Computer-Aided Planning of Rural Train Runs in Lower Saxony

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Abstract

In the last years in Germany the conditions for planning and management of public transport have been fundamentally changed: All federal states of Germany (eg. Lower Saxony or Bavaria) have to plan the rural railway traffic for their own and afterwards to order the train runs at the Deutsche Bahn AG (DB AG) or other transport companies. For this purpose the Rural Transport Planning Company of Lower Saxony (LNVG) was founded in Hannover.

The aim of the LNVG is the planning of a passenger friendly rural railway traffic in Lower Saxony. In such a complex railway system (see figure 1) even small alterations to individual components have wide consequences. This makes computer-assisted methods indespensable for the planning task. For this purpose the interactive timetable-planning-and-simulation-system SIMUPLAN was developed on the basis of the simulation model SIMU VII at the Consulting Company for Railway Operating Systems (IBS) in Hannover, Germany. By this computer-aided planning system it is possible to plan and optimize timetables for large rural network with long-distance train runs within a short time. Thus several variants of timetable operating strategies, infrastructure or train types can be evaluated and compared. SIMU VII is used for consulting work and there exist several installations for national and international railway companies.
1 The railway network of Lower Saxony

The passenger railway network of Lower Saxony consists of about 3000 kilometres of track and 360 stations (figure 1). Every day about 2000 rural passenger train services and about 350 long-distance passenger train services are offered.

Figure 1: The passenger railway network of Lower Saxony
The first step was to import all lines of the network and all passenger train runs into the system SIMUPLAN. Some of these train runs affect big parts of the network, eg. RE 3125, which runs from Emden at the North Sea to Braunschweig, a line of about 300 kilometres. An additional stop of this train in one station will affect many other trains and may cause lots of additional changes in the timetable, because restrictions in capacity or connections in other stations have to be taken into consideration. Only with the aid of computers it is possible to plan such changes or to optimize the complete operational task. The complexity of the problem and a solution by SIMUPLAN is shown by the following example:

The line Oldenburg - Osnabrück in the east of Lower Saxony connects the two towns, each of about 150000 inhabitants. It is a single track line of about 115 kilometres and 18 stations. Today there is a maximum speed of 100 km/h on 95% of the line. There are 16 train services in each direction (figure 2). Daily about 5000 passengers use the trains.

![Figure 2: Todays timetable of the line Oldenburg - Osnabrück](image)
The main tasks of LNVG for the line Oldenburg - Osnabrück is the shortening of running times and the planning of a passenger friendly regular interval timetable. For the shortening of the running times several possibilities have been taken into consideration:

- increasing the admissible speed by modification of the infrastructure
- using modern rolling stock providing higher speed or better performance
- reducing the number of stops on the line

Also different variants for a new timetable had to be developed. All these variants of infrastructure, timetables or train types were depicted and calculated by SIMUPLAN. Here we present the final solution, which will be realized the next years.

2 Model components of SIMUPLAN

SIMUPLAN is fitted into the data and programme environment of the simulation system SIMU VII [1,2]. This minimizes the effort of data import and also makes possible the use of further programmes so as to check a constructed timetable for errors and stability with the aid of simulation.

The prerequisite of every construction of a railway network is the mathematical model, which serves as a substitute for the system to be examined. Generally the real overall system is shown as a combination of various elements, whose relation with each other determine the behaviour of the system. The system „railway“ for example consists of the elements track, signalling facilities and vehicles. They are combined by the relations dynamics, timetable and disposition algorithm. SIMUPLAN possesses structures, which depict the reality on the computer with aid of suitable algorithms, data- and program-structures.

2.1 Depiction of the infrastructure

The track infrastructure is depicted in the model as a directed graph with vertices and edges (figure 3). The vertices correspond to those points in the track, which are important for the temporal and safety technical process of operation (e.g. signals or speed changes). The connections between the vertices represent the track sections, which are assigned to attributes like speed, length or gradient.
Also the security system is depicted in a very realistic manner. Therefore all block-sections and signals, which are necessary for train-movements, are described by a series of edges of the directed graph. Influences due to the construction type of the safety facilities (e.g. formation times) can be considered. Also security sections behind a signal will be evaluated. Moving block and signal less systems (e.g. for urban railways) can also be depicted.

2.2 Depiction of the operational process

The model determines the driving behaviour of the single train-movements in accordance with the locomotive type, weight of train and route resistances. The simulation requires timetables, which describe the driving process. Within SIMUPLAN a train run is the result of station runs. Each station contains data about the track to be used and stopping times. Optionally the regular departure and transfer times between different trains can be specified. The combination of the route data is carried out by the symbolic specification of the train direction, the stations and tracks. Thus an obvious depiction on the route data is achieved. The example in figure 4 demonstrates a train run from Osnabrück to Oldenburg.

