Implementation of the Timetable Planning System STRAX/TPS in Denmark

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Abstract

The TPS Timetable Planning System, as developed and implemented under the name STRAX in 2001/2002 for the Danish railway system, was introduced to the Danish National Railway Agency (DNRA) and the Danish Main Operator DSB for long and short term planning purposes.

Being based on advanced developments of existing railway simulation packages developed and maintained by HaCon in Hanover (Germany) since the mid 1980’s, STRAX/TPS consists of a set of user-group specific applications, operating on the same database and sharing infrastructure and timetable information together with additional master data. It is running as a client-server system in multi-user mode, and is able to handle parallel work on timetable data. Timetables for different periods and infrastructure data are kept underlying an internal version management in order to be able to cover the complete process of timetable management.

The system features a high resolution level of infrastructure data including tracks and routes as well as detailed security system information laid out in a principle track plan, which is always visible to the users during their planning activities. The infrastructure model is based on a graph theory approach providing the application of route search algorithms for e.g. (re-)routing of trains and service simulation. Train services are mapped into the model using detailed occupation and release information for the infrastructure elements, showing conflicts between different train services instantaneously. Besides, the train planning capabilities, STRAX/TPS is also managing possessions, track blockages or other withdrawals of network capacity as plan information.

Keywords: timetable, graphical timetable, timetable planning system, TPS infrastructure, simulation, capacity, training, planning, operating.
1 Introduction

This paper gives a brief overview about the implementation and status of the TPS Timetable Planning System at DSB and DNRA.

The TPS system was originally developed and implemented in 2001/2002 for DSB (Danish State Railways) under the name STRAX. Meanwhile, the same system in a different configuration was also introduced at the Danish infrastructure provider DNRA (Danish National Railway Agency).

The implementations at both customers feature a common infrastructure data access in order to enable a consistent timetabling across different planning horizons. The resulting periodical timetables feature about 4.000 train definitions each running on a network of 4.500 track kilometres.

STRAX/TPS is based on a further development of the successful program package UX-SIMU, for timetable simulation as provided by HaCon since 1985.

2 Goals of development

In order to implement STRAX/TPS as a production system for the Danish railway companies, a large number of requirements regarding ergonomics, data management, security and availability had to be fulfilled. Furthermore, the use and value of the system is characterised by a high measure of integration with a variety of other existing production systems of the customers, including the known timetable information system HAFAS as being supplied by HaCon.

From the beginning, a main goal was the interoperability of the system between DNRA and DSB, i.e., the infrastructure provider and the main train operator of the Danish railway system. With that, exchanging complete timetable and infrastructure data versions are part of the day-by-day tasks in order to provide fast and reliable information about trains including runtime, allowances and conflicts.

Among others, these features guided the development of STRAX/TPS towards a high sophisticated instrument for capacity planning, allocation and assignment as needed for the communication between train operating companies and infrastructure providers within the opened railway market of the EU.

Besides the functional development goals, there was a need to achieve an open and easy-to-extend architecture with the system in order to meet the challenges of future adaptations and extensions of the companies’ workflow.

3 Environment

STRAX/TPS was developed and implemented given detailed requirements of timetable planners and IT specialists for working environments ruled by tight communication and division of work. It consists of applications of different type optimised for the different roles and tasks users may have in such environments.

A parallel work (including data modifications) on single timetable versions by several users at the same time is provided. Configuration of data dependent access rights for each user or role is an included standard functionality, as well as
the integration of overall system status and control information. All system and application interaction is accessible via a modern windows based graphical user interface.

4 Functional scope

The relevant fields of functionality can be categorised as follows:

- Maintenance of infrastructure and master data
- Train (re-)routing and runtime calculation as an instrument for planning (calculation of allowances) and verification of the train services
- Timetable construction and conflict detection
- Timetable simulation (selected trains, complete timetable)
- Reporting and analysis
- Provision of data for professional printing and plotting systems
- Interfacing with other systems
- Administrative tasks

According to the day-by-day needs of the timetable planners, a STRAX/TPS application is organised using three main windows for the track plan, tabular timetable editor and graphical timetable editor (see figure 2). This allows entry, modification or check of timetable data in immediate context with underlying infrastructure information. Track occupation and conflict information (yellow areas) are seen directly within the graphical timetable after relevant data is entered or modified.

Besides train services, other capacity impacting procedures may be specified like e.g. possessions, track blockages or other withdrawals of network capacity. These processes are handled and considered in correlation to the planned train services, for instance to detect occupation conflicts or delays.
Figure 2: Graphical timetable editor.

Figure 3: Synchronous simulation.
The workflow of the timetable planning department is supported by, e.g., exchanging planner notes related to any train or state transitions for trains/timetables as well as the possibility to lock timetable information on arrival/departure time level.

Quality assurance plays a major role within the system. For instance it provides a variety of log and change tracking information and the feature of “freezing” timetables at any stage of the transition process and to compare the frozen timetables to the actual timetable version or any other freeze of it.

The synchronous simulation of the capacity plan including train services and possessions/track blockages represents a mean for validation on network level. The train interaction can be simulated also giving obstruction scenarios based on stochastic or empirical knowledge. This leads to delays within the timetable (see figure 3) and hence to evidence of robustness (i.e. quality) of the timetable.

