TATA62 CDIO-project: Scheduling of Tasks in Avionics

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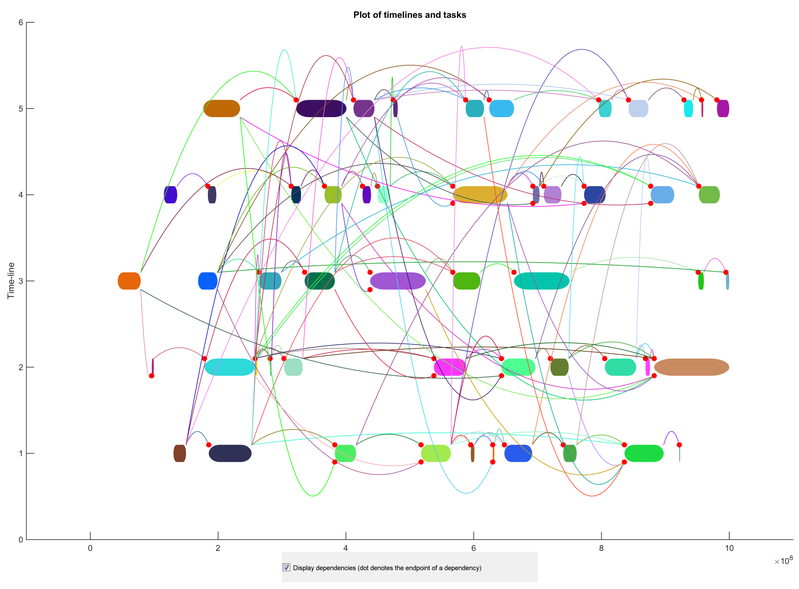
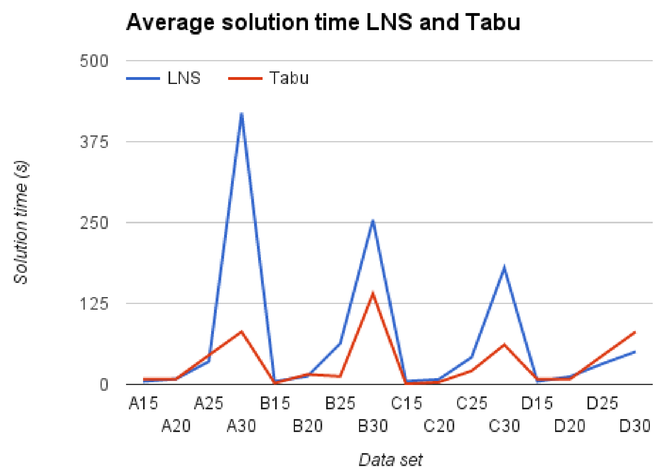
Abstract

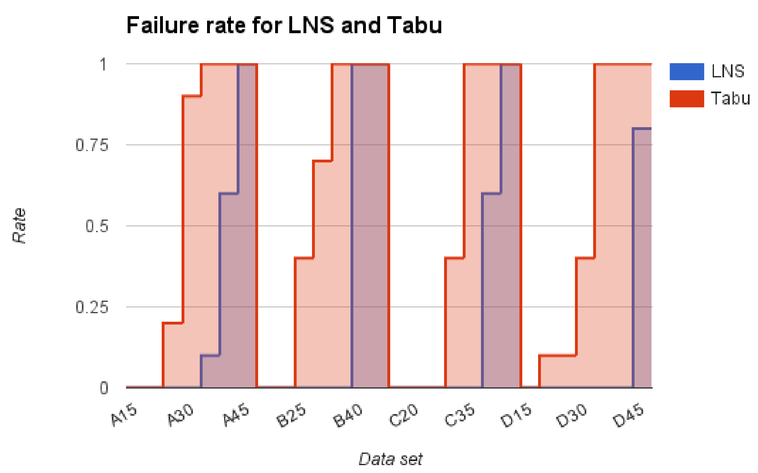
Scheduling tasks in complex integrated avionics systems is a challenging problem for aeroplane designers. We have addressed a problem where a large number of tasks need to be scheduled at different timelines. The tasks are subject to precedence constraints and can only be placed in certain intervals. In this project, we have evaluated how a large number of tasks can be scheduled using two heurisic optimization methods; Large Neighbourhood Search (LNS) and Tabu Search. Algorithms for the two heuristics were developed as well as a data generating tool and a launcher for running and evaluating tests. We could see that the algorithms worked for data up to a certain complexity. For Tabu Serach the limitation was around 60 tasks and for LNS the limit was around 300 tasks. We consider both as promising methods for solving the problem and we believe that their efficiency could be improved through further development and testing.

Example of a Data Set



Result Plots





The Data Types

Four different data types were generated in order to evaluate the algorithms: A, B, C and D data. Data sets of different complexities were generated and for all data sets a feasible solution exists.

A (standard data) For data of this type, the number of timelines is at most 5, the level of occupancy for all timelines is approximately 40%, and the total number of dependencies is twice the total number of tasks. Dependencies are randomly distributed, but sufficiently evenly distributed as to guarantee that every task is subject to at least one dependency.

B (high dependency data) For data of this type, the total number of dependencies is approximately four times the total number of tasks, but other data parameters are identical to those for the standard data.

C (high occupancy level data) For data of this type, the timelines are approximately 70% covered by tasks.

D (many timelines data) For data of this type, the number of timelines is 30.

Large Neighborhood Search

Large Neighborhood Search (LNS) is a meta-heuristic that starts from an initial solution and gradually improves upon it by alternately destroying and repairing it. Therefore, instead of solving a large optimization problem, the heuristic solves smaller parts of the problem, until a stopping criterion is met. The advantage of such a method is that it quickly moves through the solution space and there is a chance it can return a high quality solution fast.

Tabu Search

Tabu Search is a meta-heuristic which was first developed in the 1970s as an efficient search method for solving combinatorial problems. It is based on a local search method as it searches the neighbourhood of a solution for better solutions. The Tabu Search algorithm uses a "tabu list" containing previously visited solutions in order to prevent it from going around in a loop near a local optima. As is the case for most meta-heuristics, Tabu Search does not guarantee that an optimal solution is found. The search is usually terminated once a certain criterion is met and this can be a specified number of search iterations or a threshold value for the objective function.

Conclusion

Results and discussion

Looking at the figures on the left, it can be observed that the Tabu Search finds a solution much quicker compared to LNS, although the latter displays a much lower failure rate (that is, the number of times a feasible solution could not be found). It should be noted though that the data sets compared are those for which both heuristics are able to find a solution. This means that when solving more difficult data sets, the average solution time will probably rise. From these results, it is hard to conclude which heuristic is the better option. There is great potential for development in both cases and the results could thus be greatly improved for both heuristics.

Conclusions about the project

The goal of the project was to gain knowledge about the avionics scheduling problem and the two heuristics, LNS and Tabu Search. The group managed to build a testing environment for the problem, generate data and test a few designs of the heuristics. The final solvers that the group developed could solve the scheduling problem up to a certain complexity. Around 300 tasks was the limit for LNS and 60 for Tabu Search. Further studies on the behaviour of the heuristics for this problem are needed in order to improve their performance.

For more information about the project...

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