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Energy Efficiency Days 2009

Energy savings thanks to traffic flow management

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The good old times

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If you have one train in a network... :

- it needs energy for the journey from A to B
- there are no other trains which disturb your run
- it is up to you how much energy you use

Luzern in 2009 (Photo from Internet)

The „aerial view“

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If you have a network with many trains... :

- it still needs energy from A to B
- other trains may disturb your run as soon as there are delays
- energy consumption is partly out of your control!

Luzern (Google Earth)

Complex networks, mixed traffic

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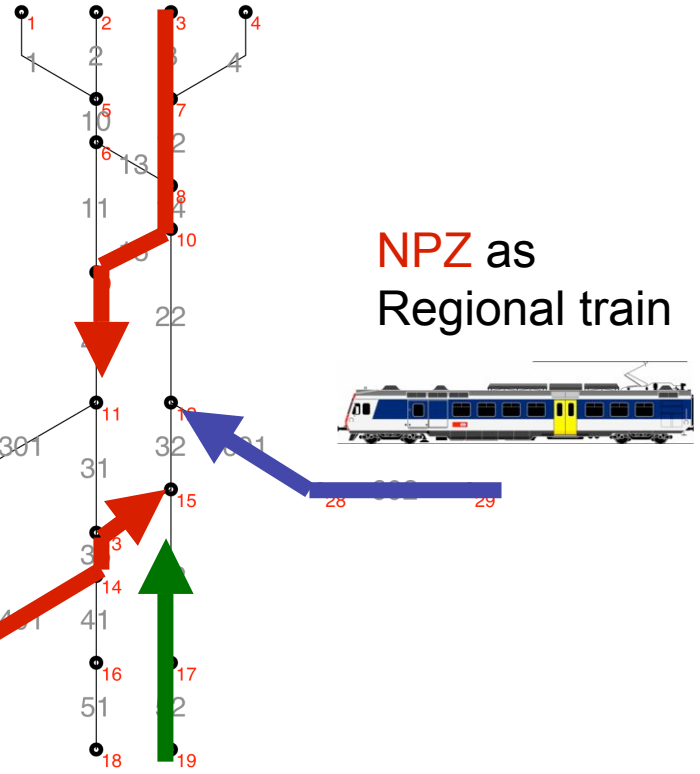
What is the routing for

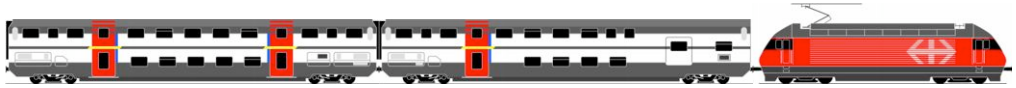
- minimum delay time ?
- minimum energy consumption ?

Eurocity with Re 4/4 II



NPZ as Regional train

IC 2000 with Re 460



FLIRT as S-Bahn

Freight train with Re 6/6

System study

The following results are from a system study, performed in 2008 / 2009 by ***emkamatik*** on behalf of SBB, with the financial support of the Swiss Federal Office of Energy (BFE), and partly based on earlier studies done by SBB.

Main characteristics:

- Focus on high network capacity at lowest energy consumption
- Reduced network dimensions (for development)
- Real train data
- Demonstration software based on MATLAB
- Core is a very fast train run simulation for speed and energy consumption versus location / time

