Heuristic Approaches for Scheduling Problems in Public Transportation

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Scheduling problems arising in public transportation are complex tasks. Considering both theoretical and practical aspects, the planning process of a vehicle scheduling system consists of four main sub-problems: vehicle scheduling, vehicle assignment, crew scheduling, and crew rostering. These can be solved as separate problems. Many studies have dealt with them, and a number of solution algorithms and methods have been published [2, 3, 4]. Though these methods give good local solutions for the sub-problems respectively, we need to solve them in a given order to attain the global solution of the scheduling problem. This does not guarantee a global solution, moreover in extreme cases – because of the fact that the methods do not consider the constraints of other sub-problems - no feasible solution exists at all. This leads to the introduction of combined approaches (see eg. [5]), but considering the fact that all sub-problems are NP-hard, these can only be used on smaller instances. Modeling such a system is a really hard and complex problem even for a middle sized-city (like in our benchmark case, Szeged, Hungary: 160.000 inhabitants, the problem having 2763 trips, 107 vehicles and 162 drivers for a regular workday). However, good solution can be given using a proper heuristic approach.

Our approach considers vehicles and drivers together. For this, a vehicle schedule is needed (given by the time-space network [6]), and based on this, a vehicle assignment has to be introduced [1]. The most crucial point of the crew scheduling is the rule of special specified breaks. The method transforms the schedules given by the vehicle assignment in such a way, that the rules regarding the breaks can be applied. According to their length, the schedules are divided into classes that are based on the maximum number of working hours assigned to a driver. The schedules can be broken down into sub-schedules, which can be inserted together to form new schedules, and trips can be moved from a schedule to another as well. If these operations still don't result in a new schedule where the breaks can inserted, well-chosen trips have to be removed to get a schedule which satisfies the rules for the breaks. The trips removed are appended to a list, and the whole process has to be started over again from the vehicle scheduling step, using the members of the list as an input, until there are no trips left on the list.

The results so far are promising, the method leads to a decrease both in the number of applied vehicles and employed drivers as opposed to the present practice used by the local bus company of Szeged.

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References

[1] Balogh, J., Békési, J., Galambos, G., Krész, M.: An Assignment Model for Real-World Vehicle Scheduling Problem with Refueling, in Proceedings of the 9th Workshop on Models and Algorithms for Planning and Scheduling Problems, Abbey Rolduc, The Netherlands, June 29 - July 03, 2009, pp. 229

[2] Bodin, L., Golden, B., Assad, A., Ball, M.: Routing and Scheduling of Vehicles and Crews: The State of the Art. Computers and Operations Research, 10, 63-212., 1983

[3] Daduna, J.R., Paixao, J.M.P.: Vehicle scheduling for public mass transit – an overview. In: J.R. Daduna et al., Editors, Computer-aided transit scheduling, LNEMS vol. 430, Springer, Berlin (1995), pp. 76–90.

[4] A.T. Ernst, H. Jiang, M. Krishnamoorthy and D. Sier, Staff scheduling and rostering: A review of applications, methods and models, European Journal of Operational Research 153, 3–27, 2004

[5] Huisman, D. , Freling, R., Wagelmans, A.P.M., Multiple-Depot Integrated Vehicle and Crew Scheduling, Transportation Science, v.39 n.4, p.491-502, 2005

[6] Kliewer, N., Mellouli, T., Suhl, L.: A time-space network based exact optimization model for multi-depot bus shceduling. European Journal of Operational Research, 175, 1616-1627, 2006