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 intensely 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

Introduction to the SBB Rail Control System (II)

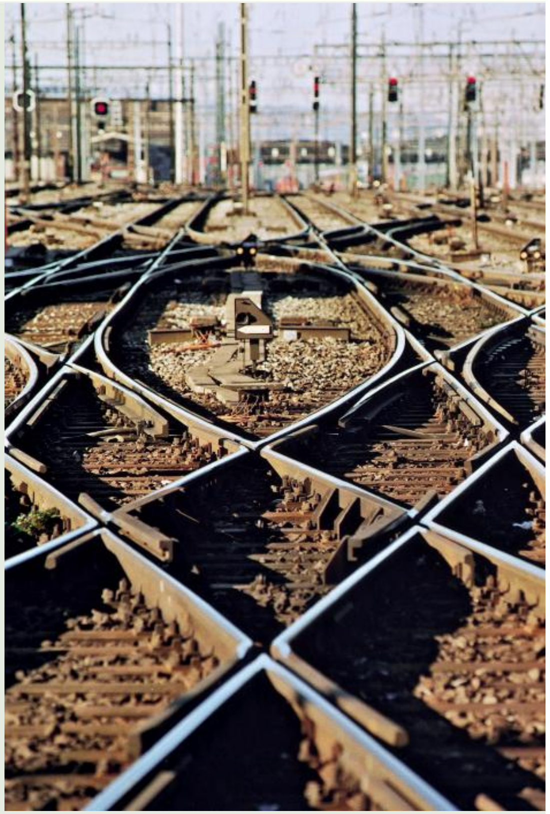
- From 2005 to 2009, the Infrastructure Division of SBB developed the Rail Control System (RCS) as an integrative dispatching system for rail traffic on the SBB, BLS and SOB networks.
- RCS will increase the quality and stability of operational production
- RCS is essential for an extremely dense rail 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)

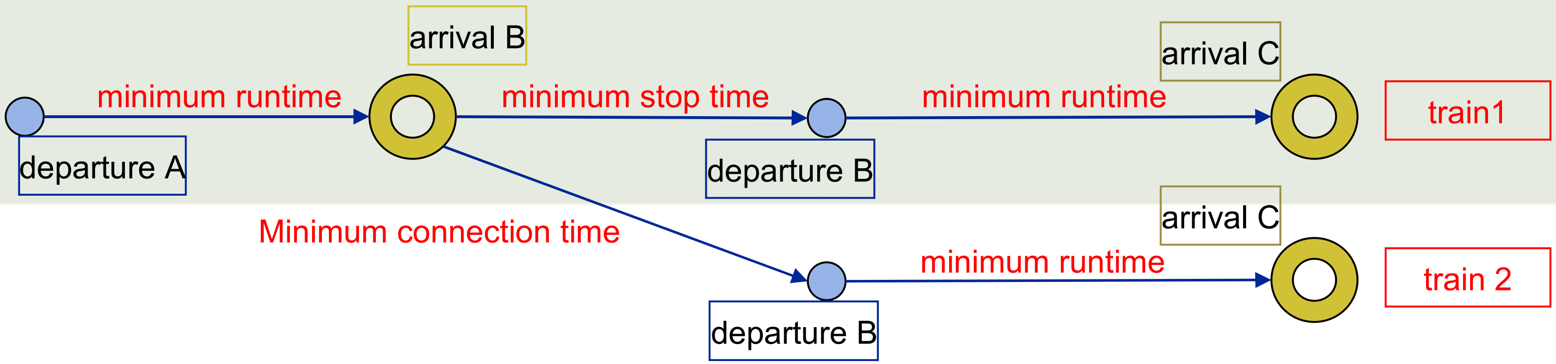
- A logging of train position while passing a main signal taking account of the next forecast.
- Forecast on the basis of runtime calculations, particular to each train
- Individual driving strategy of each train.
  - regular journey according to operational plan,
  - journey with delay reduction through 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.



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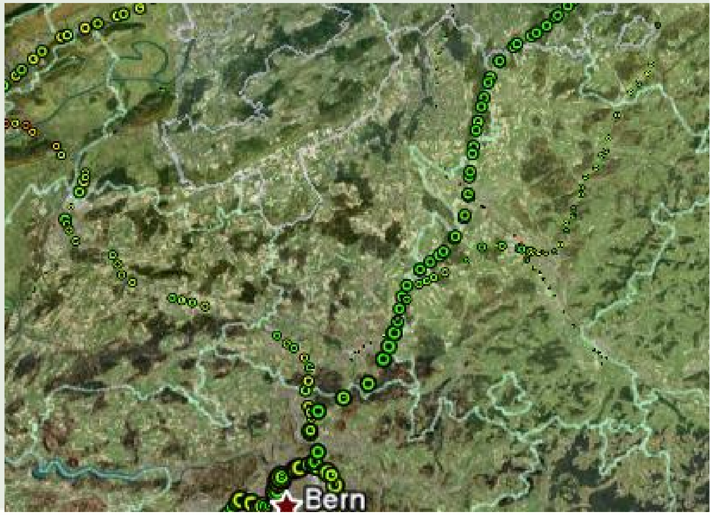
Modelling and solution

