Ad-hoc planning of timetables for accidents or maintenance sites

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Abstract

One of the biggest problems for railway operation is the management of train runs during accidents or maintenance sites on double-track-lines. The consequences of these events are barrings and speed restrictions on the main track which cause delays of the trains passing the location. Therefore it is necessary to construct a new timetable based on the existing timetable in consideration of influences of the hindrances on train runs to guarantee safety with high quality. For this purpose the interactive maintenance-site-timetable-construction-system BAUPLAN is used. With a computer-aided site-construction system it is possible to research several variants of infrastructure (e.g. the usage of additional switches in the site area) and timetable operating strategies in only a part of the time needed today for the manual layout of train diagrams.
1 Scenario

In 1996 in the outer area of Hannover between the suburbs Langenhagen and Isernhagen on the main double-track line Hamburg-Hannover the following accident happened: The long-distance passenger train IR 2433 from Hamburg to Konstanz fetched down the overhead power supply line for about 2 kilometres. The accident was caused by opponents of nuclear business, who prepared the overhead energy contract to be fetched down by the next train passing the location. The result of this action was a barring of one track for repairing works for about six hours.

In such a situation it is a problem to manage the train runs in the barring area especially on lines with high frequent traffic. Many trains will be delayed because of different reasons like using the opposite track or speed restrictions or additional stops caused by train crossings (figure 1).

![Figure 1 Operational situation caused by a barring](image)

Sometimes trains can be rerouted or even removed to avoid additional delays of other train runs. To decide whether it makes sense to reroute trains or to change the train sequence to avoid delays for high quality train runs it is necessary to construct a new timetable based on the existing timetable with regard to influences of the barring. These new timetables will be the basis for the railway staff to manage the traffic during the barring.
For the construction of such a timetable for a maintenance site there is normally enough time. But in case of an accident a short-time planning tool is needed. The following chapters will show how the problem was managed by the system BAUPLAN.

2 Computer-Aided Planning of Timetables

The prerequisite of every planning task of railway operation 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. BAUPLAN possesses structures, which depict the reality on the computer with aid of suitable algorithms, data- and program-structures. So the track infrastructure is depicted in the model as a directed graph with vertices and edges (figure 2).

The planning tasks require also timetables, which describe the operational process. For the construction of a timetable for a barring caused by accidents or maintenance sites it is absolutely necessary to extract the train runs with respect to the day(s), the period and the track area of the barring out of a timetable database which covers all train runs. This can be done by BAUPLAN within a few seconds. For example in Germany these data can
be imported into the system by a direct network access to the database of the DB AG. This guarantees actual timetables.

The computer-aided construction of a timetable for barrings can be divided into five main points:

- Definition of the barring with regard to
  - area of the closed track
  - time of restriction
  - possibilities for rerouting train runs
  - speed restrictions
- Extraction of the timetable-of-the-day out of a timetable-database
- Determination of driving possibilities and delays
- Creation of a conflict-free timetable in a train diagram
- Evaluation of statistics of delay and comparison of variants

For planners there are many advantages of the computer-aided construction of timetables. First there is the creation of a timetable for the barring with the help of an interface to timetable-database. Trains which normally use the blocked track will automatically use the opposite track. Delays which are the result of either using the opposite track or a speed restriction are calculated online and are visualized at the train diagram. Another advantage of the system is an algorithm for solving conflicts automatically. This algorithm recognizes and removes incompatibilities between routes and too short time intervals between two trains considering all evident safety and signalling facilities and driving possibilities of trains on the line. The planner can also reroute trains, remove trains from the timetable or change the order of trains manually. Statistical evaluations of the delays of train-classes or single trains are permanent present on the screen and can also be printed on paper.
The advantages of BAUPLAN came even more obvious during the daily application. Important helps for the planners are the access to a timetable database and the integrated calculation of running times by the system with respect to all aspects of maintenance sites. In the past the running times have been calculated manually or by principal running time tables. Now the running times are calculated with high accuracy guaranteeing a high planning standard. Also the conflict-solving-algorithm is used frequently by the staff. It produces within seconds a good solution, which is a basis for the definite planning task. Especially after small changes in the timetable (e.g. changing the sequence of two trains) a new conflict solution can be produced very easily.

