Optimizing crew operations in railways and subways

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Company

SISCOG – Sistemas Cognitivos (www.siscog.pt) is a Portuguese software company that develops decision support systems for planning, managing, and dispatching resources in transportation companies.

SISCOG places in the market three products:

• ONTIME covers the space and time resources (the problem of generating timetables and traffic management);

• FLEET addresses the rolling stock resources (the problem of planning, managing, and dispatching vehicles); and

• CREWS addresses the crew and local/station staff (the problem of planning, managing, and dispatching crew staff).

Figure 1 – SISCOG's product suite.

These products are fully integrated and fully customizable to customer needs.

CREWS is the most mature and deployed product developed by SISCOG. It is being used nowadays to perform the work assignments of more than 20,000 drivers and guards on several European countries on a daily basis. It has been in continuous operation for many years in the following railway/metro operators: Dutch railways (NS), Finnish railways (VR), Danish railways (DSB), Norwegian railways (NSB), Copenhagen suburban trains (S-tog), London underground (LUL), and Lisbon underground (ML). The ML system also involves ONTIME and FLEET.

One of the things that brings competitive advantage to CREWS (and to other SISCOG products) is its powerful optimization solvers. The IP Solver, incorporated in CREWS, is the most famous one. It is based on advanced operational research (see [Abbink *et al.*]) and artificial intelligence techniques (see [Morgado *et al.*]), and it is used to produce and adjust duty plans in an optimized way.

The context of the challenge

The challenge that SISCOG brings to ESGI101 is to improve a specific component of the IP Solver called the *pricing* component. In order to understand this component we provide a brief overview of the problem solved by IP Solver: the crew duty planning problem.

The *crew duty planning problem* (CDPP), also known as crew pairing problem, is the problem of producing the building blocks of the crew rostering problem. These building blocks are called duties. As shown in Figure 2, a *duty* is a sequence of tasks starting and ending on the same place (called home base), and it represents the sequence of activities that a train driver or train guard has to perform during a particular day. In order to form a duty, a sequence of tasks has to comply with a set of rules that define allowances for working times, meal breaks, check-in/check-out times, etc. These rules depend on the labour agreement set between the transportation company and the union.

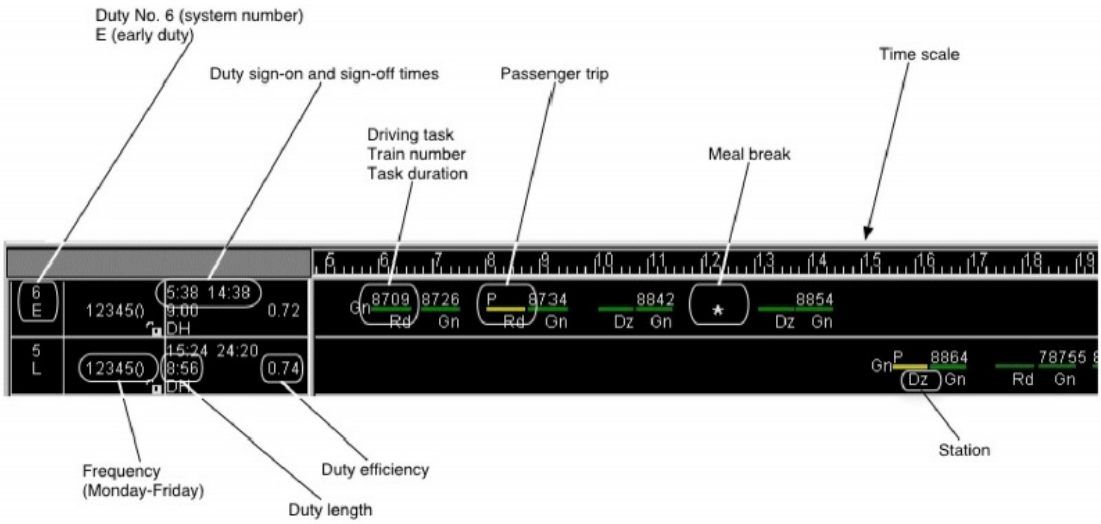

Figure 2 – Example of a specific duty.

Form a mathematical point of view the CDPP is modelled as a set covering problem with additional (side) constraints (see [Abbink *et al.*]), where the additional

constraints are constraints added to assure that the set of duties in the solution are good building blocks for the crew rostering problem.

The IP Solver solves the CDPP with a well-known OR technique called *column generation*, which decomposes the problem in several sub-problems, one of them being the pricing problem. In the context of CDPP the pricing problem is a shortest path with additional (side) constraints.

The challenge

The challenge that SISCOG brings to ESGI101 is the following: *find an algorithm to solve the shortest path with additional constraints that outperforms the existing algorithm implemented in IP Solver*.

The algorithm can take advantage of some particular properties of the CDPP graphs. These graphs have in average 8,000 nodes and 500,000 arcs. The algorithm should be fast, because the solver has to run it many times (millions) within a complete run.

In order to test the algorithm, real-world data, corresponding to one or more CDPP instances, will be supplied in digital support.

References

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