- 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

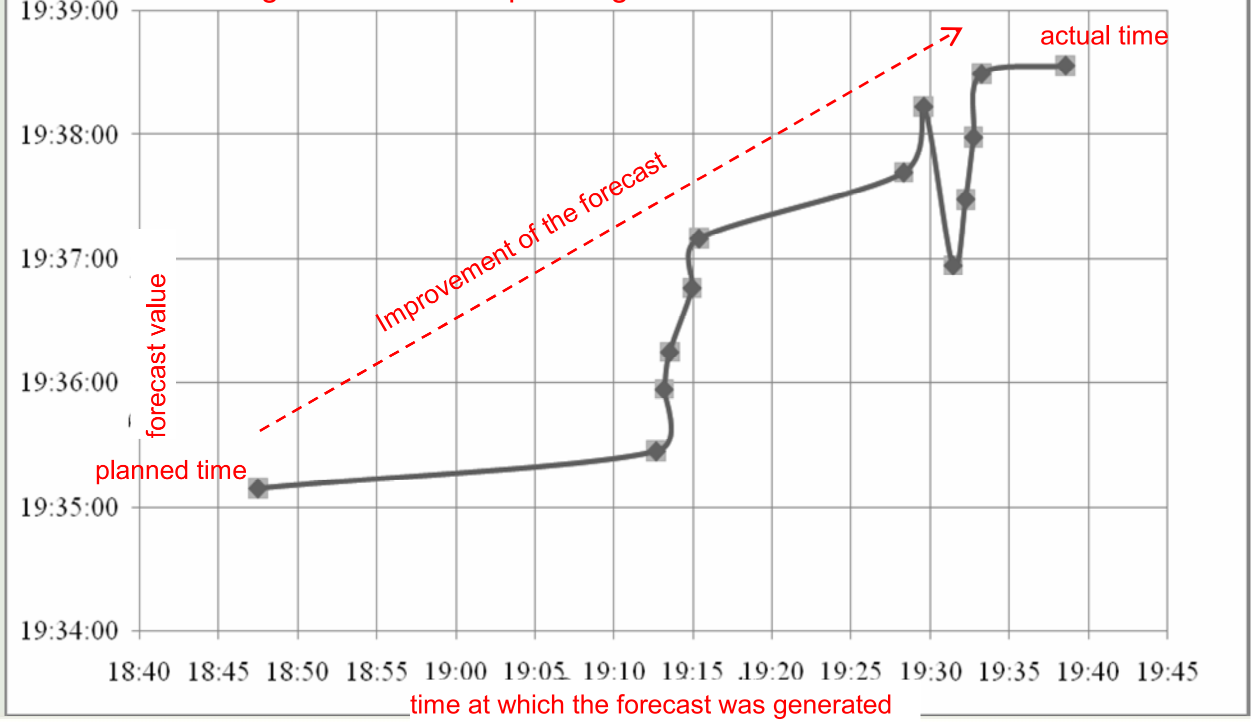
- The RCS-DISPO forecast always takes into account all trains operating on the SBB, SOB, BLS infrastructure
- The numeric model contains
  - Trains: 5000
  - Arrivals / Departures: 360000
  - Constraints: 380000
  - Processed train positions: 50000
  - Signals with train position reporting: 9600
- The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



Performance of the forecast (I)