The single-train perspective

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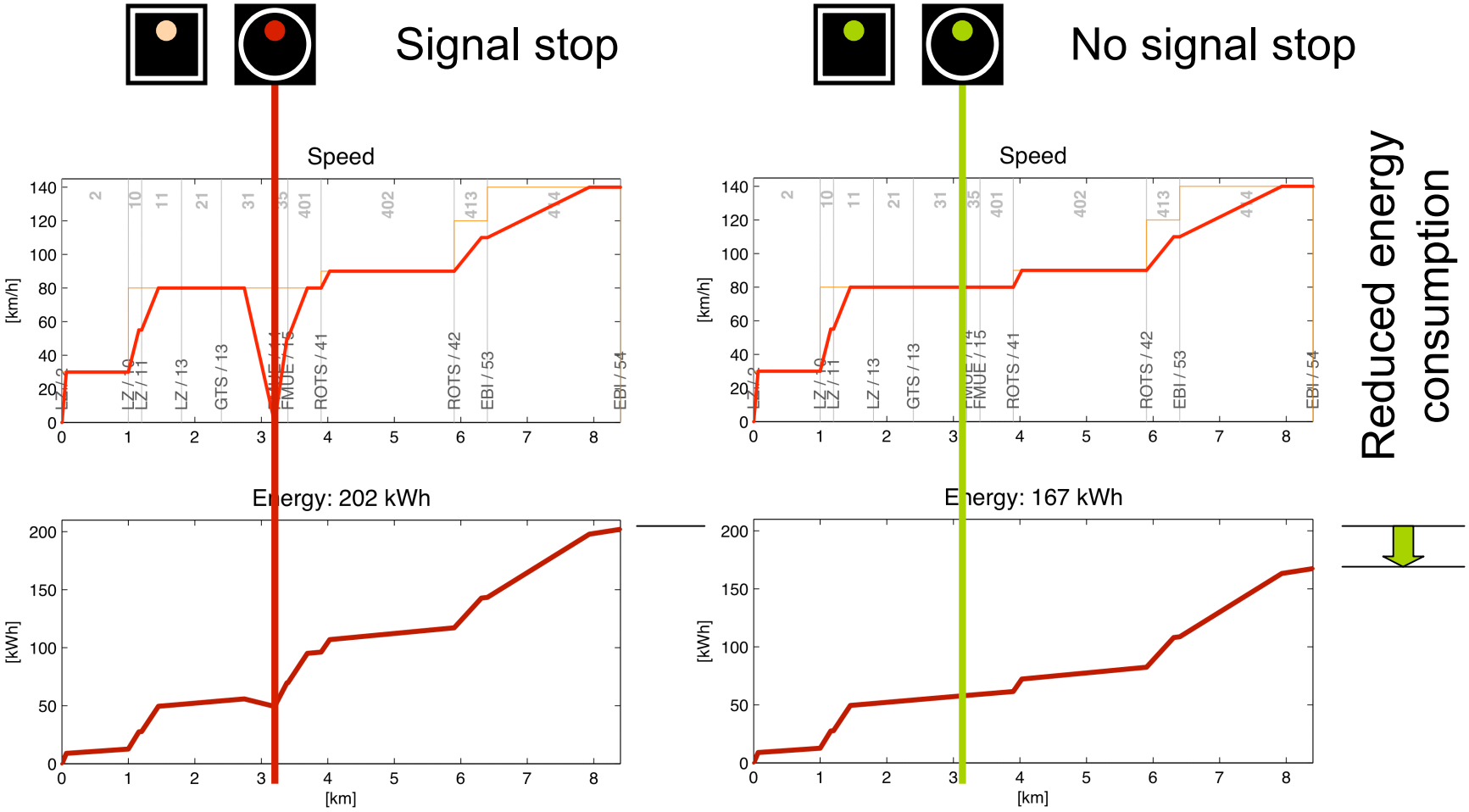

