real time train run forecast
A spotlight on the SBB - Rail Control System

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Introduction to the SBB Rail Control System (I)

- SBB (Swiss Federal Railway) is, per line-kilometre, the most intensly used railway network in Europe with 7000 passenger trains and 2000 freight trains per day.
- The Infrastructure Division of SBB brings all of these trains safely, punctually and in an economical manner to their destination.
- Traffic dispatching is a key element of railway operation.
- The Operations management department controls the dispatching of trains via four regional operations control centres.

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From 2005 to 2009, the Infrastructure Division of SBB developed the Rail Control System (RCS) as an integrative dispatching system for rail traffic on the SBB, BLS and SOB networks.

- RCS will increase the quality and stability of operational production.
- RCS is essential for an extremely dense rail traffic.
- RCS-DISPO, the main sub-project, will be productive on 6th April 2009.
**Rail Control System consists of five sub-projects (I)**

- **DISPO** (Dispatching) offers via a GUI real-time information regarding the current operational status (train courses and infrastructure statuses) on lines (time-distance line diagram and network overview) and in nodes (track occupancy plan and connection graph).

- The GUIs provide the main functions required for train dispatching in an interactive manner.

- DISPO generates forecasts regarding the future of train courses in order to reveal the consequences of conflicts and recalculate connections.
Rail Control System consists of five sub-projects (II)

- **UNO** provides topography and topology data and also configuration data of the train control systems.
- **ZLR** calculates the theoretical minimum runtime of a train based on allowed line speed, vehicle type, braking characteristics, speed-restricted zones etc.
- **ZLD** calculates the yearly and daily train guidance data for stations and transmits these to the SBB’s regional interlocking systems.
- **ALEA** is RCS’ alerting and incident assistant to provide a quick, efficient and uniform exchange of taken solutions to disturbances.
RCS forecast module

- **DISPO** incorporates a highly efficient procedure to calculate the network-wide impacts of delays.

- The forecast describes the continuation of the current status into the future, observing:
  - the current valid operational plan,
  - the mutual dependencies and
  - the obstructions between trains.

- RCS-DISPO simultaneously provides a forecast for all trains, taking into account their mutual influences.
Features of the forecast module (I)

- A logging of train position while passing a main signal taking account of the next forecast.
- Forecast on the basis of runtime calculations, particular to each train
- Individual driving strategy of each train.
  - regular journey according to operational plan,
  - journey with delay reduction through exploitation
  - early journey with perpetuation of earliness
  - early journey with reduction of earliness
  - journey at target time
Features of the forecast module (II)

- Providing a simultaneously forecast for all trains, taking into account their mutual influences
- Making use of runtime calculations, particular to each train
- Respecting all dispatching decisions, such as train cancellation, train composition, breaking and definition of connections, additional and abandoned stops, low speed zones.
- Respecting reciprocal train influences with conflicting track slots, the placing of connections and the circulation of vehicles.
- The forecast is carried out for at least the next two hours.
Modelling and solution

• The numerical model is based on an event constraint model and works on the principle of delay propagation and constructed in the form of a nodes-and-edges model.

• The nodes represent either the arrival or departure of a train at or from a main signal or station.

• The edges of the graph represent the constraints between the various nodes. The edges are evaluated with minimum time intervals, for example minimum runtime or minimum connection time.
Modelling and solution

- Since the directional edges of the prognosis model display causal and temporal interdependencies, one is also able to consider the prognosis as a scheduling problem.
- The emerging graph contains only minimum times, thus inequalities with greater or equal to relationships, and is always acyclic.
- The directed acyclic graph (DAG-structure) ultimately allows arbitrary temporal expansion in the context of the prognosis.
- To allow efficient handling of problems on DAG-Structures, the prognosis works by a procedure of topological sorting, based on a shortest path procedure.
Data volumes

- The RCS-DISPO forecast always takes into account all trains operating on the SBB, SOB, BLS infrastructure.
- The numeric model contains:
  - Trains: 5000
  - Arrivals / Departures: 360000
  - Constraints: 380000
  - Processed train positions: 50000
  - Signals with train position reporting: 9600
- The numeric model is solved every 3 seconds.
Performance of the forecast (I)

- The initial value of the forecast is the planned time.
- The forecast is continually improved.
- The diagram shows the relationship between the prognosis value and the very moment at which the prognosis was generated.


- Improvements of the forecast.
- Actual time.
- Planned time.
- Forecast value.

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The figure shows the forecast value which was generated 10 minutes before the actual logged through-run time for each signal.

The difference between the forecast and the actual logged through-run time is approximately 2 minutes.

In actual fact, the train is running a little earlier than expected.
Performance of the forecast (II)

- The prognosis works for trains running
  - behind schedule,
  - on schedule,
  - ahead of schedule
- The freight train is running ahead of schedule in the following example.

- forecast value generated 10 minutes before the actual logged through-run time
Summary

- SBB infrastructure has a highly precise and continually self-updating dispatching system, which generates forecasts for every existing combination of train and station or signal location.

- Using the delay propagation approach, SBB is now able, via circulation, connection and headway conditions to take the propagation of delays into account across its entire network.

- The train dispatcher is provided with the critical information he requires in order to achieve rapid recovery from disturbances to join the original operational plan.

- Expecting a higher level of operation stability, passengers as well as freight traffic customers will benefit from early information regarding the current operational situation.