FINDING THE OPTIMAL SOLUTION FOR A SPECIAL CASE OF THE FIXED INTERVAL JOB SCHEDULING PROBLEM WITH DIFFERENT PROCESSOR SIZE REQUIREMENTS AND A HIERARCHICAL STRUCTURE

Jim Chen, Norfolk State University, Norfolk, Virginia, U.S.A.
V. Reddy Dondeti, Norfolk State University, Norfolk, Virginia, U.S.A.
Bidhu B. Mohanty, Norfolk State University, Norfolk, Virginia, U.S.A.

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ABSTRACT

In many operational scheduling problems, we encounter situations wherein a resource with a higher capacity can undertake a job that requires a resource with a lower capacity, but not vice versa. For example, a crane with a lifting capacity of 40 tons can be used, if necessary, to lift a load of 27 tons at a construction site, but a crane with a lifting capacity of only 30 tons cannot be used to lift a load of 35 tons. Another familiar example is the assignment of airplanes to different flights. In almost all such cases, a resource that has a higher capacity is a lot more expensive than the one with a lower capacity. Further, each task has to be completed in a time interval that may be fixed or flexible. In the literature, job scheduling problems like these are called Hierarchical Class Scheduling Problems (HCSP), because of the hierarchical structure of their capacity requirements. For problems like these, currently no viable algorithmic techniques are available to determine the optimal mix of resources or processors needed to complete all the jobs on schedule, in spite of the availability of modern powerful computers. Scheduling problems of this type, among many others, are categorized as NP-hard problems in the specialized field of computer science that deals with the subject of computational complexity and solvability of problems. In this paper, we consider a special case of the Hierarchical Class Scheduling Problem (HCSP) and present some propositions that help us find the optimal solution for the special case.

Keywords*: Fixed Interval Scheduling, Hierarchical Class Scheduling, NP-hard Problems*

1. INTRODUCTION

Scheduling problems arise in almost all types of organizations. Also, the scheduling problems encountered by all organizations have some common characteristics, regardless of the scale and nature of the operations of the organizations. We refer to any type of resource that is needed to complete a task or a job as a processor. In general, there could be many different types of processors and a job may require one or more processors with specified capacities or higher.

This requirement implies that from a feasibility point of view, it may be expeditious or advantageous to assign a processor with a bigger capacity to complete a job that requires a processor with a smaller capacity, though in economic terms, a bigger processor or a resource with a higher capacity might cost a lot more than a smaller processor or a resource that has a lower capacity.

Of course, the hierarchical capacity requirement also implies that a smaller processor cannot be assigned to a job that requires a processor with a higher capacity. Obviously, for every job there are deadlines associated with its starting and completion times, which may be fixed or flexible. In addition, the time required to finish a job once the processor starts working on it may be uncertain and not known in advance. In essence, we have to deal with the capacity requirements and the deadline constraints imposed on the start and finish times of the jobs in a typical scheduling problem.

Often these problems are called “Interval Scheduling” problems (ISP) and several different versions of the ISP and algorithms to solve them are described in Kolen et al. (2007), and Kovalyov et al. (2007). It is extremely difficult to solve such scheduling problems and arrive at a schedule for completing the jobs at the lowest cost even with the modern powerful computers. In the parlance of computer science, such problems are known as NP-hard problems (Garey and Johnson, 1979).