Tabu Search Algorithms For Cyclic Machine Scheduling Problems with blocking

Peter Brucker , **Thomas Kampmeyer***
Universität Osnabrück, Fachbereich Mathematik/Informatik
49069 Osnabrück
{Peter.Brucker, Thomas.Kampmeyer}
@mathematik.uni-osnabrueck.de

Abstract

A general framework is developed to model a large variety of different cyclic machine scheduling problems with blocking with the objective to minimize the cycle time. For this framework tabu search algorithms are developed. Neighborhoods are derived which generalize the block-approach based neighborhoods which have been successfully applied to noncyclic job-shop problems and cyclic job-shop problems without blocking.
keywords: Local Search, Machine Scheduling

Cyclic scheduling is concerned with the planning of activities that have to be identically repeated at regular intervals. Such types of scheduling problems arise in different application areas like compiler design, manufacturing, digital signal processing, railway scheduling, timetabling, etc. Hanen [2] introduces a general cyclic scheduling problem which among others contains the cyclic job-shop problem as special case. Brucker and Kampmeyer [1] developed tabu-search algorithms for this general problem. Now this general model is extended to cover also blocking situations. This is done by using the alternative graph model [3].

This General Cyclic Scheduling Problem (GCSP) can be described as follows. Let $T = \{1, \ldots, n\}$ be a set of generic tasks or operations (in connection with shop scheduling problems). Task (operation) i has processing time $p_i > 0$ and must be performed infinitely often. We denote by $< i; k >$ the k-th occurrence of the generic task i. A **schedule** assigns a starting time $t(i; k)$ to each occurrence $< i; k >$. A schedule is called **periodic** with cycle time α if $t(i; k) = t(i; 0) + \alpha k$ for all $i \in T,\ k \in \mathbb{Z}$.

We assume that $t_i := t(i; 0) \geq 0$ for all $i \in T$. A periodic schedule is defined by the vector $(t_i)_{i \in T}$ and the cycle time α.

Generalized precedence constraints of the form $t(i; k) + L_{ij} \leq t(j; k + H_{ij})$ may be given for all arcs $(i, j) \in E$ of a directed graph $G = (T, E)$ with vertex set T. L_{ij} is called (start-start) **delay** and H_{ij} is called the **height** of the generalized precedence constraint. Delays are assumed to be nonnegative integers while heights may be arbitrary integers. We also postulate that $t(i; k) + p_i \leq t(i; k + 1)$ is satisfied for all $i \in T$, $k \in \mathbb{Z}$.

Finally, associated with each task i there is a dedicated machine $M(i) \in M = \{1, \ldots, m\}$, on which each occurrence $< i; k >$ of i must be processed.

Consider two operations i and j which are processed on the same machine m. Assume, that both operations are blocking operations and operation i has a successor $s(i)$ and j has a successor $s(j)$.

Then we get the following disjunctive constraints:

$$t(s(i); l + H_{i,s(i)}) \leq t(j; k) \vee t(s(j); k + H_{j,s(j)}) \leq t(i; l) \quad (1)$$

*supported by Cusanuswerk

So the following problem must be solved.

$$\min \ \alpha \tag{2}$$

s.t.

$$t(i;k) = t(i;0) + \alpha * k \quad i \in T, k \in \mathbb{Z} \tag{3}$$

$$t(i;k) + L_{ij} \leq t(j;k+H_{ij}) \quad (i,j) \in E, k \in \mathbb{Z} \tag{4}$$

$$t(i;k) + p_i \leq t(i;k+1) \quad i \in T, k \in \mathbb{Z} \tag{5}$$

$$\begin{aligned} & t(s(i);l+H_{i,s(i)}) \leq t(j;k) \\ \vee \quad & t(s(j);k+H_{j,s(j)}) \leq t(i;l) \quad i,j \in T \text{ with } i \neq j, \\ & M(i) = M(j),\ k,l \in \mathbb{Z} \end{aligned} \tag{6}$$

To solve the GCSP we apply tabu-search. We develop several neighborhoods. Some of them are based on a generalization of results for the classical job-shop problem.

Computational tests have been performed by applying our tabu-search to cyclic job-shop and flow-shop problems.

References

[1] Brucker, P. and T. Kampmeyer: 2005, 'Tabu search algorithms for cyclic Machine scheduling problems'. *J. Sched.* **8**, 303–322.

[2] Hanen, C.: 1994, 'Study of a NP-hard cyclic scheduling problem: The recurrent job-shop'. *European J. Oper. Res.* **72**, 82–101.

[3] Mascis, A. and D. Pacciarelli: 2002, 'Job-Shop scheduling with blocking and no-wait constraints'. *European J. Oper. Res.* **143**, 498–517.