Network optimisation

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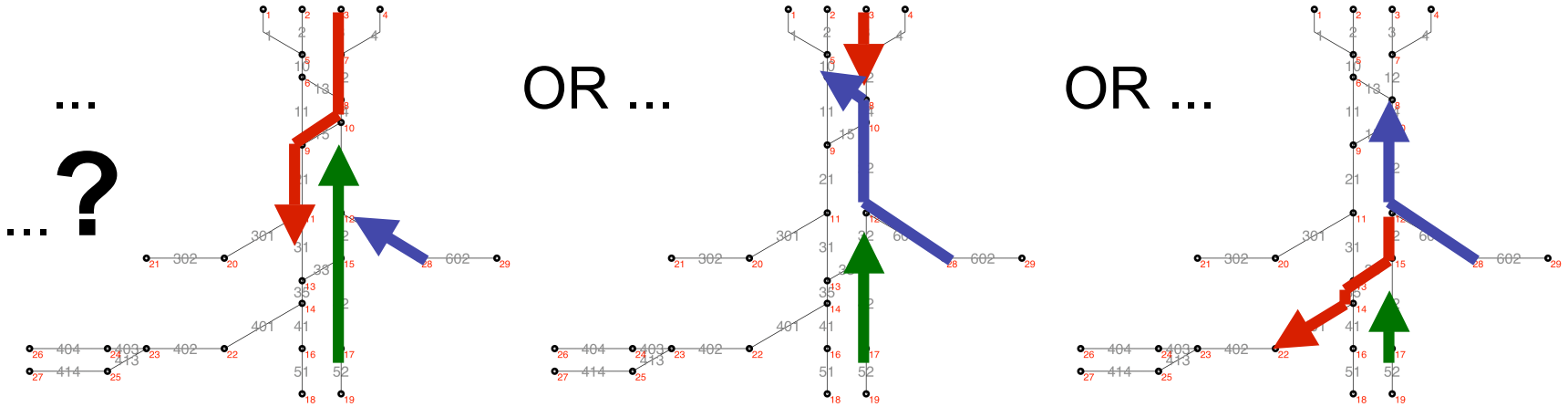
Which is the routing of trains for

- lowest total time delay
- lowest total energy consumption



A fast analysis of a large number of combinations is necessary and requires efficient numerical methods

Dependence energy – delay time

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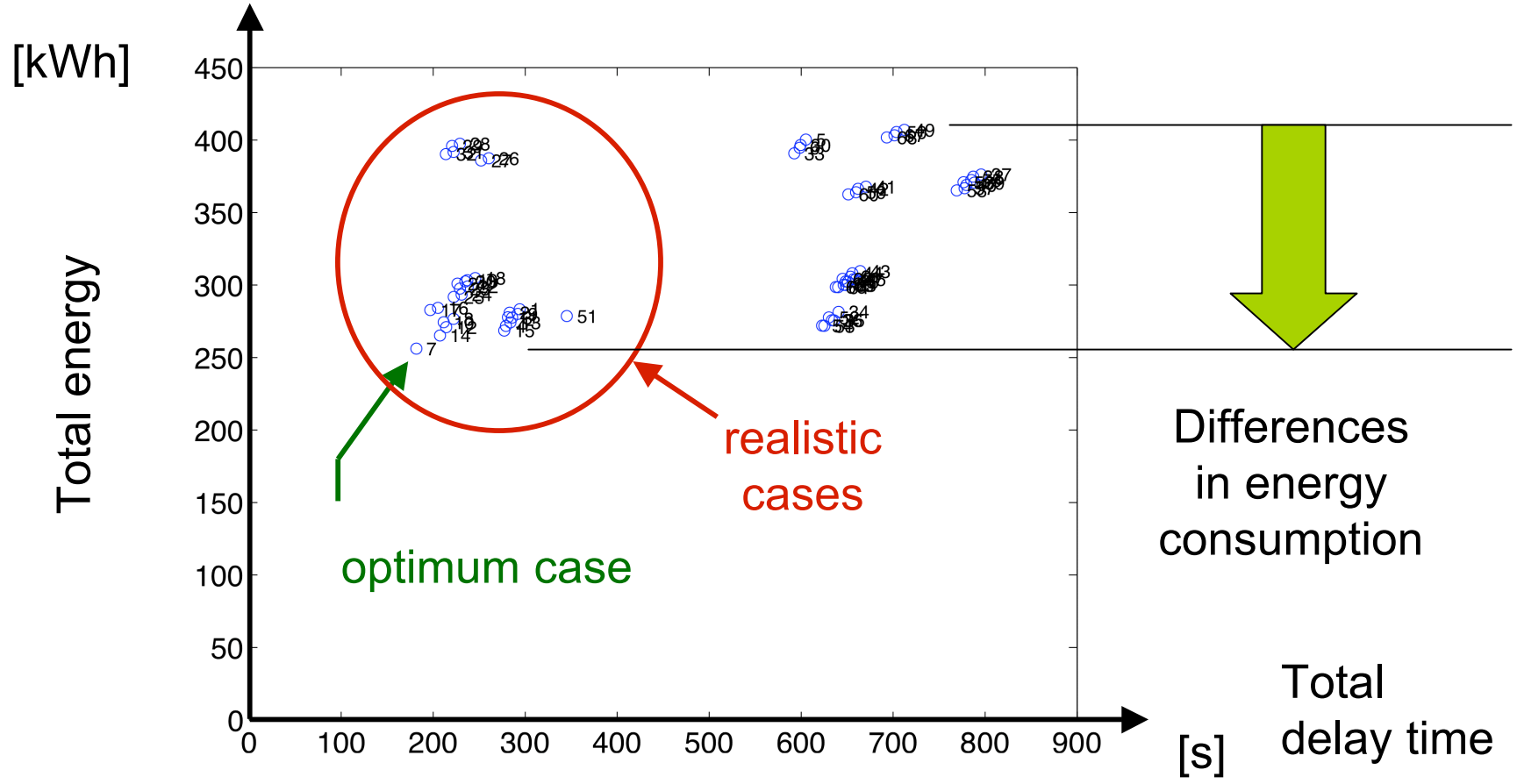
The fast algorithm allows the calculation of all reasonable routings in a few seconds:



