Scheduling by Timed Automata under Resource Conflicts

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Considering time and resource limitations in different industries, increases importance and complexity of task scheduling problems where all tasks should be executed in the minimum time. Moreover, integrating uncontrollable tasks in the procedure makes more complexity in this problems.

The main objective of our work is to propose a formal model and a tool for automatic scheduling of a system with a specific kind of resource conflict in order to minimize system's makespan as much as possible. It is noteworthy that in this problem, resource conflict means that for doing each task, multiple resources may be needed at the same time and also there might be mutual exclusion between tasks in using resources. In addition, it is assumed that all tasks are non-preemptive.

There are few studies concerning multi-resource allocation and task controllability that optimize the makespan as much as possible. Some of these studies focus on open shop scheduling problems. In these problems, every task is a job and there are resource conflicts between them while the objective is to find the smallest makespan for doing all jobs. In related studies to open shop, some researchers consider uncertainty in durations of tasks as a kind of uncontrollability; but they don't take into account multi-resource allocation to each task. Some other studies focus on optimization methods using (max, +) approach for modeling while they respect multi-resource allocation to each task and consider task uncontrollability. In this approach, they define time interval for makespane without concerning minimization of total tasks' duration.

Supervisory control is an extensive domain for solving optimization problems. There are few tools that can do supervisory control, handle multi-resource allocation to tasks and also take into account task uncontrollability; but most of them don't show the resulting optimum trajectory or time as output which is the main goal of our optimization problem.

As the first step of this research, we propose a new model and implement it in a tool named UPPAAL in order to solve aforementioned scheduling problem while considering all tasks to be controllable. For this purpose following steps are taken:

1. Illustrating resource conflicts through single state (max,+) automata.
2. Translating single state automata to a timed automata model which is compatible with UPPAAL 4.1.19 software.
3. Performing reachability analysis in UPPAAL 4.1.19 along with using "fastest diagnostic trace" feature in order to schedule and obtain the minimum makespan and one of the fastest trajectories for scheduling.
4. Designing a Gantt chart in UPPAAL 4.1.19 to visualize simultaneous execution of tasks.

As a future research, this model could be simplified in order to be formalized. Furthermore, integration of uncontrollable tasks in the model and validation of results through a realistic application will be done.