<table>
<thead>
<tr>
<th>Number of train:</th>
<th>7315</th>
<th>Type of train:</th>
<th>11 (RE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direction:</td>
<td>NORTH (HO - HOLD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Station</td>
<td>Departure Time</td>
<td>Stopping Time</td>
<td>Track</td>
</tr>
<tr>
<td>HO</td>
<td>05:22:00</td>
<td>295 s</td>
<td>12</td>
</tr>
<tr>
<td>HOHT</td>
<td>05:25:12</td>
<td>30 s</td>
<td>2</td>
</tr>
<tr>
<td>HBRM</td>
<td>05:39:30</td>
<td>60 s</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 4: Timetable of RE 7315
2.3 Simulation task

By simulation a given or a planned timetable can be checked for running under realistic conditions. It is possible for the planner to visualize the timetable on the computer. Because in reality delays can not be avoided, the system can also simulate a complex railway network considering various types of delays or faults. The resulting effects are protocoll for statistical examinations.

A simulation run for the complete railway network of Lower Saxony for one operational day will take less than 5 minutes.

2.4 The whole model

![Diagram](image)

**Figure 5: The system SIMUPLAN**

Figure 5 shows the flow of the planning task. After providing track and timetable data the interactive timetable-construction-module creates graphical outputs like train diagrams and statistical evaluations as planning results. These results can be improved by simulation runs. All modules of the system SIMUPLAN are integrated in a user-friendly shell. Most of the planners work can be done comfortably by mouse.
### 3 Computer-aided planning of timetables

For the construction of a timetable it is assumed that all the required data is available. This means the data for depiction of the track and data for calculation of running-times of the different train types. Mostly these data can be imported from an existing database. Otherwise the data input can be performed manually by using other interactive programs. A combination of both has been done for LNVG, where the rural train runs have been taken out of a data base of DB AG and high-speed-trains have been recorded manually.

![Screenshot of SIMUPLAN](image)

**Figure 6: Screenshot of SIMUPLAN**

After the start of the program an interactive program screen appears (figure 6). The screen contains the train diagram, dialog boxes with informations about selected train runs, buttons and pull down menues for selecting different program functions. In the train diagram window each train can be selected by mouse. The attributes, which belong to this train run, will be displayed in a seperated dialog box. It is used for changing the data of the selected train. For example it is possible to add or delete a stop, to change the destination track or the departure time in a station. The running-times of the train will be calculated.
on-line after every change with regard to the allowed speed, the gradient and the acceleration of the train. This is very important, because an additional stop can dramatically increase the running-time.

Other functions are available to move a train on the train diagram by mouse, to include one or more trains, to change the characteristics of a train and to change the track. Also for these changes an on-line calculation of the running-times will be carried out. It is possible to display an on-line track occupation for any station on the screen. Removing conflicts in the track occupation - especially in big stations - can also be done automatically by the program. All graphics - especially the train diagramm or track occupations - can be plotted directly on a laser-printer.

4 Results for the line Oldenburg - Osnabrück

The main aim for LNVG on this line is the decreasing of the running times between Oldenburg and Osnabrück. The following solution was found:
♦ Increasing speed to 120 km/h

♦ Closing six smaller stations with low passenger frequency on the line

♦ Modification of the timetable to a regular interval timetable with every hour one train in each direction, with two crossing stations and passenger transfer to high speed trains in Oldenburg and Osnabrück.

By this solution it is possible to decrease the running times from today 115 minutes to 89 minutes (figure 8). This result was used to convince the state Lower Saxony and the DB AG to sign a contract for the modification of the track line in March 1997.

![Figure 8: New timetable planned by SIMUPLAN](image)

The next step for LNVG will be a further shortening of the running times to a limit of 80 minutes providing the chance to integrate the line into an integrative regular interval timetable (ITF). In such a case the trains can start for example in Oldenburg 5 minutes after each hour and reach Osnabrück 5 minutes before half an hour. In both towns the passengers can catch their connections to the high speed long-distance trains at the full hour or at half an hour.

It could be proved that this aim can only be reached by using new train types on the line. Therefore the LNVG ordered detailed information of the vehicles -
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such as their traction effort, mass, load, resistance or admissible speed - from the construction companies. All these data will be imported into the system. Then the LNVG will check whether a new train type will provide acceptable running times on the line or not.

5 Conclusion

Since about one year the LNVG is using the interactive timetable-planning-and-simulation-system SIMUPLAN for their different planning tasks. During the daily application of the system the advantages of SIMUPLAN came even more obvious. Due to the decreasing of working times for constructing a timetable, the system enables the planner to create different variants within a short time. After a detailed valuation process with respect to monetary or operational aspects the planners can select the best variant. So the value of the work of the planner could be substantively improved. In Lower Saxony the results were the basis for a real improvement of the existing passenger line Oldenburg - Osnabrück.

The system SIMUPLAN runs at the LNVG on a UNIX-workstation with high resolution graphics using the X-Windows interface. Since this year there also exists a WINDOWS NT-version of the system with a performance comparable to UNIX-workstations. SIMUPLAN is also used by the DB AG and the Austrian Railways (ÖBB). The system can be provided in different languages. A presentation of the system can be done here during the conference on a laptop.

References

