

# SMARTIES – Scheduling Methods for Automated Railway Timetabling improving the Efficiency of SmartRail

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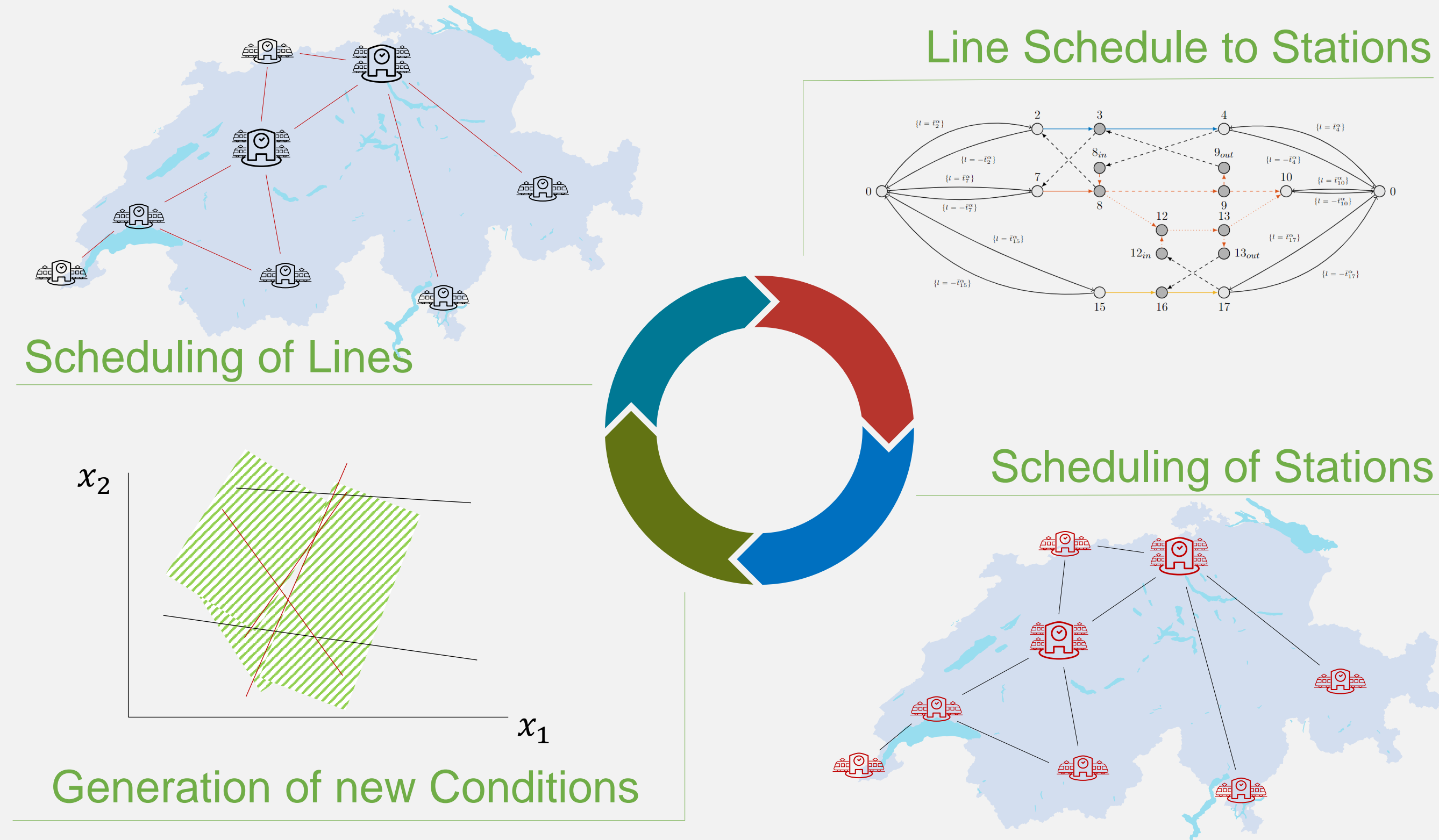
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## 1 Introduction

Railway timetabling is one of the key factors in the successful operation of a railway network. The timetable must satisfy all operational restrictions at a microscopic representation of the railway network, while maximizing transportation capacity for passengers and freight. The microscopic planning of a railway timetable is an NP-Hard problem, difficult to solve for large-scale railway networks, such as those of entire countries. The research of SMARTIES contributes towards the automation of railway timetabling in Switzerland together with SBB.

