General and Skewed General Variable Neighborhood Search Approaches for Integrated Planning and Scheduling

Universidade do Minho
Escola de Engenharia

Mário Leite, Telmo Pinto, Cláudio Alves
{mario.leite, telmo, claudio}@dps.uminho.pt

1. Introduction

- **Planning and scheduling** processes **are strongly interrelated**, but they are usually addressed separately.
- To achieve **global optimal solutions**, the related optimization problems must be addressed all together in an **integrated way** [1].
- Here, we consider the Integrated Planning and Scheduling Problem (IPSP), as it was firstly proposed in [2].

2. Objectives

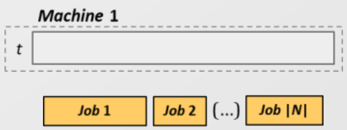
- New **heuristics and metaheuristic methods** to tackle the IPSP on parallel and identical machines [2];
- **Innovative neighborhood structures** specially designed for the IPSP **to be used** within **Variable Neighborhood Search** algorithm (**VNS**) and its variants General VNS (**GVNS**) and Skewed General VNS (**SGVNS**).

3. Problem Definition

The entire time horizon (T) is divided into τ **time periods** of length equal to $P \in \mathbb{N}$. There are $|M|$ **parallel and identical machines**, where the **set of jobs** N should be processed. Each **job** $j \in N$ has five attributes: **processing time** – $p_j \in \mathbb{N}$; **release date** – $r_j \in T$; **due date** – $d_j \in T$; **penalty factors** incurred when a job is completed before and after its due date – $e_j, l_j \in \mathbb{N}$, respectively.

Machines available time in each t period (*bins*)

Jobs processing time (*objects/packages*)



The objective of this IPSP is to **minimize the sum of all penalties** (w_t^j), where t represents the period in which job j will be processed:

$$w_t^j = \underbrace{e_j \times max\{0, d_j - t\}}_{\text{earliness}} + \underbrace{l_j \times max\{0, t - d_j\}}_{\text{tardiness}}$$

4. Neighborhood Structures

Table 1. Set of 12 jobs and attributes (**example**).

$(job)\ j$	1	2	3	4	5	6	8	9	10	11	12
r_j	1	1	1	1	1	1	1	2	3	1	1
d_j	1	1	1	1	1	2	3	3	3	1	3
p_j	3	2	2	4	4	2	2	1	4	2	3
e_j	0	0	0	0	0	10	4	7	0	0	5
l_j	10	5	12	10	9	10	8	12	10	3	8

$N = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12\}$,
$M = \{1, 2\}$, $P = 8$, $\tau = 3$

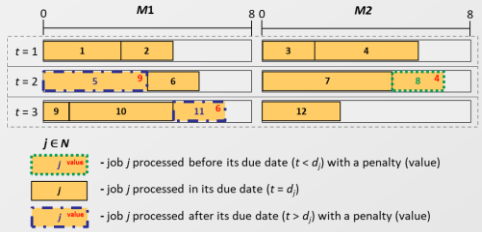


Fig. 1. A **feasible solution** S.

Fig. 2. $\mathcal{N}_1$ – Insertion of one job in another period. Solution $S' \in \mathcal{N}_1(S)$.

Fig. 3. $\mathcal{N}_2$ – Exchange between two jobs from different periods. Solution $S' \in \mathcal{N}_2(S)$.

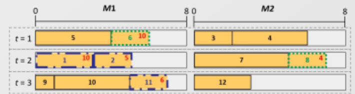


Fig. 4. $\mathcal{N}_3$ – Exchange between two different bins of different periods. Solution $S' \in \mathcal{N}_3(S)$.

Fig. 5. $\mathcal{N}_4$ – Exchange between two jobs from the same period, but from different machines, and an insertion of another job in the considered period. Solution $S' \in \mathcal{N}_4(S)$.

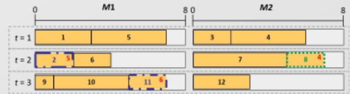


Fig. 6. $\mathcal{N}_5$ – Exchange between two jobs from necessarily adjacent periods. Solution $S' \in \mathcal{N}_5(S)$.

Fig. 7. $\mathcal{N}_6$ – Exchange between two jobs, from the same period, but from different machines. Solution $S' \in \mathcal{N}_6(S)$.

5. Computational Experiments

Experiments were performed on benchmark instances divided into three sets: **small jobs** (set A), **large jobs** (set C), and **half-half** (set B). Five runs for each instance (time limit of 5 seconds). The VNS, GVNS and SGVNS results were compared with the best results from **Exact Methods** (EM) [3].

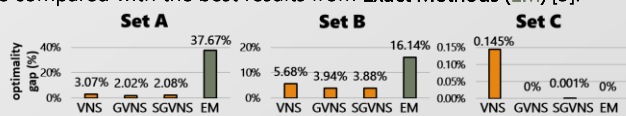


Fig. 8. Average **optimality gap** (in %).

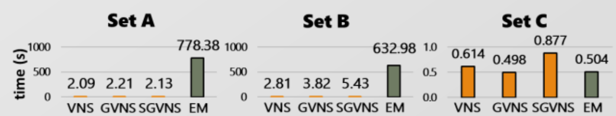


Fig. 9. Average **computational time** (in seconds).

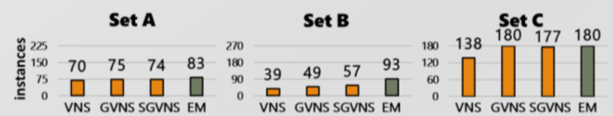


Fig. 10. **Number of instances** solved up to **optimality**.

6. Conclusions

The proposed approaches are able to obtain solutions very close to the optimal solutions (**low** values of the **optimality gap**). The major core of these approaches is the **very short time to achieve good quality solutions**, that are quite near the optimal solutions.

7. References

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[2] T. Kis and A. Kovács. A cutting plane approach for integrated planning and scheduling. Computers & Operations Research, 39(2):320–327, 2012.

[3] J. Rietz, C. Alves, N. Braga, and J. Valério de Carvalho. An exact approach based on a new pseudopolynomial network flow model for integrated planning and scheduling. Computers & Operations Research, 76:183-194, 2016.

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