Solving the Test Laboratory Scheduling Problem with Flexible Grouping

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Example schedule

**Project 1**

Job 1
(Tasks 1, 2, 3, 5)

Job 2
(Task 4)

Job 3
(Tasks 6, 7)

**Project 2**

Job 4
(Tasks 8, 9, 10, 11)

Job 5
(Task 12)

Job 6
(Tasks 13, 14, 15)

Job 7
(Task 16, 17)
A job consists of one or several tasks, which define its properties:

- Available resources: $R_j = \bigcap R_t$
- Time window: $\alpha_j = \max \alpha_t, \omega_j = \min \omega_t$
- ...
Constraint Programming

- **Major challenge**: representing grouping
- **Solution**: Representative task for each job
Constraint Programming: Example Constraints

- Resource availability:

\[ \text{assigned}[^{\text{repr}}[t], r] = 1 \implies r \in R_t \]

\[ \forall t \in \text{Tasks}, r \in \text{Resources} \]

- Resource requirements:

\[ \sum_{r \in \text{Resources}} \text{assigned}[t, r] = \begin{cases} 
\max_{t' \in \text{Tasks} : \text{repr}[t'] = t} |\text{Req}_{t'}| & \text{if } \text{repr}[t] = t \\
0 & \text{otherwise} 
\end{cases} \]

\[ \forall t \in \text{Tasks} \]
Very Large Neighborhood Search

Repeatedly generate and solve simplified CP instances:

- Only 1 project can be scheduled, the rest of the schedule is fixed
- Number increases when stuck
- Tabu list
- Some scheduling-only steps, with fixed grouping
Computational results

- 33 test instances (30 randomly generated, 3 real-world)
- Up to 1500 tasks (90 projects)
- Time limit: 2 hours
- 30 feasible solutions
- TLSP-S: fixed grouping given, results of Geibinger et al. (CPAIOR 2019)
Conclusions

- First constraint programming model for TLSP
- Mapping of tasks to each other allows handling of variable number of jobs
- Extension of VLNS for TLSP-S to work with TLSP
- Improved results despite unknown initial grouping
- New best known solutions for several large benchmark instances (including real-world data sets)
- Solution successfully deployed in test laboratory of a large company