Target function

Since both time delay (caused by conflicts between trains) and energy consumption are calculated simultaneously, it is possible to define a target function for selection of the route:

$$\sum k_i \, \Delta t_i + \sum E_i = \text{minimal}$$

By means of individual factors k_i per train, it is even possible to define priorities:

- passenger versus freight trains
- connections between trains
- etc.

Network simulation results

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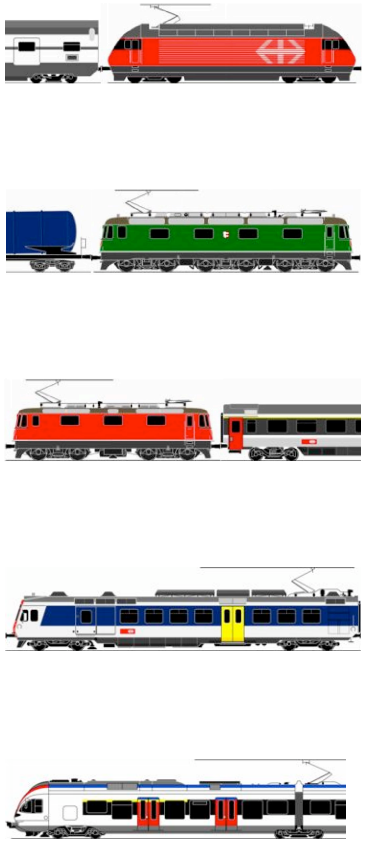

