Scheduling Multiple Cranes on a Shared Pathway

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Abstract: In many logistics applications, transport requests are conducted in parallel by several vehicles moving along a fixed shared pathway. Examples include cranes mounted on a common rail, like gantry cranes loading and unloading containers in intermodal transportation, or forklifts moving along a narrow passageway in large warehouses.

Such systems of rail-mounted vehicles play a key role in various logistic questions, and the efficiency of their operation frequently has a significant impact on the overall performance of the surrounding production environment. In theory, assigning transport requests to the vehicles of such systems and scheduling their execution amounts to finding k tours on a common line, where tours may never cross each other in time — dynamic collision constraints need to be respected. The goal is to minimize the makespan for a given set of transport requests.

This problem contains other challenging tasks like partitioning jobs to vehicles and assigning starting times to jobs.

We present a model capturing the core challenges in transport planning problems of this type and relate it to other models in the literature. Furthermore, we prove NP-hardness for the problem and present some structural insights, leading to a natural idea for an heuristic algorithm. This algorithm uses an arbitrary ordering of the jobs to create a valid solution. No sequence of jobs yields an optimal solution, although, in general, this heuristic turns out to be quite good in practice.

The same structural property can be used to formulate a mixed integer program in starting time variables, but without the assignment to vehicles. A postprocessing algorithm uses the result to prodice a feasible solution. We report on experience with this algorithm.

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