A destroy and repair search heuristic for the school bus routing and scheduling problem with transfers

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The school bus routing and scheduling problem deals with the transportation of pupils from home to school in the morning and from school to home in the evening. Variants of this problem are often studied in literature. A comprehensive overview of existing publications can be found in [2].

This work is motivated by a real life problem with about 1600 pupils, 235 bus stations and 22 schools, where the area of operation is mostly rural. We consider the so called morning problem only, i.e., the transportation of the pupils to their respective school before it begins. The goal is to generate an efficient transportation plan (according to some objective) so that every pupil arrives at school on time.

We consider multiple schools. Pupils of different schools can share a single bus and may change the bus during their way to school, referred to as transfers, which have not yet been extensively studied in the context of the school bus routing problem. Transfers in the context of transportation of goods are for example described in [1]. They use a pickup and delivery problem formulation with a predefined set of transfer points. In our case, every bus stop may be used as a transfer point and the decision which bus stops serve as transfer points is made by the optimization algorithm.

Literature distinguishes between the routing problem and the scheduling problem. School bus routes are calculated under consideration of pupil paths. Those routes are then scheduled to buses. Hence, a route is serviced by a single bus but a bus may serve multiple routes. In this work we handle both aspects of the problem.

First, we implemented a mixed integer linear program (milp) which integrates routing and scheduling under consideration of transfers. State of the art milp solvers are able to solve our formulation up to a few pupils and bus stops. To solve problem instances of the sizes of real world problems with hundreds of pupils and dozens of bus stops a heuristic approach is more promising.

Our heuristic solution concept is based on a destroy and repair search framework and uses exact methods for solving subproblems: At first a feasible set of bus and pupil routes is generated using a heuristic for a generalized minimum spanning tree with additional constraints for the given schools. Those routes are then scheduled by solving a simple temporal network.

The initial solution is then improved by iteratively applying destroy and repair operators. Parts of the routing solution are destroyed and then repaired under consideration of the bus scheduling. It may happen that for a given routing solution there exists no feasible scheduling solution. In those situations feedback loops are used where infeasibilities are stored and the routing solution is adapted according to the detected infeasibilities in the scheduling. Short term memory is used to prohibit cycling in the search.

At VeRoLog 2012 in Bologna we presented the overall problem description and the construction algorithm. This year we would like to focus on the iterative destroy and repair search method, the detection of infeasible solution parts and the feedback loop which are used to iteratively guide the search to a feasible solution.

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References

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