Last year about 150 timetables for maintenance sites were planned by the DB AG in Hannover. This number will increase dramatically during the next years because of the EXPO 2000. To manage this fact the computer-aided-timetable-construction-system BAUPLAN is in use at the DB AG in Hannover since about three years [1]. The infrastructure database covers a network of 16 lines of about 2500 kilometres around Hannover.

3 Using BAUPLAN for accidents

Because BAUPLAN was used for planning maintenance sites on the line, all required data was available. This means the data for depiction of track, data for calculation of running-times of the different train types and timetable data. In case of the accident described in chapter 1 all these data was available on the computer of the railway staff in Hannover in the department of planning of maintenance sites. This was the basis to create a timetable for the barring on the line within about half an hour. The following schedule specifies what happened during these 30 minutes.
The accident happens. Inter-Regio 2433 fetches the overhead power supply line down near Langenhagen.

The engine-driver recognizes what happened, stops the train and phones the railway-operation-management staff on the line.

The central railway-operation-department in Hannover starts BAUPLAN for the construction of a timetable for the affected track section.

The planning of the first variant for an eight-hour barring of one track is finished. The planner starts a second and a third variant with other operation strategies. In the second variant for example all ICE trains from Hamburg to Hannover have a higher priority than trains of the opposite direction to avoid delays of connections in Hannover mainstation.

Also the construction of the other variants is finished now. In only 20 minutes three timetables with different operation strategies were planned. The results of the planning are visualized in train diagrams (figure 3) and statistics of delays for all train runs. All results are plotted on a laser-printer.

The central railway-operation-department in Hannover decides with regard to the planning results to manage the train runs as planned in variant 2. The timetable of this variant is faxed to the staff on the line.

The staff on the line receives the fax. 31 minutes after the accident they have a basis to manage the traffic during the barring for the next hours.

All maintenance works are finished. The overhead power supply line is repaired. Both tracks can be used by the trains.

As a result of the planning the overall delays could be minimized to 261 minutes for 112 train runs which passed the barring. There was no need to reroute or remove a train. The cost benefit of this planning cannot be calculated because it is unknown how the staff would manage the problem.
for their own. But it can be assumed that the central department had a much better overview of the situation and that they could chose a much better solution.
4 Timetable planning in networks

As mentioned before, BAUPLAN was developed on the basis of the simulation model SIMU VII. In SIMU VII it is possible to plan timetables on long routes[2] or in big networks. For example, the model has been used for timetable planning in the passenger railway network of Lower Saxony [3]. This network consists of about 3000 kilometres of track and 360 stations (figure 4). Daily about 2000 rural passenger train services and about 350 long-distance passenger train services are offered. 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 screen of the interactive timetable planning module of SIMU VII 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

Figure 4 Railway network of Lower Saxony
run, will be displayed in a separated 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 online 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.

Very important for the construction of timetables are the internal functions for conflict detection. After any change in train arguments the program automatically checks, which conflicts with other trains occur. They are listed on the screen and should be solved during the planning process. Especially on long routes, a change in one part of the line can produce other conflicts 100 kilometres further.

After establishing the track, timetable and maintenance data the operational process can be checked by simulation. Each delay indicates a conflict and can be listed. Moreover SIMU VII can solve these conflicts automatically by various disposition algorithms providing a new timetable in a complete network. It could be shown, that a timetable which does work without delays in SIMU VII will work also in reality. Also for large networks the simulation task is much quicker than reality. Typically the simulation is about 200 times faster than reality.

5 Conclusion

Using BAUPLAN for more than three years now has proved, that it is possible to construct timetables for single track areas within a very short time. Even an ad-hoc application of the system, as shown in this paper, is possible, if all required data is available. It has also been shown that by aid of the automatical functions of the systems a new quality in planning and
optimization of timetables can be reached. So the value of the work can be substantively improved and the planning effort will be reduced. The systems are used by various railway and consulting companies (e.g. Austrian Railways (ÖBB)).

Both systems BAUPLAN and SIMU VII are continually developed and applied at the Consulting Company for Railway Operating Systems (IBS) with the support of different railway companies. One important aspect during developing them is to consider individual characteristics of the users, for example the conversion of data out of different databases. The systems can be provided in different languages.

References