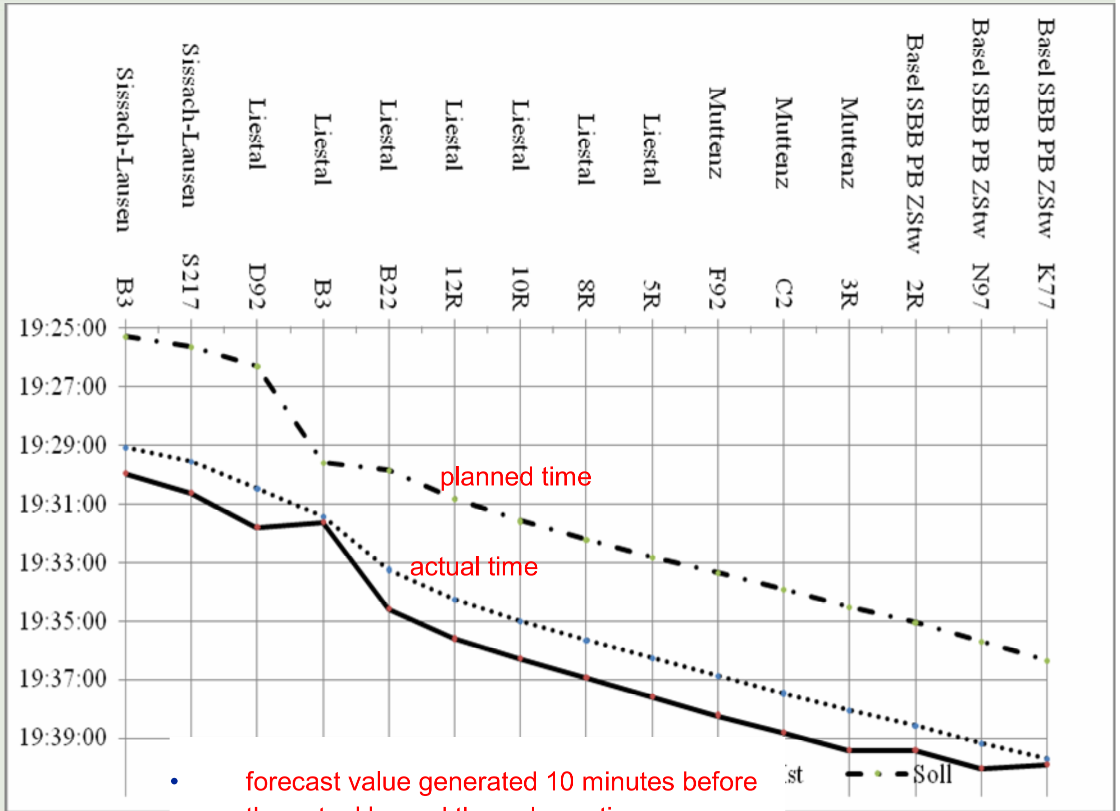
- The initial value of the forecast is the planned time.
- The forecast is continually improved
- The diagram show the relationship between the prognosis value and the very moment at which the prognosis was generated

- Prognosis development for *IR 586* (17/11/2008) at Signal *2R* of the Central Interlocking at Basel SBB's passenger station



Performance of the forecast (III)

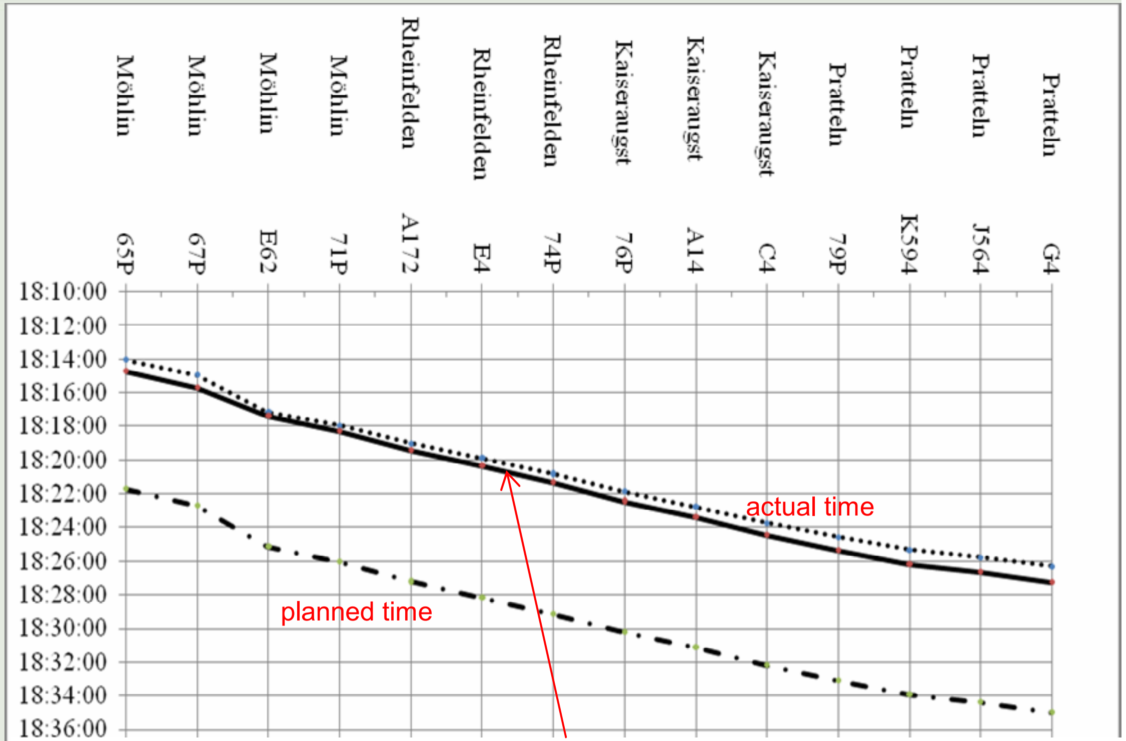
- The figure shows the forecast value which was generated 10 minutes before the actual logged through-run time for each signal.
- The difference between the forecast and the actual logged through-run time is approximately 2 minutes.
- In actual fact, the train is running a little earlier than expected.



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

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.