

# A New Approach for the Driver Rostering Problem

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This article presents a new approach for the Driver Rostering Problem (DRP). The DRP is concerned with finding out work and rest days scales for the drivers during a period of time, attending several constraints, of different nature, as the operational and union regulations ones, and, at the same time trying to find out certain objectives.

DRP is under study for the recent past 50 years (Ernst et al, 2004). Several proposals have been presented in the literature, including the ones employing set covering and set partitioning models. Integer Programming Problems are known by their complexity nature and among them the set covering and set partitioning models are considered (Goldbarg & Luna, 2005) the most difficult ones in the field of the combinatorial optimization.

The approach developed in this work was based in a private interstate transportation company, settled in a geographic region involving 3 states in Brazil. Reading the input data sets from the company, the process activates an enumerative algorithm to generate a set of possible scales. In this step the problem is represented as a graph where the vertices are journeys of work and the arcs are the transition between two different journeys.

The generation of the possible scales uses a depth-first search technique that considers the inherent characteristics of the particular problem to finding out a good initial population of service scales. As it's well known, the enumerative procedures can lead to combinatorial explosion (Wolsey, 1998), so it was necessary to create a filtering mechanism based on the assignment of weights, which moves along the solution space using an "a priori" established quality criteria which forces the search algorithm to work also as a breadth-first algorithm, so that it reaches regions of the solution space that otherwise would be lately reached by the original depth-first search algorithm.

Once obtained the initial population, 3 other criteria are used to enhancing the quality of this population even more, resulting in a new set of scales, called qualified scales. In the tests carried currently out, an initial quantity of 1 million possible scales resulted in around 50 thousand qualified scales.

From the qualified scales, next step in the heuristic is to find out the minimum set of scales that covers, at least, a pre-determined number of times, all daily company journeys. This problem can be treated as a set covering problem (Wolsey, 1998). In tests carried out at the moment, utilizing CPLEX optimizer, it was found 363 scales, which satisfy all operational and working regulations constraints, and minimizes the difference between all duration of scales related to a pre-established value, fixed by the company (for instance, the standard 8 hours of

working time for all journey). This new set of scales is called feasible scales.

Next step is to encounter a new set of scales, in the set of feasible scales, each one covering the first day of the rostering just once and letting none overall journeys uncovered. This new set of scales is called the definitive scales. For this purpose, many reductions are employed on the original set of feasible scales.

The set of definitive scales is built interactively. Initially, the set of feasible scales is used as input in a new optimization problem, modeled as set covering problem, which aims to find the minimal set of scales that cover, at least once, all daily journeys. From the optimal solution encountered, it is extracted the first column that covers one of the first journeys of the first day just once. This scale is copied to the set of the definitive scales. The original problem is then reduced, eliminating columns and lines that references the scale selected, and the problem is re-optimized. This cycle is carried out until a maximum number of definitive scales are finally extracted from the set of feasible scales. During the cycle, a strategy is used to penalize all scales that covers the same journey as the scale being extracted. This strategy aids to reach an optimal solution at each reduction and to avoid uncovered journeys for the planning period.

Finished this step, it's obtained a set of definitive scales which can be combined with the rest days patterns to produce a pair of service/rest day scales which can finally be assigned to the drivers. But to achieve the best organization for the pairs, it is vital to take into account the number of duty cover drivers generated by the process of joining scale of service and rest day patterns, so that to complete the solution of the PEM.

For this purpose a new algorithm detects the scenario of journey coincidences among all definitive scales considering that when a coincidence occurs it also forces the appearance of a forced rest day that can be used to minimize the number of duty cover drivers for that day.

As a result the current number of duty cover drivers are achieved. If this number is better than the current number of duty cover drivers used by the company, the interaction part of the heuristic is done. So, this result and the pairs obtained in the last step can finally be used in the last step: which driver best fit each pair of scales considering the talents of the individual drivers for the route. This problem can be easily modeled as an assignment problem and solved using the CPLEX solver.

When the number of duty cover drivers is higher than the one used by the company, then the first step is invoked again to obtain extra possible scales and the heuristic process repeats until the number of duty cover drivers do not vary anymore or, at least, a maximum number of interactions has occurred signaling the end of the heuristic.

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