve each of the above three types of problems. Theoretical proofs of optimality are included. The algorithms have been extensively tested both on standard benchmark problems and on randomly generated problems and have been found to perform better than the best existing methods in most situations of interest. A method for systematically generating random test problems at graded levels of difficulty is also described.