GUROBI OPTIMIZATION

Deutsche Bahn solves major optimization problems with Gurobi

At Deutsche Bahn AG, one of the largest mobility and logistics companies in Germany, there is much to plan, manage and organize. For this purpose, Gurobi is used at crucial points for optimization.

The Problem

There is a timetable that specifies which trains are traveling from destination to destination. Choosing the right traction units is crucial for the costs incurred. The schedule, which is created by the allocation of traction units to trains, must take many restrictions into account. The requirements here vary greatly, depending on the business area.

For example, the right choice of the maintenance window plays an important role in passenger transportation. All deadlines must be met, and schedule deviations, such as construction sites, should be taken into account. In the event of growing competition with little room in product design - for example, in the case of tenders in the regional transport sector - it is even more important to find the most cost-effective solution

In freight transport, however, the large number of vehicle types is crucial, especially in international traffic because of the numerous different power systems in Europe. This greatly increases the combinatorics of the problem. Even after taking into account the numerous requirements such as performance, speed and train control systems, a planner has up to 20 different engines to choose from for a freight train. In addition, the timetable for freight transport is flexible to some extent, and even a small change in the travel situation can lead to big savings.

The fact that the solutions are robust, also plays an important role, because the actual costs initially arise in the implementation of the plan. Therefore, it should be highly robust against interferences. The problem instances at Deutsche Bahn, the largest railway company in Europe, are naturally very large.

Planners use efficient optimization software that helps the company to deal with this difficult task. Here, models with more than 14 million constraints and 22 million variables need to be solved.

> **“With Gurobi, we can also tackle instances throughout Germany in good time, which allows us to investigate additional scenarios.”**
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> — Dr. Boris Krostitz, Head of transport network development and transport models.

The Model

Algorithms, to accomplish these huge models, are implemented at Deutsche Bahn in the department "Transport Network Development and Transport Models" (DB Analytics). For the aforementioned problem, DB Analytics developed the application "Fahrzeug-/LokEinsatzOptimierer" (FEO / LEO), which helps in resolving very large multi-commodity-flow problems. These mixed-integer optimization problems, depending on the application field (passenger or freight transport), can have very different structures in terms of commodity and network size. This complicates the development of specific algorithms. Therefore, Gurobi is used as a program library, which can solve different instances efficiently using the appropriate parameterization.

The Results

Schedule planners of Deutsche Bahn use the application FEO / LEO to optimize existing vehicle rotations, which ensured a significant increase in productivity in some areas. For example, significant cost reductions in the locomotive sector were ensured using Gurobi. The average productivity of a locomotive, in other words the mileage in kilometers, was increased continuously. In addition, the software to support tenders, especially in regional transport, has been used with success. The users especially appreciate the fact that the software FEO / LEO, in which Gurobi helps in creating a schedule, allows them to test and evaluate different scenarios quickly. More and more processes and planning activities are now being put to the test and are improved with the help of optimization methods.

Why we use Gurobi

Gurobi clearly has a key position at our company. We use the easily understandable C++ interface and adapt the solver to our needs. Due to the immense magnitude of the problems, we always use lazy constraints, i.e. constraints that we gradually transmit to the solver, because the whole model would be far too large to solve it completely.

We also have other requirements, for which we have to modify the behavior of the solver. These modifications do not cause any problems in Gurobi. If at times something gets stuck, Gurobi support provides quick assistance in case of any inquiries.

Direct contact with the developers of Gurobi is very important for us. Because of this, we know that our future demands will be taken into account and there will be updates of new features in future versions of Gurobi that we can benefit from.

Deutsche Bahn AG

- international provider of mobility and logistics services
- approximately 306,000 employees in 130 countries
- 6.1 million travelers per day in rail passenger transport
- more than 390 million tons of goods are transported annually
- around 5000 trains per day in rail freight traffic and approximately 23,000 passenger trains per day (without S-Bahn)

Team

The interdisciplinary department was created in 1999 and consists of more than 50 experts in the field of forecasting, optimization and simulation. Many of the developed optimization methods use Gurobi and are used throughout Europe.

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