ERCIM “Alain Bensoussan” Fellowship Scientific Report

Fellow: András Kovács
Visited Location: Cork Constraint Computation Centre, UCC, Ireland
Duration of Visit: 01/01/2006 – 30/09/2006

I - Scientific activity

Modelling and solving capacitated lot-sizing and scheduling problems with sequence-dependent setups (with Kenneth N. Brown and S. Armagan Tarim, Cork Constraint Computation Centre)

Although capacitated lot-sizing and scheduling problems have been studied in Operations Research for many years, the common practical requirement of sequence-dependent setup times still presents a challenge for current optimization techniques. We introduced a novel MIP formulation of the single-machine capacitated lot-sizing and scheduling problem with sequence-dependent setup times and setup costs. The approach is based on determining during pre-processing all item sequences that can appear in given time periods in optimal solutions. The sequences are used in a mixed-integer program in which binary variables indicate whether individual items are produced in a period, and parameters for this program are generated by a heuristic procedure in order to establish a tight formulation. Our model allows us to solve significantly larger problems than what was tractable by earlier optimal solution methods, and it often achieves orders of magnitude speedup.

These results have been published at a conference, and a journal paper has also been submitted. Currently, we are considering the possibilities of generalizing our results to the multi-machine case and the stochastic version of the problem where demand is described by random variables with known probability density functions.

Propagating the total weighted completion time objective function in constraint-based scheduling (with J. Christopher Beck, University of Toronto, and Kenneth N. Brown, Cork Constraint Computation Centre)

While constraint programming is considered one of the most effective approaches to modelling and solving scheduling problems, its computational efficiency is limited to certain maximum-type objective functions. The purpose of our research was to extend the applicability of constraint-based scheduling to other, practically relevant sum-type optimization criteria. This required from us the definition of constraint propagation algorithms for the given objective functions, since these are not available in the literature.

We developed a novel constraint propagation algorithm for the total weighted completion time objective function in single-machine scheduling problems. It is based on a list scheduling algorithm for the pre-emptive relaxation of the scheduling problem, and has been implemented in Ilog Scheduler. In computational experiments, the application of the novel constraint propagator resulted in an orders of magnitude speedup compared to the former, naïve constraint-based model of the scheduling problem.

We are planning to generalize our propagation algorithm to multi-machine project scheduling problems, and publish the results at a forthcoming conference.

II- Publication(s) during your fellowship

András Kovács, József Váncza. Progressive Solutions: A Simple but Efficient Dominance Rule for Practical RCPSP. In: Proc. of CPAIOR 2006, Springer LNCS 3990, pp. 139-151, 2006.

Abstract. This paper addresses the solution of practical resource-constrained project scheduling problems (RCPSP). We point out that such problems often contain many, in a sense similar projects, and this characteristic can be exploited well to improve the performance of current constraint-based solvers on these problems. For that purpose, we define the straightforward but generic notion of progressive solution, in which the order of corresponding tasks of similar projects is deduced a priori. We prove that the search space can be reduced to progressive solutions. Computational experiments on two different sets of industrial problem instances are also presented.

András Kovács, Kenneth N. Brown, S. Armagan Tarim. An Efficient MIP Formulation for the Capacitated Lot-sizing and Scheduling Problem with Sequence-dependent Setups. In Proc. of the 14th International Symposium on Inventories, p. 77, 2006.

Abstract. Although capacitated lot-sizing and scheduling problems have been studied in Operations Research for many years, the common practical requirement of sequence-dependent setup times still presents a challenge for current optimization techniques. We propose a novel MIP formulation of the single-machine capacitated lot-sizing and scheduling problem with sequence-dependent setup times and setup costs. The approach is based on generating in a pre-processing step all efficient item sequences that might be produced within a time period, as well as using item-related binary variables in the MIP. Our model allows us to solve instances with 4 items and 20 time periods or 10 items and 6 time periods in reasonable time. Compared to the best previously published MIP, it solves significantly larger problems, often with orders of magnitude speedup.

András Kovács, Kenneth N. Brown, S. Armagan Tarim. Generating Efficient Models of Capacitated Lot-sizing and Scheduling Problems with Sequence-dependent Setups. Submitted to the International Journal of Production Economics.

Abstract. In this paper, we propose a novel mathematical programming approach to the single-machine capacitated lot-sizing and scheduling problem with sequence-dependent setup times and setup costs. The approach is based on determining during pre-processing all item sequences that can appear in given time periods in optimal solutions. The sequences are used in a mixed-integer program which uses binary variables to state whether individual items are produced in a period, and parameters for this program are generated by a heuristic procedure in order to establish a tight formulation. Our model allows us to solve in reasonable time instances where the product of the number of items and number of time periods is at most 60–70. Compared to known optimal solution methods, it solves significantly larger problems, often with orders of magnitude speedup.

III -Attended Seminars, Workshops, and Conferences

- CP-AI-OR 2006, 3rd International Conference on Integration of AI and OR Techniques in Constraint Programming for Combinatorial Optimization Problems. May 30-June 2, 2006, Cork, Ireland
- 14th International Symposium on Inventories. August 21-25, 2006, Budapest, Hungary.