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Scheduling with High Multiplicity

Marc E. Posner
Professor of Operations Research
Department of Industrial, Welding and Systems Engineering
The Ohio State University

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When a production shop has a large number of identical parts, the parts are often recorded by a part description and quantity. This differs from the type of description used by standard scheduling problems, which assume all parts or jobs are unique. In high-multiplicity scheduling problems, identical jobs are encoded in an efficient format similar to that of the production shop. The input describes one of the jobs and the number of such identical jobs. Identical machines can also be encoded in high-multiplicity format. We analyze several classes of parallel machine problems where the objective is to minimize the sum of completion times. For several problems, we demonstrate that the recognition versions can be solved in polynomial time, while the optimization versions require pseudo-polynomial time. Also, some general complexity results for high-multiplicity encoding are established.

We also consider a single machine, earliness-tardiness problem with job-specific weights. High-multiplicity techniques are used to provide a new method for creating a lower bound for this NP-complete problem. We disaggregate each job into identical sub-jobs with unit processing times. Then, using high-multiplicity encoding for this disaggregated problem, we create a lower bound on the optimal objective function value of the original problem in polynomial time. Heuristic solutions are generated using a randomized rounding technique on the lower bound solution. These results are used in a branch and bound solution method. Analytical and computational results are presented. Our combination of disaggregation and high-multiplicity encoding provides a new method for creating lower bounds on the objective functions of NP-complete problems.

Marc E. Posner is a Professor of Operations Research in the Industrial, Welding and Systems Engineering Department at The Ohio State University. He received a B.A. in Mathematics form Brandeis University, and an M.S. and Ph.D. in Operations Research from the University of Pennsylvania. He has published in most of the major operations research journals on a variety of topics ranging from the construction of statistical decision rules to decomposing nonlinear programming problems. Currently, his research is primarily in the field of deterministic optimization with an emphasis on integer programming. He is interested both in heuristic and exact methods. A recent area of focus is on scheduling and production problems.