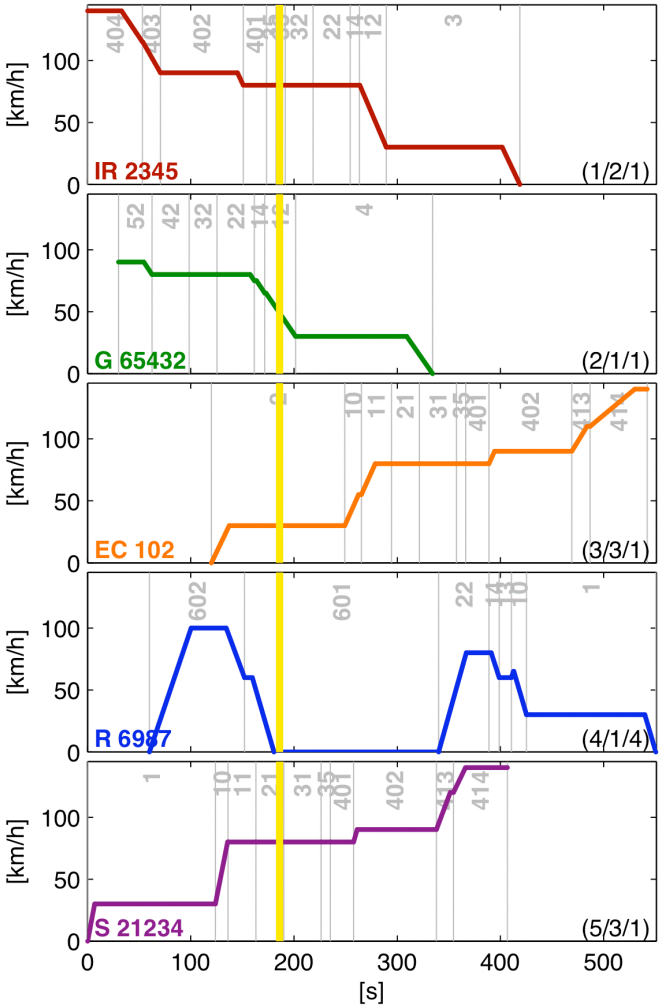

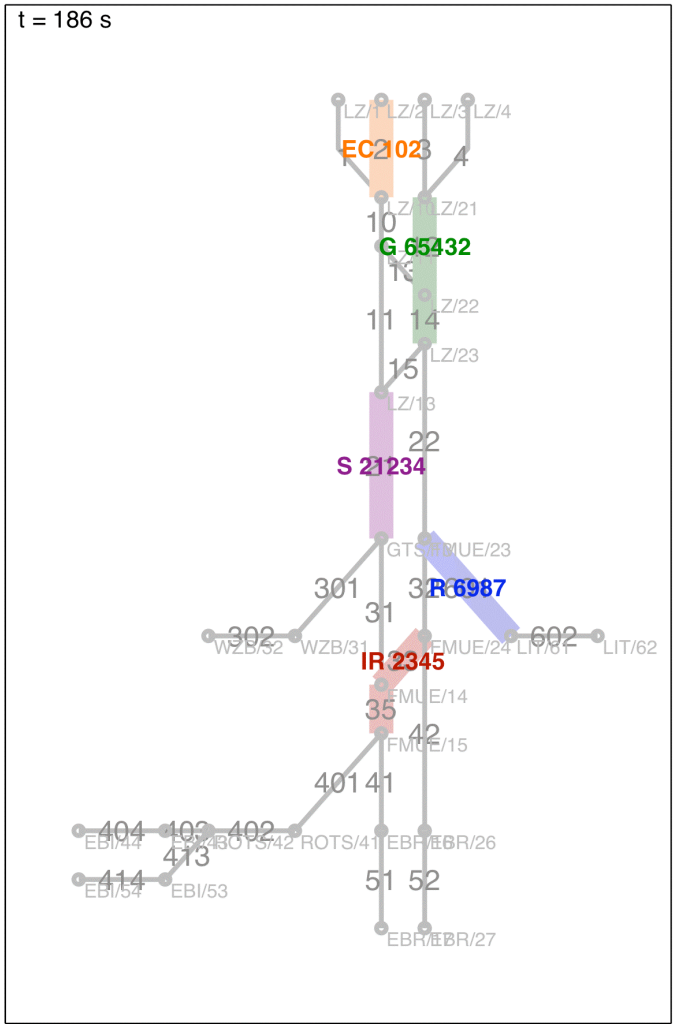

Required system architecture

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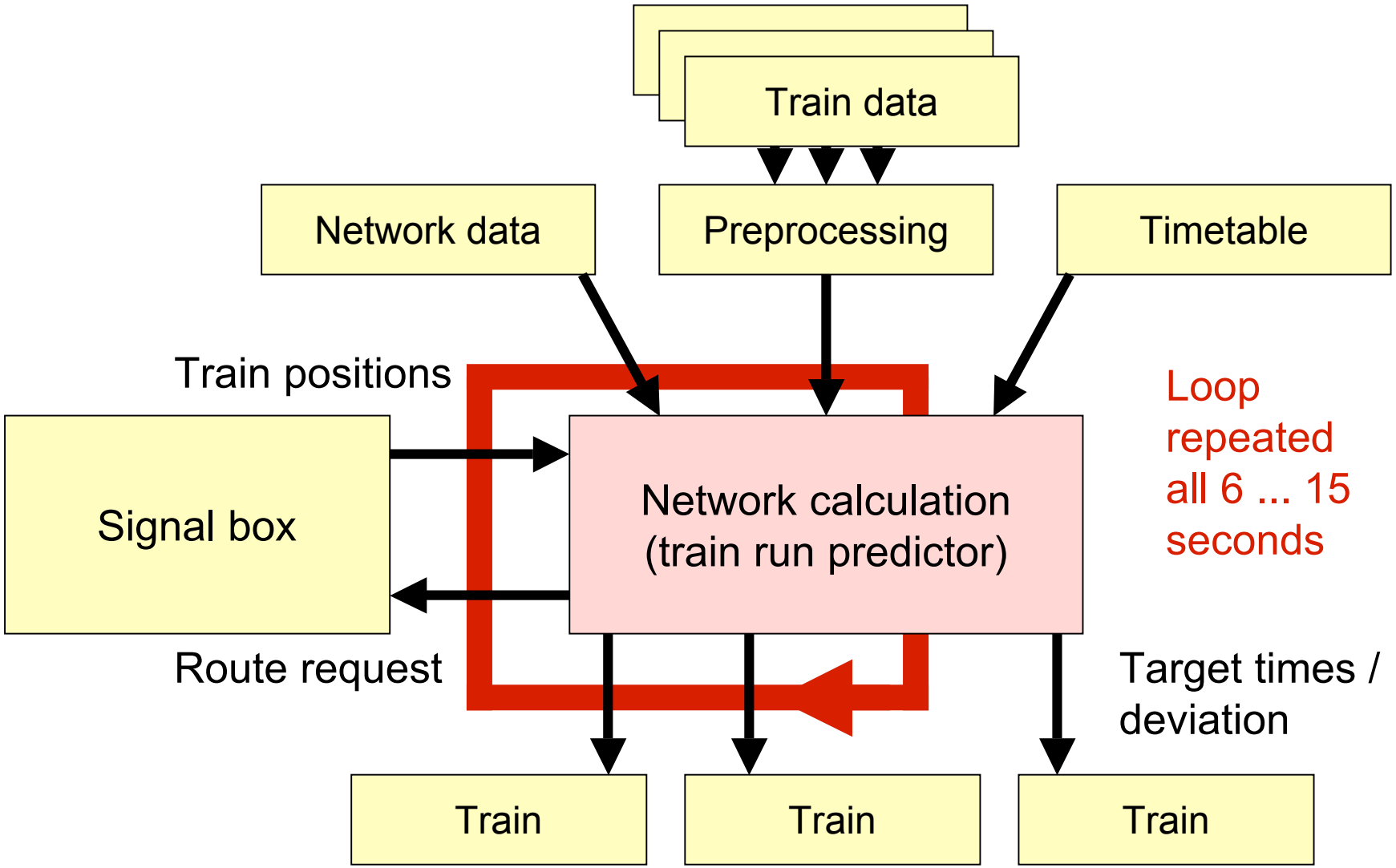

Conclusions

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The system study has shown:

- There are promising methods for on-line optimisation of rail traffic flow; energy consumption can be addressed explicitely
- Energy consumption and network capacity are not in contradiction
- A reduction of the total consumption by about 5% seems to be realistic in the medium future in Switzerland