## 2 Decomposition

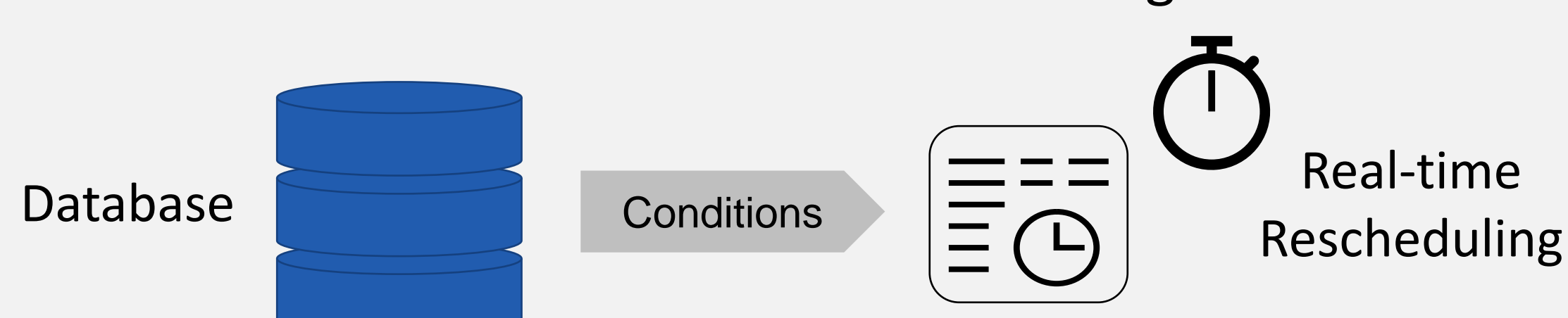
Railway stations are areas in the railway network which are well interconnected. In such areas many alternative schedules for the trains are possible, which all are different in operation but equal in operational quality. With a logic Benders decomposition approach, we separate the scheduling in railway stations, a problem with many equal solutions, from the scheduling of railway traffic between different stations.



## 3 Timetabling & Rescheduling with Decomposition

Decomposition in railway scheduling enables us to schedule scenarios of **twice** the size as with a conventional centralized approach up to **x40** times faster.

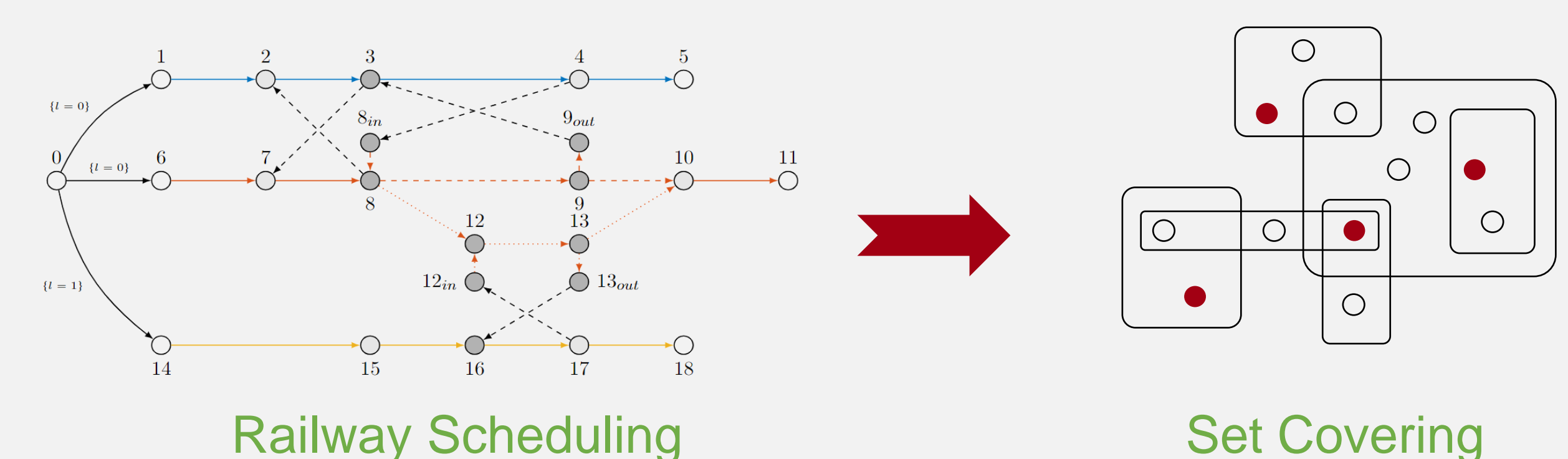
A byproduct of timetabling with a logic Benders decomposition are conditions for the scheduling of traffic on lines between stations. These conditions can be reused for rescheduling during the real-time control of the railway network. A database framework for precomputed conditions can be used to accelerate rescheduling:



With a database of conditions, we can achieve an additional speed up of factor **x2** for rescheduling.