5 Data model

The structure of the data model features a logical separation of the areas master data, timetable data, infrastructure data and the superordinate capacity plan (called “project”), combining timetable and infrastructure data versions.

Figure 4: Track plan.

The class of master data includes entities with respect to rolling stock, operating day types, public station/track information and information about train operating companies (TOCs) whereas infrastructure data within the underlying
model is used for mapping of the existing track sections as well as signalling and security systems of the railways. The visualised track plan incorporates a graph theory approach featuring nodes, edges, block sections, directions and velocity profiles. It is presented to the user within one of the three main screens of a STRAX/TPS application (see figure 4). The timetable data features besides all relevant train attributes (e.g. TOC information, operating days, route, arrival/departure times etc., see figure 5 and 6) also connections between trains for mapping waiting conditions or exchange procedures such as coupling, splitting, change of train numbers.

![Figure 5: Tabular timetable editor.](image)

Timetable and infrastructure data are managed by versioning, where the resulting timetable and infrastructure versions are traversing different states (e.g. planned, verified, released, in operation) in order to support workflow procedures. This versioning enables the user to combine any timetable and infrastructure data version to an overall capacity plan, establishing the context of the validity period. The full standard scope of data management functionality as for instance create, copy, import/export, modify, deleting is available for the timetable and infrastructure versions.

The system wide consistency of the data is achieved on database level (model consistency) by use of referential integrity constraints and data checks and on application level by the ability of the STRAX/TPS system to configure rules and verifications (“Rules of the Plan”) as part of the implementation. The latter covers more complex calculations and verifications of railway specific operational rules such as e.g. data dependent minimum allowance settings and
conflict definition rules. Another difference between these two consistency levels is, that the data consistency is ensured ad hoc, meaning immediately when data is entered or modified whereas the second level allows entering or modifying data resulting in post-entry rule violations. The solution of such rule violations is supported by context sensitive violation lists guiding the user through necessary data adjustments in a most effective way.

Figure 6: Editor for operating day patterns.

6 System aspects

The more system oriented features of STRAX/TPS can be characterised by:

- Client Server System with ability of supporting heterogeneous clients (X-Windows, MS-Windows, Intranet/Internet) and servers (UNIX, MS-Windows)
- Central relational database management system (ORACLE)
- Network integration based on industry standards
- Mechanisms for automatic control and messaging
- Interface Server for quality assured interface operations in ad-hoc or batch mode

The applications are designed to fulfil diverse ergonomic needs:

- Three interacting main screens to provide optimal work focus
- Minimisation of windows operations (move, minimise, maximise, resize, close)
- Data treatment in context (e.g. by comprehensive GUI-focussing of correlated data entities)
- Clear, context sensitive messages about errors, conflicts/rule violations
- Undo/Redo
- Context sensitive online help facility
- Keyboard control of all functions
- Toolbars

Figure 7: STRAX/TPS system concept.

Figure 8: STRAX/TPS change lifecycle.
7 Change management

Within the co-operative change management process for the synchronised implementation of new or modified functions at the infrastructure provider and the main operator, a software lifecycle model is used as shown in figure 8. This model ensures a long term partnership of meeting the future challenges of timetable system use in modern railway companies of today.

8 Training of staff

After having implemented the system in a test environment, the system was inaugurated in early 2003 for full-scale planning purposes. Just before this, the staff had to be trained in using the system. The training of the staff was carried out over 7 days by 2 teachers from Atkins Denmark in classes of up to 5 students, each having their own setup of a 3 screen monitor solution. Each group was comprised of staff with different backgrounds and fields of work. In order to obtain a better understanding of the program as a whole, each student had to get an overview of the entire program, thus getting a better understanding of the program as a whole, and thereby ease the communication between the different groups, i.e. timetable planners and infrastructure maintainers.

The training was carried out on a step by step explain – do basis, thus ensuring an understanding of the program. At first the programs history and concept, as described before this, was explained for the staff. Then each student, was given an infrastructure, which they had to build within the system. Each day had its own task, which had to be completed, e.g. drawing the tracks, placing the signals etc. First the papers, describing the task at hand were distributed. This was then explained for the staff, by showing them where to find the tools needed to complete the task, and finally they had to do it themselves. This was done logically for each of the three modules in the program, infrastructure, timetables and graphical timetables. At the end of the training, the class got a copy of the Danish infrastructure. They now had to use what they had learned in different parts of the course, e.g. correcting some infrastructure, correcting train runs, making new train connections, with as little guidance from the teachers as possible.

9 Perspectives

With the amount of data contained in this system it is logical to want to extract these data and present them elsewhere, e.g. in a GIS system, which already has been done in other kinds of traffic models [1]. One could imagine that it is needed to get a graphical presentation of how many trains are running a specific section, line or network. These data are contained in STRAX/TPS and could then be exported to a GIS system. This could be couple with data that described the cost of running trains this trains pr. kilometre. The application could also be extended, so it calculates the power consumption for the trains running on a given line. With an extended module for statistic analysis the program could also
calculate the punctuality at e.g. a station for large variety of delay distributions, and aggregate them into graphical presentation, that e.g. show the delay at the station for hundred simulations on that line [2].

References