ERCIM "Alain Bensoussan" Fellowship Scientific Report

Fellow:	András Kovács
Visited Location:	INRIA Rocquencourt, France
Duration of Visit:	01/10/2006 – 30/06/2007

I - Scientific activity

Global cost constraints for total weighted completion time (with J. Christopher Beck, University of Toronto, Canada)

In the second period of the fellowship, we continued our research on the definition of global cost constraints for scheduling. We expect this work to extend the applicability of constraint-based solution techniques to scheduling with various practically important sum-type optimization criteria.

We introduced a novel global cost constraint, called COMPLETION, for the total weighted completion time of activities on a single unary capacity resource. For propagating the constraint, we make use of the pre-emptive mean busy time relaxation of the scheduling problem. We investigated applications and extensions of the proposed constraint to different problem domains:

- Single unary machine scheduling problems for minimizing the total weighted completion time of activities, where the COMPLETION constraint applies directly;
- Multiple-machine project scheduling problems, where an additional question is how to relate jobs weights to activities;
- Discrete resource scheduling problems, which required an extension of the COMPLETION constraint and the definition of a novel lower bound;
- Container loading problems, where the discrete-resource version of the COMPLETION constraint can be used to bound the location of the center of gravity of the loaded container.

The COMPLETION constraint boosted the performance of current CP solution techniques on the above scheduling problems, while the application to container loading problems is an ongoing work.

The results of the research have been published in one conference paper (CPAIOR'07) and one submitted workshop paper (COPLAS'07). We are planning to submit an extended presentation of the result to an international journal.

Constraint-based solution techniques for warehouse management in the automotive industry (with François Fages, INRIA Rocquencourt, France)

We investigated the applicability of constraint-based solution techniques to various problems related to warehouse management in the automotive industry. The applications include the design of containers, the re-design of the line-side storage area, and the scheduling of replenishment activities. In this research we benefited from the cooperation of INRIA with a FIAT and PSA in the Net-WMS project. The early results of the investigations have been described in internal reports of INRIA.

This research is connected to the previous topic through the possible application of the COMPLETION constraint to the location of the centre of the gravity in container loading problems.

II- Publication(s) during your fellowship

Kovács, A., Beck, J.C. A Global Constraint for Total Weighted Completion Time. In: Proc. of CPAIOR 2007, the 4th Int. Conf. on Integration of AI and OR Techniques in Constraint Programming for Combinatorial Optimization Problems (Springer LNCS 4510), Brussels, pp. 112-126, 2007.

Abstract. We introduce a novel global constraint for the total weighted completion time of activities on a single unary capacity resource. For propagating the constraint, an $O(n^4)$ algorithm is proposed, which makes use of the preemptive mean busy time relaxation of the scheduling problem. The solution to this problem is used to test if an activity can start at each start time in its domain in solutions that respect the upper bound on the cost of the schedule. Empirical results show that the proposed global constraint significantly improves the performance of constraint-based approaches to single-machine scheduling for minimizing the total weighted completion time. Since our eventual goal is to use the global constraint as part of a larger optimization problem, we view this performance as very promising. We also sketch the application of the global constraint to cumulative resources and to problems with multiple machines.

Kovács, A., Beck, J.C. Extensions of the COMPLETION Constraint. Submitted to the COPLAS'07 Workshop on Constraint Satisfaction Techniques for Planning and Scheduling Problems, 2007.

Abstract. The COMPLETION global constraint has been proposed for single-machine, unary-resource, total weighted completion time scheduling problems where it has shown good performance. In this paper, we look at extending the constraint in three ways. First, we apply the constraint to multiple machine scheduling problems, in the form of job shop scheduling. It is shown that under the right allocation of weights to activities, the COMPLETION constraint results in significantly better scheduling performance compared to the standard expression of the weighted completion time. Second, we extend the constraint from the unary to discrete resources. This extension is more challenging that the first and our results indicate a decrease in choice points but an increase in overall solve time on a set of single-machine, discrete-resource problem instances. Finally, we propose a general framework, abstracting from the COMPLETION constraint, for developing cost-based global constraints.

Furthermore the following paper, written in the first period of the fellowship, has been accepted with a request for revision to an international journal. During revision, we have changed the original title to

András Kovács, Kenneth N. Brown, S. Armagan Tarim. An Efficient MIP Model for the Capacitated Lot-sizing and Scheduling Problem with Sequence-dependent Setups. Submitted to the International Journal of Production Economics.

III -Attended Seminars, Workshops, and Conferences

- CP-AI-OR 2007, 4th International Conference on Integration of AI and OR Techniques in Constraint Programming for Combinatorial Optimization Problems. May 23-26, 2007, Brussels, Belgium
- JFPC 2007, 3èmes Journées Francophones de Programmation par Contraintes. June 4-6, 2007, Rocquencourt, France
- CSCLP 2007, Annual ERCIM Workshop on Constraint Solving and Constraint Logic Programming. June 7-8, 2007, Rocquencourt, France