## 3 Minimal Cost approximating Timetabling

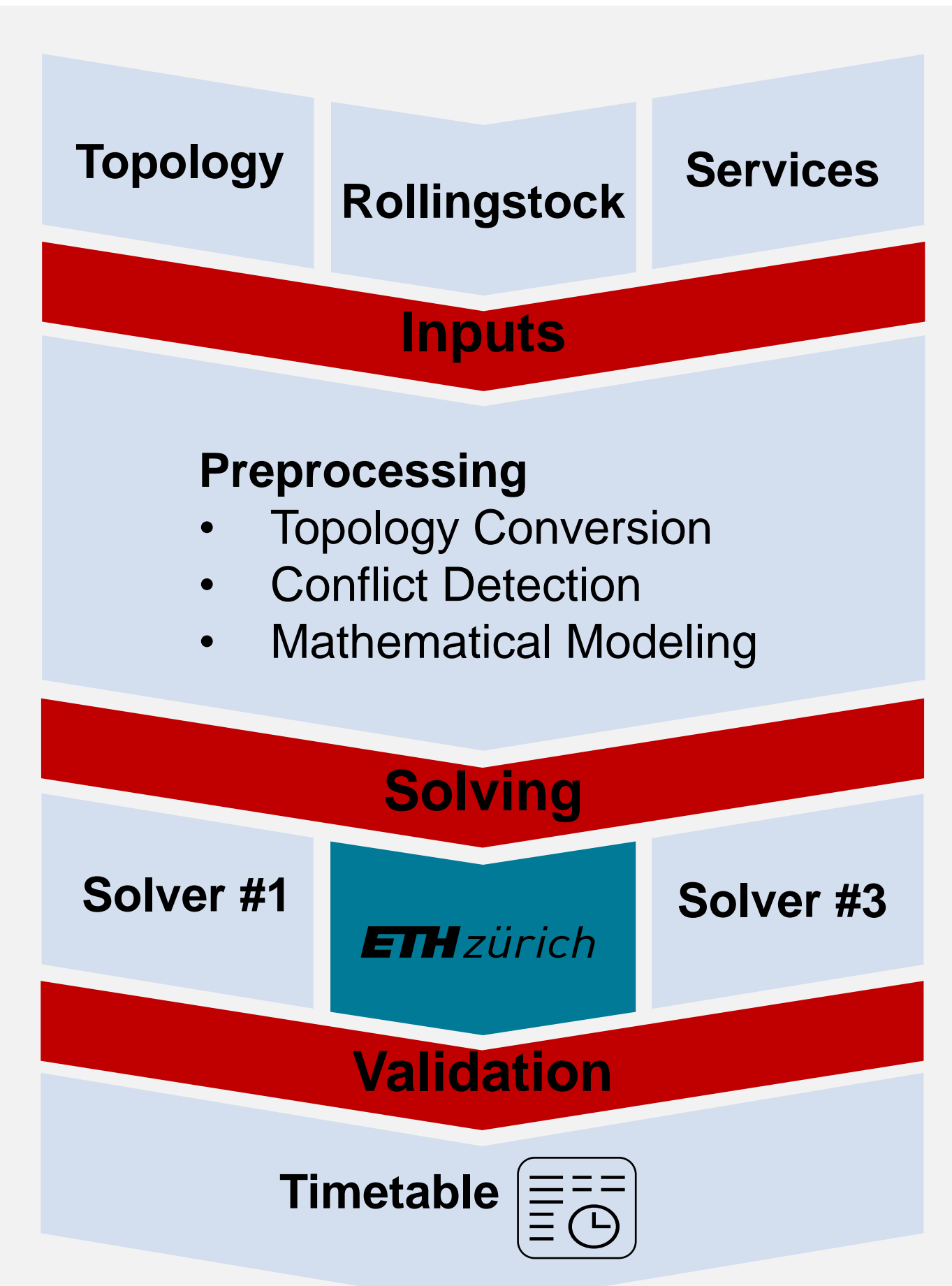
With the design of an Infeasibility-Proof-Detection algorithm we can detect minimal cost generating elements in a large-scale railway timetabling problem. Minimal cost generating elements contain valuable information about the timetabling problem and can be used to transform the problem of timetabling into a problem of set covering. Set covering problems are well understood and existing heuristics can be used to solve the railway timetabling related set covering problem extremely efficient.



## 4 Integration

A continuous integration of latest ETH developments and designs into the cloud services of SBB enables a direct evaluation from industry. In a collaboration between ETH and SBB a platform has been designed where newest developments are deployed directly and made available to the operators at SBB.

Tools of SBB evaluate the industrial correctness of solutions provided by ETH and give valuable feedback to the researchers at ETH in Zurich.



## 5 Conclusion and expected impact

- Decomposition proved successful as an approach towards scaling automated railway scheduling for large-scale railway networks.
- Accelerated decomposition proved valuable for rescheduling.
- Heuristic Railway Timetabling provides valuable results quickly.

The algorithm developments at ETH Zurich will provide valuable knowledge and algorithms for the future of automation in railway timetabling at SBB, for the railways in Switzerland.

## References

1. Leutwiler, Florin, and Francesco Corman. "A logic-based Benders decomposition for microscopic railway timetable planning." *European Journal of Operational Research* (2022).