Research Plan for Combinatorial Optimisation for Scheduling

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Background of the research

The problem of scheduling tasks arises in industries all the time. It is not hard to imagine that generating an optimized schedule can be of great profit for production or logistic operations. Optimization can for example be minimizing the overall required time or minimizing the delay before starting a task. Because this type of problem is so prevalent it has already been subject to much research.
Formally this specific type of problem is known as the resource-constrained project scheduling problem (RCPSP). On its own the problem definition for RCPSP is to limited to be of use for realistic application. To make sure the researched algorithms solving the scheduling problem would have a wider use case many variations and extensions to the problem definition have been classified over time [4], [1]. More recently the variations and extensions have also been surveyed and put into a structured overview [3].
For this research the preemptive resource-constrained project scheduling problem with setup times (PRCPSP-ST) variant is under study. Preemption allows an activity to be interrupted during its scheduled time by another activity. Each interruption can be seen as a split of the activity into multiple smaller activities. The setup times are introduced for each interruption in an activity to discourage endless splits resulting in a chaotic schedule. This model has already been established [5] and a proposed algorithm was found to result in a reduction of the makespan [6] compared to the optimal schedule without activity preemption. Within this algorithm the activities are split into all possible integer time segments and a SAT solver makes a selection from these segments. The resulting list is used to construct a schedule with a genetic algorithm [2].

Research Question

Can the addition of a heuristic for activity segment selection in the SAT solver algorithm applied to PRCPSP-ST models reduce the average makespan of the resulting schedules generated from the selected activity segment list in either an equal amount of iterations or the same amount time?

- What is a RCPSP activity-on-the-node network?
- How can a RCPSP activity-on-the-node network be transformed to include activity preemption?
- How can setup times be included in the activity network for splits in an activity schedule?
- What is the role of a SAT solver in an RCPSP optimization algorithm?
- What is the required input of a SAT solver?
- How can PRCPSP-ST problems be modelled as an input to a SAT solver for activity segment selection?
- How can the output of a SAT solver be used to construct an activity schedule?

- What could be a possible heuristic for a SAT solver?
- Where can a heuristic be used by a SAT solver?
- Why could a heuristic be beneficial for solving PRCPSP-ST problems?
- How does the heuristic change the resulting activity schedule?
- How does the heuristic change the time required by the SAT solver?

Method

TBD in the final version of the research plan.

Planning of the research project

To make finish the project successfully a planning is outlined in this section. For each week the meetings and presentations are outlined in the fist subsection. The next subsection contains all the activities that should be performed and lastly a list of deliverables is provided to keep track of all parts required for the following weeks.

0.1 Week 1

0.1.1 Meetings

Participants	Objective	Date and time
Peers + supervisor	Detailing research topic	April 20 9:00 am
Peers	Discussing research plan and background information	April 21 or April 22

0.1.2 Activities

Activity	Objective
Read reference paper from project forum	
	• Gain insight in the RCPSP problem
	• Learn about the pre-emption variant of the problem
	• Learn a way to model the problem
	• Analyse the use of the model in a SAT-solver
Analyse research topic	
	• Formulate the research topic
	• Formulate a research question
	• Derive sub-questions
	• Make search queries
	• Selecting information sources
	• Store information sources
	• Generate a literature list
Read abstracts from literature list	
	• Make tags for literature list
	• Find an example for a RCPSP problem model
	• Gather information for the background of the research
Transform sub-questions into tasks	
	• Find the required tasks to answer the research question
	• Make a time-line for the remaining 9 weeks of the project
Make a list of tools/software/data	
	• Making sure all required parts are accessible
	• Checking for completeness with supervisor
Write research plan	
	• Finishing the first deliverable to get feedback from supervisor

0.1.3 Deliverables

After all the activities have been finished the following deliverables should have been made:

- Research question

- Sub-questions
- Information sources
- Literature list (with tags)
- Example for a RCPSP problem model
- Written background research
- List of tasks
- Time-line for tasks and official deadlines
- List of tools/software/data
- Final version research plan

References

[1] Peter Brucker, Andreas Drexl, Rolf MÃ¶hring, Klaus Neumann, and Erwin Pesch. Resource-constrained project scheduling: Notation, classification, models, and methods. *European Journal of Operational Research*, 112(1):3–41, 1999.

[2] Dieter Debels and Mario Vanhoucke. A decomposition-based genetic algorithm for the resource-constrained project-scheduling problem. *Operations Research*, 55(3):457–469, 2007.

[3] SÃ¶nke Hartmann and Dirk Briskorn. A survey of variants and extensions of the resource-constrained project scheduling problem. *European Journal of Operational Research*, 207(1):1–14, 2010.

[4] Willy Herroelen, Erik Demeulemeester, and Bert De Reyck. *A Classification Scheme for Project Scheduling*, pages 1–26. Springer US, Boston, MA, 1999.

[5] Lori Kaplan. Resource-constrained project scheduling with setup times. 1991.

[6] Mario Vanhoucke and JosÃ© Coelho. Resource-constrained project scheduling with activity splitting and setup times. *Computers Operations Research*, 109:230–249, 2019.